Agenda Item D.1
Situation Summary
April 2013

NATIONAL MARINE FISHERIES SERVICE REPORT

National Marine Fisheries Service (NMFS) Northwest Region will briefly report on recent regulatory developments relevant to groundfish fisheries and issues of interest to the Council.

NMFS Northwest Fisheries Science Center (NWFSC) will also briefly report on groundfish-related science and research activities.

Council Task:

Discussion.

Reference Materials:

1. Agenda Item D.1.b, Attachment 1: *Federal Register* Notices Published Since the Last Council Meeting.

Agenda Order:

a. Agenda Item Overview — Kelly Ames
b. Regulatory Activities — Frank Lockhart
c. Fisheries Science Center Activities — John Stein and Michelle McClure
d. Reports and Comments of Advisory Bodies and Management Entities
e. Public Comment
f. Council Discussion

PFMC
03/15/13

Agenda Item D.1.b
Attachment 1
April 2013

Groundfish and Halibut Notices
2/7/13 through 03/19/2013

Documents available at NMFS Sustainable Fisheries Groundfish Web Site
http://www.nwr.noaa.gov/publications/frn/groundfish_frns.html

78 FR 9660. Pacific Halibut Fisheries; Catch Sharing Plan. Action: Proposed Rule - 2/11/13

78 FR 16423. Pacific Halibut Fisheries; Catch Sharing Plan. Action: Final Rule - 3/15/13

small entities and still meet the requirements of the statute 10 U.S.C. 2533b.

V. Paperwork Reduction Act

The rule does not contain any information collection requirements that require the approval of the Office of Management and Budget under the Paperwork Reduction Act (44 U.S.C. chapter 35).

List of Subjects in 48 CFR Part 252

Government procurement.

Kortnee Stewart,

Editor, Defense Acquisition Regulations System.

Therefore, DoD amends 48 CFR part 252 as follows:

PART 252—SOLICITATION PROVISIONS AND CONTRACT CLAUSES

■ 1. The authority citation for part 252 continues to read as follows:

Authority: 41 U.S.C. 1303 and 48 CFR Chapter 1.

252.212–7001 [Amended]

■ 2. Section 252.212–7001 is amended by—

■ a. Removing clause date ''(FEB 2013)'' and adding ''(MAR 2013)'' in its place; and

■ b. In paragraph (b)(7), by removing the clause date ''(JUL 2009)'' and adding ''(MAR 2013)'' in its place; and

■ c. In paragraph (b)(8), by removing the clause date ''(JUN 2012)'' and adding ''(MAR 2013)'' in its place.

■ 3. Section 252.225–7008 is amended by—

■ a. Removing clause date ''(JUL 2009)'' and adding ''(MAR 2013)'' in its place; and

■ b. Removing the numerical designations preceding the definition headings of ''Alloy''; ''Produce''; ''Specialty metal''; and ''Steel''.

■ c. Revising the definition of ''Produce'' in paragraph (a) to read as follows:

252.225–7008 Restriction on Acquisition of Specialty Metals.

* * * * *

(a) * * *

Produce means—

(i) Atomization;

(ii) Sputtering; or

(iii) Final consolidation of non-melt derived metal powders.

* * * * *

■ 4. Section 252.225–7009 is amended by—

■ a. Removing clause date ''(JUN 2012)'' and adding ''(MAR 2013)'' in its place; and

■ b. Removing the numerical designations preceding the definition headings of ''Alloy''; ''Assembly''; ''Commercial derivative military article''; ''Commercially available off-the-shelf item''; ''Component''; ''Electronic component''; ''End item''; ''High performance magnet''; ''Produce''; ''Qualifying country''; ''Required form''; ''Specialty metal''; ''Steel''; and ''Subsystem''.

■ c. Revising the definition of ''Produce'' in paragraph (a) to read as follows:

252.225–7009 Restriction on Acquisition of Certain Articles Containing Specialty Metals.

* * * * *

(a) * * *

Produce means—

(i) Atomization;

(ii) Sputtering; or

(iii) Final consolidation of non-melt derived metal powders.

* * * * *

252.244–7000 [Amended]

■ 5. Section 252.244–7000 is amended by—

■ a. Removing clause date ''(JUN 2012)'' and adding ''(MAR 2013)'' in its place; and

■ b. In paragraph (b), by removing the clause date ''(JUN 2012)'' and adding ''(MAR 2013)'' in its place.

[FR Doc. 2013–07107 Filed 3–27–13; 8:45 am]
BILLING CODE 5001–06–P

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 660

[Docket No. 120313185–3252–01]

RIN 0648–BC01

Fisheries Off West Coast States; Pacific Coast Groundfish Fishery; Trawl Rationalization Program; Reconsideration of Allocation of Whiting

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Final rule.

SUMMARY: This action revises several portions of the Pacific Coast Groundfish Fishery Trawl Rationalization Program (program) regulations in response to a court order requiring the National Marine Fisheries Service (NMFS) to reconsider the initial allocation of Pacific whiting (whiting) to the shorebased individual fishing quota (IFQ) fishery and the at-sea mothership fishery. Additionally, NMFS concludes after review of public comments and the record as a whole, that the Pacific Fishery Management Council's (Council's) recommendation to maintain the existing initial allocations of whiting is consistent with the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the Pacific Coast Groundfish Fishery Management Plan (Groundfish FMP), and other applicable law. This final rule will affect the transfer of quota share (QS) and individual bycatch quota (IBQ) between QS accounts in the shorebased IFQ fishery, and severability of catch history assignments (CHAs) in the mothership fishery, both of which will be allowed on specified dates, with the exception of widow rockfish. Widow rockfish is no longer an overfished species and transfer of QS for this species will be reinstated pending reconsideration of the allocation of widow rockfish QS in a future action. The divestiture period for widow rockfish QS in the IFQ fishery will also be delayed indefinitely.

DATES: This rule is effective April 1, 2013.

ADDRESSES: Information relevant to this final rule, which includes a final environmental assessment (EA), and a final regulatory flexibility analysis (FRFA), including a regulatory impact review (RIR), are available from William W. Stelle, Jr., Regional Administrator, Northwest Region, NMFS, 7600 Sand Point Way NE., Seattle, WA 98115–0070. Electronic copies of this final rule are also available at the NMFS Northwest Region Web site: *http://www.nwr.noaa.gov.*

FOR FURTHER INFORMATION CONTACT: Ariel Jacobs, 206–526–4491; (fax) 206–526–6736; *Ariel.Jacobs@noaa.gov.*

SUPPLEMENTARY INFORMATION:

Background

This final rule revises several provisions of the Pacific coast trawl rationalization program and supersedes regulatory delays and/or revisions NMFS established through temporary emergency action in a final rule published on August 1, 2012 (77 FR 45508), and extended on January 17, 2013 (78 FR 3848). Specifically, this action will:

(1) Allow transfer of QS or IBQ (except for widow rockfish QS) between QS permit holders in the shorebased IFQ fishery beginning January 1, 2014;

(2) Require QS permit holders in the shorebased IFQ fishery holding QS or

IBQ in excess of the accumulation limits to divest themselves of excess QS (except for widow rockfish QS) or IBQ by November 30, 2015;

(3) Allow limited entry trawl permit holders in the mothership fishery to request a change (or transfer) of mothership/catcher vessel (MS/CV) endorsement and its CHA beginning September 1, 2014;

(4) Require MS/CV endorsed limited entry trawl permit owners to divest themselves of ownership in permits in excess of the accumulation limits by August 31, 2016; and

(5) Extend the divestiture period delay and moratorium on transfer of widow rockfish QS in the shorebased IFQ fishery indefinitely.

Each of these elements, along with additional background information, were described in detail in the proposed rule (78 FR 72, January 2, 2013), and are not repeated here.

NMFS Decision on Reconsideration of the Initial Allocation of Whiting

NMFS has determined that the Council's recommendation to maintain the existing initial whiting allocations (No Action Alternative) is consistent with the MSA, the Groundfish FMP, the court's order in *Pacific Dawn* v. *Bryson,* No. C10–4829 TEH (N.D. Cal.) (*Pacific Dawn*), and other applicable law. This determination is based on NMFS' review of the entire record, including the Council's record and NMFS' consideration of comments received on the proposed rule. After considering the required statutory factors and the goals and objectives of the trawl rationalization program and the Groundfish FMP, NMFS has determined that the existing initial whiting allocations provide for a fair and equitable allocation to the shorebased IFQ program and the mothership coop program. These initial allocations of whiting take the form of QS for both harvesters and processors in the shorebased IFQ program, and CHA for harvesters in the mothership fishery. For the purposes of this action, ''quota'' is used to describe allocations of both CHA and QS to harvesters in the shorebased IFQ and mothership fisheries, as well as to describe allocation of QS to shoreside processors.

In the context of the relatively narrow remand ordered by the court in *Pacific Dawn,* NMFS has determined that many MSA factors show minimal differences, or none at all, between the alternatives under consideration. Additionally, where there are differences, they are tempered by the relatively modest shifts in quota among the various alternatives and other relatively minor variations that result. For example, comparing the No Action Alternative to the alternative most favoring recent history (Alternative 4) reveals overall modest shifts in quota from status quo holders to others (17% for shorebased harvesters, 3% for shoreside processors, and 18% for mothership harvesters) and generally modest shifts among most individual permit holders and processors. This is principally the result of the fact that a majority of participants in the whiting fishery have generally continuous participation in the fishery. Given this, and in balancing the various factors in this decision (including control date, investment and dependence, disruption, efficiency, employment, current and historic participation, communities), NMFS has concluded there are fundamental and compelling reasons to maintain the existing initial allocations of whiting. Of most importance, maintaining existing allocations takes into account the intent of the 2003 control date and principal policy goals of the trawl rationalization program (including reducing overcapitalization and ending the race for fish). Maintaining status quo also reduces concentration of quota among participants and achieves a wider geographic distribution of initial program benefits. NMFS believes these key factors, among other considerations, outweigh the reasons supporting alternatives that favor more recent history (e.g., recognizing recent fishery participants' dependence and investments, reducing future quota leasing or acquisition costs, reducing quota to recent non-participants, and reflecting more recent market and fishery conditions). More detailed discussion on the specific statutory factors under MSA section 1853a(c)(5)(A) and related provisions is set forth in the preamble to the proposed rule and not repeated here.

Maintaining the initial whiting allocations, including the use of qualifying years of 1994–2003 for whiting harvesters and 1998–2004 for whiting processors, supports the Council's and NMFS' efforts to reduce overcapitalization and end the race for fish by not rewarding increases in harvesting or processing that occurred after the end of the qualifying periods (i.e., after the 2003 control date). The existing whiting allocations also support the importance of the control date for this and future rationalization programs, minimize the concentration of harvester quota, and provide for a wider initial geographic distribution of the program benefits along the coast and the corresponding fishing communities.

Importance of the Control Date

Two fundamental purposes of Amendment 20 were to reduce overcapitalization in the groundfish fishery and to end the race for fish. The Council adopted and announced the 2003 control date to further these purposes, seeking to discourage speculative capitalization and discourage effort by putting participants on notice that any fishing history earned beyond 2003 may not count towards a future allocation system. Since the original notice of the 2003 control date in the **Federal Register** on January 9, 2004 (69 FR 1563), there has been continuous and systematic work to develop the trawl rationalization program. Throughout the reconsideration, many participants testified or provided written comment with respect to how the announcement of the control date affected their business decisions. NMFS acknowledges that a control date is not a guarantee that any specific period will count toward initial allocations. NMFS believes, however, that recognition of the business and investment decisions made by participants who interpreted the control date as signaling the likely end of the qualifying period is consistent with the fundamental purposes of Amendment 20. While no mechanism exists to separate speculative from non-speculative effort after the control date, maintaining the control date for harvesters does not reward any speculative behavior after the control date and does not penalize those who honored the control date. Additionally, an important signal is sent for future programs (nationally as well as on the Pacific Coast)—the use of control dates is still a valid tool to deter increases in effort or capitalization that would undermine conservation and management goals pending development of a limited access privilege program.

Moreover, for processors, the record establishes valid reasons to end the qualifying period for processors one year after the 2003 control date, including accounting for processor investments that took place prior to the announcement of the control date but that did not begin to earn processing history until 2003 and 2004. In addition, the purpose of applying control dates to onshore processors, while important, is not necessarily as significant as for harvesters, who have a greater ability to move into and out of various fisheries to gain potential fishing history. These factors, in addition to the fact that it was not clear until 2005 that the 2003 control date potentially applied to processors, support the decision that a one year shift, to 2004, was a reasonable cutoff date for processors.

While maintaining the end of the qualifying periods necessarily excludes providing credit for more recent participation, publication of the control date and the continuous and active deliberation of the Council provided notice to all participants that this was a possibility. Thus, those participants who did increase their investments or effort in the fishery were on notice that any history established in later years might not count towards initial allocations. Additionally, participants had the opportunity to purchase permits from others to bolster their catch history totals to potentially reflect their increased investments and effort (as the record reflects did occur). The fairness of maintaining the initial cut-off dates also is reflected in the public comments of participants that supported No Action Alternative despite the fact that they would receive higher levels of quota if an alternative favoring more recent history were adopted.

Although the length of time between the original control date and the agency approval in 2010, implementation of the program in 2011, and this decision in 2013 is longer than the time span in most programs that announce control dates, this is explained by the complexity of the program, which resulted in significant time needed to involve the public and fishery participants, develop alternatives, develop appropriate analytical documents, reach a final decision, implement that decision, and then engage in this reconsideration process. Additionally, the Council and NMFS have fully considered all applicable fishing and processing history for this decision, leaving no gap in the available information considered.

Minimize Concentration of Quota

The record reflects that basing initial whiting allocations on alternatives that include more recent history would generally have the effect of concentrating quota for harvesters in fewer hands, creating fewer winners and more losers compared to maintaining the existing allocations (see EA, Section 4.5.3.2 and FRFA). Moreover, when viewed in the context of the trawl rationalization program as a whole, moving the end date of the qualifying period to a more recent year could have the effect of creating ''double-dip'' gains and losses for certain participants due to having different allocation periods for whiting compared to some non-whiting species. For example, there were seven permits that, after 2003, reduced their share of harvest in the non-whiting fishery while increasing their share in the whiting fishery (see EA, Section 2.2.3.2). Using an allocation period other than the No Action Alternative would benefit those participants with more whiting history in recent years because they would receive an amount of non-whiting quota allocated under a 2003 cut-off while simultaneously receiving increased whiting quota (i.e., double-dipping) if a later end year was used for whiting allocations, creating inequities in the allocation of target species.

Wider Geographic Distribution of the Initial Benefits of the Program

The record reflects that maintaining the existing allocations would provide a more even distribution of initial whiting allocations along the coast and to the corresponding fishing communities. Shifting to alternatives favoring more recent history could contribute to a northward shift in initial quota distribution, and accordingly a similar shift in any benefits stemming from that initial allocation (see EA, Section 4.3.3). The northward shift is expected to be relatively small (less than 8 percent of the total quota—2 percent for processors and 6 percent for harvesters between the No Action Alternative and Alternative 4), and the analysis shows whiting landings have been shifting northward in recent years (due to fish availability and investments in ports). Although the 8 percent difference is relatively modest, NMFS believes that maintaining the initial whiting allocations supports historic fishing communities in more southern locations and creates a wider geographic distribution of the initial benefits associated with allocations. Maintaining initial whiting allocations would further support one of the guiding principles in the development of Amendment 20 (see Am 20 EIS, Section 1.2.3)—to minimize negative impacts resulting from localized concentrations of fishing [and processing] effort. For processors, in addition to the distribution of wealth associated with initial allocations, the wider distribution of initial allocation of whiting QS may provide some additional influence over where deliveries are made along the coast than if the initial allocation were based on more recent qualifying years that would shift allocations and potentially landings northward.

Comments and Responses

In the proposed rule, NMFS solicited public comments on the regulatory revisions and on NMFS' preliminary determination that the Council's recommendation to maintain the initial allocations of whiting for the shorebased IFQ fishery and the at-sea mothership fishery is consistent with the MSA, the Groundfish FMP, and other applicable law. The comment period ended February 1, 2013. NMFS received 19 written comments on the proposed rule reflecting comments from individuals, organizations and other agencies. NMFS also received oral comments regarding the existing initial whiting allocations at a meeting during the comment period. The U.S. Department of the Interior submitted a letter indicating that it had no comment. One written comment also addressed the proposed regulatory revisions. The comments received and NMFS' responses are below.

Process

Comment 1: NMFS has the responsibility of reviewing the record as a whole and ensuring that the action is consistent with the Groundfish FMP and the MSA. NMFS must not simply defer to the Council.

Response: NMFS agrees that it must make the final decision and cannot simply defer to the Council with respect to whether the recommendation to maintain the existing initial whiting allocations and make associated regulatory revisions is consistent with the Groundfish FMP, the MSA, including the national standards, and other applicable law. NMFS has taken its own hard look at the entire record, including public comment on the proposed rule, and determined that this action satisfies those requirements.

Comment 2: The public reconsideration process was thorough, lengthy, open, and transparent. To make appropriate decisions, Council members need stakeholder involvement and the Council reviewed and heard numerous public comments and advisory body statements from various perspectives. In addition, the majority of Council members that participated in the reconsideration were not members of the Council when it took its original action in 2008, which allowed for thorough review of the fairness and equity of that decision.

Response: NMFS agrees that stakeholder involvement is the foundation of an open public Council process and is an important component of decision making, especially with respect to allocations. The Council, including NMFS representatives, reviewed and considered many comments from various perspectives at Council meetings and NMFS has further considered stakeholder input through the comments received on the proposed rule.

Comment 3: It is unclear what role the NOAA Catch Share Policy played in the reconsideration of initial whiting allocations. Further, based on the section of the NOAA Catch Share Policy entitled ''evaluating catch share applicability,'' three of the characteristics for use in determining whether a fishery is a suitable candidate for a catch share program—overcapitalization, overfished stocks, and bycatch—do not appear to be present in the whiting fishery in 2010 and therefore it is unclear whether the whiting fishery was a good candidate for a catch share program.

Response: NMFS considered the NOAA Catch Share Policy (the Policy) as part of the reconsideration. Generally, the Policy recommends that allocations be revisited on a regular basis and that an allocation decision should include consideration of conservation, economic, and social criteria in furtherance of the goals of the underlying FMP. The reconsideration of initial whiting allocations reflected consideration of the factors identified in the Policy. The decision to include whiting in the trawl rationalization program was approved in Amendment 20 and implemented in 2011. NMFS also considered provisions of the Policy at that time. Amendment 20 was developed to address among other things, overcapitalization, overfishing, and bycatch, including bycatch of overfished species, in the groundfish trawl fishery (75 FR 78344). The decision to include the whiting fisheries as part of the trawl rationalization program is not part of the reconsideration of initial whiting allocations or this rule.

Comment 4: Consideration of a factor means that it must be weighed and taken into account, not noted and ignored. NMFS must provide a reasoned analysis that connects the factor with the decision it makes with respect to initial whiting allocations.

Response: NMFS agrees that consideration of a factor entails more than noting its existence. However, when making an allocation decision, the factors that must be considered do not require any particular outcome. For example, the requirement to consider current harvests when establishing a fair and equitable initial allocation does not mandate that the qualifying periods for initial whiting allocations be expanded to include years beyond the existing cut-offs. As the record demonstrates, there is a rational basis for excluding more recent years from the qualifying periods. The existing initial allocations further the goals and objectives of Amendment 20 and avoid rewarding increases in harvesting or processing at a time when the fishery was overcapitalized, and a time after participants were aware that history beyond 2003 may not qualify for use in an allocation formula.

Current and Historical Harvests

Comment 5: More recent years should be used in the qualifying period for allocating whiting to processors to reflect changes in the marketplace. The whiting market has changed since the end of the existing qualifying periods, specifically with the growth of the market for the whiting headed and gutted product. The changes made the fishery more efficient and economically stable after 2004, so more recent years should be more heavily weighted to establish a fair and equitable allocation.

Response: NMFS agrees that there have been changes in the markets for whiting. These changes have led to changes in the amounts and types of product made out of whiting. Since the early 1990s, shorebased processors have converted whiting into headed and gutted (H&G), surimi, fillets, and fish meal products. In the early 1990s, there was a much greater emphasis on surimi. New plants came on line in response to the demand for surimi caused by the phase out of Japanese and Korean fleets off the U.S. and Russian waters. In recent years there has been a much greater emphasis on H&G products, sparked by the increased world demand for H&G products. In the early 1990s, the market for H&G products was a limited domestic market and now the H&G market is international.

The surimi market has declined, based on changes in the Japanese and Korean demand and from foreign competition. As a result, surimi plants have either shut down or reduced production. Prior to 2004, up to five plants were producing surimi. Currently, there is only one shorebased plant that is producing whiting surimi and that plant is also producing H&G products.

In response to changing world markets, company restructuring, and other factors, there has always been entry and exit within the whiting processing sector. There have also been changes in relative prices of products that in turn determine the mix of various products. Underlying both the development of the surimi processing capacity, and now H&G processing capacity, have been declining trends in world groundfish production.

Overall, the major companies of the processing industry that existed prior to 2004 still exist in 2012. For companies that no longer exist, the quota that would have been allocated to those entities has been distributed to existing companies in proportion to the size of their quota allocations under the existing initial allocations. NMFS recognizes the influence of H&G prices and the new world markets, but does not believe these changes should result in selecting an alternative that includes more recent years in the whiting allocation formula, as all companies are partaking in the expanded market for H&G whiting and can continue to do so irrespective of the amount of the whiting QS received by that entity. Furthermore, recent entrants into the processing sector entered at a time when they could benefit from the expanded market for H&G whiting, which could allow them to be competitive despite receiving no, or a lesser amount, of an initial whiting allocation. They also entered at a time after the control date had been announced and while the Council was actively pursuing development of the trawl rationalization program. NMFS believes that it is fair and equitable to use qualifying years that more heavily reflect the investments and processing history that occurred prior to 2004, consistent with the intent of discouraging speculative increases in capacity and minimizing disruption to processors that invested under the old management regime prior to the Council beginning its efforts to rationalize the fishery.

Comment 6: Using more recent years in the qualifying period promotes conservation because larger fish tend to occur in northern waters, and northern processors have a better opportunity to process larger and higher quality fish. Under alternatives that would shift more quota to the north, fewer larger fish can be harvested, leaving more fish in the water to spawn and sustain the fishery. Using more recent years would also promote conservation because H&G product has higher recovery rates than surimi product which dominated the whiting fishery in earlier years.

Response: NMFS agrees that northern processors may have a greater opportunity to process larger and higher quality fish. However, NMFS disagrees that using more recent years promotes conservation to any meaningful extent. Any conservation benefit associated with the alternatives is extremely small and highly speculative, and does not justify selecting an alternative that uses more recent years when considered in light of all the factors.

The EA analyzes the potential biological impacts associated with the alternatives that were considered. Generally, for whiting, harvesting a larger proportion of older fish in any given year is likely to have an upward influence on stock productivity relative to harvesting the same amounts of whiting with a smaller proportion of older fish. In an extreme hypothetical where all harvests were delayed until September of each year—when whiting are typically larger and located further to the north—a 10 percent increase in stock productivity was projected when compared to having all harvest occurring in April.

In contrast, the amount of quota that could initially be shifted geographically and potentially result in changes in the location of harvest is much smaller than in the all-harvest hypothetical above. To begin, the allocation alternatives are unlikely to affect the location of harvest in the mothership fishery or the catcher/processor fishery because these fisheries are not tied to a need for shorebased processing. Together, the mothership and catcher/processor fisheries are allocated 58 percent of the non-tribal commercial allocation (24 percent for the mothership sector and 34 percent for the catcher-processors). Of the remaining 42 percent of the non-tribal commercial allocation given to the shorebased IFQ fishery, the allocation most likely to have any short term effects on geographic area of harvest is the QS issued to processors, which is a maximum of 20 percent of the 42 percent allocated to the shoreside fishery, or 8.4 percent of the non-tribal commercial whiting allocation. The EA also indicates that the effects of initial allocations on the distribution of fishing among communities are difficult to predict because over the long term quota will likely move toward those ports where profit margins tend to be the highest, regardless of the initial allocations (see EA Section 4.3.3). Using the 10 percent hypothetical result as a maximum, and applying that result to the 8.4 percent of the non-tribal commercial whiting allocation to processors, results in an upper bound on the impact on stock productivity of less than 1 percent. Even this is likely an overstatement, however, given that only a relatively small amount of the quota actually shifts to more northern based processors when comparing the No Action Alternative to Alternative 4 (which most favors recent history).

NMFS also notes that when adding Canadian and Tribal fisheries to the analysis, the potential for conservation benefits becomes smaller. For 2011, the total U.S. and Canadian Total Allowable Catch (TAC) limit was 393,751 mt. The U.S. portion of the TAC was 290,903 mt, which includes the U.S. shorebased allocation of 92,818 mt. The 20 percent of shorebased whiting QS allocated to processors is approximately 5% of the U.S. and Canadian coastwide TAC. NMFS further notes that depending on the strength of the year classes, it may be difficult, even in the northern portion of the fishery, to avoid small fish (see Status of the Pacific hake (Whiting) stock in U.S. and Canadian Waters in 2012, International Joint Technical Committee for Pacific Hake, Final Document 2/29/2012, pages 27–28, *http://www.nwr.noaa.gov/fisheries/management/whiting/pacific_whiting.html*).

The EA concludes that given the relatively small amount of quota that may be reallocated among geographic regions, the fact that QS trading will likely change geographic distribution regardless of the initial allocations, and considering fleet mobility, the effect of the initial allocations on area of harvest and resulting biological impacts are negligible. Additionally, even assuming recovery rates for H&G products are greater than those for surimi, NMFS does not anticipate that initial allocations to processors will have a significant influence on the type of whiting products produced by processors, especially in the long term. As a result, there does not appear to be a difference in conservation among the alternatives in terms of product recovery. Also see response to comment 5 addressing the transition from surimi to H&G for the whiting fishery.

In sum, selecting an alternative that uses more recent years in the qualifying period is not justified based on differences in biological impacts and NMFS believes that other considerations justify maintaining the existing initial allocations.

Comment 7: The purpose of considering current and historical harvests for processors is that it allows a council and the Secretary to consider the relative value of investments made in processing capacity early in the development of a fishery compared to the value of investments in processing made late in a fishery that is already heavily overcapitalized. This is one of the considerations that should go into the decision of which years of processing participation are best used for fair and equitable allocations to processors.

Response: NMFS agrees and has concluded that investments in processing capacity made earlier in the fishery should be more heavily taken into account when determining the initial allocation qualifying periods. This is in part because the allocation of quota to processors was intended to minimize disruption to processors that had invested under an expectation of operating under the pre-Amendment 20 fishing regime, and also because any investments made after the announcements of the control date were made at a time when it was evident that the Council was actively pursuing an effort to rationalize the trawl fishery.

Dependence, Investment, Participation, and Latent Permits

Comment 8: A significant portion of quota was allocated to permits that had no history of landings in the fishery after 2003. The EA indicated that allocations went to 21 permits that had no participation in the shorebased whiting fishery during the seven years between 2004 and 2010, representing 10.2% of the shorebased whiting quota. Furthermore, the EA also identified that whiting allocations went to 14 permits (representing 9.6% of the quota allocated to the mothership sector) that had no participation in the mothership sector during the same seven years between 2004 and 2010. Considering the number of permits that received quota but have not participated in the fishery since 2003, it is evident that the existing qualifying periods were based at least partially on some industry members' desire to sell their quota and retire. The initial allocations should instead be based on what is best for those currently participating. When considering investment as a measure of dependence, NMFS should focus only on whiting and not on other fisheries.

Response: NMFS acknowledges that quota was allocated to some permits that did not directly participate by harvesting or landing whiting in the whiting fishery in the years between 2004 and 2010. However, NMFS does not believe that this fact warrants including more recent years in the qualifying period because many of the permit owners owned other permits that were active in the whiting fishery during those years, participated in other fisheries including other sectors of the whiting fishery, or held those inactive permits as an investment.

Groundfish fisheries on the West Coast are frequently prosecuted based on a ''portfolio'' approach where fishermen participate in various sectors or corollary fisheries throughout a given year and between years to maximize benefits. To the extent permits received quota but did not actively participate in West Coast fisheries during the years referenced, the quota was still allocated to the permit owner at the time of initial allocation and reflects the investment of the participant in the permit. As discussed in the EA, a limited entry trawl permit is a highly fishery-dependent investment that must be renewed annually. Public comment, both at the Council meetings and through comments on the proposed rule, also indicated that some fishermen actively chose to invest in permits in the hope that they would receive initial allocation quota amounts that would accommodate their intended fishing strategies. As noted in public comment on the proposed rule in support of the existing allocations of whiting, the initial harvester allocation to current permit owners recognizes recent participation and investments in the fishery. After the 2003 control date, 18 permits were sold to new permit owners and the permit's catch history went to those new permit owners. Another commenter made a similar comment that business decisions were made to retire vessels after the control date rather than investing in vessel upgrades and maintenance, with the understanding that the intent of the program was to promote consolidation within an overcapitalized fishery. Furthermore, as discussed below, when considering permits that were truly inactive in either the shorebased or mothership sectors of the whiting fishery after 2003, only approximately 1.5 percent of the history based quota was allocated to those permits. Finally, the topic raised by the commenter regarding the business decisions made by those who acquire QS through initial allocation (e.g., whether to sell or lease that quota to another participant or eventually sell the QS/CHA once it becomes transferable) are present irrespective of the qualifying period chosen.

With respect to inactive permits being owned by an entity that also actively participated in the whiting fisheries through the use of other permits, for shorebased whiting permit QS allocation recipients, 4 of the 21 permits referenced by the commenter were owned by entities that also controlled other shorebased whiting permits. Those four permits received No Action QS allocations totaling 2.35% (i.e., 2.9% of the total shorebased whiting allocation to permits). Similarly, 4 of the 13 permits referenced by the commenter (the EA demonstrates there were 13 rather than 14 as stated in the comment, Section 4.5.2.1) that received CHA were owned by entities that also control other MS whiting permits. Those four permits received No Action CHA allocations totaling 3.8% (i.e., 3.8% of the total MS whiting CHA allocation to permits). In addition, for permits that received either shorebased whiting QS or mothership CHA allocations, there were a total of 15 permits that had no shorebased whiting or Mothership whiting history after 2003. Those 15 permits received No Action Shorebased whiting QS allocations totaling 3.8% (i.e., 4.75% of the total shorebased whiting allocation to permits), and No Action Mothership CHA allocations totaling 1.46% (i.e., 1.46% of the total MS whiting CHA allocation to permits). Six of those 15 permits were owned by entities that also controlled other shorebased whiting permits. Those six permits received No Action shorebased whiting QS allocations totaling 2.46% (i.e., 3.1% of the total shorebased whiting allocation to permits). None of the 15 permits were owned by entities that also controlled other MS/CV whiting permits. When looking at the whiting fishery as a whole, only 1.46% of the CHAs and only 1.65% of the shorebased QS was allocated to permits that were truly latent in both the mothership and shorebased sectors. NMFS defines ''truly latent'' permits as those that received either mothership CHA or shorebased quota share allocations where the permit itself was not fished in either the mothership fishery or the shoreside whiting fishery, and the owner of the permits also did not fish other owned permits in the mothership or shoreside whiting fishery after 2003.

Additionally, after accounting for participation in other fisheries, including those off Alaska, there were a total of only nine permits (shorebased or mothership) where the owner apparently had no fishing activity off the West Coast or Alaska after 2003. These nine permits translate into only 1.3 percent of the shorebased QS and 1.0 percent of the mothership catch history assignment used for the 2011 and 2012 fisheries.

Accordingly, the existing allocations allocate only a very small portion of quota to permits that are held by owners that did not participate in whiting, West Coast, or Alaskan fisheries or own other permits that did participate after 2003.

Comment 9: NMFS seemed to have difficulty defining dependence although the meaning of dependence in the MSA is clear and means to rely upon the fishery for financial support and income. Also, it is not fair and equitable to give quota to permits which, based upon the available objective information, did not participate in the fishery for some time and arguably no longer demonstrate any financial dependence on the fishery.

Response: NMFS did not have difficulty defining dependence in the proposed rule. In the proposed rule, NMFS noted that the MSA does not provide a definition of dependence, provided an explanation of the meaning of dependence, and noted that factors related to dependence may be measured in numerous ways. As stated, in general terms, dependence upon the fishery relates to the degree to which participants rely on the whiting fishery as a source of wealth, income, or employment to financially support their business. Current harvests, historical harvests, levels of investment over time, and levels of participation over time are all aspects of dependence, as they can all be connected to the processes that fishers and processors use to generate income. For purposes of this decision, NMFS believes that including all potential sources of income in assessing the level of dependence is appropriate.

NMFS also considered the Council's approach as discussed in Section 5.4.2 of the EA. The EA cites the NOAA technical memorandum ''The Design and Use of Limited Access Privilege Programs,'' (Anderson and Holliday 2007), which notes that ''various measures of dependence on the fishery [exist] including percent of revenue or opportunities to participate in other fisheries, and inter-relations with other fishery related business especially with respect to employment.'' The existing initial allocations do not provide history based quota to harvesters after 2003 or processors after 2004. As described above, that does not mean that investment and dependence during that period were ignored. Rather, the issue of investment and dependence for more recent years has been thoroughly explored, and there are valid policy reasons for excluding those years as discussed elsewhere. One important fact to recognize is that most current harvesters and processors in the fishery were also historical participants during the qualifying periods for initial allocation, and the shifts in quota among the initial allocation alternatives considered were relatively modest overall and for a majority of the participants. Permit owners receiving initial allocation received quota reflecting their historic participation and current permit ownership (reflective of dependence and investment) as well as a share of the buyback quota that was equally distributed.

Comment 10: Catch history years should be 1994–2010 or 2000–2010 to be fair and equitable and permits with no active involvement after 2004 should not be allocated whiting quota. Another commenter stated that NMFS should adopt 2000–2010 for the catch history years and adopt a present participation requirement that would require permits to have landed at least 500 mt of whiting in the period 2003–2010 to recognize the factors required for consideration in allocation decisions.

Response: As discussed in the preamble and in response to other comments, NMFS has concluded that excluding years beyond 2003 for harvesters and beyond 2004 for processors results in a fair and equitable allocation. Selecting an alternative that would include years beyond the existing cut-offs would be contrary to the policies underlying Amendment 20. Requiring permits to have landed at least 500 mt of whiting in the period 2003–2010 is not necessary to recognize the factors required in consideration of an allocation decision. Furthermore, adopting a present participation requirement for the period of 2003–2010 that would exclude any inactive permits would be inconsistent with the Groundfish FMP history since the Council rejected ''Use It or Lose It'' rules in 1994 relating to the development of Amendment 6 to the FMP (adopting the limited entry program). Similarly, requiring a participation requirement spanning the years after the announcement of the control date creates an incentive and a reward for increasing participation at a time the Council was attempting to address overcapitalization. Finally, the requirement suggested by the comment could undermine decisions made relative to investments in permits.

Comment 11: It is instructive that other fishery management councils are considering the problem of allocation of quota to license holders with minimal history or participation. The North Pacific Council, in a February 2013 problem statement stated that ''distributing shares with minimal history may be argued to be inconsistent with the requirement to allocate shares based on fishery dependence.'' Further, in a footnote, the council paper noted that acquisition of a permit ''is clearly an investment in the fishery,'' but ''reflects only an investment in a fishery privilege, and not an investment in a fishery operation.'' (Citing Item C–3(b) for the upcoming North Pacific Council meeting).

Response: First, NMFS notes that the Pacific Council and NMFS considered investments in and dependence upon the fishery in making this decision on whiting allocation. Second, NMFS notes that when fishery management councils develop catch share or other programs, councils may choose to weigh the factors differently based on the specific facts before them, including the factor of dependence and investment. NMFS notes that for purposes of the Pacific groundfish fishery and the decision on reallocation of initial whiting quota, a permit is viewed as a highly fishery dependent investment. Permits have no alternative use outside of accessing the trawl fishery; therefore permit owners are entirely dependent on the trawl groundfish fishery for recovery of their investment in permits. Other fishing assets, such as vessels, have some value in alternative uses.

Employment

Comment 12: Several commenters addressed the issue of employment. Some commenters expressed concern that companies that have scaled down their employment more recently would qualify for more quota based on their historical participation, while companies with larger recent harvesting and processing history will lose employment if they cannot afford to lease or buy quota. Another commenter stated employment on catcher vessels that benefitted from improved market conditions during 2000–2010 will be strongly disadvantaged given a 1994–2003 qualifying period because their quota shares will be less than their participation in recent years. Another commenter said 1994–2003 (status quo) maintained, on average, their fleet's historic and current access to whiting, their number of vessels, and their number of crewmember jobs in both the shorebased and mothership fisheries. Another commenter noted the analysis shows that overall the stability or level of employment does not vary much between all alternatives, including status quo; however, there are anticipated effects on individual fishing businesses based on any change from status quo.

Response: The final EA addresses impacts to employment (see section 5.4.3.5). While there may be some initial local shifts or variations in employment among the alternatives, the analysis did not anticipate notable variations in the stability or level of employment overall. As discussed elsewhere in the responses to comments, the relatively modest differences in the alternatives overall and for a majority of individuals also likely means even initial changes in employment will be limited. Overall, NMFS believes it has adequately considered impacts to employment in the harvesting and processing sectors in arriving at its decision.

Leasing, Competitive Advantage, and Efficiency Issues

Comment 13: Quota allocation to processors can provide a significant competitive advantage. Processors are unique from harvesters in that their investments are rooted to the community and the local fisheries that support that community, making dependence different for a processor than for a harvester. Initial allocations should use processing history from 2000–2010 because that period of time captures current and historical harvests and reflects a period of time when the fishery had recovered from being overfished and reached record revenues for fishery participants. Some processor companies made significant investments over the last decade to upgrade their facilities that supports using more recent years.

Response: NMFS is aware that initial quota allocation may provide advantages to one processor over another. However, given that the overall amount of quota that may shift between processors is only 3%, the degree of competitive advantage or even its existence depends on the business decisions of the quota recipient and numerous other considerations such as processor location, presence of local competition, access to markets, fleet dynamics, and status of the whiting stock, among other factors.

One main purpose of allocating 20 percent of the shorebased whiting quota to processors was recognition of the significant processing investments that had been made in reliance upon the fishery prior to the announcements of the control date and the development of Amendment 20. The allocation to processors was, in part, an attempt to minimize the disruption during the transition to the new system and provide some consideration and measure of stability. (See EA section 10.1, statement of Mr. Anderson; Amendment 20 EIS, Section 2.6.6).

NMFS and the Council acknowledge that testimony indicated that investments were made by some processors after 2004, including investments in infrastructure to process other stocks, such as sardines. However, it is reasonable to provide initial allocations more heavily weighted to reflect the investments and dependence on the fishery that occurred prior to the time it was evident that the Council was pursuing a change to the management system. Development of the trawl rationalization program could be most disruptive to processors that invested prior to 2004 because the program was likely to result in changes to the timing of landings, and potentially result in fewer vessels participating in the fishery—part of the effort to reduce overcapitalization. Given the establishment of the 2003 control date and subsequent clarification after the 2004 season that the 2003 control date could apply to processors, businesses that entered the processing sector or made investments after 2003 did so with a degree of risk regarding receiving any initial allocations or larger allocations.

NMFS recognizes that how quota is initially allocated to processors has some influence on the competitive advantage of processors between themselves and with respect to new entrants, including the potential for increased bargaining power with harvesters. However, other processors may have locational advantages whether it is to infrastructure (e.g., cold storage facilities, highways, water supply and waste removal) or closer access to the resource itself (some processing of whiting has occurred in inland locations). Northern processors, in addition to being located closer to where much of the harvest has recently occurred, also have a locational advantage in the sense that they have more immediate access to tribal whiting resources as tribal fisheries are located in northern Washington. Since 2003, one processor in particular has processed over 99% of the tribal shorebased whiting harvests.

Any competitive advantages processors gain under the alternatives are relatively modest given that the entire allocation is only 20 percent of the shorebased fishery. Overall, only 3 percent of the processor quota shifts from status quo holders to others, and the levels of shift among most individual processors are similarly modest, especially when compared to overall volumes of fish processed and revenues generated.

Additionally, although the effect is relatively modest, based on the analysis in the EA regarding the potential for northward shift in quota, and public comment relative to the competitive advantages for processors from being allocated quota, maintaining the existing initial allocations rather than selecting an alternative that uses more recent years could also help mitigate negative impacts resulting from localized concentrations of fishing and processing effort while providing the initial allocations necessary for the trawl rationalization program to function.

Comment 14: One commenter stated that five new processors entered the fishery after 2004 and that NMFS failed to explain why it is rational to exclude these new entrants. For example one processor that went out of business in 2000 received quota under the existing allocations but a processor that began processing whiting in 2006 and has risen to become a significant player in the whiting market received no quota.

Response: NMFS did not allocate quota to processors that went out of business. For processors that would have been allocated quota but did not exist at the time of initial allocation, that quota was distributed to the other qualifying processors proportional to their initial QS amounts. Any new entrant after 2005 is in the same situation as a new entrant in 2012, as neither would have initially allocated quota and would need to purchase or lease quota if doing so was a desired part of their business strategy. After the 2005 clarification that the 2003 control date applied to processors, new entrants were on notice that their history might not count towards initial allocations. NMFS notes that depending on how processor is defined (e.g., company, buying/processing site, etc.) the number of new processor entrants after 2004 will vary. The EA notes that eight processors entered the shorebased whiting processing market for the first time after 2004 and did not receive an initial allocation, and of these eight processors only two consistently processed whiting since entering the fishery.

Comment 15: The cost of leasing quota was not appropriately analyzed or considered. The added costs of purchasing or leasing quota from inactive permit holders is contrary to National Standard 7, which states that ''Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.'' In addition, the costs associated with increasing observer costs, the Pacific Coast Groundfish Fishery buyback program and the soon to be implemented cost recovery program are new costs that NMFS failed to consider when making a decision as to whether the initial allocation of quota should be changed or not. The costs associated with leasing quota will be particularly constraining on smaller businesses. Local small community companies need whiting quota to keep their businesses going. Larger processing companies can afford to lease or buy IFQ no matter what the price. Smaller, family-owned vessels will be lost over time to corporations owning multiple vessels or other assets. One of the commenters also made an attempt to estimate the fair market values and leasing costs of whiting quota. The projections were approximately as follows: value of shorebased whiting allocated to the 21 permits that were reportedly inactive during 2004–2010 is $8,500,000 and that the annual cost of leasing this IFQ is conservatively $680,000. For the mothership sector, the fair market value of the whiting quota allocated to the 14 permits reportedly inactive during 2004–2010 is $4,320,000 and that the annual cost of leasing this quota is near $350,000.

Response: Leasing is an expected activity in many fisheries. Before the trawl rationalization program, limited entry permits were being leased by fishermen in order to gain access to trawl fisheries. Consistent with the MSA requirement to establish a policy and criteria for transferability, through sale or lease, of limited access privileges such as whiting IFQ, 16 USC 1853a(c)(7), the ability to lease quota was an element of the trawl rationalization program analyzed and adopted through Amendment 20. Some level of leasing is expected under the program. Leasing is expected in the Shorebased IFQ Program in particular given that 20% of the whiting catch history-based quota of shorebased harvesters was allocated to processors—as a result many shorebased whiting fishermen, especially those not strongly affiliated with a processor, may have to lease quota to return to pre-trawl rationalization catch levels.

The environmental impact statement for Amendment 20 (Amendment 20 EIS) considered the economic condition of the fishery, which was one of the motivations for considering alternate management approaches for the trawl fishery. The Amendment 20 EIS also considered efficient utilization of the resource in the design elements of the program, especially compared to the previous trip limit management fishery. It also weighed the costs and benefits of such a program, including initial allocations and leasing costs, on different user groups such as harvesters, processors, and potential new entrants for the IFQ and MS fisheries (see Amendment 20 EIS sections 4.4, 4.6.2.5, 4.6.3.4, 4.6.3.7, 4.7.2.3, 4.9.2.2, and 4.9.3.7). The issue of leasing costs was also addressed in the final rule implementing the trawl rationalization program. (75 FR 60868, 74 October 1, 2010, Comment 27).

In addition to the Amendment 20 EIS, the EA for the reconsideration of whiting allocation weighed the costs and benefits of allocation on different user groups, including harvesters, processors, potential new entrants, and communities for the IFQ and MS fisheries (see EA sections 4.3, 4.5.3, 5.4, and 5.8). The EA also discussed costs of leasing in other fisheries and potential effects on Pacific groundfish fisheries (EA section 3.3.2.6 and 4.5.3.1), and the value of limited entry permits as an investment whether actively fished in recent years or not (EA section 3.3.2.5 and 4.3). Regarding leasing costs, the EA for this action recognized that leasing costs will occur, that the benefits of the program (which requires an initial allocation) outweigh the costs, and that, ultimately, quota will tend towards the most efficient users, especially once trading is allowed.

NMFS recognizes that those receiving initial allocations may be placed at a competitive advantage over new entrants or existing participants who must purchase more quota if they desire to maintain their recent harvest levels. (EA section 5.4). However, any new costs associated with leasing also come with new benefits—the opportunity to acquire a desired amount of quota that can then be harvested without competing in a race for fish, along with the other benefits anticipated under the trawl rationalization program. The EA demonstrates that quota was transferred to many shorebased whiting fishermen in 2011, allowing successful harvest well in excess of some participants' initial allocations. (EA section 3.3.2.7). NMFS also considered the costs associated with the buyback program that was implemented in 2005 (70 FR 40225, July 13, 2005). The loan associated with the buyback program financed most of the cost of a fishing capacity reduction program in the Pacific Coast groundfish fishery and corollary fisheries. To repay the loan, participants in the Shorebased IFQ Program and the MS Coop Program currently pay five percent of the full delivery value of fish harvested and delivered to processors. In addition, the MSA requires that cost recovery be a component of a LAPP such as the trawl rationalization program. Under the proposed cost recovery program (78 FR 7371, February 1, 2013), participants in the Shorebased IFQ Program and the MS Coop Program would be required to pay a fee, not to exceed three percent of the ex-vessel value of fish delivered to processors, to cover part of the costs of management, data collection, and enforcement of the trawl rationalization program. Costs associated with the trawl rationalization program, including the costs of observer coverage, were also considered in the Amendment 20 EIS, section 2.6.3, A–2.3.3. NMFS notes that the agency currently covers the majority of the costs for observers off the West Coast (but not the North Pacific). NMFS also notes that there is a national effort underway to explore the use of electronic monitoring as one potential tool to address the costs associated with observers. See *http://www.nmfs.noaa.gov/sfa/reg_svcs/Councils/ccc_2013/K_NMFS_EM_WhitePapers.pdf.*

Although some alternatives could more closely align initial allocation amounts with recent levels of harvest associated with a given permit, and potentially minimize leasing costs to those participants in the short term, when balanced with the other considerations, NMFS has determined that the Council's recommendation is consistent with National Standard 7 and minimizes costs to the extent practicable. The costs associated with the buyback program (which benefitted the industry by helping to reduce the level of overcapacity and substantially expanded fishing opportunity for all vessels, as reflected by higher trip limits), the observer program, and the statutorily required cost recovery program, do not alter NMFS' conclusion. NMFS notes that some commenters felt that NMFS did properly analyze and consider the impact of the initial allocation on costs and benefits, as required by National Standard 7, and that status quo balances costs and benefits by allocating to a large amount of recipients with a geographic spread among those that received initial allocations.

The commenter that provided estimates of fair market values of quota and leasing costs used a multiplier of 3.75 applied to the ex-vessel value of whiting to determine fair market value of whiting QS. NMFS does not have sufficient information to evaluate the use of a multiplier of 3.75 to project the value of quota, particularly as quota has yet to be traded. However, the EA considered that the ratio of QS to ex-vessel value ranged from 4:1 to 9:1 in a Canadian groundfish trawl fisher might be representative. Based on information developed from quota pounds sold or leased via the *Jefferson State Trading Company* Web site (*http://jeffersonstatetradingco.com/cgi-bin/auction/auction.pl*), which tracks the trading of quota pounds for this program, the leasing ratio of 30% of the ex-vessel value may be high but representative. Even assuming that the projections provided by the commenter are accurate, it does not alter NMFS conclusions for the reasons described above and throughout this final rule.

In response to the comment about the impacts of costs on smaller businesses, and smaller, family-owned vessels, in general, impacts of the allocation decision on both small and large businesses were considered, and regulations are in place that attempt to minimize any undue burden placed upon small businesses (e.g., accumulation limits). As discussed below in the summary of the final regulatory flexibility analysis (FRFA), over the years 1998 to 2010, there were 17 processors that participated in the fishery and that meet the recent participation criteria of the various alternatives. After taking into account ownership and affiliation relationships, there are 12 processing entities based on Small Business Administration (SBA) definitions. Of these 12 processing entities, there are 9 small processing entities and three large processing entities that are affected by this rule. The FRFA also notes that regardless of the allocation alternative chosen some small businesses will be affected.

As discussed in response to comment 14, although NMFS agrees that in some circumstances the initial allocations of quota could result in some degree of competitive advantage, the degree of that advantage is dependent on numerous factors. Furthermore, owning whiting QS is not required to process whiting. New entrants or processors with lower initial allocations may choose to lease or purchase quota as part of their business plans, but may also use other methods to incentivize delivery of whiting to their facilities. Furthermore, any advantages processors may gain under the alternative considered are relatively modest given the entire allocation is only 20 percent of the shorebased whiting QS, overall only 3 percent of the processor quota shifts from status quo holders to others, and the levels of shift among most individual processors are similarly modest, especially when compared to overall volumes of fish processed and revenues generated.

Comment 16: An article critical of the effects of leasing in the Canadian halibut fishery, ''The elephant in the room: The hidden costs of leasing individual transferable fishing quotas,'' Evelyn Pinkerton, Danielle N. Edwards, Marine Policy 33 (2009) 707–713, was not sufficiently considered in the context of whether the existing allocations are consistent with National Standard 5, which states that ''Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measures have economic allocation as its sole purpose.'' The failure to give the most quota to the most active participants through 2010 creates new leasing costs and is not justified in terms of economic objectives.

Response. NMFS considered the article referenced by the commenters, and its position that certain conditions that allow for the efficiency benefits of individual transferable quotas (ITQs) to accrue are not present in the Canadian halibut fishery; therefore, the authors argue in part that vessels operating with initially granted quota are more financially viable than new entrants and can afford to pay higher quota lease fees, eventually having the effect of bidding up the lease price.

NMFS notes that there was also a published comment in response to this article questioning the article's data and assertions. (A rejoinder to E. Pinkerton et al. The elephant in the room: The hidden costs of leasing individual transferable fishing quotas, Bruce R. Turris, Marine Policy 34 (2010) 431–436). One of the main conclusions of the published response was that it would be incorrect to suggest that quota will not be transferred to the most economically efficient operators. The commenter noted that even with transaction costs and other limitations, tradable quota should move to more efficient operators, and further noted that those who initially start out with quota may be more profitable than new entrants or those that need to lease more quota, but that issue is one of income distribution and not an efficiency issue. The initial authors published a short response to the comment, asserting that the commenter did not directly address the major points of their article and that their data analysis was appropriate. (Ignoring market failure in quota leasing? Evelyn Pinkerton, Danielle N. Edwards. Marine Policy 34 (2010) 1110–1114.)

The debate appears to be one of whether the halibut program in Canada is achieving efficiency at all or whether the halibut program is more efficient than the former derby style of fishery it replaced. This debate is also about the distribution of rent—who shares in the profits or income generated in the fishery. The debate is not whether there have been efficiency gains, but whether additional gains can be achieved. Pinkerton claims they have not achieved full efficiency because of market inefficiencies and the lack of access to capital for some participants. However, it is not clear why participants who were granted quota would not try to be as efficient as possible and why they would not get out and lease their quota if they were less efficient. High lease prices may suggest that efficiency is high as owner operators are making high profits and are unwilling to lease quota to other fishermen unless the lease price is at the level where it is more profitable to lease than fish. In terms of the reconsideration of initial whiting allocations, these articles discuss the effects of leasing, which was a component of Amendment 20 and will exist regardless of the years chosen for determining the allocation of quota. See response to comment 15.

With respect to the net economic benefit to the nation, the effects of the alternatives are similar. The initial allocation of whiting is a one-time distribution of wealth in the form of QS and CHA to members of the fishing industry, which allows for implementation of the program. In addition to assisting existing participants' transition to the new management system, the initial allocation will likely affect harvester and processor competitiveness. To the degree that initial allocations match up with the harvesters that will use the quota, transition costs will be lessened. However, whatever initial allocation alternative is selected does not affect the long-term efficiency and operation of the fishery. In the short run, there may be transition costs and disruption to participants' operations depending on how closely the initial allocations are distributed to the most efficient participants. To the degree that initial allocations match up with the harvesters and processors that will use the quota, transition costs and disruption will be lessened as the fishery moves to its long-term, more efficient state. Regardless of the allocation alternative chosen, it is unlikely that the initial allocation will be that allocation that represents the most efficient users. NMFS does not currently know which users are the most efficient and which users in the future will be the most efficient. Note that the biggest users of the resource may not be the most efficient users. Over the long term, it is expected that operations will move, or quota will be traded, to the ports in which the highest profits can be earned, taking into account all forms of costs such as average distance to fishing grounds and catch and bycatch rates.

With the choice of maintaining the existing initial allocations over alternatives that reflect more recent history, NMFS and the Council are providing to those who have historically participated in the fishery (the majority of which are also recent participants) and are anticipated to have a better chance to benefit from the market processes described above. NMFS considered how the short and long term impacts of leasing may vary between the alternative whiting allocations and has concluded that the benefits of more heavily favoring history prior to the end of the existing qualifying periods furthers the purposes of Amendment 20, rewards investments and dependence consistent with the policies underlying announcing a control date, and minimizes disruption to those participants that made business decisions based on the assumption that quota formulas were unlikely to include more recent years.

With regard to the comment on National Standard 5, the trawl rationalization program was designed, in part, to reduce fleet capacity and to economically rationalize the groundfish trawl fishery. Reducing excess capacity is expected to improve the efficiency in the utilization of fishery resources as well as reduce the levels of incidental catch. NMFS' decision to maintain the initial whiting allocations would not change any of those program design features that would allow more efficient utilization of the resource, such as reductions in fleet capacity, reduced regulatory discards, and once the moratorium is lifted, quota trading. After considering the relevant factors, including costs associated with leasing, NMFS has determined that the existing initial allocations consider efficiency in the utilization of fishery resources, where practicable, and are consistent with National Standard 5.

Comment 17: The North Pacific Council has recognized the problem of absentee ownership of crab harvest shares by persons or corporations with little or no involvement in the prosecution of the fisheries, which limits the amount of quota available for active participants in the Bearing Sea/Aleutian Islands (BSAI) Crab Rationalization Program. The same problem exists in the Pacific whiting fishery under the status quo allocations.

Response: NMFS agrees that the North Pacific Council is considering the issue of absentee ownership of crab harvest shares, and notes that in its report of the February 2013 North Pacific Council meeting, the Council:

> elected to take no further action considering alternatives to define active participation requirements for vessel owner harvest shares. Currently, holders of those shares have no ongoing requirement to remain active in the fisheries as either vessel owners or crewmembers. The Council also received a discussion paper concerning the development of cooperative measures to i) promote share acquisition by action participants; ii) address high quota lease rates; and iii) ensure reasonable crew compensation. Although the Council elected to take no regulatory action, it expressed concern with high lease rates, crew compensation, and the availability of quota shares to active participants in the fisheries. To that end, the Council passed a motion requesting that each cooperative in the program submit a voluntary report annually describing measures taken by the cooperative to facilitate share acquisitions by active participants and affecting high lease rates and crew compensation * * *. The motion

suggests that these reports be provided at the Council's October meeting.

News and Notes, North Pacific Fishery Management Council, February 2013, page 4, available at *http://www.fakr.noaa.gov/npfmc/PDFdocuments/newsletters/news213.pdf*.

Relative to the reconsideration of the initial allocation of whiting, NMFS acknowledges that in the future there may be similar issues that need to be considered and potentially addressed during the five year review. However, the crab rationalization program and the Pacific groundfish trawl rationalization program are significantly different and it is not possible to predict that the issues and potential solutions will be the same.

Comment 18. NMFS should determine how many of the inactive, or latent, permits from 2004–2010 actively harvested their whiting allocations during the post-rationalized fishery, 2011–2012.

Response: NMFS considered the information in the final EA, which shows the number of permits that did not land fish in 2011. Information for 2012 was not available for use during the reconsideration.

Comments on Control Date

Comment 19: Control dates are merely advisory and do not obligate the Council or NMFS to use them. The MSA does not contain any overarching considerations such as a control date that trump the National Standards and other statutory criteria. The control date should not be used as a basis for maintaining the existing initial allocations.

Response: NMFS acknowledges that a control date is not a guarantee that any specific period will count toward initial allocations. NMFS believes, however, that recognition of the business and investment decisions made by participants who interpreted the control date as signaling the likely end of the qualifying period is consistent with the fundamental purposes of Amendment 20, including reducing overcapacity. Commenters supporting existing allocations noted that it is important to adhere to control dates to prevent speculative increases in harvesting or processing, and that doing so supports a fundamental objective of the program to address longstanding overcapacity issues in both the harvesting and processing sectors of the whiting fishery. The overarching considerations described in the propose rule reflect consideration of the factors identified in National Standard 4 and the MSA provisions at 16 U.S.C. 1853a(c)(5)(A) in light of all relevant factors, including the other National Standards and the control date. After considering those factors, and taking into account public comment on the proposed rule, NMFS has considered all of the factors related to the initial allocations and has concluded that use of the 2003 control date as the cut-off period for harvesters, and use of 2004 for processors is rational. As described in the preamble and in response to other comments, the control date and the underlying policy goals of Amendment 20, while important, are not the sole basis for NMFS' decision.

Comment 20: While it was a lengthy process between announcing the control date and implementation, the process was lengthy because of the complexity of the trawl rationalization program, including the allocation decisions The control date could not be considered ''stale'' because there was no period of inactivity between the control date and implementation, there was no major change in the broad policy fishery managers were pursuing or in the fundamental design of the program.

Response: NMFS agrees that the control date is not ''stale.'' The EA documents the extensive process required for developing the trawl rationalization program and the numerous stages for stakeholder input. (EA table 1–1, 1–2). Considering the amount of time necessary to develop the program, the length of time between the control date and program implementation, as well as this reconsideration, is reasonable. Furthermore, NMFS has not ignored the years beyond the control date, but rather has considered all the required information, including harvests after 2003, in deciding to maintain the existing initial allocations.

Comment 21: Not adhering to control dates as announced when allocating initial quota sets a dangerous precedent, and could potentially result in increased harvesting or processing capacity in an attempt to increase the initial allocation of quota in the development of future limited entry or limited access privilege programs (LAPPs). Relying on the control date is consistent with National Standard 4 and the groundfish FMP management goals that list conservation as the first goal, as well as the Amendment 20 EIS that states that failure to use a control date may exacerbate conservation concerns. Several other commenters also noted that they would benefit by receiving increased harvester allocations if more recent years were included, but they believe that reliance on the control dates is fair because everyone in the fishery knew the consequences of fishing after the control date and therefore support the existing allocations.

Response: NMFS agrees that, in general terms, control dates serve a useful purpose of deterring speculative increased capacity or effort during the development of LAPPs. NMFS further agrees that not using the announced date of 2003 for harvesters could have a negative effect in the future when the Pacific Council or other councils begin to consider limited entry or LAPP programs, and further notes that there is a rational basis for modifying the control date by one year for processors. Further, NMFS believes that the reliance on the control date expressed by many commenters benefited the underlying purposes of Amendment 20 pending its implementation. The fact that several participants commented that they would benefit financially from selecting an alternative that uses more recent years, but nevertheless support the existing allocations, is indicative of the fairness and equity of the Council's recommendation and NMFS' decision.

Comment 22: Harvests after the control date should be rewarded because fishing and processing was happening in the Pacific coast whiting fishery where and when there were market opportunities.

Response: As noted in the proposed rule, no mechanism exists to separate speculative from non-speculative effort after the control date and by maintaining the control date for harvesters, any speculative behavior after the control date is not rewarded and those who acted consistent with the control date and goals of Amendment 20 are not penalized. As explained in this final rule, and after consideration of the statutory factors, NMFS has determined that the control date of 2003 as the cut-off for the harvester qualifying period is rational, as is the use of 2004 as the cut-off for the processor qualifying period, and the end result is a fair and equitable initial allocation.

Comment 23: The policies supporting a control date for harvesters do not apply to processors, and are at best a theoretical and indirect concern. Processor interests in acquiring quota are to ensure that fish continue to support the processing plants. Processors do not speculatively increase capacity to acquire quota as an asset to later be bought, sold, leased, or traded. Testimony at the June 2012 Council meeting indicated concern about undercapitalization in the processing sector, not overcapitalization.

Response: The control date was intended to put the industry on notice and deter speculative increases in effort and capitalization, regardless of sector. Section 3.3.2.4 of the EA discusses the key indicators that were used to identify overcapacity issues within the fishery. Fishing season length is a key indicator of overcapacity in a fishery because in the absence of excess capacity, a fishing season could potentially run through December 31, assuming other constraining factors are taken into account. Although allowable harvests increased in the years from 2004–2010, season length in the shorebased whiting fishery decreased during this period. The weekly harvest pattern for the shorebased fishery during this period demonstrates substantial excess capacity. Fleet weekly harvest was used as a proxy for effort and capacity in the shorebased sector (both harvesters and processors). Even if the fleets were capable of sustained fishing at only one half their lowest annual maximum weekly rate, the amount of time required to take the maximum allocation available in recent years would be far less than the potential number of season days available. Despite a situation of excess capacity, after 2004 the number of vessels participating was generally on an upward trend in both the shorebased and mothership sectors. While one commenter noted that with respect to processors, speculation and overcapacity was a theoretical or indirect concern, another commenter noted that in industrial fisheries like Pacific whiting, all harvests are landed and processed. Therefore the harvest and subsequent processing of that harvest provides a proxy for investments and dependence in the fishery by harvesters and processors. The purpose of applying control dates to onshore processors, while important, is not necessarily as significant as for harvesters, who have a greater ability to move into and out of various fisheries to gain potential fishing history. In addition, comments on the proposed rule and public testimony at Council meetings noted that including 2004 in the qualifying period for processors takes into account more recent investments that were made in 2003 but that did not come online and start acquiring history until 2004. These factors, in addition to the fact that it was not clear until 2005 that the 2003 control date potentially applied to processors, support the decision that a one year shift, to 2004, was a reasonable cutoff date for processors.

Although one commenter testified at the June 2012 Council meeting that the shorebased processing sector was undercapitalized, other public testimony indicated that the fishery was heavily overcapitalized and there was no shortage of processing capacity available, and that the control date was meant as to deter the entire industry from injecting more capital into an already overcapitalized fishery, or at the very least put them on notice that doing so was not guaranteed to be rewarded by being credited for initial allocations. NMFS also notes that a commenter asserted that those who made investments in harvesting and processing capacity later in the development of a fishery, after it was already overcapitalized, have made investments that are at a net loss to society and therefore should not necessarily be rewarded for their investments with allocations of quota.

Control dates are largely preemptive tools meant to signal that speculation will not be rewarded. NMFS is unable to determine whether speculation would have been worse had no control date been issued. However, in the absence of a control date, that incentive would have been present. For all these reasons, NMFS believes it is appropriate to continue to apply the 2004 cut-off date to processors.

Comment 24: The **Federal Register** notices regarding the control date were unclear on how the control date applied to processors, even after the clarification in 2005.

Response: NMFS agrees that the original announcement of the 2003 control date, 69 FR 1563, did not explicitly state that it applied to processors. However, the notice published in 2005, 70 FR at 29714, reiterated the 2003 control date and clarified that it did not preclude processors from participating in the trawl rationalization program and being eligible for quota. The original announcement that was clarified stated that the control date ''will apply to any person potentially eligible for IQ shares,'' but the list of eligible persons did not include processors. In clarifying that processors could be eligible for initial allocation, the 2005 notice included processors as an entity eligible for IQ shares to which the 2003 control date would apply. However, NMFS recognizes that processors were not expressly included until after the end of the 2004 season and thus potentially not on notice, which is one reason why NMFS determines that it is reasonable to extend the cut-off for processors to 2004.

Comments on Current and Historical Participation of Fishing Communities

Comment 25: The Council and NMFS considered current and historical participation of fishing communities, partially through the allocation of quota to processors. The existing allocations spread the processor allocation along the coast among seven processors in five communities from Westport, WA to Eureka, CA. All of the alternatives other than the No Action Alternative would shift quota north devaluing the FMP objective to protect communities.

Response: NMFS agrees that the record reflects that maintaining the existing allocations would provide a more even distribution of initial whiting allocations along the coast and to the corresponding fishing communities. Shifting to alternatives favoring more recent history could contribute to a northward shift in initial quota distribution, and accordingly any benefits stemming from that initial allocation (see EA, Section 4.3.3). The northward shift is expected to be relatively small (less than 8 percent of the total quota—2 percent for processors and 6 percent for harvesters between the No Action Alternative and Alternative 4) and the analysis shows whiting landings have been shifting northward in recent years (due to fish availability and investments in ports). Some commenters noted that this northward shift would benefit two processors at the cost to all of the remaining processors. Similarly, a few harvesters would benefit at the cost of many. Although the shift in quota would be relatively modest, NMFS believes that maintaining the initial whiting allocations supports historic fishing communities in more southern locations and creates a wider geographic distribution of the initial wealth associated with allocations. Maintaining initial whiting allocations would further support one of the guiding principles in the development of Amendment 20 (see Am 20 EIS, Section 1.2.3)—to minimize negative impacts resulting from localized concentrations of fishing [and processing] effort. For processors, in addition to the distribution of wealth associated with initial allocations, the wider distribution of initial allocation of whiting QS may provide some additional influence over where deliveries are made along the coast than if the initial allocations are based on more recent qualifying years that would shift allocations and potentially landings northward. However, as discussed in response to other comments, it is difficult to determine the degree of competitive advantage or the impacts of the geographic location of QS allocated to processors on location of future harvest. Ultimately, the QS issued to processors should assist in mitigating for the changes expected in the timing and location of harvest expected over the long-term under the trawl rationalization program.

Comments on industry support for allocation

Comment 26: One commenter said that the law is clear; NMFS cannot make the decision about the proper allocation method based on political considerations or popularity, only on the facts of the case and the applicable law. In addition, no referendum was held so it is impossible to determine exactly the degree of support for the initial allocation system.

Response: NMFS agrees that the agency cannot make the decision based on political considerations or popularity. As described in detail in this final rule, the agency has independent reasons that support its decision to maintain the existing initial allocations. NMFS further agrees that the agency cannot determine exactly the ''degree of support'' for the agency's adoption of the No Action Alternative because a referendum was not held; however the record is clear that the majority of participants that commented during the Council process and on the proposed rule support the Council/agency proposal. The extensive and transparent public process followed for this reconsideration, and the fact that a majority of commenters support the Council's recommendation, including some of those that would receive higher allocations under other alternatives, is one factor that the agency considered. Irrespective of the degree of industry support, NMFS believes the agency's decision results in a fair and equitable allocation.

Comment 27: Several commenters stated that they supported the existing initial allocations and noted that the Council and NMFS did a thorough and transparent reconsideration process, in which a major portion of the affected stakeholders participated.

Response: NMFS agrees.

Comment 28: Some commenters noted that industry continues to support the No Action Alternative as a fair and equitable decision that balances the necessary conditions, avoids disruption to the fishery, and upholds the validity of control dates and the integrity of the Council process. Industry support for the No Action Alternative is highlighted by several members of industry who would benefit under alternatives that included years after the control dates, yet they continue to support the No Action Alternative for the same reasons.

Response: NMFS agrees that the no action alternative is a fair and equitable allocation. A review of the record indicates that there were members of the industry that testified or commented in support of the No Action Alternative, although they would stand to benefit through a revised initial allocation. Any allocation scheme will create winners and losers. NMFS acknowledges the fact that some members of industry who might gain quota under other alternatives still support maintaining the existing initial allocations.

Comment 29: The trawl rationalization program (including the status quo initial allocation) has generated conservation benefits for groundfish stocks and economic benefits for the fishing industry and communities. Discards of overfished species have dropped dramatically, and per vessel revenues have increased, despite the fact that the fishery was previously overcapitalized, had been subject to overfishing, and had been declared an economic disaster in 2000. Several comments supported maintaining the existing whiting allocations and emphasized: the importance of honoring the control date and the underlying policy goals of Amendment 20, the fact that those who increased effort or capitalization post the control date did so with notice any history earned may not count towards an initial allocation, and the protection of historic fishing communities and a wider distribution of the initial allocations among those communities.

Response: NMFS agrees and has concluded that the reasons supporting maintaining the existing allocations for the shorebased IFQ and mothership whiting fisheries (e.g., taking in to account the intent of the 2003 control date and the policy goals of Amendment 20, not rewarding speculative behavior, minimizing concentration of quota, and achieving wider geographic distribution of initial program benefits) outweigh the reasons supporting alternatives that favor more recent history (e.g., providing greater amounts of quota to the recent fishery participants to recognize their recent fishery dependence/investments, potentially reducing future leasing or acquisition costs, reducing quota to latent permits, and reflecting the more recent market and fishery conditions). The initial allocation is a fair and equitable allocation and is consistent with the requirements of the MSA, the Groundfish FMP, other applicable law, and the court's order in *Pacific Dawn.*

Comments on Widow Rockfish QS

Comment 30: One commenter noted that while the draft regulatory language extends the prohibition on transferability of widow rockfish QS, it does not provide for the limited exception that would address outcomes of court actions such as might occur in probate or bankruptcy. The commenter requested that the regulations be clarified to state that any prohibition on the transferability of widow rockfish QS would also be subject to the current limited exception that allows transferability under a U.S. court order or authorization as approved by NMFS.

Response: NMFS agrees with the commenter that the regulations should be clarified to state that the current exception applies to transfer of widow rockfish QS and has modified the regulatory language, as described below. The existing prohibition on QS transferability allows for transferability under the limited exception raised by the commenter. The extension of the prohibition on transferability of widow rockfish QS should have more explicitly included the extension of the limited exception.

Change From the Proposed Rule

This rule extends the moratorium on transfer of widow rockfish QS in the IFQ fishery indefinitely, pending reconsideration of the allocation of QS for widow rockfish. In response to a public comment, a change has been made for the final rule to clarify that transfer of widow rockfish QS may be allowed under U.S. court order or authorization, and as approved by NMFS. This is consistent with the current transfer exception for QS or IBQ between QS accounts at § 660.140(d)(3)(ii)(B)(*2*). NMFS will make this change at § 660.140(d)(3)(ii)(B)(*2*). Additionally, two minor changes were made for clarity in § 660.140(d)(4)(v) and in § 660.150(g)(3)(i)(D).

Classification

Pursuant to section 304(b)(1)(A) of the MSA, the NMFS has determined that this final rule is consistent with the Groundfish FMP, the MSA, and other applicable law. To the extent that the regulations in this rule differ from what was deemed by the Council, NMFS invokes its independent authority under 16 U.S.C. 1855(d).

NMFS finds good cause to waive the 30-day delay in effectiveness pursuant to 5 U.S.C. 553(d)(3), so that this final rule is effective on April 1, 2013. As described in the preamble to the proposed rule (78 FR 72, January 2, 2013), the initial allocations of whiting to the shorebased IFQ and mothership sectors were challenged in *Pacific Dawn.* On February 21, 2012, the court in that case issued an order remanding the regulations establishing the initial allocations of whiting for the shorebased IFQ fishery and the at-sea mothership fishery ''for further consideration.'' The order requires NMFS to implement revised regulations before the 2013 Pacific whiting fishing season begins on April 1, 2013. Waiving the 30-day delay in effectiveness is necessary to comply with the court-ordered deadline. Reconsideration of the initial allocations was a significant undertaking that required development and consideration of different alternatives, review of new information, development of new analyses, and preparation of draft and final environmental assessments and proposed regulations through the Pacific Fishery Management Council, which held three Council meetings and took public comment at all of them. NMFS and the Council devoted substantial effort and resources to accomplish this reconsideration by April 1, including providing a 30-day comment period on the proposed rule to allow time for public comment. Except for the portion of § 660.140(d)(3)(ii)(B)(2) that addresses widow rockfish, the regulatory revisions contained within this rule reinstate certain provisions that were suspended by temporary action (77 FR 45508, August 1, 2012; 78 FR 3848, January 17, 2013) pending reconsideration of the initial allocations and, as specified in the regulatory text, do not actually affect regulated entities until January 1, 2014, at the earliest. Thus, there is more than sufficient time for the public to become aware of and to come into compliance with or take other actions regarding these provisions. Some provisions of this rule (e.g. allowing participants in the program to transfer quota and requiring divestiture of quota in excess of accumulation limits) were components of the original program implemented under Amendment 20 to the FMP (*see* 75 FR 78344; Dec. 15, 2010) that NMFS delayed until it could respond to the court order. The public is well aware of these measures and does not need to come into compliance with them within the next 30 days. NMFS previously provided for a 30-day delay in effectiveness of these measures when it issued the rule implementing Amendment 20. In addition, for the portion of § 660.140(d)(3)(ii)(B)(2) that continues the current restriction on transfer of widow rockfish quota shares, the public is aware that this prohibition is in place under the temporary actions cited above and as such, do not require any additional time to prepare to comply with the restriction. For the above reasons, there is good cause under 5 U.S.C. 553(d)(3) to establish an effective date less than 30 days after date of publication.

NMFS prepared an Environmental Assessment (EA) for the reconsideration of initial whiting allocation and concluded that there will be no significant impact on the human environment as a result of this rule. NMFS prepared a finding of no significant impact (FONSI) which can be found in Section 6.2 of the EA. A copy of the EA is available on NMFS' Web site at *http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/Trawl-Program/index.cfm.* Aspects related to this action were previously discussed in the final environmental impact statement (EIS) for Amendment 20 to the Pacific Coast Groundfish FMP which discussed the structure and features of the original trawl rationalization program.

This final rule has been determined to be not significant for purposes of Executive Order 12866.

A Regulatory Impact Review (RIR) was prepared on the action in its entirety and is included as part of the final regulatory flexibility analysis (FRFA) on the regulatory changes. The FRFA and RIR describe the impact this rule will have on small entities. The FRFA incorporates the IRFA, a summary of the significant issues raised by the public comments in response to the IRFA, and NMFS responses to those comments, and a summary of the analyses completed to support the action. A copy of the FRFA is available from NMFS (*see* **ADDRESSES**) and a summary of the FRFA, per the requirements of 5 U.S.C. 604(a), follows:

No significant issues were raised by the public comments that were directed to the IRFA itself. However, economic issues were raised in the comments to the Proposed Rule. These mainly concerned the application of the MSA criteria for determining allocations. These issues are addressed in the comments above. Although not directed to the IRFA, there was one comment that touched on the effects on leasing for small companies. This is addressed above in Comment 15.

Reconsideration of Initial Allocation of Whiting

The Council considered four alternatives for allocating whiting. The following analysis compares the No Action Alternative to Alternative 4 as they show greatest differences between the pre-control date fishery and post-control date fishery. The No Action Alternative allocates whiting using the years 1994 to 2003 for harvesters (shoreside and mothership) and 1998–2004 for processors. Alternative 4 allocates whiting using the years 2000–2010 for both harvesters (shoreside and mothership) and processors.

Over the years 1994–2010, there were 65 fishing permit holders that participated in the shoreside fishery and 37 permit holders that participated in the mothership fishery. Over the years 1998 to 2010, there were 17 processors that participated in the fishery and that meet the recent participation criteria of the various alternatives. For quota share purposes there are 17 potential processing plants based on fish ticket information. After taking into account ownership and affiliation relationships, there are 12 processing entities based on SBA definitions. Of these 12 processing entities, there are nine small processing entities and three large processing entities that are affected by this rule. Comparing the No Action Alternative to Alternative 4 in terms of 2011 ex-vessel revenues, information on the gainers and losers in each of these affected groups can be developed from information in the Environmental Assessment (EA). The allocation of 98,000 mt to the 2011 shorebased whiting fishery was worth approximately $21 million (ex-vessel value). Based on the No Action Alternative allocations, eighty percent of these quota pounds were allocated to fishing permits ($17 million) and 20 percent to the shorebased processors ($4 million). The allocation of 57,000 mt whiting to the whiting mothership catcher vessels was worth $12 million in ex-vessel value. It is important to note that 2011 was a peak year for the shorebased fishery and a near-peak year for the mothership fishery (see Figure 3–5 of the EA). (Note: although ex-processor or ''first wholesale'' revenues are higher than ex-vessel values and would be a better indicator of processing activity levels, data on ex-processor sales were not readily available for use by the Council. A better indicator of the gains and losses by groups would be changes in profits (revenues less operating costs)).

The Northwest Fisheries Science Center (NWFSC) has developed an estimate of economic net revenue that is an indicator of profits. Economic net revenue seeks to measure economic profit, which includes the opportunity costs of operating a commercial fishing vessel. The NWFSC collected and assessed 2008 cost-earning data on vessels participating in the shoreside groundfish fisheries including whiting. Vessels that participate in the shoreside whiting fishery are typically classified as either ''whiting'' vessels or ''Alaska'' vessels depending on whether or not they operated in Alaska. Whiting vessels are defined as those with at least $100,000 revenue, of which at least 33% comes from whiting. Alaska vessels are defined as those vessels that earned at least $100,000 in revenue of which at least 50% comes from Alaska fisheries. Based on the responses received, whiting vessels earned 37% of their revenue from West Coast-caught whiting in 2008, Alaska vessels 46%. The average economic net revenue of a whiting vessel in 2008 was $167,457, which represents 19.2% of revenue from all fisheries. Limited entry trawl vessels classified as Alaska vessels had an average economic net revenue of $493,915, 28.3% of the $1,744,793 revenue earned from all sources by these vessels. These estimates are based on revenue and cost information directly related to the operation of a commercial fishing vessel such as those associated with office space. Revenues are from West Coast landings, Alaska landings, at-sea deliveries, sale and leasing of permits, chartering for research purposes and other activities related to the operation of the vessel. Compared to other years, these estimates may be high as whiting revenues and overall groundfish revenues were at their highest annual level during the 2001–2010 period during 2008. However, crab revenues during 2008 on the West Coast were at their lowest level since 2003.

Compared with the No Action Alternative, under Alternative 4 approximately 17% ($3.7 million) of the allocation to shorebased catcher vessels would be transferred away from the No Action Alternative/status quo holders; twenty eight permit holders would gain quota share including six permits that did not qualify under the No Action Alternative (Table 4–4 of the EA). The largest gain by a single permit holder is 3.3% ($700,000). Alternative 4 would lead to 37 permits losing quota share including 12 permits that would not receive any quota share. The largest loss by a single permit holder would be 2.0% of quota share ($340,000). A total of 41 out of 65 permits will see a change of less than $100,000 (increase or decrease) in revenues in comparing Alternative 4 to the No Action Alternative.

In comparing Alternative 4 to the No Action Alternative for shorebased processors, approximately 2.7% ($567,000) of the shoreside allocation of $21 million would be transferred away from the No Action/status quo holders; ten processing plants would gain, including seven processing plants that did not qualify under the No Action Alternative (Table 4–29 of the EA). The largest gain by a single plant is 1.0% of quota share ($214,000). Alternative 4 would lead to seven processing plants losing quota share including three plants that would not receive any quota share. The largest loss by a single plant is 0.9% of quota share ($189,000). Twelve out of 17 processing plants would see a change of less than $100,000. (Note—The Draft EA used processor counts that included one processor that operated four processing plants. Each of these four plants established a QS account and received separate processors' QS allocations under No Action—status quo. For this analysis, especially in regards to estimating impacts on communities, it was decided each of these four processing plants should be treated separately. This treatment changes the number of processors that were active in the fishery at some point during 1994–2010 from 16 to 19 (see, for example, Figure 4–13 in the EA). However, two of those processing plants are no longer in existence and so did not receive processors' QS allocations under No Action—status quo. Consequently in the Final EA's displays that include counts of processors receiving QS allocations under the alternatives, the processor count is reduced from 19 to 17 (see, for example, Table 4–30 in the EA).)

In comparing Alternative 4 to the No Action Alternative for whiting mothership catcher vessels, approximately 18% ($2 million) of the total catch history assignment would be transferred away from the status quo holders; 16 mothership catcher vessel endorsed permits would gain (Table 4–16 of the EA). No new permits would qualify. The largest gain by a single permit holder would be 4.5% of catch history assignment ($545,000). Alternative 4 would lead to 21 permits with reduced catch history assignments, including 10 permits that would not receive any catch history assignment. The largest loss by a single catch history assignment holder would be 2.7% ($333,000). Eighteen out of 36 permits would see a change of less than $100,000.

In terms of net economic benefit to the nation, the effects of the alternatives are similar. According to the Pacific States Marine Fisheries Council (PSMFC's) Scientific and Statistical Committee:

> The way the fisheries are actually prosecuted (geographic location of fishing and landings, timing of fishing, and participants) will, in the long-term, tend not to be affected by who receives the initial allocation of catch shares. Over time, the use of the catch shares will likely migrate through leases or sales to the participants who can put them to their most profitable use. This means that the eventual biological, ecological, and economic performance of the fisheries will be relatively independent of the initial allocation of catch shares. It has been the experience of many catch share programs that such transitions occur rather quickly, often within the first few years. As a consequence, the initial allocation of quota shares is not an effective tool to direct fishing or processing effort to particular geographic locations.

The initial allocation of whiting is a one-time distribution of wealth in the form of quota shares and catch history assignments to members of the fishing industry. The initial allocation is essentially the granting of a capital asset that will affect harvester and processor competitiveness and assist existing participants in the transition to the new management system. To the degree that the initial allocation matches up with the harvesters that will use the quota, transition costs and disruption will be lessened as the fishery moves to its long-term, more efficient state.

Similarly, those processors who receive an initial allocation may experience a boost in their competitive advantage due to the infusion of new wealth (the value of the QS received). The initial allocation does not affect the long-term efficiency and operation of the fishery. However, liquidity constraints, and perhaps other unknown constraints, may mean that there are some short-term inefficiencies. For example, this one time distribution of wealth may affect expenditures in the communities depending on location and spending patterns of recipients of these quota shares and catch history assignments. The EA provides the following regarding impacts on communities:

> The effects of the initial allocations on the distribution of fishing among communities are difficult to predict. Quota is tradable and highly divisible, giving it a fluidity such that it will likely move toward those ports in which profit margins tend to be the highest, regardless of the initial allocations. Where profit margins are similar, allocations given to entities that are already invested in whiting fishery-dependent capital assets are likely to stay with those entities at least in the near term. Similarly, where profit margins are similar, there will likely be some tendency in the near term for quota that is traded to move toward locations where whiting fishery-dependent capital assets already exist. Regardless of how the quota is distributed, vessels may move operations between ports during the year based on the geographic distribution of fishing opportunities. Processors are likely to use their shares in the port in which their facilities are located, however, some processors have facilities in more than one port and so may shift harvest between ports in response to the location of fishing

opportunities. At the same time, the recent shift of harvest toward more northern ports appears to be a response to investments in those ports, indicating that the location of fish is not the only factor driving the location of landings. Over the long term, it is expected that operations will move, or quota will be traded, to the ports in which the highest profits can be earned, taking into account all forms of costs such as average distance to fishing grounds and catch and bycatch rates.

While the discussion above concerns the long term efficiency and operation of the fishery, short term distributional effects matter to NMFS and the Council. The initial allocation of quota shares affects each participant's business operation, investments, and community. With the choice of the No Action Alternative over alternatives that reflect more recent history, NMFS and the Council are providing to those who have historically participated in the fishery (the majority of which are also recent participants) a potentially better chance to benefit from the market processes described above.

RAW 1

This action also would revise several regulations that were delayed on an emergency basis in response to the Court order. RAW 1 delayed the ability to transfer QS and IBQ between QS accounts in the shorebased IFQ fishery, and to the ability to sever mothership/catcher vessel endorsement and its associated catch history assignment (CHA) from limited entry trawl permits in the mothership fishery, pending the outcome of the reconsideration.

NMFS postponed the ability to trade quota shares as well as the ability of mothership catcher vessels to trade their endorsements and catch history assignments separately from their limited entry permits. NMFS also postponed all trading of QS species/species groups because for many affected parties, their QS allocations (especially for bycatch species) are a composite of whiting-trip calculations and non-whiting trip calculations. Postponing these activities, while NMFS and the Council reconsidered the whiting allocation, minimized confusion and disruption in the fishery from trading quota shares that have not yet been firmly established by regulation. For example, if QS trading was not delayed, QS permit owners would be transferring QS amounts that potentially could change (increase or decrease) after the reconsideration.

For similar reasons, NMFS also delayed the ability to transfer a mothership catcher vessel (MS/CV) endorsement and associated catch history assignment from one limited entry trawl permit to another in the mothership sector. The ability to sell or trade a limited entry permit with the endorsement and catch history remains. The use of the catch history assignment to be assigned to a co-op to be fished continues. These delays were expected to be temporary in nature and to benefit both small and large entities as they help smooth the transition to any changes in how Pacific whiting is allocated, and reduce the uncertainty to existing and potential new holders of these allocations.

With these revised regulations, those who find themselves with excess QS (except for widow QS) and IBQ, have until November 30, 2015, to divest. MS/CV-endorsed limited entry trawl permit owners will have to divest themselves of ownership in permits in excess of the accumulation limits by August 31, 2016. This rule allows limited entry trawl permit holders in the mothership sector to request a change (or transfer) of MS/CV endorsement and its associated CHA beginning September 1, 2014. Finally, this rule allows transfer of QS or IBQ, except widow rockfish QS, between QS permit holders beginning January 1, 2014.

The Small Business Administration has established size criteria for all major industry sectors in the U.S., including fish harvesting and fish processing businesses. A business involved in fish harvesting is a small business if it is independently owned and operated and not dominant in its field of operation (including its affiliates) and if it has combined annual receipts not in excess of $4.0 million for all its affiliated operations worldwide. A seafood processor is a small business if it is independently owned and operated, not dominant in its field of operation, and employs 500 or fewer persons on a full time, part time, temporary, or other basis, at all its affiliated operations worldwide. A business involved in both the harvesting and processing of seafood products is a small business if it meets the $4.0 million criterion for fish harvesting operations. A wholesale business servicing the fishing industry is a small business if it employs 100 or fewer persons on a full time, part time, temporary, or other basis, at all its affiliated operations worldwide. For marinas and charter/party boats, a small business is one with annual receipts not in excess of $7.0 million.

NMFS now collects small business information as part of its permit renewal processes. For quota share purposes there are 17 potential processing plants based on fish ticket information. After taking into account ownership and affiliation relationships, there are 12 processing entities based on SBA definitions. Of these 12 processing entities, there are nine small processing entities and three large processing entities that are affected by this rule. Sixteen of the limited entry trawl permits that participated in the shorebased whiting fishery are associated with large companies and 49 of these permits are associated with small companies. In the mothership fishery, 14 catcher vessel permits are associated with large companies and 23 with small companies. When permits associated with the shoreside fishery and the mothership fisheries are combined, there are 66 limited entry permits of which 21 are associated with large companies. Given the review of the various alternatives, the amount of ex-vessel revenues that may change hands, and how each alternative differs slightly in the mixture of large and small entities that qualify for whiting quota share, maintaining the No Action/status quo allocations should not have a significant economic impact on a substantial number of small entities.

No Federal rules have been identified that duplicate, overlap, or conflict with the action.

Section 212 of the Small Business Regulatory Enforcement Fairness Act of 1996 states that, for each rule or group of related rules for which an agency is required to prepare a FRFA, the agency shall publish one or more guides to assist small entities in complying with the rule, and shall designate such publications as ''small entity compliance guides.'' The agency shall explain the actions a small entity is required to take to comply with a rule or group of rules. As part of this rulemaking process, a public notice that also serves as small entity compliance guide was prepared. Copies of this final rule and public notice are available from NMFS Northwest Regional Office, and are posted on its Web site (*http://www.nwr.noaa.gov/fisheries/management/about_groundfish/index.html*), and will be emailed to members of our groundfish fishery email listserve.

NMFS issued Biological Opinions under the Endangered Species Act (ESA) on August 10, 1990, November 26, 1991, August 28, 1992, September 27, 1993, May 14, 1996, and December 15, 1999, pertaining to the effects of the Pacific Coast groundfish fisheries on Chinook salmon (Puget Sound, Snake River spring/summer, Snake River fall, upper Columbia River spring, lower Columbia River, upper Willamette River, Sacramento River winter, Central Valley spring, California coastal), coho salmon (Central California coastal, southern Oregon/northern California coastal), chum salmon (Hood Canal summer, Columbia River), sockeye salmon (Snake River, Ozette Lake), and steelhead (upper, middle and lower Columbia River, Snake River Basin, upper Willamette River, central California coast, California Central Valley, south/central California, northern California, southern California). These biological opinions have concluded that implementation of the Pacific Coast groundfish fishery is not expected to jeopardize the continued existence of any endangered or threatened species under the jurisdiction of NMFS, or result in the destruction or adverse modification of critical habitat.

NMFS issued a Supplemental Biological Opinion on March 11, 2006, concluding that neither the higher observed bycatch of Chinook in the 2005 whiting fishery nor new data regarding salmon bycatch in the groundfish bottom trawl fishery required a reconsideration of its prior ''no jeopardy'' conclusion. NMFS also reaffirmed its prior determination that implementation of the Groundfish FMP is not likely to jeopardize the continued existence of any of the affected ESUs. Lower Columbia River coho (70 FR 37160, June 28, 2005) and Oregon Coastal coho (73 FR 7816, February 11, 2008) were relisted as threatened under the ESA. The 1999 biological opinion concluded that the bycatch of salmonids in the Pacific whiting fishery were almost entirely Chinook salmon, with little or no bycatch of coho, chum, sockeye, and steelhead.

On December 7, 2012, NMFS completed a biological opinion concluding that the groundfish fishery is not likely to jeopardize non-salmonid marine species including listed eulachon, green sturgeon, humpback whales, Steller sea lions, and leatherback sea turtles. The opinion also concludes that the fishery is not likely to adversely modify critical habitat for green sturgeon and leatherback sea turtles. An analysis included in the same document as the opinion concludes that the fishery is not likely to adversely affect green sea turtles, olive ridley sea turtles, loggerhead sea turtles, sei whales, North Pacific right whales, blue whales, fin whales, sperm whales, Southern Resident killer whales, Guadalupe fur seals, or the critical habitat for Steller sea lions.

As Steller sea lions and humpback whales are also protected under the Marine Mammal Protection Act, incidental take of these species from the groundfish fishery must be addressed under MMPA section 101(a)(5)(E). On February 27, 2012, NMFS published notice that the incidental taking of Steller sea lions in the West Coast groundfish fisheries was addressed in NMFS' December 29, 2010, Negligible Impact Determination (NID) and this fishery has been added to the list of fisheries authorized to take Steller sea lions (77 FR 11493, Feb. 27, 2012). NMFS is currently developing MMPA authorization for the incidental take of humpback whales in the fishery.

On November 21, 2012, the U.S. Fish and Wildlife Service (FWS) issued a biological opinion concluding that the groundfish fishery will not jeopardize the continued existence of the short-tailed albatross. The (FWS) also concurred that the fishery is not likely to adversely affect the marbled murrelet, California least tern, southern sea otter, bull trout, nor bull trout critical habitat.

Pursuant to Executive Order 13175, this rule was developed after meaningful consultation and collaboration, through the Council process, with the tribal representative on the Council. The revised regulations have no direct effect on the tribes.

List of Subjects in 50 CFR Part 660

Fisheries, Fishing, and Indian fisheries.

Dated: March 22, 2013.

Alan D. Risenhoover,

Director, Office of Sustainable Fisheries, performing the functions and duties of the Deputy Assistant Administrator for Regulatory Programs, National Marine Fisheries Service.

For the reasons stated in the preamble, 50 CFR part 660 is amended as follows:

PART 660—FISHERIES OFF WEST COAST STATES

■ 1. The authority citation for part 660 continues to read as follows:

Authority: 16 U.S.C. 1801 *et seq.*, 16 U.S.C. 773 *et seq.*, and 16 U.S.C. 7001 *et seq.*

■ 2. In § 660.140, revise paragraphs (d)(3)(ii)(B)(*2*) and (d)(4)(v) to read as follows:

§ 660.140 Shorebased IFQ Program.

* * * * *

(d) * * *

(3) * * *

(ii) * * *

(B) * * *

(*2*) *Transfer of QS or IBQ between QS accounts.* Beginning January 1, 2014, QS permit owners may transfer QS (except for widow rockfish QS) or IBQ to another QS permit owner, subject to accumulation limits and approval by NMFS. QS or IBQ is transferred as a percent, divisible to one-thousandth of a percent (i.e., greater than or equal to 0.001%). Until January 1, 2014, QS or IBQ cannot be transferred to another QS permit owner, except under U.S. court order or authorization and as approved by NMFS. QS or IBQ may not be transferred between December 1 through December 31 each year. QS or IBQ may not be transferred to a vessel account. The prohibition on transferability of widow rockfish QS is extended indefinitely pending final action on reallocation of widow rockfish QS, except under U.S. court order or authorization and as approved by NMFS.

* * * * *

(4) * * *

(v) *Divestiture.* Accumulation limits will be calculated by first calculating the aggregate non-whiting QS limit and then the individual species QS or IBQ control limits. For QS permit owners (including any person who has ownership interest in the owner named on the permit) that are found to exceed the accumulation limits during the initial issuance of QS permits, an adjustment period will be provided during which they will have to completely divest their QS or IBQ in excess of the accumulation limits. QS or IBQ will be issued for amounts in excess of accumulation limits only for owners of limited entry permits as of November 8, 2008, if such ownership has been registered with NMFS by November 30, 2008. The owner of any permit acquired after November 8, 2008, or if acquired earlier, not registered with NMFS by November 30, 2008, will only be eligible to receive an initial allocation for that permit of those QS or IBQ that are within the accumulation limits; any QS or IBQ in excess of the accumulation limits will be redistributed to the remainder of the initial recipients of QS or IBQ in proportion to each recipient's initial allocation of QS or IBQ for each species. Any person that qualifies for an initial allocation of QS or IBQ in excess of the accumulation limits will be allowed to receive that allocation, but must divest themselves of the QS (except for widow rockfish QS) or IBQ in excess of the accumulation limits by November 30, 2015. Holders of QS or IBQ in excess of the control limits may receive and use the QP or IBQ pounds associated with that excess, up to the time their divestiture is completed. Once the divestiture period is completed, any QS or IBQ held by a person (including any person who has ownership interest in the owner named on the permit) in excess of the accumulation limits will be revoked and redistributed to the remainder of the QS or IBQ owners in proportion to the QS or IBQ. On or about January 1, 2016, NMFS will redistribute the revoked QS or IBQ excess percentages to the QS or IBQ owners in proportion to their QS or IBQ holdings based on ownership records as of January 1, 2016. No compensation will be due for any revoked shares.

* * * * *

■ 3. In § 660.150,

■ a. Revise paragraphs (g)(2)(iv)(B), add paragraph (g)(2)(iv)(C), and revise (g)(3)(i)(D) to read as follows:

§ 660.150 Mothership (MS) Coop Program.

* * * * *

(g) * * *

(2) * * *

(iv) * * *

(B) *Application.* NMFS will begin accepting applications for a change in MS/CV endorsement registration beginning September 1, 2014. A request for a change in MS/CV endorsement registration must be made between September 1 and December 31 of each year. Any transfer of MS/CV endorsement and its associated CHA to another limited entry trawl permit must be requested using a Change in Registration of a Mothership/Catcher Vessel Endorsement/Catch History Assignment Application form and the permit owner or an authorized representative of the permit owner must certify that the application is true and correct by signing and dating the form. In addition, the form must be notarized, and the permit owner selling the MS/CV endorsement and its CHA must provide the sale price of the MS/CV endorsement and its associated CHA. If any assets in addition to the MS/CV endorsement and its associated CHA are included in the sale price, those assets must be itemized and described.

(C) *Effective date.* Any change in MS/CV endorsement registration from one limited entry trawl permit to another limited entry trawl permit will be effective on January 1 in the year following the application period.

* * * * *

(3) * * *

(i) * * *

(D) *Divestiture.* For MS/CV-endorsed permit owners that are found to exceed the accumulation limits during the initial issuance of MS/CV-endorsed permits, an adjustment period will be provided during which they will have to completely divest of ownership in permits that exceed the accumulation limits. Any person that NMFS determines, as a result of the initial issuance of MS/CV-endorsed permits, to own in excess of 20 percent of the total catch history assignment in the MS Coop Program applying the individual and collective rule described at § 660.150(g)(3)(i)(A) will be allowed to receive such permit(s), but must divest themselves of the excess ownership by August 31, 2016. Owners of such permit(s) may receive and use the MS/CV-endorsed permit(s), up to the time their divestiture is completed. After August 31, 2016, any MS/CV-endorsed permits owned by a person (including any person who has ownership interest in the owner named on the permit) in excess of the accumulation limits will not be issued (renewed) until the permit owner complies with the accumulation limits.

[FR Doc. 2013–07162 Filed 3–27–13; 8:45 am]

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DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 679

[Docket No. 111213751–2102–02]

RIN 0648–XC596

Fisheries of the Exclusive Economic Zone Off Alaska; Pacific Cod by Catcher Vessels Less Than 60 feet (18.3 meters) Length Overall Using Jig or Hook-and-Line Gear in the Bogoslof Pacific Cod Exemption Area in the Bering Sea and Aleutian Islands Management Area

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Temporary rule; closure.

SUMMARY: NMFS is prohibiting directed fishing for Pacific cod by catcher vessels less than 60 feet (18.3 meters (m)) length overall (LOA) using jig or hook-and-line gear in the Bogoslof Pacific cod exemption area of the Bering Sea and Aleutian Islands management area (BSAI). This action is necessary to prevent exceeding the limit of Pacific cod for catcher vessels less than 60 feet (18.3 m) LOA using jig or hook-and-line gear in the Bogoslof Pacific cod exemption area in the BSAI.

DATES: Effective 1200 hours, Alaska local time (A.l.t.), March 25, 2013, through 2400 hours, A.l.t., December 31, 2013.

FOR FURTHER INFORMATION CONTACT: Obren Davis, 907–586–7228.

SUPPLEMENTARY INFORMATION: NMFS manages the groundfish fishery in the BSAI according to the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area (FMP) prepared by the North Pacific Fishery Management Council under authority of the Magnuson-Stevens Fishery Conservation and Management Act. Regulations governing fishing by U.S. vessels in accordance with the FMP appear at subpart H of 50 CFR part 600 and 50 CFR part 679.

In accordance with § 679.22(a)(7)(i)(C), the Administrator, Alaska Region, NMFS (Regional Administrator), has determined that 113 metric tons of Pacific cod have been caught by catcher vessels less than 60 feet (18.3 m) LOA using jig or hook-and-line gear in the Bogoslof exemption area described at § 679.22(a)(7)(i)(C)(*1*). Consequently, the Regional Administrator is prohibiting directed fishing for Pacific cod by catcher vessels less than 60 feet (18.3 m) LOA using jig or hook-and-line gear in the Bogoslof Pacific cod exemption area.

After the effective date of this closure the maximum retainable amounts at § 679.20(e) and (f) apply at any time during a trip.

Classification

This action responds to the best available information recently obtained from the fishery. The Assistant Administrator for Fisheries, NOAA (AA), finds good cause to waive the requirement to provide prior notice and opportunity for public comment pursuant to the authority set forth at 5 U.S.C. 553(b)(B) and § 679.25(c)(1)(ii) as such requirement is impracticable and contrary to the public interest. This requirement is impracticable and contrary to the public interest as it would prevent NMFS from responding to the most recent fisheries data in a timely fashion and would delay the closure of Pacific cod by catcher vessels less than 60 feet (18.3 m) LOA using jig or hook-and-line gear in the Bogoslof Pacific cod exemption area. NMFS was unable to publish a notice providing time for public comment because the most recent, relevant data only became available as of March 22, 2013.

The AA also finds good cause to waive the 30-day delay in the effective date of this action under 5 U.S.C. 553(d)(3). This finding is based upon the reasons provided above for waiver of prior notice and opportunity for public comment.

This action is required by § 679.22 and is exempt from review under Executive Order 12866.

Authority: 16 U.S.C. 1801 *et seq.*

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CLERK, U.S. DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA

UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

SAN FRANCISCO DIVISION

NC

PACIFIC DAWN LLC, OCEAN GOLD SEAFOODS, INC., CHELLISSA LLC, and JESSIE'S ILWACO FISH COMPANY,

Plaintiffs,

v.

REBECCA BLANK, Acting Secretary of Commerce, in her official capacity as Secretary of the United States, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, and NATIONAL MARINE FISHERIES SERVICE,

Defendants.

Case No. C-13 1419

COMPLAINT FOR DECLARATORY AND INJUNCTIVE RELIEF

[Administrative Procedure Act Case]

INTRODUCTION

1. This case is a further, follow-on legal challenge to actions taken, and regulations issued, by the Secretary of Commerce, acting through its subsidiary agencies, the National Oceanic and Atmospheric Administration ("NOAA") and the National Marine Fisheries Service ("NMFS") (collectively "Federal Defendants"), in carrying out regulatory responsibilities under

the Magnuson-Stevens Fishery Conservation and Management Act (the "Magnuson-Stevens Act"), 16 U.S.C. § 1801 et seq., with respect to management of the Pacific Coast Groundfish Fishery, in particular the Pacific whiting fishery. Plaintiffs filed a predecessor lawsuit on October 25, 2010 raising nearly the same issues being addressed in this lawsuit: the initial allocation of individual fishing quotas ("IFQs") for the shoreside and mothership sectors of the Pacific whiting fishery, including allocations to harvesters and processors. *See* Order, December 22, 2011, *Pacific Dawn LLC, et al. v. Rebecca Blank*, No. C10-4829 (TEH) ("*Pacific Dawn I*") (Dkt. No. 49) (Exhibit 1) (*Pacific Dawn I*); Remedy Order, January 21, 2012, Pacific Dawn I (Dkt. No. 60) (Exhibit 2). The Remedy Order issued in that action directed Federal Defendants to reconsider regulations initially promulgated on October 1, 2010. After "reconsideration," Federal Defendants determined that no change to the original IFQ allocations were necessary to comply with the Magnuson-Stevens Act. Notice of the agency action was published in the Federal Register on March 28, 2013 at 78 Fed. Reg. 18879 (Exhibit 3). There is now a new administrative record on these questions that is subject to judicial review.

2. Plaintiffs, fishing and processing entities with a history of participating in and depending on the Pacific whiting fishery, now challenge the decision not to change their initial IFQ allocations after remand in *Pacific Dawn I* in a manner that reflects their recent history and dependence on the fishery and without considering the overall impact of the IFQ Program on the efficiency of their businesses and the costs imposed by this new fishery management program. The IFQ Regulations originally made fixed allocations awarding fishery participants a certain quantity of fish that the participant could then harvest in a fishing season, based on relative fishing and/or processing history in the fishery. For harvesters, the history years were 1994-2003; for processors the history years were 1998-2004. Processors were allocated 20 percent of the overall annual quota, which was then apportioned out on the basis of the history of receiving lawful deliveries of Pacific whiting to their processing plants. The processors use the IFQ allocation to assure a continual supply of fish to their processing operations, which in the case of Plaintiffs Ocean Gold Seafoods, Inc. and Jessie's Ilwaco Fish Company, are located in small fishery-

dependent communities in the State of Washington.

3. Under the IFQ Program, a harvester must possess the proper permits from NMFS to harvest the fish and may not capture any more Pacific whiting than that allowed under that entity's IFQ allocation. To obtain the privilege of harvesting additional amounts over and above their initial IFQ allocations, Plaintiffs now must either lease or buy IFQ from another permit-holder, thereby creating a new overhead cost that did not exist prior to the institution of the IFQ Program and that reduces their productivity and efficiency. During the reconsideration process, it was brought to the attention of Federal Defendants that a significant amount of IFQ was issued to permit-holders who had ceased actively fishing in the Pacific whiting fishery after 2003 and, therefore, had not demonstrated real dependency on the fishery at the time the IFQ Program was created in 2011 and therefore were not "present participants" in the fishery at the time IFQ was actually distributed.

4. Plaintiffs submit that Federal Defendants have again failed to satisfy the requirements in the Magnuson-Stevens Act with respect to the design of the IFQ Program. In particular, IFQ allocations must give consideration to recent fishing activity of harvesting vessels and processing history for processing facilities so that dependency on the fishery is recognized and costs (including leasing and purchasing IFQ) are minimized. Instead, the IFQ Regulations favor those with fishing history in the period 1994 to 2003 and those with processing history from 1998 to 2004, history years that arbitrarily do not recognize, or give consideration for, recent fishing or processing history and the attendant investment commitment to the fishery on an on-going basis. Moreover, IFQ allocations were given to permit-holders who had not used their permits to land any Pacific whiting after 2003, transferring enormous amounts of wealth to former participants in the fishery who have made an objective decision to stop fishing Pacific whiting prior to the institution of the IFQ Program in 2010. Simply holding a permit that entitles the permit-holder to engage in a fishing privilege is not the same as making continual investments in a fishing operation in the Pacific whiting fishery.

5. Under the original 2010 regulations, IFQ was issued to each of the Plaintiffs in this

DAVIS WRIGHT TREMAINE LLP

action and each is eligible to receive IFQ under the IFQ Program. Plaintiffs aver and believe that, had the agencies complied with the Magnuson-Stevens Act with regard to the initial allocation, each would have received more IFQ than they were in fact given by the agency. By refusing to change the initial allocation after the court-ordered "reconsideration," Federal Defendants have allocated IFQ to permit-holders with no active participation in the Pacific whiting fishery or dependence on that fishery and to permit-holders who have less dependence on the fishery than they do. As a result, the IFQ Regulations and Federal Defendants' recent regulatory action to affirm the original IFQ allocations without change violate the Magnuson-Stevens Act and the Administrative Procedure Act ("APA"), 5 U.S.C. § 706.

JURISDICTION, VENUE AND INTRADISTRICT ASSIGNMENT

6. This Court has jurisdiction pursuant to 28 U.S.C. § 1331 (federal question), 28 U.S.C. § 2201-2202 (declaratory judgment); 16 U.S.C. §§ 1855(f), 1861(d) (Magnuson-Stevens Act); and 5 U.S.C. § 701-706 (APA).

7. Venue is proper in this Court pursuant to 28 U.S.C. § 1391(e).

8. The Pacific Groundfish Fishery that is the subject of this case is prosecuted along the coasts of Oregon, Washington, and California.

RELATED CASE

9. a. *Pacific Dawn I* is related to this case within the meaning of Local Rule 3-12 in that this action involves substantially the same parties or events and is a direct challenge to the same regulations issued by Federal Defendants following a court-ordered reconsideration by Federal Defendants of that regulation.

b. Remand oversight jurisdiction has been retained by Judge Thelton Henderson in *Pacific Dawn I* and to that extent, the case is still ongoing. Assignment of this case to Judge Henderson would promote the efficient determination of the present action.

PARTIES

10. Plaintiff Pacific Dawn LLC ("Pacific Dawn") is a company based in Seattle, Washington which operates the fishing vessel Pacific Challenger. Pacific Dawn currently holds

permits for fishing for Pacific Groundfish, including whiting, and is otherwise eligible to receive IFQ. Pacific Dawn has received an IFQ initial allocation under the IFQ Program. However, the IFQ Regulations do not recognize the recent fishing history held by Pacific Dawn from 2003 to 2010 in calculating its initial IFQ. As a consequence, Pacific Dawn must lease or buy IFQ from others in order to maintain harvests levels at or near the levels of their recent history in the fishery. If IFQ was not issued to permit-holders who did not land any Pacific whiting between 2003 and 2010, Pacific Dawn would have been issued a greater amount of IFQ. And, if Federal Defendants had included Pacific whiting fishing history between 2003 and 2010 in the allocation formula, Pacific Dawn would have been issued a greater amount of IFQ.

11. Ocean Gold Seafoods, Inc. ("Ocean Gold") is a corporation organized under the laws of the State of Washington with facilities located in Westport, Washington. Ocean Gold is eligible for and has been issued IFQ as a processing entity for use in the Pacific whiting fishery. In 1997, Ocean Gold constructed a new plant in Westport designed to process whiting into headed and gutted products, the first such plant to be dedicated to this type of product rather than the surimi products that dominated the processing industry at that time. Since then, foreign markets for headed and gutted product has become the dominant markets for selling Pacific whiting and the surimi market has declined significantly. Because of the history years chosen by Federal Defendants, the initial allocation of Pacific whiting IFQ went to companies with history during the surimi processing years, even though the current state of the market favors headed and gutted products. Because of the IFQ Regulations, Ocean Gold has had to reduce its operations below its recent Pacific whiting processing history and reduced employment at its plant.

12. Plaintiff Chellissa LLC ("Chellissa") owns the fishing vessel Chellissa and is based in Florence, Oregon. Chellissa currently holds permits for fishing for Pacific Groundfish, including whiting, and is otherwise eligible to receive IFQ under the Trawl Rationalization Program. The final rule fails to recognize the recent fishing history held by Chellissa from 2003 to the present in calculating its initial IFQ allocation and otherwise treats Chellissa unfairly and unlawfully under the IFQ Regulations.

13. Plaintiff Jessie's Ilwaco Fish Company ("Ilwaco Fish") is a fish processing firm based in Ilwaco, Washington that has purchased and processed Pacific whiting since 1976. Its plant is located in a small fishing community on the Washington Coast and it employs approximately 100-300 workers in its operations each year. Ilwaco Fish holds the appropriate permits to receive a share of the initial issuance of whiting quota share to be issued to qualified shoreside processors, which has been set at 20 percent of the overall quota share available. However, Ilwaco Fish's processor quota share does not reflect its recent history of processing after 2004 to the present, including 14 million pounds in 2005, 19 million pounds in 2006, and 10 million pounds in 2007. As a consequence, Ilwaco Fish has lost market share it has built up in the Pacific whiting fishery over recent years and reduced employment at its plant.

14. Defendant Rebecca Blank, the Acting Secretary of the U.S. Department of Commerce, is responsible under the Magnuson-Stevens Act for approving fishery management plans and promulgating fishery management regulations, including the IFQ Program, pursuant to the Magnuson-Stevens Act. Secretary Blank is sued in her official capacity.

15. Defendant National Oceanic and Atmospheric Administration (NOAA) is a subunit of the U.S. Department of Commerce with supervisory responsibility for NMFS. The Secretary of Commerce has delegated certain administrative functions under the Magnuson-Stevens Act to NOAA, which in turn has sub-delegated certain fishery management functions to NMFS.

16. Defendant NMFS is the federal agency that administers the fishery management plan for the Pacific Coast Groundfish Fishery, of which the IFQ Program is now a part, and is a subunit of NOAA and the U.S. Department of Commerce.

17. Secretary Blank, NOAA and NMFS approved Amendments 20 and 21 to the Pacific Coast Groundfish Fishery Management Plan ("FMP") that comprise in substantial part the IFQ Program and issued final regulations implementing those Amendments in the Federal Register on October 1, 2010, 75 Fed. Reg. 60868-60999 (Oct.1, 2010), and on December 15, 2010, 75 Fed. Reg. 78344-78427 (Dec. 15, 2010). On March 28, 2013. NOAA issued a notice in the Federal Register of its determination that no change was required to the original IFQ

regulations or the FMP following remand in *Pacific Dawn I* and reconsideration of the IFQ allocation formula.

LEGAL AND FACTUAL BACKGROUND

18. The Magnuson-Stevens Act created a national fishery management system for fish resources and fishing activity located in a 200-nautical mile Exclusive Economic Zone along the U.S. coast, including California, Oregon and Washington.

19. Pursuant to that national fishery management system, the responsible federal agencies, NOAA and NMFS, acting upon recommendations of the Pacific Fishery Management Council created to provide for "bottom-up" fishery management plans for various groups of marine fisheries, long ago adopted the Pacific Coast Groundfish FMP. Approximately 90 species of groundfish, including whiting, are managed pursuant to the FMP through a number of measures, including annual harvest limits, trip and landing limits, no-fishing areas, seasonal closures, and gear restrictions. New entrants into the fisheries are limited and the size of the trawl fleet has declined by nearly 50 percent over the last decade. The Pacific Coast Groundfish Fishery is one of the most strictly regulated fisheries in the world, and overall is considered one of the healthiest by recent peer-reviewed scientific analysis.

20. Upon approval of the FMP by NOAA and NMFS, acting for the Secretary of Commerce, regulations were promulgated to implement the FMP, which is amended and updated on a regular basis as environmental and economic conditions change. Further, the FMP is updated and amended at least bi-annually but sometimes every quarter-year or monthly when appropriate. The goal is to conserve the various fisheries subject to the FMP to ensure the long-term conservation of fish stocks while taking into account the impacts of the FMP on fishing communities, individuals and companies that depend on the fisheries.

21. On October 1, 2010, NOAA published the October Regulations implementing Amendments 20 and 21 to the FMP. Amendment 20 establishes a Trawl Rationalization Program that consists of an IFQ program for the shorebased trawl fleet and cooperative programs, for the at-sea mothership and catcher/processors trawl fleets. The Trawl Rationalization Program is

intended to increase net economic benefits, create individual economic stability, provide full utilization of the trawl sector allocation, consider environmental impacts, and achieve individual accountability of catch and bycatch. Amendment 21 establishes fixed allocations of quotas for limited entry trawl participants.

22. On December 15, 2010, NOAA published additional regulations implementing Amendments 20 and 21 to the FMP (the "December Regulations").

23. The IFQ Regulations (the October Regulations and the December Regulations) contain standards and procedures for issuance of IFQ permits and initial allocations of IFQ (based on a catch history possessed by current permit holders), among other provisions. The allocation formulas in the IFQ Regulations are based on vessel landings for the trawl vessel sector or processor receipt history for the shoreside sector. For Plaintiffs, each is expected to receive an initial allocation of IFQ that will cause them to reduce their operations, leading to a reduction in the market share each has recently developed.

24. The Pacific whiting fishery is one of the most important commercial fisheries, and the largest, off the Pacific Coast and is found in Oregon, Washington, and California. Recent harvest levels have been within the annual conservation guidelines set by NOAA and NMFS and the stock is not considered overfished. In fact, the independent Marine Stewardship Council in 2009 certified the Pacific whiting fishery as sustainable and well-managed. Since 2001, the coast-wise limit on the harvest of Pacific whiting has never been exceeded.

25. The IFQ Regulations allocate 80 percent of the Pacific whiting IFQ to current vessel permit holders and 20 percent of the shoreside harvest allocation to shoreside processors.

26. With respect to vessel permits, the IFQ Regulations state the following (75 Fed. Reg. at 60959): "Whiting QS [quota share] based on each limited entry trawl permit's history will be allocated based on the permit's relative history from 1994 to 2003." History after 2003 was not considered important or relevant, and was rejected as a basis for allocation.

27. With respect to shoreside processors, the IFQ Regulations state the following: (75 Fed. Reg. at 60960): "For each eligible shoreside processor, whiting QS [quota share] will be

allocated based on the eligible shoreside processor's relative history from 1998 through 2004." History after 2004 was not considered important or relevant, and was rejected as a basis for allocation.

28. On December 22, 2011, Judge Thelton Henderson ruled that Federal Defendants had violated the Magnuson-Stevens Act by basing initial IFQ allocations on fishing history only through 2003 for harvesters and 2004 for processors. In his *Pacific Dawn I* Order on Remedy, issued February 21, 2012, Judge Henderson remanded the regulations for "reconsideration prior to the start of the fishing season that begins on April 1, 2013," ordered Federal Defendants to file status reports every three months, and retained oversight jurisdiction, if necessary, to conduct a hearing on the question of whether Federal Defendants were "on track."

29. On March 28, 2013, Federal Defendants published notice of the final rule in the Federal Register and announced the results of their "reconsideration" and decided, wrongfully in Plaintiffs' view, that no changes to the initial allocation were required. Under the final rule, effective April 1, 2013, the existing initial IFQ allocations will be maintained without any revisions despite the *Pacific Dawn I* ruling.

30. All fishery management plans and regulations implementing such plans must comply with the requirements of Magnuson-Stevens Act in order to be binding and effective. Any such regulations that are not so consistent are unenforceable.

31. The Administrative Procedure Act, 5 U.S.C. § 706(2), authorizes a federal court to hold unlawful and set aside agency actions, findings, and conclusions found to be arbitrary, capricious, an abuse of discretion, and otherwise not in accordance with law. Under the APA, among other requirements, Federal Defendants must articulate a satisfactory explanation for its action that demonstrates a rational connection between the facts found and the choices made.

CAUSES OF ACTION

FIRST CAUSE OF ACTION

(Violation of Magnuson-Stevens Act in failing to properly consider and credit fishing history after 2003 for dependent Pacific whiting trawl vessels)

32. Plaintiffs incorporate by reference all preceding paragraphs

33. The Magnuson-Stevens Act contains a number of requirements for adopting FMPs and implementing regulations to carry out FMPs, including, inter alia, the requirement of considering both recent harvests and historic harvests, basing determinations on the best available information, considering the impacts on local fishing communities, and making allocations fair and equitable to all fishermen, among other required considerations. In designing an IFQ program, Federal Defendants are required, among other things, to take into account historical fishing practices in, and dependence on, the particular fishery at issue (16 U.S.C. § 1853(b)(6)(B)) and in developing an allocation Federal Defendants shall provide for consideration of investments in, and dependence on, the fishery (16 U.S.C. § 1853a(c)(5)(A)(iii)).

34. By failing to consider and credit recent fishing history for trawl vessels after 2003 in the Pacific whiting fishery, the IFQ Regulations creating the IFQ Program violated the Magnuson-Stevens Act. In particular, among other things, failing to consider recent harvests caused IFQ to be allocated to permit-holders with less dependence on the fishery than Plaintiffs or gave IFQ to permit-holders who were not presently participating in the Pacific whiting fishery as of 2010.

SECOND CAUSE OF ACTION

(Violation of Magnuson-Stevens Acts for failing to properly consider and credit recent processing history after 2004 for dependent whiting shoreside processors)

35. Plaintiffs incorporate by reference all preceding paragraphs.

36. The Magnuson-Stevens Act contains a number of requirements for adopting FMPs and implementing regulations to carry out FMPs, including, inter alia, the requirement of considering both recent harvests and historic harvests, basing determinations on the best available information, considering the impacts on local fishing communities, and making allocations fair and equitable to all fishermen among other required considerations. In designing an IFQ program,

Federal Defendants are required, among other things, to take into account historical fishing practices in, and dependence on, the particular fishery at issue (16 U.S.C. § 1853(b)(6)(B)) and in developing an allocation Federal Defendants shall provide for consideration of investments in, and dependence on, the fishery (16 U.S.C. § 1853a(c)(5)(A)(iii)).

37. By failing to consider and credit recent fish receipts for shoreside processors in the Pacific whiting fishery after 2004, the IFQ Regulations creating the IFQ Program violated the Magnuson-Stevens Act. In particular, failing to consider and include recent history in the processing sector allocation caused IFQ to be allocated to processors with less dependence on Pacific whiting because their history was based on surimi processing.

THIRD CAUSE OF ACTION
(Violation of Magnuson-Stevens Act's National Standard 5 for failing to properly consider efficiency in designing the initial allocation of IFQ)

38. Plaintiffs incorporate by reference all preceding paragraphs.

39. The Magnuson-Stevens Act requires that fishery management plans, and regulations issued to implement them, to be consistent with ten National Standards. 16 U.S.C. § 1851. National Standard 5 states as follows: Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall economic allocation as its sole purpose. 16 U.S.C. § 1851(a)(5).

40. NOAA has issued guidelines with respect to National Standard 5 and state that "[g]iven a stated set of objectives for the fishery, an FMP should contain management measures that result in as efficient a fishery as is practicable or desirable." 50 C.F.R. § 600.330(b). The guidelines define an efficient fishery as one that enables the harvest of the maximum sustainable yield with the minimum use of economic inputs, such as labor, capital, interest and fuel. *Id.* at § 600.330(b)(2). The guidelines go on to say that efficiency in terms of aggregate costs then becomes a conservation objective, where "conservation" constitutes wise use of all resources involved in the fishery, not just fish stocks. *Id.* The guidelines go on further with respect to an allocation, such as an IFQ Program, and recommend that the alternatives examined should search for an efficient outcome and the FMP should demonstrate that the management measure aimed at

efficiency (i.e. the IFQ Program) does not simply distribute gains and burdens without an increase in efficiency.

41. Federal Defendants' initial allocation of IFQ, as confirmed by its recent "reconsideration," violates National Standard 5 in that IFQ has not been allocated to those most active in and dependent on the fishery, as demonstrated by fishing history and actual landings through 2010, thereby increasing the costs of active participants because of the obligation to buy or lease IFQ from others. Prior to the institution of the IFQ Program, no such lease or purchase costs existed. The IFQ allocation formula distributed gains to those less active in the fishery and did not result in increased efficiency in the fishery. The allocation of IFQ in the Pacific whiting fishery is not consistent with National Standard 5. As a consequence, the allocation of IFQ in the Pacific whiting fishery violated the Magnuson-Stevens Act.

FOURTH CAUSE OF ACTION
(Violation of Magnuson-Stevens Act's National Standard 7 for failing to minimize costs in designing the initial allocation of IFQ)

42. Plaintiffs incorporate by reference all preceding paragraphs.

43. National Standard 7 states as follows: Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication. 16 U.S.C. § 1851(a)(7); 50 C.F.R. § 600.340. In preparing an FMP and associated regulations, Federal Defendants must consider whether a particular management measure "can produce more efficient utilization" as well as the costs associated with an FMP.

44. Creation of the IFQ Program created IFQ leasing and purchase costs for on-going participants in the fishery that did not exist before. In addition, the agencies will be imposing new management costs of up to 3% to cover certain administrative costs associated with the IFQ Program. Other costs with regard to government regulatory expenses are also possible. Federal Defendants have not analyzed these costs nor considered how the initial IFQ allocation could be designed to produce more efficient utilization of the resource. For example, allocating more IFQ to participants the greatest history in the fishery would reduce the need to lease or buy more IFQ and not allocating any IFQ to permit-holders with no present participation or dependence on the

fishery would allow the active participants to be more efficient and be capable of managing impending and new administrative costs.

45. The allocation of IFQ in the Pacific whiting fishery is not consistent with National Standard 7. As a consequence, the allocation of IFQ in the Pacific whiting fishery violated the Magnuson-Stevens Act.

FIFTH CAUSE OF ACTION
(Violation of Magnuson-Stevens Act's National Standard 8 for failing to take into account the needs of fishing communities and to provide for sustained participation of such communities in the Pacific whiting fishery)

46. Plaintiffs incorporate by reference all preceding paragraphs.

47. National Standard 8 states as follows: "Conservation and management measures shall, consistent with the conservation requirements of the Magnuson-Stevens Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to: (1) Provide for the sustained participation of such communities; and (2) To the extent practicable, minimize adverse economic impacts on such communities." 16 U.S.C. §1851(a)(8); 50 C.F.R. 600.345(a). Federal Defendants must, therefore, take into account "the importance of fishery resources to fishing communities" when preparing a FMP. 50 C.F.R. 600.345(b).

48. Federal Defendants failed to analyze, among other things, the "likely positive and negative social and economic impacts of the alternative management measures, over both the short and the long term, on fishing communities." 50 C.F.R. 600.345(c)(4). In particular, the IFQ Program did not take into account the impact of the allocations on communities including Westport, Washington and Ilwaco, Washington, for example, where Ocean Gold and Ilwaco Fish are based. Both Ocean Gold and Ilwaco Fish are negatively affected by IFQ allocations that fail to include more recent history and have lost market share or been forced to reduce their operations as a result.

49. The allocation of IFQ in the Pacific whiting fishery is not consistent with National Standard 8. As a consequence, the allocation of IFQ in the Pacific whiting fishery violated the Magnuson-Stevens Act.

SIXTH CAUSE OF ACTION
(Violation of the APA)

50. Plaintiffs incorporate by reference all preceding paragraphs.

51. The IFQ Regulations with respect to the initial allocation of IFQ for the Pacific whiting fishery violate the Magnuson-Stevens Act and are arbitrary and capricious, an abuse of discretion, and otherwise not in accordance with law.

52. The IFQ Regulations therefore violate the APA.

PRAYER FOR RELIEF

Wherefore, Plaintiffs respectfully request that the Court:

1. Enter a declaratory judgment that finding that Federal Defendants, in the IFQ Regulations, violated the Magnuson-Stevens Act and the APA by:

a. unlawfully failing to consider and credit Pacific whiting trawl fishing history after 2003 in making initial allocations of IFQ and by allocating IFQ to permit-holders with less history and dependence on the fishery or to permit-holders who left the fishery after 2003;

b. unlawfully failing to consider and credit Pacific whiting processing history after 2004 in making initial allocations of IFQ to processing plants with less recent history and processors whose history was based on surimi;

c. unlawfully adopting an initial allocation of IFQ for the Pacific whiting fishery that is not consistent with National Standard 5 of the Magnuson-Stevens Act;

d. unlawfully adopting an initial allocation of IFQ for the Pacific whiting fishery that is not consistent with National Standard 7 of the Magnuson-Stevens Act;

e. unlawfully adopting an initial allocation of IFQ for the Pacific whiting fishery that is not consistent with National Standard 8 of the Magnuson-Stevens Act; and

f. unlawfully adopting an initial allocation of IFQ for the Pacific whiting fishery that is arbitrary and capricious, an abuse of discretion and inconsistent with applicable law.

2. Remand the IFQ Regulations for proceedings and action consistent with the

Magnuson-Steven Act and the APA;

3. Award plaintiffs their fees, expenses and costs pursuant to the Equal Access to Justice Act, 28 U.S.C. § 2412; and

4. Provide such other relief as is just and proper.

Respectfully submitted,

DATED: March 29, 2013

DAVIS WRIGHT TREMAINE LLP

By:
James P. Walsh
Gwen Fanger

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Pacific Dawn LLC, Ocean Gold Seafoods Inc., Chellissa LLC, and Jessie's Ilwaco Fish Company

EXHIBIT 1

IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF CALIFORNIA

PACIFIC DAWN, LLC, et al.,
Plaintiffs,
v.
JOHN BRYSON, et al.,
Defendants.

NO. C10-4829 TEH

ORDER GRANTING IN PART AND DENYING IN PART PLAINTIFFS' AND DEFENDANTS' MOTIONS FOR SUMMARY JUDGMENT

This matter came before the Court on December 12, 2011, on the parties' cross-motions for summary judgment. After carefully considering the parties' written and oral arguments, the Court now GRANTS IN PART and DENIES IN PART the motions for the reasons discussed below.

I. BACKGROUND

This case concerns the manner in which Defendants John Bryson, sued in his official capacity as Secretary of Commerce ("Secretary");[1] National Marine Fisheries Service ("NMFS"); and National Oceanic and Atmospheric Administration ("NOAA") regulate the fishing of Pacific whiting off the coasts of Washington, Oregon, and California. The Secretary oversees NOAA, which includes NMFS among its member agencies. Plaintiffs Pacific Dawn LLC, Chellissa LLC, James and Sandra Schones, Da Yang Seafood Inc., and Jessie's Ilwaco Fish Company own three fishing vessels and two processing companies that participate in the Pacific whiting industry.

[1]Bryson is substituted for Defendant Gary Locke pursuant to Federal Rule of Civil Procedure 25(d).

Plaintiffs contend that Defendants violated the Magnuson-Stevens Fishery Conservation and Management Act ("MSA" or "Act"), 16 U.S.C. §§ 1801-84, when they adopted Amendments 20 and 21 to the fishery management plan for Pacific groundfish, which includes Pacific whiting. Amendment 20 created a limited access privilege program through which participants in the trawl sector of the fishery receive permits to harvest a specific portion of the fishery's total allowable catch via individual fishing quotas ("IFQs"). Amendment 21 allocated total allowable catch for certain species in the fishery between the trawl and non-trawl sectors.

Congress enacted the MSA, among other purposes, "to conserve and manage the fishery resources found off the coasts of the United States," "to promote domestic commercial and recreational fishing under sound conservation and management principles," and "to provide for the preparation and implementation, in accordance with national standards, of fishery management plans which will achieve and maintain, on a continuing basis, the optimum yield from each fishery." 16 U.S.C. § 1801(b)(1), (3)-(4). The Act created eight regional fishery management councils, including the Pacific Fishery Management Council ("Council") that governs the fishery at issue in this case. 16 U.S.C. § 1852. These councils must develop, and submit to the Secretary for approval, fishery management plans ("FMPs") and "amendments to each such plan that are necessary from time to time (and promptly whenever changes in conservation and management measures in another fishery substantially affect the fishery for which such plan was developed)." 16 U.S.C. § 1852(b), (h)(1). FMPs must comply with ten national standards, 16 U.S.C. § 1851(a), and the MSA also enumerates certain factors that councils must take into account when developing programs that limit access to a fishery. *E.g.*, 16 U.S.C. §§ 1853(b)(6), 1853a.

Of relevance to Plaintiffs' instant claims,[2] NMFS issued regulations implementing Amendment 6 to the FMP for Pacific Groundfish in 1992, to take effect on January 1, 1994.

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[2]The parties are familiar with the facts of this case, and the Court here offers only a brief summary of relevant portions of the extensive administrative record.

Those regulations required federal permits to participate in the limited entry segment of the fishery and established different levels of endorsements, including "A" and "B." 57 Fed. Reg. 32,499, 32,501-03 (July 22, 1992). "A" endorsements were transferable endorsements that were granted to vessels that met specific minimum landing requirements during the qualifying window period of July 11, 1984, through August 1, 1988. *Id.* at 32,501. "B" endorsements were non-transferable and granted to vessels that "landed some groundfish prior to August 1, 1988," but that did not meet the requirements to receive an "A" endorsement. *Id.* "'B' endorsements expire[d] at the end of the 1996 fishing year, by which time vessel owners must have obtained a permit with an 'A' endorsement or have left the limited entry fishery." *Id.* at 32,503.

In 2004, NMFS published an advanced notice of proposed rulemaking announcing that the Council was:

> considering implementing an individual quota (IQ) program for the Pacific Coast groundfish limited entry trawl fishery off Washington, Oregon and California. The trawl IQ program would change management of harvest in the trawl fishery from a trip limit system with cumulative trip limits for every 2-month period to a quota system where each quota share could be harvested at any time during an open season. The trawl IQ program would increase fishermen's flexibility in making decisions on when and how much quota to fish. This document announces a control date of November 6, 2003, for the trawl IQ program. The control date for the trawl IQ program is intended to discourage increased fishing effort in the limited entry trawl fishery based on economic speculation while the Pacific Council develops and considers a trawl IQ program.

69 Fed. Reg. 1563 (Jan. 9, 2004).

The Council subsequently decided to allocate IFQs for Pacific whiting to current permit holders based on fishing history associated with such permits from 1994 to 2003 for harvesters, and from 1994 to 2004 for on-shore processors. Fishing history under "B"-endorsed permits was included when determining the total catch for the fishery in each year of the qualifying periods, but it was not included "in calculating any permit's individual qualifying history." Nov. 21, 2011 Joint Supplemental Br. at 3 (ECF Docket No. 47) (parties' jointly agreed description of how "B"-permit history was used in calculating IFQs);

see also 75 Fed. Reg.60,869, 60,956 (Oct. 1, 2010) (setting forth allocation rules). The final rules implementing Amendments 20 and 21 were issued in October and December 2010, and implementation of the IFQ system began on January 1, 2011. 75 Fed. Reg. 60,869; 75 Fed. Reg. 78,344 (Dec. 15, 2010).

The MSA requires that:

> In developing a limited access privilege program to harvest fish a Council or the Secretary shall –
>
> (A) establish procedures to ensure fair and equitable initial allocations, *including consideration of* –
>
> (i) *current and historical harvests*;
>
> (ii) employment in the harvesting and processing sectors;
>
> (iii) investments in, and dependence upon, the fishery; and
>
> (iv) the current and historical participation of fishing communities.

16 U.S.C. § 1853a(c)(5) (emphasis added). Plaintiffs contend that Defendants violated subsection (i) of this provision – and also failed to base their decisions on "the best scientific information available," as required by National Standard Two, 16 U.S.C. § 1851(2) – in two ways: first, by not considering fishing history for harvesters beyond 2003 and for processors beyond 2004 and, second, by not adequately considering fishing history associated with "B" permits.[3] Plaintiffs argue that their initial IFQs would have been higher had harvests beyond 2003 and 2004 been considered.[4] Plaintiff Pacific Dawn further asserts that it obtained ownership of the fishing history of the Amber Dawn, a vessel that fished under a "B"-endorsed permit from 1994 to 1996, and that this history was not but should have been included when Defendants determined Pacific Dawn's initial IFQ. The parties agree that

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[3]In their papers, Plaintiffs discuss separately the 2003 and 2004 cutoff dates for harvesters and processors, respectively. The Court considers these issues concurrently because they are based on the same legal arguments.

[4]Plaintiff Da Yang Seafood Inc. did not receive an initial IFQ because it had no history prior to the 2004 cut-off date for processors. It contends that it should have received one based on its more recent history.

summary judgment is an appropriate mechanism for resolving Plaintiffs' claims, and their cross-motions for summary judgment are now pending before the Court.

II. LEGAL STANDARD

A court shall set aside regulations adopted under the MSA if they are "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law." 5 U.S.C. § 706(2)(A); 16 U.S.C. § 1855(f)(1)(B) (adopting the standards for judicial review under 5 U.S.C. § 706(2)). This is a "highly deferential" standard of review, and an agency's action is presumed to be valid and should be affirmed "if a reasonable basis exists for its decision." *Indep. Acceptance Co. v. California*, 204 F.3d 1247, 1251 (9th Cir. 2000) (internal quotation marks and citation omitted). A reviewing court's "only task is to determine whether the Secretary has considered the relevant factors and articulated a rational connection between the facts found and the choices made." *Midwater Trawlers Coop. v. Dep't of Commerce*, 282 F.3d 710, 716 (9th Cir. 2002). The court "cannot substitute [its] judgment of what might be a better regulatory scheme . . . if the Secretary's reasons for adopting it were not arbitrary and capricious." *Alliance Against IFQs v. Brown*, 84 F.3d 343, 345 (9th Cir. 1996).

"[S]ummary judgment is an appropriate mechanism for deciding the legal question of whether the agency could reasonably have found the facts as it did." *Occidental Eng'g Co. v. INS*, 753 F.2d 766, 770 (9th Cir. 1985). Review is generally "limited to the administrative record on which the agency based the challenged decision." *Fence Creek Cattle Co. v. U.S. Forest Serv.*, 602 F.3d 1125, 1131 (9th Cir. 2010). The Ninth Circuit allows expansion of the record only "in four narrowly construed circumstances: (1) supplementation is necessary to determine if the agency has considered all factors and explained its decision; (2) the agency relied on documents not in the record; (3) supplementation is needed to explain technical terms or complex subjects; or (4) plaintiffs have shown bad faith on the part of the agency." *Id.* In this case, neither party has asked the Court to supplement the administrative record.

III. DISCUSSION

As an initial matter, Defendants correctly argue that the Act's use of the word "consideration" does not mandate a particular outcome. *See e.g., Pac. Coast Fed'n of Fishermen's Ass'ns v. Locke*, Case No. C10-4790 CRB, 2011 WL 3443533 (N.D. Cal. Aug. 5, 2011), at *5-7. However, unlike the plaintiffs in *Pacific Coast Federation*, Plaintiffs here challenge not simply the end result, but also whether Defendants considered the required statutory factors in reaching that result. The MSA unambiguously requires that Defendants consider certain factors, including "current and historical harvests." 16 U.S.C. § 1853a(c)(5)(A)(i). As explained above, Defendants must have "considered the relevant factors and articulated a rational connection between the facts found and the choices made." *Midwater Trawlers Coop.*, 282 F.3d at 716.

A. <u>Consideration of fishing history beyond 2003 and 2004</u>

Plaintiffs first argue that Defendants improperly failed to consider "current" harvests when, in 2010, they based initial IFQs on fishing histories through 2003 for harvesters and 2004 for processors. Defendants assert that they adequately considered current harvests by allocating quota shares to current permit owners rather than to individuals or vessels that may have participated in the fishery in the past. However, the statute requires consideration of current harvests, not current permits, and considering historical harvests of current permits is distinguishable from considering current harvests themselves. Defendants have cited no authority to the contrary.

Defendants' main argument on this issue is that they reasonably based the end of the qualifying period on the previously published 2003 control date. Plaintiffs raise several challenges to the validity of that control date, none of which have merit. First, Plaintiffs assert that the 2003 date reflected only a political statement or compromise, but they cite no evidence for this assertion.[5] Thus, this case is distinguishable from *Hadaja, Inc. v. Evans*, in which the regional council "urged the industry groups to reach a compromise," and the

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[5]As noted below, there is evidence in the record, however, that the extension of the qualifying period for processors to 2004 was the result of compromise.

"limited access scheme was adopted directly from the compromise reached." 263 F. Supp. 2d 346, 350, 354 (D.R.I. 2003). Plaintiffs also argue that a proposed control date is only valid if it is adopted as a formal regulation. However, Plaintiffs cite no authority to support that conclusion, and the Third Circuit recently rejected that argument, concluding that the government need not go through formal rule promulgation procedures before setting a control date; instead, the court held that publication of a proposed control date in the Federal Register was sufficient. *Gen. Category Scallop Fishermen v. Sec'y of Commerce*, 635 F.3d 106, 113 (3d Cir. 2011). Finally, Plaintiffs argue that an interim amendment to the FMP – Amendment 15 – superseded the control date, but they cite no authority to rebut Defendants' conclusion in the record, in response to a comment to the proposed regulation, that:

> Nowhere does Amendment 15 address the 2003 control date or purport to change the qualifying period for the Groundfish trawl program. Amendment 15 was a limited interim action for the non-Tribal whiting fishery issued in anticipation of the trawl rationalization that in no way attempted to address matters beyond its limited scope. Moreover, the Council has explicitly stated that vessels that qualified for whiting fishery participation under Amendment 15 were not guaranteed future participation or inclusion in the Pacific whiting fishery under the provisions of Amendment 20.

B22:638 (June 2010 Final Environmental Impact Statement prepared by the Council and NMFS) (citation omitted).[6] In light of all of the above, the Court finds that the proposed control date was procedurally valid and was not subsequently invalidated by Amendment 15.

Defendants explain that they chose to base the qualifying period on the announced control date because using a later date would "reward those who disregarded the control date announcement, create perceptions of inequity, and encourage fishermen to ignore such dates in the future, negatively affecting the Council's ability to credibly use control dates." B22:A-151; *see also* B22:A-146 ("The allocation period that would most likely minimize dislocation and the attendant costs would be the few years just prior to the initial allocation.

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[6]The Court adopts the parties' system of citation to the administrative record. Thus, the quoted language appears at page 638 of document B22. Pagination denoted with an asterisk refers to page numbers in the document's PDF format rather than pagination identified on the document itself.

That period is not used, in part, because of issues related to the need to establish credible control dates to effectively manage the fishery while deliberations on new LE [limited entry] programs are underway."). A similar rationale was upheld by the Ninth Circuit in *Alliance Against IFQs v. Brown*. In that case, the relevant statute required that "present participation in the fishery" be "take[n] into account."[5] 84 F.3d at 346 (quoting 16 U.S.C. § 1853(b)(6)(A)). The government allocated quota shares in 1993 to owners or lessees of vessels that made legal landings of halibut or sablefish during the years 1988 to 1990. *Id.* at 345-46. The Ninth Circuit found that the most persuasive reason for a 1990 cutoff date "was that if participation in the fishery while the rule was under consideration had been considered, then people would have fished and invested in boats in order to obtain quota shares, even though that would have exacerbated overcapacity and made no economic sense independently of the regulatory benefit." *Id.* at 346. The court ultimately concluded that the three-year period between the end of the cutoff period and promulgation of the regulations was not arbitrary or capricious:

> Congress left the Secretary some room for the exercise of discretion, by not defining "present participation," and by listing it as only one of many factors which the Council and the Secretary must "take into account." While the "participation" that the Council actually considered was admittedly in the "past" judged from the time when the final regulations were promulgated, it was roughly "present" with the time when the regulations were first proposed: The Council began its process on this plan in 1990, and considered participation in 1988, 1989, and 1990. The process required to issue a regulation necessarily caused substantial delay. The process of review, publication, public comments, review of public comments, and so forth, had to take a substantial amount of time, *see* 16 U.S.C. § 1854(a), and the environmental impact review also was lengthy, as it typically is, *see* 42 U.S.C. § 4332(2)(C). "Present" cannot therefore prudently be contemporaneous with the promulgation of the final regulations.

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[5]Plaintiffs assert that Congress intended the word "current" to refer to more recent events than "present," but they cite no authority for that position. Moreover, their moving papers rely on a dictionary definition of "current" expressed in terms of "present." Pls.' Mot. at 9 (defining "current" as "presently elapsing, occurring in or existing at the present time; most recent") (quoting Merriam-Webster Unabridged Dictionary (2010)).

> We further believe that the Secretary had a good reason for disregarding participation in the fishery during this lengthy process, because the alternative would encourage the speculative over-investment and overfishing which the regulatory scheme was meant to restrain. Under the regulations, eligibility for quota shares depends on fishing during the years 1988, 1989, and 1990. Whatever years are used necessarily recede into the distant past. Even in 2005, assuming the regulatory scheme lasts that long, the quota shares will be based on fishing prior to 1991. Future generations of fishermen will continue to be governed by these pre-1991 allocations. Had the Secretary extended the 1990 cutoff, the incentive to pour money and time into the fishery in order to get a bigger quota share, for those who could afford a long term speculation, would have been enormous.
>
> Thus, while the length of time between the end of the participation period considered and the promulgation of the rule *pushed the limits of reasonableness*, we are unable to characterize use of a 1988 through 1990 period as so far from "present participation" when the regulation was promulgated in 1993 as to be "arbitrary or capricious."

Id. at 347-48 (emphasis added) (citations omitted).

Alliance Against IFQs would clearly support upholding the regulations at issue in this case had they been promulgated in 2006 rather than 2010. The same "good reason" that supported the cutoff date in that case applies equally here: the desire to curb speculation while the regulations were under review. *Id.* at 347. Plaintiffs counter that there is no evidence of rampant speculation in the whiting industry that would undermine conservation and management efforts, and a control date was therefore unnecessary, but it could very well be that the announcement of a control date is what curbed any such speculation.

However, if three years between the end of a qualifying period and promulgation of a regulation "pushe[s] the limits of reasonableness," *Alliance Against IFQs*, 84 F.3d at 348, then the six- and seven-year periods in this case arguably fall beyond those limits. While "current" cannot "prudently be contemporaneous with the promulgation of the final regulations," it may be that a 2003 cutoff date is "so far" from "current" harvests when the regulation was promulgated in 2010 as to be arbitrary or capricious. *Id.* at 347-48. At oral argument, Defendants asserted that this case was more factually complex than *Alliance Against IFQs* – for example, because more species were at issue and Congress passed amendments to the MSA while the regulations were under consideration – and that a longer period of time to develop the regulations was therefore reasonable. The parties did not brief this issue, and it may be that the increased factual complexity would, indeed, render the delays in this case reasonable.

The Court need not and does not decide this question because an independent basis exists for rejecting the regulations in this case: Even if it was conceptually reasonable for Defendants to have relied on a 2003 control date when promulgating regulations in 2010, the manner in which they did so here was not rational. As Defendants correctly observe, the record demonstrates that harvests up to 2006 were considered for some purposes. At first glance, this would appear to support Defendants because it indicates that they considered harvests more recent than 2003. However, it actually undermines Defendants' position because Defendants fail to explain why it was rational to rely on the control date for some purposes but not others. For example, Defendants considered harvests from 2003 to 2006 when examining species considered to be overfished. *E.g.*, D45:*64-68 (Aug. 3, 2010 Decision Memorandum from NOAA Regional Administrator William W. Stelle, Jr. to NOAA Assistant Administrator for Fisheries Eric C. Schwaab). They justified going beyond the 2003 control date as follows:

> The ratios could not be calculated without using information from the West Coast Groundfish Observer Program. This program was not fully operational until 2003, so use of earlier years would not have been practicable. In addition, the Rockfish Conservation Areas (RCAs) were first created in 2003. Fishing operations were greatly affected by the creation of the RCAs, which will remain in place for the foreseeable future. The Council considered it important to recognize the changes caused by the RCAs, that choosing earlier years would not have done so, and that an estimate of likely patterns of activity should be based on a period of time when the RCAs were in place. The Council also considered using later years, but rejected this approach because the years 2003-2006 reasonably reflected recent fishing patterns, while not diverging too far from the target species allocation period of 1994-2003.

D45:*66. While the development of the RCAs provides a rational basis for departing from the 2003 control date in allocating QS for overfished species, it is questionable that Defendants considered whether the chosen qualifying period "reasonably reflected recent fishing patterns" for these species when they do not appear to have undertaken the same analysis for Pacific whiting. For instance, the distribution of whiting among Washington, Oregon, and California appears to have shifted significantly after 2003, with Washington's share moving from 29% in 2003 to 50% in 2008, but Defendants have not cited to any portion of the record where they considered whether the IFQ allocations based on history through 2003 and 2004 "reasonably reflected" these more recent fishing patterns. *See* M379:6, 8 (July 9, 2010 comments on proposed rule prepared for Plaintiff Pacific Dawn by Steve Hughes).

Defendants also looked at more recent harvests when considering whether new entrants would be prejudiced. B22:A-216. They concluded that:

> With respect to whiting, five new buyers have entered the fishery since 2004 (the end of the whiting QS [quota share] allocation period for processors), but these buyers have purchased nearly 3 percent of the shoreside whiting landings and about 9 percent of the landings in California (which are much smaller than for Oregon and Washington, Table A-76). With the possible exception of California, it does not appear that there are many post-2004 entrants with significant amounts of landings that will not receive an initial allocation of whiting QS under the IFQ program.

Id. Defendants make no argument as to why it was rational for them to exclude these new entrants, particularly the ones that had "significant amounts of landings that will not receive an initial allocation of whiting QS under the IFQ program." There does not appear to be any evidence, for example, that the new entrants engaged in speculation when they entered the market after the announced 2003 control date.

Most problematic is Defendants' explanation of why the qualifying period for processors was extended to 2004. Defendants did not rely on the 2003 control date for processors "because keeping the date at 2003 was viewed to disadvantage a processor that was present as a participant during the window period but had increased its share of the processing substantially since the close of the original allocation period (2003)." B22:A-214. Thus, the extension to 2004 was made to benefit a single processor, which begs the question of why that particular processor should benefit – notwithstanding an earlier control date – when others should not. This appears to be a quintessential case of arbitrariness. Moreover, the record unequivocally states that the extension of the period to 2004 for harvesters was the result of "a compromise arrived at during industry negotiations," B22:A-146, thus undermining any argument that Defendants' decision-making was free from political compromise.

While Defendants correctly argue that they have broad discretion to make decisions, and that no particular outcome is required by the MSA, they have failed to present a reasonable explanation for relying on the 2003 control date for some purposes but not others. Consequently, the Court finds that Defendants' failure to consider fishing history beyond 2003 for harvesters and 2004 for processors was arbitrary and capricious. Plaintiffs' motion for summary judgment is GRANTED on this issue, and Defendants' motion is DENIED.

B. Consideration of "B"-permit history

Plaintiffs next argue that Defendants violated the MSA by failing to give adequate consideration to fishing history conducted under "B" permits. The parties agree that "B"-permit history was not credited to any current permit holder when determining qualifying history for purposes of allocating initial IFQs. Defendants explain that such history was excluded because they followed a policy of having fishing history follow the permit – i.e., they allocated shares to owners of current permits to "ensure[] that the allocation will go to those that currently own assets in the fishery," B22:A-119, and based such allocations on the catch history associated with each given permit, not the catch history of any particular vessel.

Given the decision to base IFQs on fishing history associated with current permits – a decision that Plaintiffs do not challenge – it was not arbitrary or capricious for Defendants to exclude "B"-permit history when calculating qualifying fishing history. While Plaintiff Pacific Dawn may well have entered into an agreement to purchase the fishing history of the Amber Dawn, the "B" permit under which the Amber Dawn fished expired in 1996. Contrary to Plaintiffs' assertions, the record is clear that "B" permits were not transferable and were no longer valid after 1996. *E.g.*, 57 Fed. Reg. 32,499, 32,501 ("A 'B' endorsement allows the vessel to participate in the limited entry fishery through 1996, when all 'B' endorsements will expire."); *id.* at 32,503 ("The non-transferable 'B' endorsement provides short-term access to the fishery. . . . 'B' endorsements expire at the end of the 1996 fishing year, by which time vessel owners must have obtained a permit with an 'A' endorsement or have left the limited entry fishery."). Plaintiffs have failed to establish that the history of the Amber Dawn when it fished under a "B" permit is associated with any current permit, and it was therefore reasonable for Defendants not to have credited such history when it allocated initial IFQs. Accordingly, Defendants' motion for summary judgment is GRANTED on this issue, and Plaintiffs' motion is DENIED.

C. Remedy

Having found for Plaintiffs on one issue, the Court must now determine an appropriate remedy. Plaintiffs ask that the regulations be set aside and the matter be remanded to NOAA, but Defendants request an opportunity to file additional briefs on an appropriate remedy. In their reply, Plaintiffs failed to offer any reason why such briefing would be unnecessary and instead merely repeated their conclusory request that the regulations be set aside and that NOAA be ordered to revise the regulations in compliance with the MSA. Although the parties could – and should – have included more discussion on an appropriate remedy in their papers, they did not. The Court therefore finds it prudent to consider supplemental briefing before granting any relief.

IV. CONCLUSION

As discussed above, Plaintiffs' and Defendants' motions for summary judgment are both GRANTED IN PART and DENIED IN PART. Plaintiffs prevail on the issue of whether Defendants violated the MSA by basing initial IFQ allocations on fishing history only through 2003 for harvesters and 2004 for processors. Defendants prevail on the issue of whether they adequately considered fishing history conducted under "B" permits.

The parties shall submit supplemental briefing on an appropriate remedy. They shall file simultaneous briefs on or before **January 30, 2012,** and simultaneous reply briefs on or before **February 13, 2012.** The matter will then be deemed submitted on the papers unless the Court subsequently orders oral argument. Alternatively, if the parties wish to appeal this order before litigating an appropriate remedy, the Court will consider a motion to make the requisite findings for an interlocutory appeal under 28 U.S.C. § 1292.

IT IS SO ORDERED.

Dated: 12/22/11

THELTON E. HENDERSON, JUDGE
UNITED STATES DISTRICT COURT

EXHIBIT 2

IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF CALIFORNIA

PACIFIC DAWN, LLC, et al.,
Plaintiffs,
v.
JOHN BRYSON, et al.,
Defendants.

NO. C10-4829 TEH

ORDER ON REMEDY

On December 22, 2011, this Court granted in part and denied in part Plaintiffs' motion for summary judgment. The Court found that Defendants' failure to consider history beyond 2003 for harvesters and 2004 for processors when setting initial fishing quotas ("IFQs") for Pacific whiting was arbitrary and capricious. The Court ordered supplemental briefing on remedy because the parties' summary judgment papers failed to address that issue adequately. Having carefully considered the parties' supplemental briefs, the Court finds it appropriate, for the reasons discussed below, to remand the regulations for reconsideration prior to the start of the fishing season that begins on April 1, 2013.

DISCUSSION

The parties agree that the regulations at issue should be remanded to Defendants for further consideration consistent with the Court's summary judgment ruling. However, they disagree on a deadline for adopting new regulations and whether the current regulations should be vacated pending remand.

Plaintiffs assert that Defendants can and should adopt new regulations prior to the start of the 2012 fishing season for Pacific whiting, which they contend begins on May 15, 2012. Their initial supplemental brief also suggested that the existing regulations remain in place unless Defendants fail to implement new regulations prior to December 1, 2012.

Plaintiffs altered their position in their supplemental reply, in which they request either that the existing regulations be vacated if Defendants fail to implement revised regulations prior to May 15, 2012, or that they be vacated indefinitely pending the implementation of revised regulations.

Defendants, by contrast, contend that it would be impossible for them to implement new regulations by the start of the 2012 Pacific whiting fishing season, which they assert begins on April 1, 2012, but state that new regulations can be in place by the start of the 2013 fishing season on April 1, 2013. Defendants further argue that this Court should not vacate the existing regulations while the matter is under review.

Time for Implementing New Regulations

The start of the Pacific whiting fishing season is governed by regulation. It begins on May 15 of each year for the catcher/processor and mothership sectors, but as early as April 1 for the shorebased IFQ program, depending on geographical latitude. 50 C.F.R. § 660.131(b)(2)(iii). Thus, Defendants are correct that the fishing season begins as early as April 1, and not on May 15, as Plaintiffs assert.

Defendants also presented evidence that it would be unworkable to change quota share amounts once the fishing season has begun:

> Each owner of a whiting quota share permit receives two distributions of whiting quota pounds. The first limited distribution of 2012 whiting quota pounds occurred on December 29, 2011, based on the lower range of potential whiting harvest amounts. The final whiting harvest amount is known by March 25. Once the final harvest amount is known, another distribution of whiting quota pounds occurs so that the total quota pounds issued for that year is equal to the permit owner's whiting quota share multiplied by that year's whiting shorebased trawl allocation. . . . Once the quota pounds are distributed to quota share accounts, the quota pounds can be sold, transferred, or leased to other participants in the shorebased IFQ fishery. Any change in initial quota share amounts that occurs during 2012 after the primary shorebased whiting fishery begins could be virtually impossible to implement. For example, if a permit owner's whiting quota share were reduced mid-season, the permit owner's corresponding whiting quota pounds would need to be reduced. However, if the quota share permit owner has already transferred quota pounds based on private business agreements, NMFS [the National Marine Fisheries Service] lacks

> the ability to determine who currently owns the quota pounds attributable to different quota share accounts, and also lacks the ability to determine if quota pounds already fished are attributable to a specific quota share account. Simply put, once quota pounds are issued and quota pound trading or fishing occurs, taking back quota pounds to adjust for changes in quota share amounts is impracticable mid-season.

Lockhart Decl. ¶ 12. The Court finds this evidence persuasive, especially in the absence of any contrary evidence or argument by Plaintiffs that changing quotas mid-season is feasible. The question for the Court is therefore whether it should order implementation of new regulations prior to April 1, 2012, or April 1, 2013.

Plaintiffs have presented no authority for ordering the implementation of revised regulations in less than two months, or even in three months if Plaintiffs' asserted start date were assumed to be true, and the Court finds such a timetable to be unreasonable. Indeed, Plaintiffs' initial supplemental brief appears to recognize that it may not be feasible to implement regulations by May 15, 2012, since it requested vacatur of existing regulations only if revised regulations were not in place by December 1, 2012. In addition, the primary case relied on by Plaintiffs in their supplemental reply brief ordered a one-year deadline on remand – far longer than the three months Plaintiffs request here. *See Natural Res. Def. Council v. Locke*, Case No. C01-0421 JL (N.D. Cal.), Apr. 29, 2010 Order on Remedy (Ex. 3 to Pls.' Suppl. Reply Br.).

Plaintiffs appear to assume that Defendants need only perform simple mathematical calculations using existing historical catch data before they can implement new regulations. While that is one option open to Defendants, it is not the only one. For example, Defendants might also want to consider whether it is "appropriate to increase the number of worst years that any individual may drop (from two in the current formula to some higher number); earlier years in the allocation period might be removed to maintain a consistent length for the allocation period; or a different method for weighting the years might be appropriate." Second Lockhart Decl. ¶ 13. Put simply, Plaintiffs are not entitled to have Defendants adopt their requested methodology, nor is it the Court's role to dictate to Defendants how the regulations should be revised. As the Supreme Court has explained:

> If the record before the agency does not support the agency action, if the agency has not considered all relevant factors, or if the reviewing court simply cannot evaluate the challenged agency action on the basis of the record before it, the proper course, except in rare circumstances, is to remand to the agency for additional investigation or explanation. The reviewing court is not generally empowered to conduct a *de novo* inquiry into the matter being reviewed and to reach its own conclusions based on such an inquiry.

Fla. Power & Light Co. v. Lorion, 470 U.S. 729, 744 (1985); *see also Midwater Trawlers Coop. v. Dep't of Commerce*, 282 F.3d 710, 721 (9th Cir. 2002) (remanding to NMFS "to either promulgate a new allocation consistent with the law and based on the best available science, or to provide further justification for the current allocation that conforms to the requirements of the Magnuson-Stevens Act and the Treaty of Neah Bay," rather than remanding with specific instructions on how to determine a new allocation). Plaintiffs have not persuaded the Court that this case presents "rare circumstances" in which a specific remand order would be appropriate, and Plaintiffs themselves appear to recognize the impropriety of a specific remand order, noting that an order on timing "is all that plaintiffs seek here." Pls.' Suppl. Reply at 7 n.5.

In light of all of the above, the Court finds it appropriate to remand the affected regulations for reconsideration in light of the Court's summary judgment ruling, with revised regulations to be implemented no later than April 1, 2013. Plaintiffs argue that Defendants may adopt emergency regulations by statute, 16 U.S.C. § 1855(c), but the Court agrees with Defendants that it would be improper to order Defendants to exercise their discretionary power to adopt emergency regulations – although, on remand, Defendants should consider whether use of this mechanism is appropriate.

Whether Existing Regulations Should Be Vacated Pending Remand

When determining whether to vacate regulations pending remand, courts consider several factors, including "the seriousness of the [regulations'] deficiencies (and thus the extent of doubt whether the agency chose correctly) and the disruptive consequences of an interim change that may itself be changed," *Allied-Signal, Inc. v. U.S. Nuclear Regulatory Comm'n*, 988 F.2d 146, 150-51 (D.C. Cir. 1993) (internal quotation marks and citation omitted), as well as "the purposes of the substantive statute under which the agency was acting" and "potential prejudice to those who will be affected by maintaining the status quo," *Natural Res. Def. Council v. U.S. Dep't of Interior*, 275 F. Supp. 2d 1136, 1144 (C.D. Cal. 2002).

Plaintiffs initially agreed that vacatur need not be ordered as long as new regulations were implemented by December 1, 2012. *See, e.g.*, Pls.' Suppl. Br. at 5 ("[E]quity supports a finding that the existing IFQ Regulations should be preserved pending remand."). As discussed above, the Court finds it would be unworkable to change allocations in the middle of a season. Thus, based on Plaintiffs' initial agreement that the regulations need not be vacated before December 1, 2012, it would be appropriate to leave the existing regulations in place through the start of the 2013 fishing season on April 1, 2013.

Plaintiffs changed their position in their supplemental reply brief and now argue that vacatur is necessary pending remand unless Defendants implement new regulations prior to May 15, 2012. However, they have presented no evidence of changed circumstances that would warrant a change in position from their opening supplemental brief, filed just two weeks earlier.

Moreover, the Court finds the balance of factors in this case to weigh against vacatur. Plaintiffs argue that they will be harmed economically if the existing regulations are left in place, but their assertions of harm are exaggerated, as well as imprecise as to the amount of their projected harm. Plaintiffs begin with the incorrect premise that the existing regulations will remain in place for an additional two years when, in fact, the Court has ordered the regulations to be revised by the start of the 2013 fishing season, leaving the regulations in place for only one additional year. In addition, while Plaintiffs might well gain quota share after Defendants have revised the regulations, this outcome is not guaranteed. Plaintiffs have also failed to present evidence that they would benefit economically from a fishing season in which overall harvest was limited but no individual quotas existed, which would be the effect of vacatur. It could be, for example, that other participants would increase their catch beyond their existing individual quotas and do so more quickly than Plaintiffs, thereby diminishing the amount of catch available to Plaintiffs before the overall harvest limit were reached.

As Plaintiffs acknowledge, leaving existing regulations in place will benefit some fishery participants while harming others. Marchand Decl. ¶ 5. However, the magnitude of such benefits and harms remains unknown because it is uncertain how Defendants will revise the regulations on remand. Additionally, Plaintiffs have offered no evidence to rebut Defendants' evidence that vacatur would lead to significant disruptions in the fishery. For example:

> No shorebased processors would receive individual whiting quota, which would result in lost revenue and less flexibility to adapt to the changes in the groundfish fishery expected under the trawl rationalization program. Whiting processors may also have [to] revisit any contracts that they have entered into with fishers, while vessels involved with the coop may have to revisit decisions on whether to remain in Alaska to fish Pollock or come down to fish Pacific whiting. In addition, fishing strategies, business plans, capital investments, and other aspects of the whiting fishery that are currently being implemented based on the expectation that whiting will be managed with IFQs and coop programs, would all be affected if the existing regulations were vacated.

Lockhart Decl. ¶ 14. Vacatur would also cause disruption in the management of the fishery by NMFS and, due to the "highly variable behavior" that would result if no individual quotas were in place, could result either in "closing the fishery too early, resulting in millions of dollars of lost revenue to struggling coastal communities, or too late, with potential conservation costs to the affected stocks." *Id.* ¶ 15. After balancing relevant factors, the Court therefore finds it appropriate to leave the existing regulations in place pending remand. If Defendants fail to adopt revised regulations prior to the start of the 2013 fishing season, the Court may re-visit this determination.

CONCLUSION

For the reasons set forth above, the Court now remands the regulations affected by its December 22, 2011 summary judgment ruling for further consideration consistent with that ruling, the Magnuson-Stevens Fishery Conservation and Management Act, and all other governing law. Defendants shall implement revised regulations before the 2013 Pacific whiting fishing season begins on April 1, 2013. In the interim, the existing regulations shall remain in effect. The Court shall retain jurisdiction over Defendants' actions on remand.

The Clerk shall enter judgment and close the file administratively. However, until the revised regulations have been implemented, Defendants shall file status reports with this Court every three months, beginning on April 1, 2012. The Court may schedule a hearing to consider whether interim remedies are appropriate if it becomes apparent that Defendants are not acting as expeditiously as possible and do not appear to be on track to meet the April 1, 2013 deadline ordered by this Court.

IT IS SO ORDERED.

Dated: 02/21/12

THELTON E. HENDERSON, JUDGE
UNITED STATES DISTRICT COURT

United States District Court
For the Northern District of California

EXHIBIT 3

See: Agenda Item D.1.b
Supplemental Attachment 2
April 2013

Science, Service, Stewardship

Agenda Item D.1.c
Supplemental NMFS Science Center PowerPoint
April 2013

NMFS Groundfish Science Report

April 2013

Michelle McClure

NOAA FISHERIES SERVICE

NOAA FISHERIES SERVICE

Overview

- News and updates
- Economic data report – process and schedule
- Bycatch reduction in the news
- Current research events

NOAA FISHERIES SERVICE

News and Updates

- Programmatic Review – data for Groundfish assessments
  - NMFS and non-NMFS
  - September, 2013
- 2013 Bottom Trawl Survey
  - 2nd pass will likely have only one vessel

Economic Data Collection Reports

5 Reports:

1. Administration and Operations
2. Catch Vessel
3. Mothership
4. Catcher-processor
5. First receiver and shorebased processor

Scheduling suggestion:

- Review by all advisory bodies at June meeting for final acceptance.

Science, Service, Stewardship

2012-13 Bycatch Reduction Research Projects

- **Development and testing of industry-designed rockfish excluder in the Pacific hake fishery**
  - Year 1, completed in June/July 2012 aboard *F/V Perseverance (report sent to industry March 2013)*
  - Year 2, July 2013 aboard *F/V Perseverance*
- **Codend mesh size study in bottom trawl fishery**
  - Completed in September 2012 aboard *F/V Last Straw*
- **Further testing of Pacific halibut flexible sorting grid excluders in the bottom trawl fishery**
  - Work begins May/June 2013 aboard *F/V Excalibur*
- **Investigate light stimulus to enhance Chinook salmon escapement in the Pacific hake fishery**
  - Work begins June 2013 (charter vessel RFP open for submissions through 4.26.2013)

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FISHERIES
SERVICE

Development and Testing of Industry-Designed Rockfish Excluder in the Pacific Hake Fishery

- 2012 tests:
  - High retention of hake, > 96%
  - Rockfish bycatch reduced by 70%
  - Significant problem w/ clogging under heavy fish volumes
  - Release of report to industry (March 2013)
- 2013 testing modifications to address clogging

Codend / Catch

Excluded Fishes

Excluded Rockfishes

NOAA
FISHERIES
SERVICE

Codend mesh size study in bottom trawl fishery – NWFSC, PSMFC, ODFW, Industry

- Completed in Sept 2012 aboard F/V Last Straw

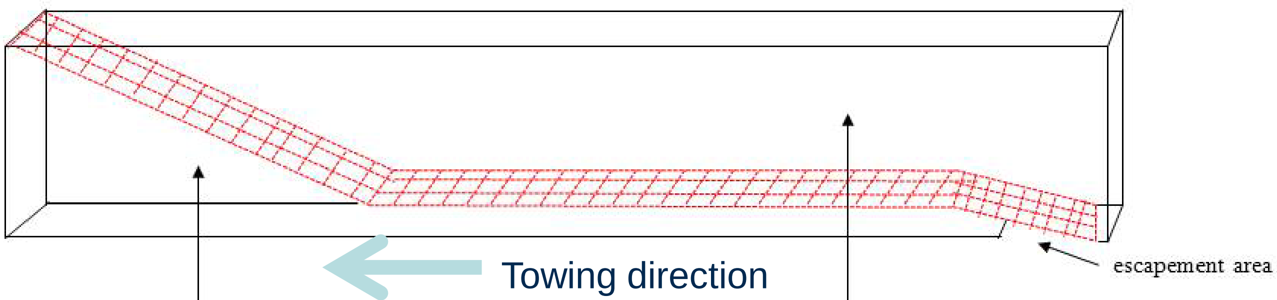
Preliminary Results

- 4.5” diamond (status quo) - least effective at reducing discards plus high percent loss of marketable-sized flatfishes
- 4.5” T90 - retained marketable-sized fishes (86%) and reduced discards, but still some issues with flatfish discards
- 5.5” T90 – effective at reducing discards, but high loss of marketable fishes
- More work needed: PSMFC is applying for funding to test 4.5 and 5.0” diamond and 4.5 and 5.0” T90 in 2014

4.5” T90 codend tested in 2012

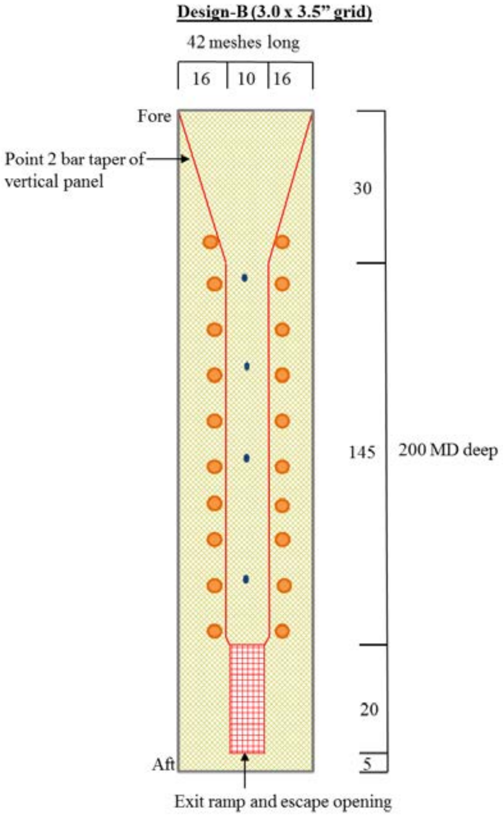
Candidate design and in situ images of Pacific halibut flexible sorting grid excluder

(Testing, May/June 2013)



Looking aft, view of the forward portion of the downward ramp

Looking forward toward the aft end of the excluder



(images courtesy of Brett Hearne)

Science, Service, Stewardship

A California Current bomb radiocarbon reference chronology and petrale sole age validation

Melissa Haltuch, Owen Hamel, Kevin Piner, Patrick McDonald, Craig R. Kastelle, and John Field

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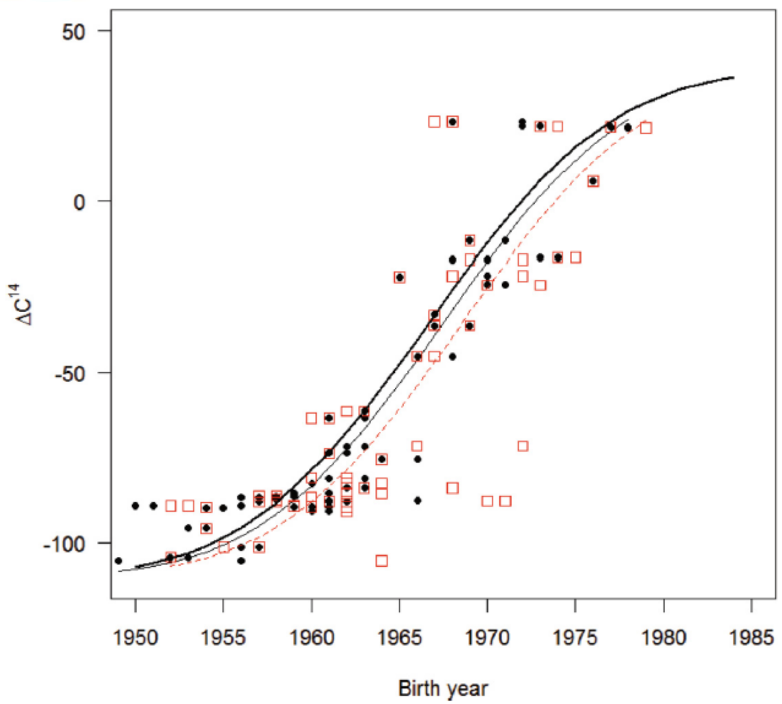
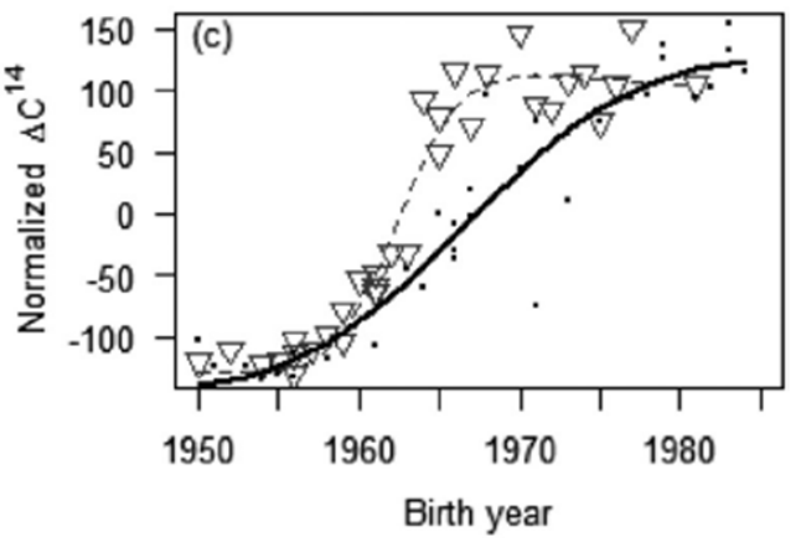


The normalized reference chronologies for straight forward comparison for Pacific halibut samples (open triangles) and model fit (dashed line) and the petrale sole samples (solid circles) and model fit (bold black line) (*c*).



The bomb radiocarbon, 14C, chronologies used to validate the assumption that there was no aging bias for petrale sole. The coupled function model fit from the reference curve (bold black line) is compared with the surface read (open squares, dashed grey line) and break and burn (solid circle, thin black line) aging methods. Data for both age readers is plotted.

Science, Service, Stewardship

Spatial ecology of krill, micronekton and top predators within the central California Current: Implications for identifying ecologically important areas

JA Santora, JC Field, ID Schroeder, KM Sakuma,
BK Wells, and WJ Sydeman

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Progress in Oceanography 106 (2012): 154–174

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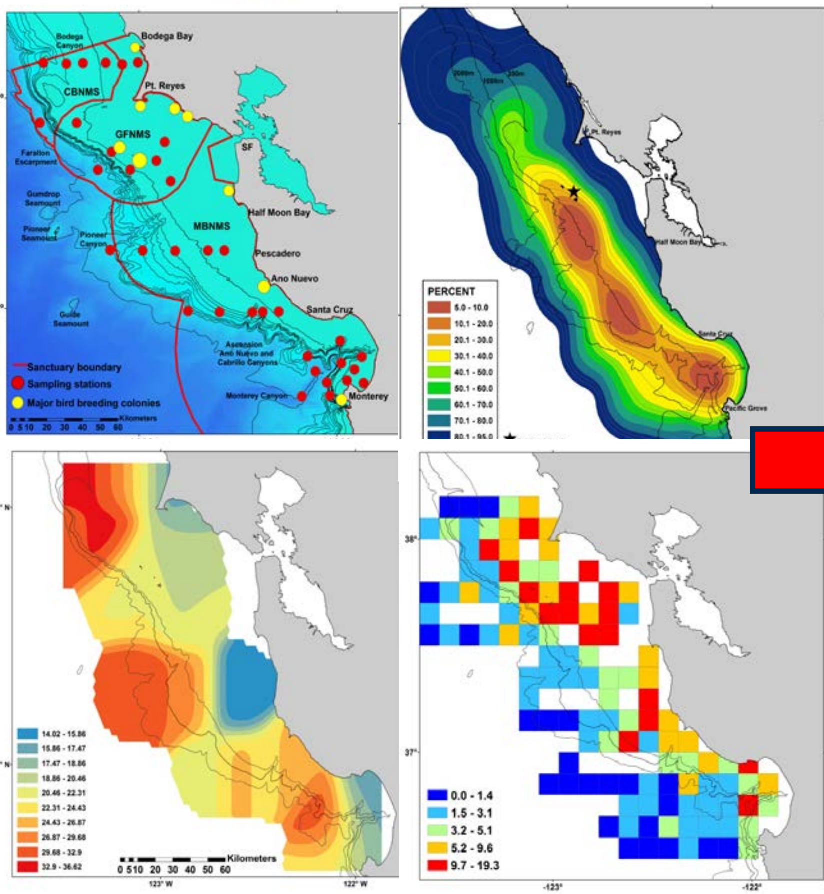

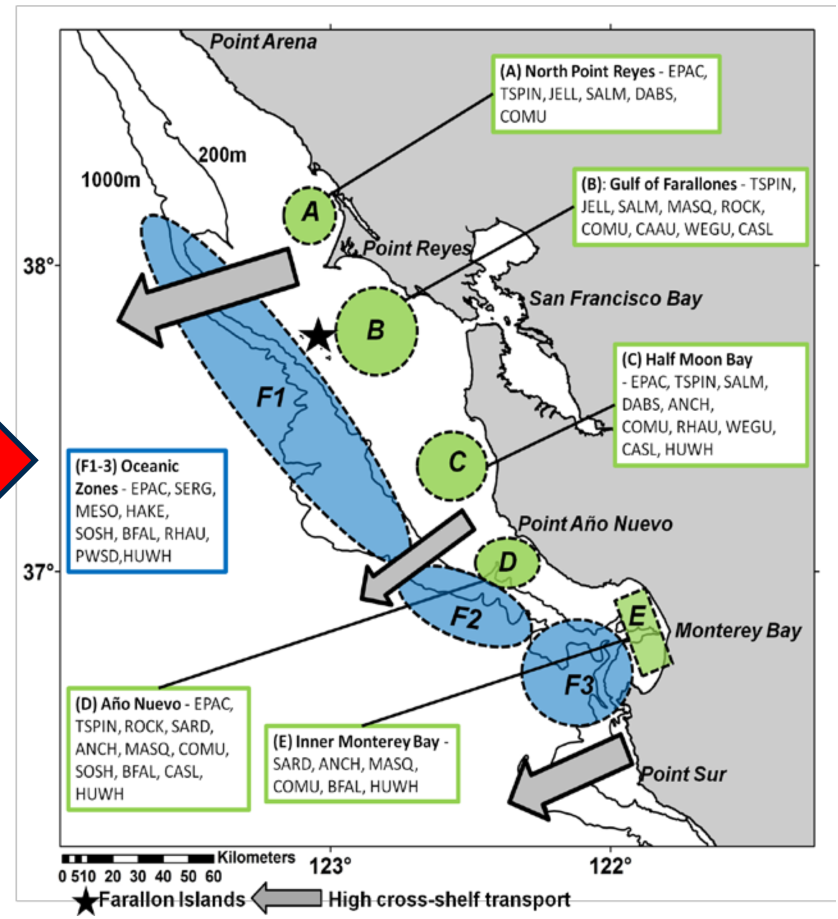

Science, Service, Stewardship

Variation in demersal fish biomass based on the U.S. west coast bottom trawl survey

A. Keller, J. Buchanan, J. Wallace, V. Simon, O. Hamel,
K. Bosley, M. Bradburn, I. Stewart, D. Kamikawa, J. Harms,
M. Head, V. Tuttle, and D. Draper

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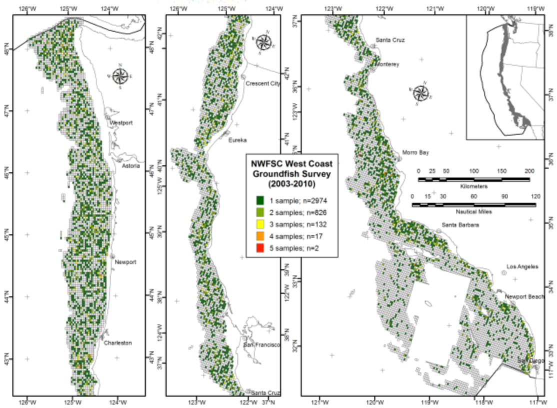
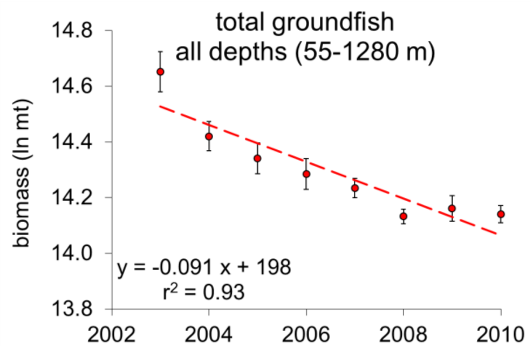
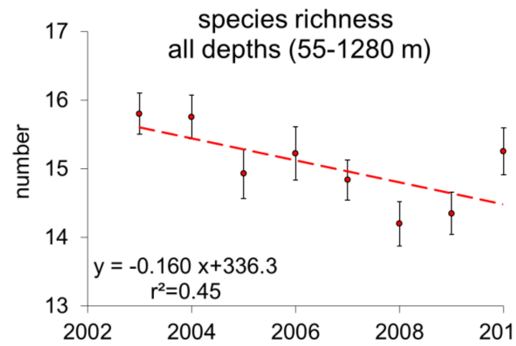
NWFSC West Coast Bottom Trawl Survey

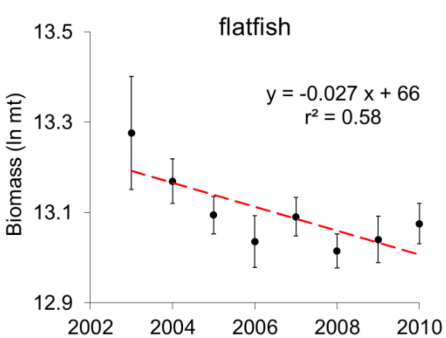
1) Total coast-wide demersal fish biomass and species richness declined from 2003 to 2010

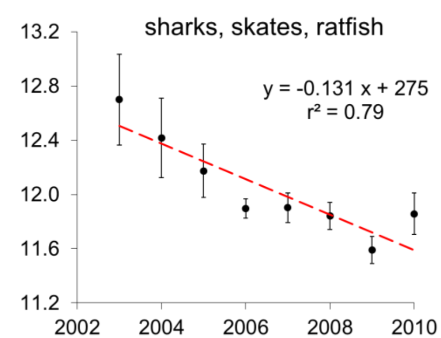


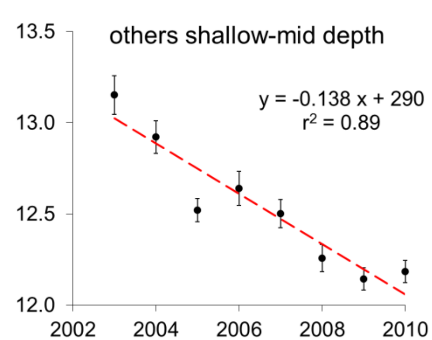


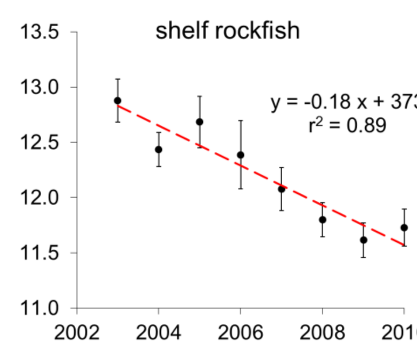


2) Decreases occurred for flatfish, sharks, shallow to mid-depth species, and shelf rockfish but not for slope rockfish, thornyheads, or deep-water species (>650 m)









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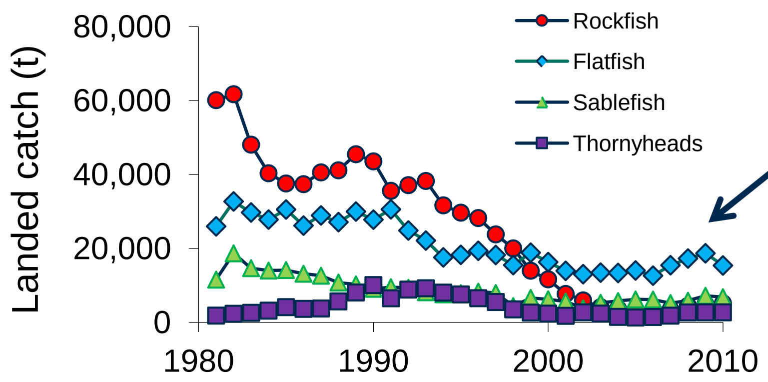
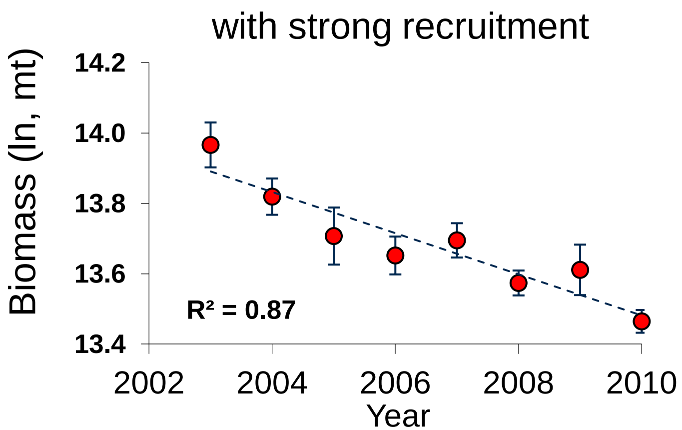
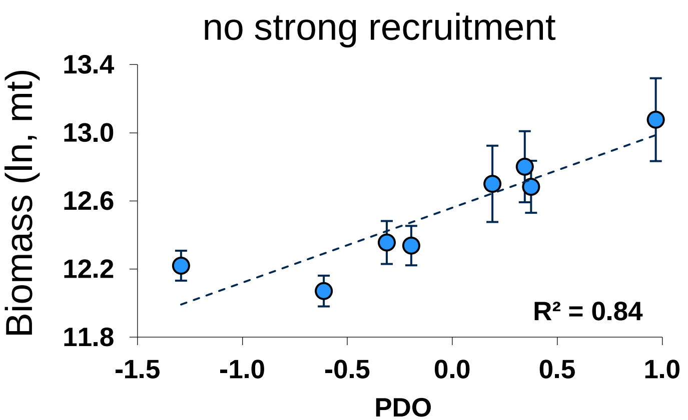


Observed decreases occurred during a period of reduced groundfish catch





- For 13 species with a strong 1999 year class, decreases were more closely tied to depletion of an exceptional year class following this strong recruitment event

- For 11 species without strong 1999 year class decreases were more closely tied to environmental factors as measured by the Pacific Decadal Oscillation (PDO)

Special Issue of *Fisheries Research*
Using Stock Synthesis (SS)

- Improving SS documentation
- Provides techniques for limited data situations (i.e. catch data only)
- Enables the inclusion of pre-recruit survival (dogfish relevant)
- Develops a technique allowing differential removal of individuals based on growth rate

Agenda Item D.2
Situation Summary
April 2013

STATUS OF THE RATIONALIZED TRAWL FISHERY

The trawl rationalization (catch shares) program was implemented in January 2011. It has now been in place for over two years. Each year, the mothership and catcher-processor co-ops are required to submit annual reports to NMFS and the Council. These reports are provided under this agenda item (Agenda Item D.2.b, Attachment 1 and Agenda Item D.2.b, Attachment 2), and a verbal report will be provided to the Council on the mothership sector co-op under Agenda Item D.2.b. For the shoreside fishery, National Marine Fisheries Service will provide a fishery data report (Agenda Item D.2.c, NMFS Report) and a compliance report from the Office of Law Enforcement (Agenda Item D.2.c, NMFS Office of Law Enforcement Report) with information on performance over the first two years of the program.

Also received and presented as public comment under this agenda item is the Fort Bragg – Central Coast Risk Pool Annual Summary Report 2012 (Agenda Item D.2.d, Public Comment).

Council Action:

Discussion.

Reference Materials:

1. Agenda Item D.2.b, Attachment 1: Whiting Mothership Cooperative: An Amendment 20 Mothership Catcher Vessel Cooperative Report on the 2012 Pacific Whiting Fishery.
2. Agenda Item D.2.b, Attachment 2: Pacific Whiting Conservation Cooperative Amendment 20 Catcher/Processer Cooperative Final Annual Report 2012.
3. Agenda Item D.2.c, Supplemental NMFS Report: Annual Catch Report for the West Coast Groundfish, Shorebased IFQ Program in 2012.
4. Agenda Item D.2.c, NMFS Office of Law Enforcement Report: TRAT Compliance Summary, 2012.
5. Agenda Item D.2.d, Public Comment: Fort Bragg – Central Coast Risk Pool Annual Summary Report 2012.

Agenda Order:

a. Agenda Item Overview — Jim Seger
b. Annual Report for the At-Sea Co-op — Brent Paine
c. Reports and Comments of Advisory Bodies and Management Entities
d. Public Comment
e. Council Discussion

PFMC
03/25/13

http://www.pcouncil.org/groundfish/fishery-management-plan/trailing-actions/

Fishery Management Plan and Amendments: Trawl Rationalization (Amendment 20) and Intersector Allocation (Amendment 21) Trailing Actions

At its September 2010 meeting, the Council began a series of trailing actions for the trawl rationalization program and intersector allocation which have continued up through the present. These trailing actions address issues of concern which were outstanding as of the completion of the Council's initial work on the program (e.g. rules for the distribution of the quota set aside for the Adaptive Management Program and safe harbors from control rules for risk pools). The actions also address provisions needed to complete or clarify the final program and new concerns identified during and after program implementation.

Work on a number of trailing actions is in progress or has already been completed. A summary of the status of these actions is provided below. (Note: other actions affecting or modifying the trawl rationalization program and intersector allocation may be taken up as part of the groundfish biennial specifications.)

Final Council Action Taken, NMFS Approval and Implementation Pending

Whiting Catch Share Reallocation. At its March, 2012 meeting, the Council considered matters associated with the December 22, 2011 District Court Judge Thelton E. Henderson decision in the case C10-4829-TEH: Pacific Dawn, LLC, et al. v. John Bryson, et al., including the February 21, 2012 Court Order on Remedy (see full March Council meeting reference materials, including public comment at http://www.pcouncil.org/resources/archives/briefing-books/march-2012-briefing-book/#groundfish). This order remanded "for further consideration" the regulations addressing the initial allocation of whiting for the shoreside IFQ and the at-sea mothership fishery. In response, the Council adopted a three-meeting process to meet the court-ordered deadline. Under that process, in April the Council adopted alternatives for analysis, in June it reviewed analysis but decided not to designate a preliminary preferred alternative, and in September 2012 it selected status quo allocations as part of the final preferred alternative and recommended that:

- the moratorium on QS transferability originally set to expire for all species at the end of 2012 be continued, as necessary, throughout the end of 2013 for all QS of all species, and
- the provisions to allow mothership catcher vessel endorsements and allocations to be separated from the permits, originally scheduled to go into place at the start of 2013, be delayed until September 1, 2013.

On August 1, 2012, a temporary rule implementing these adjustments was published in the Federal Register (see http://www.pcouncil.org/wp-content/uploads/2012-18780.pdf). The temporary rule will expire on January 28, 2013, but will be extended or changed in regulation, as needed to implement these recommendations.

The Council transmitted its final recommendations relative to a possible reallocation of whiting quota shares and catch history assignments on October 30, 2012:

- Transmittal Letter, October 30, 2012
- Statement of Council Rationale
- Preliminary Draft Environmental Assessment
- Council Proposed Regulations

On January 2, 2013 NMFS published a proposed rule on whiting reallocation. Final action is expected by April 1st.

Cost Recovery. At its September 2011 meeting, the Council adopted a cost recovery program structure. Download the complete description of the Council's recommendations on Cost Recovery. National Marine Fisheries Service (NMFS) published a proposed rule on cost recovery on February 1, 2013. The comment period on the rule is open through March 18. Implementation is expected mid-year in 2013. Details regarding how costs are determined and how the fee is calculated will be included as part of this rule. Based on the Council recommendations, the NMFS-proposed cost recovery rates are expected to be no more than 3% of exvessel value of the individual quota fishery (IFQ) species delivered for the shoreside IFQ program, 2% of the value of the whiting delivered for the mothership sector, and 1% of the value of the whiting harvested for the catcher-processor sector. The Council's Cost Recovery Committee has been tasked with identifying efficiencies which might reduce costs and fees over the long run, and will be meeting to address this issue.

Chafing Gear. At its April 2012 meeting, the Council recommended an alternative that would address industry concerns about the current restrictiveness of the chafing gear regulations for the midwater trawl fishery. The Council reconsidered this issue at its November 2012 meeting, but stayed with the final preferred alternative that it recommended in April 2012. Implementation of its final recommendation is expected in 2013.

NMFS Proposed Trailing Actions. At its April 2012 meeting, the following NMFS-proposed trailing actions were approved for implementation. Implementation is expected for the 2013 fishery. NMFS is continuing to work on implementation rules for these actions.

- Implementation of certification and decertification requirements for observer providers
- Numerous revisions to details of the observer program provisions
- Revision to briefing periods in catch monitor certification requirements
- Changes to first receiver site license application requirement and reduction of site inspection requirements
- Removal of the end-of-year ban on quota pound (QP) transfers between vessel accounts
- Clarification that mothership/catcher vessels with more than one catch history allocation may commit each to a different mothership
- Change of the term "permit holder" to "vessel owner," as necessary, to clarify the regulations
- Clarification of the process for vessel owners to request a change in vessel ownership through the Fisheries Permit Office

Top

Final Council Action Taken, NMFS Approval and Implementation Delayed

At its September 2011, April 2012, and November 2012 meetings, the Council adopted final recommendations on a number of trailing actions, but implementation may be delayed due to Council and NMFS staff workload related to the reconsideration of the allocations periods for whiting catch shares.

Quota Share/Quota Pound (QS/QP) Control Rules – Safe Harbors for Risk Pools. At its September 2011 meeting, the Council voted to provide risk pools a safe harbor from the QS control rules.

Allow Fixed Gear and Trawl Permit Stacking. At its April 2012 meeting, the Council recommended allowing a fixed gear permit and a trawl permit to be registered to the same vessel at the same time.

Change the Opt-out Requirement for QP Deficits. At its April 2012 meeting, the Council recommended changing the opt-out requirement for QP deficits lasting more than 30 days, in order to allow vessels to rejoin the fishery after deficits are cleared.

Eliminate Double Filing of Whiting Co-op Reports. At its April 2012 meeting, the Council recommended eliminating the required annual filing of a preliminary co-op report in November, leaving in place the requirement that a final report be submitted in March of the following year. This requirement applies to the whiting mothership and catcher-processor sectors.

Quota Share/Quota Pound (QS/QP) Control Rules – Safe Harbors for Lenders. At its April 2012 meeting, the Council selected a preliminary preferred alternative that would provide lenders with a safe harbor from the QS control rules. At its November 2013 meeting, the Council finalized its preliminary recommendations, with a few adjustments.

Move the Whiting Season Opening Date. At its March 2012 meeting, the Council selected as its preliminary preferred alternative moving the shoreside sector primary whiting season opening date to May 15, starting in 2013. At its November 2012 meeting, the Council finalized its preliminary recommendation.

Top

Council Deliberations In Progress

Electronic Monitoring. Identification of cost efficiencies for the trawl rationalization program continues to be an important Council priority. In this regard, observer costs and the opportunity for gaining efficiencies through the use of at-sea electronic monitoring has been an area of emphasis. Moving from 100 percent observer coverage would have a variety of implications for other provisions of the trawl rationalization program. The Council received a number of presentations on this issue at its April 2012 meeting, including one on an electronic monitoring field study being conducted by Pacific States Marine Fisheries Commission (PSMFC). At its November 2012 meeting, the Council decided to hold a workshop on electronic monitoring. This workshop was held February 25-27, 2013, in Portland, Oregon. See the Electronic Monitoring webpage for further information. A report from the workshop is scheduled for the April 2013 Council meeting. At that time, the Council will decide how to proceed on this issue, pending the identification of needed funding.

Top

Council Deliberations Delayed

Action on the following have been delayed due to Council and NMFS staff workload. Next action on all of these issues has been delayed until the September 2013 Council meeting, at which time there will be a general scoping and prioritization session for trawl trailing actions.

Regulation Review and Gear Issues. The Council is considering whether certain restrictions in the trawl fishery can be alleviated now that the trawl rationalization program provides for individual accountability for catch. A gear workshop was convened in Portland, Oregon on August 29-30, 2012 to evaluate gear and area of catch regulations which may no longer be needed. A report on that workshop was provided at the November 2013 Council meeting. Further action on gear issues other than chafing gear will be delayed while other priorities are addressed (until at least September 2013).

Lender Issues other than Safe Harbors. The Council has not selected a preliminary preferred alternative for other lender issues. The topics under this category have been narrowed to the question of whether the NMFS QS tracking system should include a capability that would allow the QS owner and lender to attach lender information to the QS account. In

March 2012, the Groundfish Advisory Subpanel recommended no action on this issue.

Reconsideration of the Widow QS Allocation. At its April 2012 meeting, the Council decided to consider reallocation of the widow rockfish QS, now that widow rockfish is rebuilt. At its June 2012 meeting, the Council decided that for widow rockfish QS, the moratorium on QS trading should be continued until December 31, 2014, or until the widow rockfish reallocation process is complete, whichever comes first. Thus, when QS trading starts for all other species, the QS trading moratorium may continue to remain in place for widow rockfish QS. Further action on this issue has been delayed to address other Council priorities.

Whiting Surplus QP Carryover Provision. A workshop was held on November 2 to explore possibilities for fully implementing whiting surplus carryover in 2013 and a report was presented to the Council at its November meeting. The Council decided that it will review this issue again when during the 5 year program review, scheduled for 2016.

Non-Whiting Surplus QP Carryover Provision. As part of its action on the 2013-2014 specifications, the Council adopted an interim solution to partially address full implementation of the carryover provision for nonwhiting species. The Council requested further analysis and development of options to ensure that, in the long term, the surplus carryover program can be implemented with greater certainty.

Top

Issues Prioritized for 2014 and Beyond

Research and policy development work on some of the following issues may occur in 2012, however, regulatory changes are not likely to be in place prior to 2014, at the earliest.

- Implement criteria for allocation of Adaptive Management Program (AMP) QP (for possible 2015 implementation)
- Exempt vessels from observer coverage when they are testing trawl gear
- Add a vessel monitoring system declaration code for “transiting” with gear stowed (for possible 2014 implementation)
- Consider revisions to weight conversion factors based on new information (for possible 2014 implementation)
- Take actions to facilitate continuation of surplus QP carryover provision
- Provide credit for discards of sablefish and lingcod

Top

Trailing Actions Implemented

The following trailing actions were implemented subsequent to the January 11, 2011 start of the trawl rationalization program.

TRAILING ACTIONS IMPLEMENTED JANUARY 1, 2012

The following were implemented as part of the first Program Improvements and Enhancement Rule (published in the *Federal Register*, December 1, 2011). This rule included Amendment 21-1, a modification of the intersector allocation amendment and regulatory amendments pertaining to the trawl rationalization program.

Amendment 21-1

- clarified that the Amendment 21 allocation percentages supersede the limited entry/open access allocations for certain groundfish species, and
- revised the amount of bycatch QP that will be issued for the shoreside trawl fishery to cover Pacific halibut mortality, to better match the objective specified in Amendment 21.

Trawl Rationalization Regulatory Amendments. The regulatory amendments pertaining to the Amendment 20 trawl rationalization program included, but were not limited to:

- severability of the mothership/catcher vessel endorsement and associated whiting catch history assignments from the limited entry trawl permit,
- continuation of the AMP QP pass-through, through 2014 of the Shorebased IFQ Program or until an AMP process is established, whichever is earlier,
- an exemption from the prohibition on processing at sea for qualified participants in the Shorebased IFQ Program,
- revisions to the observer coverage requirement while a vessel is in port and before the offload is complete,
- revisions to the electronic fish ticket reporting requirements,
- revisions to the first receiver site license requirement,
- further clarification on moving between limited entry and open access fisheries, and
- a process for end-of-the-year vessel account reconciliation.

These and other included recommendations were adopted by the Council at its June 2011 meeting; the minutes and briefing materials for that meeting include numerous reference documents detailing the issues before the Council and the Council final action on each. The final environmental assessment was published October 2011.

TRAILING ACTIONS IMPLEMENTED SEPTEMBER 7, 2012

- Change of renewal dates from September 1st to September 15th

Top

Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101

Whiting Mothership Cooperative

An Amendment 20 Mothership Catcher Vessel Cooperative

Report on the 2012 Pacific Whiting Fishery

Prepared by: dave fraser, WMC Coop Manager

Submitted to the NMFS: February 2013

WMC Report on the 2012 Year Pacific Whiting Fishery

Introduction

In March of 2011, the owners of the thirty seven trawl limited entry catcher vessel permits (MS/CV LEPs) endorsed for operation in the Mothership sector of the Pacific whiting fishery formed a fishing cooperative to coordinate harvesting efforts. This cooperative is the Whiting Mothership Cooperative (WMC). The owners of all of the MS/CV LEPs remain members in good standing of the WMC for the 2012 fishing year.

The WMC receives an allocation of whiting based on the cumulative catch histories of the members of the cooperative. The WMC operates under the WMC Membership Agreement contract which allocates whiting to members proportionate to the contribution to the cooperative's allocation made by NMFS on the basis of the whiting catch history assigned to the Cooperative by the members.

One of the primary purposes of the WMC cooperative is the management of bycatch of the four allocated overfished rockfish species and Chinook salmon. To that end the members of the WMC have all signed a WMC Bycatch Agreement that sets out the rules for modification of fishing behaviour with which members are obligated to comply.

Purpose of Report

This report is intended to disclose all information required or identified in Federal Regulations at 50 CFR 660.113(d)(3). The catch data in this report is for the 2012 fishing year beginning May 15th and ending December 31st. The catch data was provided by Sea State,, Inc. and was obtained from the NMFS – At-Sea Hake Observer Program.

Reporting Requirements

The required Annual Report elements (A-E) are found in the 50 CFR 660.113(d)(3)

> *(3) Annual coop report — (i) The designated coop manager for the mothership coop must submit an annual report to the Pacific Fishery Management Council for their November meeting each year. The annual coop report will contain information about the current year's fishery, including:*

(A) The mothership sector's annual allocation of Pacific whiting and the permitted mothership coop allocation;
(B) The mothership coop's actual retained and discarded catch of Pacific whiting, salmon, Pacific halibut, rockfish, groundfish, and other species on a vessel-by-vessel basis;
(C) A description of the method used by the mothership coop to monitor performance of coop vessels that participated in the fishery;
(D) A description of any actions taken by the mothership coop in response to any vessels that exceed their allowed catch and bycatch; and
(E) Plans for the next year's mothership coop fishery, including the companies participating in the cooperative, the harvest agreement, and catch monitoring and reporting requirements.

(A) Annual allocation of Pacific whiting to the WMC coop

The Mothership sector of the Pacific Whiting fishery was initially allocated 32,515 tons of whiting, followed by a re-apportionment in October of 6,720 tons. 100% of the Mothership sector whiting was allocated to the Whiting Mothership Cooperative.

(B) The Mothership coop's actual retained and discarded catch of Pacific whiting, salmon, Pacific halibut, rockfish, groundfish, and other species on a vessel-by-vessel basis

All thirty seven of the MS/CV endorsed trawl limited entry permit holders joined the Whiting Mothership Cooperative (WMC).

As of December 31st, 2012, seventeen MS/CVs fished in the MS sector of the whiting fishery..

Data on the catch, as of December 31st 2012, of Whiting, Salmon, Halibut, Rockfish, Groundfish and Other Species, is shown in the tables attached tables #1 & 2(a-f) (Attachment 1). The table #1 shows the aggregate fleet catch, with a breakdown of each species category. The following tables #2(a-f) show the vessel by vessel catch for each species category. In interpreting the tables a cell with “0.00 mt” indicates at least a trace amount of this species was caught; a blank cell indicates no amount of that species was caught.

(C) A description of the method used by the mothership coop to monitor performance of coop vessels that participated in the fishery

The WMC retained Sea State, Inc. Inc. as the Monitoring Agent for the coop. All WMC members provide NMFS and the VMS providers with the needed confidentiality waivers to allow Sea State, Inc. to access both Observer data and VMS data in real time.

The WMC provided Sea State, Inc. with a harvest schedule of each MS/CVs share of whiting and pro-rata portion of the allocated bycatch species. Sea State, Inc. queries the NORPAC observer database to obtain the Mothership observer reports on a daily basis. Sea State, Inc. uses this data to produce daily reports which are distributed by email to all WMC members, the Coop manager, and to the Mothership processors.

The Sea State, Inc. report shows several tables of information, including:

- the daily catch and bycatch amounts for the fleet as a whole for most recent 10 days
- the overall YTD rates and percent of whiting quota and bycatch harvested for the fleet in aggregate
- the YTD bycatch rates for each Mothership's fleet
- the YTD bycatch rates and amounts for each vessel
- the percent and amounts of whiting quota and bycatch allocations harvested by each seasonal pool
- the balance of whiting available in each seasonal pool by vessel

As MS/CV observers are debriefed, their data is incorporated into NORPAC and Sea State, Inc. updates its accounting accordingly. On the basis of the Sea State, Inc. data, the Coop manger audits vessel harvest amounts relative to the individual members' share of the quota and transfers between members to see that the coop's allocations are not exceeded.

A copy of the final daily report of the season is included as Attachment 2.

(D) A description of any actions taken by the mothership coop in response to any vessels that exceed their allowed catch and bycatch

To date, no vessels have exceeded their allowed catch amounts under the Coop Agreement. The coop makes vessel specific whiting allocations, however, the bycatch allocations are managed as a common pool resource. This is not to say that vessels are not subject to individual accountability for bycatch performance.

One vessel exceeded its pro-rata share of the bycatch of widow rockfish allocated to its seasonal pool. Under the terms of the coop agreements, the vessel was not allowed to transfer the balance of its whiting from that pool into a subsequent pool.

The Coop agreement includes a variety of measures that serve to mitigate against the possibility of exceeding allowed catch and bycatch limits. These include:

- Precautionary closures of past bycatch hotspots.
- Night fishing restrictions
- Fleet relocation triggers and fleet to fleet reporting
- In season "hot spot" closure authority
- Seasonal apportionments ("pools") of whiting and bycatch allowances
- Sanctions against vessels that have exceeded a bycatch rate within a seasonal pool.

Precautionary Closures of Past Bycatch Hotspots

Prior to the beginning of the 2011 whiting fishery, the WMC created a "Bycatch Committee" which met several times to develop proposed closures that would apply seasonally. The committee reviewed GIS analysis of 10 years of at-sea observer data overlaid on fine scale bathymetry. The analysis included bycatch rates and amounts as well as amounts of whiting. VMS tracklines of high bycatch tows were also incorporated in the review. Additionally, the committee reviewed logbook information from individual captains' historic directed rockfish experience, which provided insight into habitat associations for rockfish species.

The committee ended up recommending closure of 9 areas, totaling nearly 2000 km^2 which were adopted by the WMC board. The board also identified several other "cautionary" areas.

The bycatch committee met again prior to the 2012 fishing season and recommended retaining the 2011 bycatch avoidance measures. The recommendations were adopted by the board. The bycatch committee met during the season to review whether to modify or maintain the closures. One additional cautionary area was adopted by the board subsequent to the opening of the 2012 season.

Night Fishing

Based on the recommendations of the bycatch committee the board adopted a restriction on night fishing between 10:00 PM and 5:30 AM prior to September 1st. The board modified the night fishing restriction for the fall, restricting night fishing inside 100 fathoms between 7:00 PM and 7:00 AM.

Fleet Relocation and Real Time Fleet to Fleet Reporting

The Coop established Base Rates which were based on the pro-rata amounts of bycatch allocations relative to whiting allocations to the MS sector. Each Mothership processor maintains a spreadsheet reporting its fleet performance, measured against the Base Rates. The spreadsheet reports are shared each day between all the processing ships.

Each fleet's performance relative to the Base Rates constitutes a trigger requiring the fleet to relocate if they encounter a bycatch "hotspot". Relocation is required in the event of any of the following situations:

- If a fleet's three day rolling average rate of exceeds the Base Rate for any bycatch species, and that Fleet's cumulative year to date bycatch rate exceeds half of the Base Rate for that species,

- If a fleet's three day rolling average rate of exceeds 125% of the Base Rate for a bycatch species

- If a fleet's bycatch rate during any single day exceeds twice the Base Rate for a bycatch species,

This real time mechanism for response to bycatch encounters coupled with a requirement for test tows upon entering a new area, has served to avoid using up bycatch allocations.

In-season Hot Spot Closures

The WMC board delegated authority to Sea State, Inc. to impose In-season Hot Spot closures if they perceive a problem. However, the 'relocation' triggers described above have pre-empted the need to use this authority during the 2012 season.

Seasonal Pools

The Coop agreement provides for dividing the whiting allocation into as many as 4 pools with various start dates. During the 2012 season the whiting was divided into 3 pools. Each pool received a share of the bycatch allocations pro-rata to whiting. The Coop Agreement provides that if a pool reaches its share of the bycatch prior to harvesting its whiting allocation, the members of the pool must cease fishing.

Sanctions Against Member Vessels

In the event that a pool closes because of bycatch, members of that pool whose cumulative bycatch rate exceeded their pro-rata share by 25%, that vessel is restricted from harvesting additional whiting in a subsequent seasonal pool.

During the 2012 season one pool was closed due to bycatch. There have not been any violations of the WMC Bycatch Agreement.

(E) Plans for the next year's mothership coop fishery, including the companies participating in the cooperative, the harvest agreement, and catch monitoring and reporting requirements

The WMC provides that membership in the Coop continues in the following year unless a member provides notice of intent to withdraw before November 1st. No members filed notice of intent to withdraw. The only changes in membership between 2011 and 2012 were the result of changes of ownership of two permits. Therefore the member permits will continue as in 2012, as shown in Exhibit A of the WMC Membership Agreement (Attachment 3) filed with the MS cooperative permit application NMFS for the 2012 season.

There have been no changes to the 2012 harvest agreement, catch monitoring, or reporting requirements. The board will review the Membership Agreement and consider modifications prior to the Coop Permit Renewal deadline in 2013.

Attachment 1

Table 1 (part 1)

SpeciesName	Code	WMC FLEET TOTALS			
ROUNDFISH	Code	Retained mt	Discard mt	Total	# of Vessels
PACIFIC HAKE	206	38,338.450	140.030	38,478.480	16
PACIFIC COD	202	0.000	0.006	0.000	2
SABLEFISH (BLACK COD)	203	0.267	0.655	0.900	9
LINGCOD	603	0.096	0.069	0.170	9
FLATFISH	Code				
FLATFISH - UNIDENT.	100	0.004	0.000	0.000	1
REX SOLE	105	0.138	0.159	0.300	6
DOVER SOLE	107	0.010	0.015	0.030	3
SLENDER SOLE	111	0.016	0.000	0.020	1
ARROWTOOTH FLOUNDER (TURBOT)	141	1.181	0.927	2.110	16
ROCKFISH	Code				
PACIFIC OCEAN PERCH	301	1.020	0.335	1.360	14
WIDOW ROCKFISH	305	11.172	26.061	37.240	16
DARK BLOTCHED ROCKFISH	311	0.555	0.698	1.250	16
CANARY ROCKFISH	314	0.015	0.133	0.160	11
BOCACCIO	302	0.012	0.031	0.040	4
SHARPCHIN ROCKFISH	304	0.001	0.000	0.000	1
ROUGHEYE ROCKFISH	307	10.341	1.311	11.660	14
RED BANDED ROCKFISH	308	0.000	0.005	0.000	1
SILVERGRAY ROCKFISH	310	0.071	0.054	0.120	11
SPLITNOSE ROCKFISH	315	7.853	2.835	10.680	14
SHORTBELLY ROCKFISH	318	0.096	0.172	0.270	11
BLACKGILL ROCKFISH	319	0.003	0.000	0.000	1
YELLOWMOUTH ROCKFISH	320	0.042	0.000	0.040	3
YELLOWTAIL ROCKFISH	321	4.967	6.418	11.400	15
REDSTRIPE ROCKFISH	324	0.009	0.020	0.020	7
CHILIPEPPER ROCKFISH	325	0.003	0.004	0.000	3
SHORTRAKER ROCKFISH	326	0.012	0.000	0.010	1
AURORA ROCKFISH	334	0.000	0.007	0.010	1
BANK ROCKFISH	337	0.007	0.000	0.010	1
SHORTSPINE THORNYHEAD (IDIOT)	350	0.157	0.351	0.520	8
REMAINING GROUNDFISH SPECIES	Code				
SQUID - UNIDENT.	50	11.448	16.061	27.510	16
OCTOPUS - UNIDENT.	60	0.004	0.002	0.000	2
PACIFIC SLEEPER SHARK	62	0.000	0.099	0.100	3
SOUPFIN SHARK	64	0.000	0.072	0.070	2
SPINY DOGFISH SHARK	66	6.832	22.772	29.600	16
SALMON SHARK	67	0.000	1.267	1.270	3
BROWN CAT SHARK	68	0.448	4.449	4.900	13
BLUE SHARK	69	0.000	0.105	0.100	1
LAMPREY - UNIDENT.	75	0.023	0.009	0.030	9
RATTAIL (GRENADIER) -UNIDENT.	80	0.000	0.010	0.000	4
PACIFIC ELECTRIC RAY	93	0.000	0.034	0.040	2
BIG SKATE	94	0.000	0.007	0.010	1
LONGNOSE SKATE	95	0.000	0.032	0.040	2

Table 1 (part 2)

SpeciesName	Code		WMC FLEET TOTALS			
PROHIBITED SPECIES - Salmon	Code		Retained #s	Discard #s	Total	# of Vessels
CHUM SALMON (DOG)	221		0	2	2	1
KING SALMON (CHINOOK)	222		0	2,295	2,295	14
SILVER SALMON (COHO)	223		0	4	4	2
PROHIBITED SPECIES - - other	Code		Retained mt	Discard mt	Total	# of Vessels
PACIFIC HALIBUT	101		0.000	0.100	0.100	6
NON-GROUNDFISH SPECIES	Code					
JELLYFISH - UNIDENT.	35		0.006	0.523	0.520	14
ASCIDIAN, SEA SQUIRT, TUNICATE	43		0.000	0.012	0.010	3
CHUB MACKEREL (PACIFIC)	199		0.048	0.632	0.680	6
JACK MACKEREL	207		0.746	8.836	9.580	13
RAGFISH	280		0.296	0.418	0.740	7
OPAH	297		0.000	0.018	0.020	1
HUMBOLDT SQUID	511		0.000	0.013	0.010	2
RIBBONFISH - UNIDENT.	563		0.018	0.041	0.060	3
AMERICAN SHAD	606		0.182	0.503	0.680	15
KING-OF-THE-SALMON	608		0.339	0.372	0.710	11
PACIFIC SARDINE	614		0.008	0.009	0.010	4
LANTERNFISH - UNIDENT.	700		0.000	0.003	0.000	2
DUCKBILL BARRACUDINA	769		0.011	0.050	0.050	8
BARRACUDINA - UNIDENT.	770		0.000	0.002	0.000	1
PACIFIC POMFRET	775		0.000	0.009	0.010	2
MEDUSAFISH	776		0.000	0.012	0.000	4
TUBESHOULDER - UNIDENT	807		0.000	0.002	0.000	1
OCEAN SUNFISH	810		0.021	0.073	0.110	7
NORTHERN FULMAR	854		0.000	0.002	0.000	1
FISH WASTE (HEADS, DECOMP,ETC)	899		0.002	0.000	0.000	1
MISC - UNIDENT.	900		0.000	0.026	0.010	8
INVERTEBRATE - UNIDENT.	902		0.000	0.029	0.020	5

Table 2a (part 1)

SpeciesName	ARCTIC FURY		BAY ISLANDER		BLUE FOX	
ROUNDFISH	Retained mt	Discard mt	Retained mt	Discard mt	Retained mt	Discard mt
PACIFIC HAKE	3128.448	0.000	2017.841	0.000	772.690	0.000
PACIFIC COD	0.000	0.003				
SABLEFISH (BLACK COD)	0.045	0.077				
LINGCOD	0.000	0.008	0.004	0.000		
FLATFISH						
FLATFISH - UNIDENT.						
REX SOLE	0.000	0.071				
DOVER SOLE	0.000	0.008				
SLENDER SOLE						
(TURBOT)	0.000	0.241	0.148	0.000	0.008	0.000
ROCKFISH						
PACIFIC OCEAN PERCH	0.007	0.127	0.028	0.000	0.000	0.021
WIDOW ROCKFISH	0.463	0.906	0.391	0.000	0.260	15.184
DARK BLOTCHED ROCKFISH	0.002	0.158	0.200	0.000	0.000	0.011
CANARY ROCKFISH	0.004	0.015			0.000	0.003
BOCACCIO						
SHARPCHIN ROCKFISH						
ROUGHEYE ROCKFISH	0.634	0.333	1.843	0.000	0.000	0.056
RED BANDED ROCKFISH						
SILVERGRAY ROCKFISH	0.000	0.003	0.021	0.000		
SPLITNOSE ROCKFISH	0.000	1.736	0.015	0.000	0.000	0.111
SHORTBELLY ROCKFISH	0.000	0.054	0.029	0.000		
BLACKGILL ROCKFISH						
YELLOWMOUTH ROCKFISH						
YELLOWTAIL ROCKFISH	0.290	0.769	0.580	0.000	0.000	0.066
REDSTRIPE ROCKFISH					0.000	0.001
CHILIPEPPER ROCKFISH						
SHORTRAKER ROCKFISH			0.012	0.000		
AURORA ROCKFISH						
BANK ROCKFISH						
SHORTSPINE THORNYHEAD (IDIOT)	0.035	0.101				
REMAINING GROUNDFISH SPECIES						
SQUID - UNIDENT.	0.158	2.790	0.432	0.443	0.362	0.000
OCTOPUS - UNIDENT.					0.000	0.002
PACIFIC SLEEPER SHARK	0.000	0.014				
SOUPFIN SHARK	0.000	3.553				
SPINY DOGFISH SHARK			0.025	1.340	0.000	1.103
SALMON SHARK			0.000	0.127		
BROWN CAT SHARK	0.000	1.542	0.000	0.006	0.000	0.003
BLUE SHARK						
LAMPREY - UNIDENT.	0.000	0.001				
RATTAIL (GRENADIER) -UNIDENT.					0.000	0.005
PACIFIC ELECTRIC RAY					0.000	0.007
BIG SKATE						
LONGNOSE SKATE	0.000	0.015				

Table 2a (part 2)

SpeciesName		ARCTIC FURY			BAY ISLANDER			BLUE FOX	
PROHIBITED SPECIES - Salmon		Retained #s	Discard #s		Retained #s	Discard #s		Retained #s	Discard #s
CHUM SALMON (DOG)						2			
KING SALMON (CHINOOK)			128			116			32
SILVER SALMON (COHO)						2			
PROHIBITED SPECIES - - other		Retained mt	Discard mt		Retained mt	Discard mt		Retained mt	Discard mt
PACIFIC HALIBUT					0.000	0.027			
NON-GROUNDFISH SPECIES									
JELLYFISH - UNIDENT.		0.000	0.072		0.000	0.023		0.000	0.011
ASCIDIAN, SEA SQUIRT, TUNICATE									
CHUB MACKEREL (PACIFIC)		0.011	0.001						
JACK MACKEREL		0.078	0.595		0.015	0.000		0.000	0.613
RAGFISH		0.000	0.075		0.000	0.056			
OPAH									
HUMBOLDT SQUID		0.000	0.009						
RIBBONFISH - UNIDENT.		0.000	0.013						
AMERICAN SHAD		0.000	0.020		0.029	0.000			
KING-OF-THE-SALMON		0.000	0.046		0.023	0.005		0.000	0.069
PACIFIC SARDINE		0.000	0.001						
LANTERNFISH - UNIDENT.		0.000	0.001						
DUCKBILL BARRACUDINA		0.000	0.020					0.000	0.001
BARRACUDINA - UNIDENT.									
PACIFIC POMFRET		0.000	0.003						
MEDUSAFISH		0.000	0.005					0.000	0.002
TUBESHOULDER - UNIDENT									
OCEAN SUNFISH		0.000	0.011						
NORTHERN FULMAR									
FISH WASTE (HEADS, DECOMP,ETC)									
MISC - UNIDENT.		0.000	0.001		0.000	0.003			
INVERTEBRATE - UNIDENT.		0.000	0.003						

Table 2b (part 1)

SpeciesName	LISA MELINDA		MARATHON		MARK I	
ROUNDFISH	Retained mt	Discard mt	Retained mt	Discard mt	Retained mt	Discard mt
PACIFIC HAKE	2269.696	99.155	990.479	0.000	3979.410	3.355
PACIFIC COD						
SABLEFISH (BLACK COD)	0.024	0.052			0.000	0.033
LINGCOD	0.013	0.006			0.000	0.018
FLATFISH						
FLATFISH - UNIDENT.						
REX SOLE	0.064	0.051			0.000	0.008
DOVER SOLE	0.010	0.007				
SLENDER SOLE						
(TURBOT)	0.153	0.077	0.116	0.000	0.000	0.249
ROCKFISH						
PACIFIC OCEAN PERCH	0.349	0.002	0.026	0.000	0.048	0.016
WIDOW ROCKFISH	1.620	0.022	0.244	0.000	0.558	4.747
DARK BLOTCHED ROCKFISH	0.029	0.006	0.092	0.000	0.023	0.010
CANARY ROCKFISH					0.000	0.016
BOCACCIO	0.000	0.005				
SHARPCHIN ROCKFISH						
ROUGHEYE ROCKFISH	2.064	0.083	1.292	0.000	0.772	0.250
RED BANDED ROCKFISH					0.000	0.005
SILVERGRAY ROCKFISH	0.027	0.002	0.015	0.000	0.000	0.018
SPLITNOSE ROCKFISH	0.036	0.002			0.000	0.042
SHORTBELLY ROCKFISH	0.007	0.000			0.000	0.027
BLACKGILL ROCKFISH						
YELLOWMOUTH ROCKFISH	0.033	0.000				
YELLOWTAIL ROCKFISH	0.156	0.157	0.150	0.000	1.975	1.208
REDSTRIPE ROCKFISH			0.009	0.000	0.000	0.006
CHILIPEPPER ROCKFISH			0.068	0.000		
SHORTRAKER ROCKFISH			0.000	0.002		
AURORA ROCKFISH	0.000	0.007				
BANK ROCKFISH	0.007	0.000				
SHORTSPINE THORNYHEAD (IDIOT)	0.093	0.105			0.000	0.010
REMAINING GROUNDFISH SPECIES						
SQUID - UNIDENT.	0.783	0.705	0.583	0.000	0.153	2.647
OCTOPUS - UNIDENT.						
PACIFIC SLEEPER SHARK	0.000	0.040				
SOUPFIN SHARK					0.000	0.022
SPINY DOGFISH SHARK	0.754	0.177	0.000	0.812	0.000	3.807
SALMON SHARK						
BROWN CAT SHARK	0.118	1.631	0.000	0.006	0.000	0.285
BLUE SHARK					0.000	0.104
LAMPREY - UNIDENT.	0.000	0.002				
RATTAIL (GRENADIER) -UNIDENT.	0.000	0.001			0.000	0.002
PACIFIC ELECTRIC RAY	0.000	0.027				
BIG SKATE						
LONGNOSE SKATE						

Table 2b (part 2)

SpeciesName	**LISA MELINDA**		**MARATHON**		**MARK I**	
PROHIBITED SPECIES - Salmon	Retained #s	Discard #s	Retained #s	Discard #s	Retained #s	Discard #s
CHUM SALMON (DOG)						
KING SALMON (CHINOOK)		55				177
SILVER SALMON (COHO)						
PROHIBITED SPECIES - - other	Retained mt	Discard mt	Retained mt	Discard mt	Retained mt	Discard mt
PACIFIC HALIBUT					0.000	0.001
NON-GROUNDFISH SPECIES						
JELLYFISH - UNIDENT.	0.001	0.164			0.000	0.067
ASCIDIAN, SEA SQUIRT, TUNICATE						
CHUB MACKEREL (PACIFIC)					0.031	0.379
JACK MACKEREL	0.037	0.000			0.047	0.150
RAGFISH	0.000	0.062	0.000	0.106		
OPAH					0.000	0.018
HUMBOLDT SQUID					0.000	0.004
RIBBONFISH - UNIDENT.					0.000	0.028
AMERICAN SHAD	0.031	0.000			0.010	0.091
KING-OF-THE-SALMON	0.053	0.002			0.000	0.090
PACIFIC SARDINE					0.006	0.006
LANTERNFISH - UNIDENT.	0.000	0.002				
DUCKBILL BARRACUDINA	0.000	0.009			0.000	0.009
BARRACUDINA - UNIDENT.						
PACIFIC POMFRET						
MEDUSAFISH	0.000	0.004				
TUBESHOULDER - UNIDENT	0.000	0.002				
OCEAN SUNFISH	0.006	0.000			0.000	0.009
NORTHERN FULMAR	0.000	0.006				
DECOMP,ETC)						
MISC - UNIDENT.					0.000	0.001
INVERTEBRATE - UNIDENT.					0.000	0.011

Table 2c (part 1)

SpeciesName	MISS BERDIE		MUIR MILACH		PACIFIC CHALLENGER	
ROUNDFISH	Retained mt	Discard mt	Retained mt	Discard mt	Retained mt	Discard mt
PACIFIC HAKE	1747.143	5.302	3522.074	3.294	2180.334	0.000
PACIFIC COD	0.000	0.003				
SABLEFISH (BLACK COD)	0.000	0.102	0.001	0.002		
LINGCOD			0.007	0.000		
FLATFISH						
FLATFISH - UNIDENT.						
REX SOLE	0.000	0.027				
DOVER SOLE	0.000	0.001				
SLENDER SOLE						
(TURBOT)	0.000	0.274	0.186	0.000	0.007	0.002
ROCKFISH						
PACIFIC OCEAN PERCH	0.424	0.075	0.016	0.000	0.002	0.000
WIDOW ROCKFISH	0.213	0.083	3.356	0.039	0.676	0.072
DARK BLOTCHED ROCKFISH	0.017	0.012	0.013	0.003	0.091	0.000
CANARY ROCKFISH	0.000	0.023	0.006	0.000		
BOCACCIO			0.012	0.000		
SHARPCHIN ROCKFISH			0.001	0.000		
ROUGHEYE ROCKFISH	1.384	0.368	1.147	0.000	0.000	0.012
RED BANDED ROCKFISH						
SILVERGRAY ROCKFISH			0.006	0.000		
SPLITNOSE ROCKFISH	0.000	0.037	0.102	0.002	0.001	0.000
SHORTBELLY ROCKFISH			0.021	0.001	0.011	0.000
BLACKGILL ROCKFISH			0.003	0.000		
YELLOWMOUTH ROCKFISH			0.006	0.000		
YELLOWTAIL ROCKFISH	1.320	0.840	0.158	0.001		
REDSTRIPE ROCKFISH			0.004	0.000		
CHILIPEPPER ROCKFISH			0.003	0.000		
SHORTRAKER ROCKFISH						
AURORA ROCKFISH						
BANK ROCKFISH						
SHORTSPINE THORNYHEAD (IDIOT)	0.000	0.108	0.003	0.000		
REMAINING GROUNDFISH SPECIES						
SQUID - UNIDENT.	0.100	0.913	2.188	0.944	0.007	1.742
OCTOPUS - UNIDENT.			0.004	0.000		
PACIFIC SLEEPER SHARK						
SOUPFIN SHARK						
SPINY DOGFISH SHARK	0.019	2.012	2.585	0.280	0.000	0.655
SALMON SHARK						
BROWN CAT SHARK	0.000	0.823	0.076	0.013	0.000	0.005
BLUE SHARK						
LAMPREY - UNIDENT.			0.000	0.001		
RATTAIL (GRENADIER) -UNIDENT.	0.000	0.002				
PACIFIC ELECTRIC RAY						
BIG SKATE						
LONGNOSE SKATE						

Table 2c (part 2)

SpeciesName		MISS BERDIE			MUIR MILACH			Pacific Challenger	
PROHIBITED SPECIES - Salmon		Retained #s	Discard #s		Retained #s	Discard #s		Retained #s	Discard #s
CHUM SALMON (DOG)									
KING SALMON (CHINOOK)						177			134
SILVER SALMON (COHO)									
PROHIBITED SPECIES - - other		Retained mt	Discard mt		Retained mt	Discard mt		Retained mt	Discard mt
PACIFIC HALIBUT		0.000	0.037		0.000	0.010			
NON-GROUNDFISH SPECIES									
JELLYFISH - UNIDENT.		0.000	0.018		0.002	0.030		0.000	0.014
ASCIDIAN, SEA SQUIRT, TUNICATE					0.000	0.002			
CHUB MACKEREL (PACIFIC)									
JACK MACKEREL		0.000	0.151		0.033	0.000		0.075	0.007
RAGFISH									
OPAH									
HUMBOLDT SQUID									
RIBBONFISH - UNIDENT.								0.018	0.000
AMERICAN SHAD		0.000	0.019		0.009	0.000		0.003	0.000
KING-OF-THE-SALMON		0.000	0.053		0.097	0.000		0.000	0.020
PACIFIC SARDINE		0.000	0.001						
LANTERNFISH - UNIDENT.									
DUCKBILL BARRACUDINA		0.000	0.005						
BARRACUDINA - UNIDENT.		0.000	0.002						
PACIFIC POMFRET		0.000	0.006						
MEDUSAFISH								0.000	0.001
TUBESHOULDER - UNIDENT									
OCEAN SUNFISH		0.000	0.018		0.015	0.000		0.000	0.007
NORTHERN FULMAR									
FISH WASTE (HEADS, DECOMP,ETC)					0.002	0.000			
MISC - UNIDENT.					0.000	0.006			
INVERTEBRATE - UNIDENT.								0.000	0.007

Table 2d (part 1)

SpeciesName	PACIFIC PRINCE		PEGASUS		PERSEVERANCE	
ROUNDFISH	Retained mt	Discard mt	Retained mt	Discard mt	Retained mt	Discard mt
PACIFIC HAKE	4239.229	0.000	2679.568	3.497	1169.873	0.000
PACIFIC COD						
SABLEFISH (BLACK COD)	0.058	0.000	0.118	0.386		
LINGCOD					0.027	0.010
FLATFISH						
FLATFISH - UNIDENT.						
REX SOLE	0.074	0.000	0.000	0.002		
DOVER SOLE						
SLENDER SOLE	0.016	0.000				
(TURBOT)	0.188	0.000	0.000	0.071	0.165	0.000
ROCKFISH						
PACIFIC OCEAN PERCH	0.117	0.000			0.000	0.019
WIDOW ROCKFISH	2.749	0.000	0.473	1.004	0.000	0.258
DARK BLOTCHED ROCKFISH	0.058	0.000	0.000	0.051	0.000	0.073
CANARY ROCKFISH	0.003	0.000	0.000	0.005	0.000	0.016
BOCACCIO			0.000	0.015		
SHARPCHIN ROCKFISH						
ROUGHEYE ROCKFISH	0.408	0.000	0.240	0.097	0.000	0.088
RED BANDED ROCKFISH						
SILVERGRAY ROCKFISH	0.003	0.000			0.000	0.005
SPLITNOSE ROCKFISH	7.700	0.000	0.000	0.142	0.000	0.002
SHORTBELLY ROCKFISH	0.017	0.000	0.004	0.016		
BLACKGILL ROCKFISH						
YELLOWMOUTH ROCKFISH	0.003	0.000				
YELLOWTAIL ROCKFISH	0.259	0.000	0.040	0.053	0.000	1.009
REDSTRIPE ROCKFISH	0.005	0.000	0.000	0.002		
CHILIPEPPER ROCKFISH					0.000	0.001
SHORTRAKER ROCKFISH						
AURORA ROCKFISH						
BANK ROCKFISH						
SHORTSPINE THORNYHEAD (IDIOT)	0.017	0.000	0.000	0.027		
REMAINING GROUNDFISH SPECIES						
SQUID - UNIDENT.	3.115	1.230	0.060	2.750	0.035	0.023
OCTOPUS - UNIDENT.						
PACIFIC SLEEPER SHARK						
SOUPFIN SHARK						
SPINY DOGFISH SHARK	3.226	0.003	0.000	3.174	0.000	0.327
SALMON SHARK						
BROWN CAT SHARK	0.254	0.000	0.000	0.116		
BLUE SHARK						
LAMPREY - UNIDENT.	0.000	0.002	0.000	0.001	0.006	0.000
RATTAIL (GRENADIER) -UNIDENT.						
PACIFIC ELECTRIC RAY						
BIG SKATE					0.000	0.007
LONGNOSE SKATE						

Table 2d (part 2)

SpeciesName		PACIFIC PRINCE			PEGASUS			PERSEVERANCE	
PROHIBITED SPECIES - Salmon		Retained #s	Discard #s		Retained #s	Discard #s		Retained #s	Discard #s
CHUM SALMON (DOG)									
KING SALMON (CHINOOK)			626			150			14
SILVER SALMON (COHO)									
PROHIBITED SPECIES - - other		Retained mt	Discard mt		Retained mt	Discard mt		Retained mt	Discard mt
PACIFIC HALIBUT		0.000	0.012		0.000	0.013			
NON-GROUNDFISH SPECIES									
JELLYFISH - UNIDENT.		0.001	0.058		0.000	0.019			
ASCIDIAN, SEA SQUIRT, TUNICATE									
CHUB MACKEREL (PACIFIC)		0.006	0.000		0.000	0.236			
JACK MACKEREL		0.449	0.000		0.012	0.154			
RAGFISH		0.296	0.000		0.000	0.062			
OPAH									
HUMBOLDT SQUID									
RIBBONFISH - UNIDENT.									
AMERICAN SHAD		0.001	0.000		0.000	0.032		0.005	0.000
KING-OF-THE-SALMON		0.165	0.000						
PACIFIC SARDINE									
LANTERNFISH - UNIDENT.									
DUCKBILL BARRACUDINA		0.011	0.000		0.000	0.002			
BARRACUDINA - UNIDENT.									
PACIFIC POMFRET									
MEDUSAFISH									
TUBESHOULDER - UNIDENT									
OCEAN SUNFISH									
NORTHERN FULMAR					0.000	0.002			
DECOMP,ETC)									
MISC - UNIDENT.		0.000	0.003						
INVERTEBRATE - UNIDENT.					0.000	0.004			

Table 2e (part 1)

SpeciesName	SEA STORM		SEADAWN		SEEKER		WESTERN DAWN	
ROUNDFISH	Retained mt	Discard mt	Retained mt	Discard mt	Retained mt	Discard mt	Retained mt	Discard mt
PACIFIC HAKE	3354.202	9.859	1626.211	0.000	3172.614	15.569	1488.639	0.000
PACIFIC COD								
SABLEFISH (BLACK COD)	0.009	0.000			0.012	0.003		
LINGCOD			0.000	0.026	0.045	0.000	0.000	0.001
FLATFISH								
FLATFISH - UNIDENT.					0.004	0.000		
REX SOLE								
DOVER SOLE								
SLENDER SOLE								
(TURBOT)	0.011	0.004	0.070	0.004	0.128	0.000	0.000	0.006
ROCKFISH								
PACIFIC OCEAN PERCH	0.000	0.026	0.003	0.011				
WIDOW ROCKFISH	0.075	1.393	0.013	0.528	0.045	1.380	0.037	0.444
DARK BLOTCHED ROCKFISH	0.000	0.120	0.029	0.138	0.000	0.098	0.000	0.018
CANARY ROCKFISH	0.000	0.015	0.000	0.011	0.002	0.028		
BOCACCIO	0.000	0.011						
SHARPCHIN ROCKFISH								
ROUGHEYE ROCKFISH			0.558	0.023	0.000	0.002		
RED BANDED ROCKFISH								
SILVERGRAY ROCKFISH	0.000	0.002	0.000	0.011	0.000	0.012		
SPLITNOSE ROCKFISH	0.000	0.130	0.000	0.002	0.000	0.630		
SHORTBELLY ROCKFISH	0.000	0.022			0.000	0.011	0.007	0.041
BLACKGILL ROCKFISH								
YELLOWMOUTH ROCKFISH								
YELLOWTAIL ROCKFISH	0.000	0.407	0.023	0.163	0.016	1.739	0.000	0.005
REDSTRIPE ROCKFISH	0.000	0.004			0.000	0.007		
CHILIPEPPER ROCKFISH	0.000	0.002						
SHORTRAKER ROCKFISH								
AURORA ROCKFISH								
BANK ROCKFISH								
SHORTSPINE THORNYHEAD (IDIOT)								
REMAINING GROUNDFISH SPECIES								
SQUID - UNIDENT.	2.389	0.420	0.149	0.000	0.857	0.218	0.075	1.237
OCTOPUS - UNIDENT.								
PACIFIC SLEEPER SHARK					0.000	0.045		
SOUPFIN SHARK					0.000	0.050		
SPINY DOGFISH SHARK	0.000	1.976	0.222	0.349	0.000	3.024	0.000	0.178
SALMON SHARK			0.000	0.634	0.000	0.507		
BROWN CAT SHARK	0.000	0.002			0.000	0.016		
BLUE SHARK								
LAMPREY - UNIDENT.	0.001	0.000	0.006	0.000	0.010	0.001		
RATTAIL (GRENADIER) -UNIDENT.								
PACIFIC ELECTRIC RAY								
BIG SKATE								
LONGNOSE SKATE	0.000	0.017						

Table 2e (part 2)

SpeciesName	SEA STORM		SEADAWN		SEEKER		WESTERN DAWN	
PROHIBITED SPECIES - Salmon	Retained #s	Discard #s	Retained #s	Discard #s	Retained #s	Discard #s	Retained #s	Discard #s
CHUM SALMON (DOG)								
KING SALMON (CHINOOK)		370		8		182		126
SILVER SALMON (COHO)				2				
PROHIBITED SPECIES - - other	Retained mt	Discard mt	Retained mt	Discard mt	Retained mt	Discard mt	Retained mt	Discard mt
PACIFIC HALIBUT								
NON-GROUNDFISH SPECIES								
JELLYFISH - UNIDENT.	0.000	0.024	0.002	0.000	0.000	0.019	0.000	0.003
ASCIDIAN, SEA SQUIRT, TUNICATE	0.000	0.008			0.000	0.001		
CHUB MACKEREL (PACIFIC)	0.000	0.012			0.000	0.005		
JACK MACKEREL	0.000	4.832			0.000	2.191	0.000	0.142
RAGFISH					0.000	0.058		
OPAH					0.000	0.039		
HUMBOLDT SQUID								
RIBBONFISH - UNIDENT.								
AMERICAN SHAD	0.000	0.165	0.026	0.000	0.000	0.090	0.000	0.085
KING-OF-THE-SALMON	0.000	0.075			0.000	0.013		
PACIFIC SARDINE					0.001	0.000		
LANTERNFISH - UNIDENT.								
DUCKBILL BARRACUDINA					0.000	0.004		
BARRACUDINA - UNIDENT.								
PACIFIC POMFRET								
MEDUSAFISH								
TUBESHOULDER - UNIDENT								
OCEAN SUNFISH							0.000	0.028
NORTHERN FULMAR								
FISH WASTE (HEADS, DECOMP,)								
MISC - UNIDENT.							0.000	0.004
INVERTEBRATE - UNIDENT.							0.000	0.005

Attachment 2

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November 29, 2012

Catch and bycatch totals

	Whiting	Canary	Widow	Dark blotched	POP	Chinook
Totals year to date	38,476	0.15	37.23	1.25	1.36	2294
Rate year to date		0.004	0.968	0.033	0.035	0.060
2012 Allocation for Motherships	39,235	3.60	61.20	6.00	7.20	*1,923*
Percentage Taken	98.1%	4.1%	60.8%	20.9%	18.8%	119.3%

	Whiting	Canary	Widow	Dark blotched	POP	Chinook
1st seasonal pool total catch	11,940	0.06	7.05	0.65	0.50	329
1st pool allocation	12,741	1.17	19.87	1.95	2.34	624
Percentage Taken	93.7%	5.3%	35.5%	33.2%	21.4%	52.7%

2nd seasonal pool total catch	11,547	0.06	8.45	0.27	0.70	455
2nd pool allocation	13,237	1.22	20.65	2.02	2.43	649
Percentage Taken	87.2%	5.2%	40.9%	13.5%	28.7%	70.0%

3rd seasonal pool total catch	14,989	0.02	21.73	0.33	0.16	1,511
3rd pool allocation	13,256	1.22	20.68	2.03	2.43	650
Percentage Taken	113.1%	1.9%	105.1%	16.5%	6.6%	232.4%

Sum of Total catch from pools 1 & 3	26,929	0.08	28.78	0.98	0.66	1,840
Sum of allocation of pools 1 & 3	25,997	2.39	40.55	3.98	4.77	1,274
Percentage Taken	103.6%	3.6%	71.0%	24.6%	13.8%	144.4%

Catch by vessel and pool

Pool	Harvesting vessel	Whiting (ytd)	Canary (ytd)	Widow (ytd)	Dark blotched (ytd)	POP (ytd)	Chinook (ytd)
1	BAY ISLANDER	1,019	0.00	0.31	0.17	0.02	17
1	LISA MELINDA	2,369	0.00	1.64	0.03	0.35	55
1	MARATHON	990	0.00	0.24	0.09	0.03	0
1	MUIR MILACH	2,547	0.01	3.34	0.01	0.02	125
1	PERSEVERANCE	1,170	0.02	0.26	0.07	0.02	14
1	SEA STORM	824	0.00	0.36	0.04	0.03	103
1	SEADAWN	1,626	0.01	0.54	0.17	0.01	8
1	SEEKER	1,394	0.02	0.35	0.05	0.02	7
2	ARCTIC FURY	3,128	0.02	1.37	0.16	0.13	128
2	MARK I	3,983	0.02	5.31	0.03	0.06	177
2	MISS BERDIE	1,752	0.02	0.30	0.03	0.50	0
2	PEGASUS	2,683	0.01	1.48	0.05	0.00	150
3	BAY ISLANDER	999	0.00	0.08	0.03	0.00	99
3	BLUE FOX	773	0.00	15.44	0.01	0.02	32
3	MUIR MILACH	977	0.00	0.05	0.00	0.00	52
3	PACIFIC CHALLENGER	2,180	0.00	0.75	0.09	0.00	134
3	PACIFIC PRINCE	4,239	0.00	2.75	0.06	0.12	626
3	SEA STORM	2,538	0.01	1.10	0.08	0.00	267
3	SEEKER	1,794	0.01	1.08	0.04	0.01	175
3	WESTERN DAWN	1,489	0.00	0.48	0.02	0.00	126

Agenda Item D.2.b
Attachment 2
April 2013

Pacific Whiting Conservation Cooperative

Amendment 20 Catcher/Processor Cooperative

Final Annual Report 2012

Submitted to the

National Marine Fisheries Service

March 2013

Pacific Whiting Conservation Cooperative Final Annual Report for 2012

Introduction

In 1997, the owners of the catcher/processor (C/P) vessels operating in the Pacific whiting fishery formed a fishing cooperative to coordinate harvesting efforts. This research and harvesting cooperative is the Pacific Whiting Conservation Cooperative (PWCC). A private contract dictates the activities of the PWCC and a harvest agreement facilitates efficient management and accurate accounting of harvest by the PWCC and PWCC member companies.

In 2011, rationalization of the US Pacific coast groundfish trawl fishery was implemented via Amendments 20 and 21 to the Pacific Coast Groundfish Fishery Management Plan. National Marine Fisheries Service (NMFS) summarized the significant effects of Amendment 20 on the shoreside groundfish trawl and mothership whiting fisheries, as well as the effect on the C/P fishery in the September 2, 2011 proposed rule for the Program Improvement and Enhancement (PIE) Rule:

> "In January 2011, NMFS and the Pacific Fishery Management Council set up a new management program called the trawl rationalization program. This program significantly changes how two of these groups work. Shore trawlers now fish under their own set of individual species quotas by vessel…. [T]he mothership fishery works as a coop where catcher-vessels and motherships work together collectively. The catcher-processor fleet continues as a single coop."

Currently, trawl rationalization regulations require a preliminary report be submitted to the Pacific Fishery Management Council in November of the current year and a final report to NMFS in March the following year.

Purpose of Report

This report is intended to disclose all information required or identified in Federal Regulations at 50 CFR 660.113(d)(3). The table in this report is largely self-explanatory. The catch data in this report was provided by Sea State, Inc. and was obtained from the NMFS – At-Sea Hake Observer Program. Prior to trawl rationalization, NMFS provided a similar report, but with catch information at the sector level (rather than vessel-by-vessel). Catch information at the C/P-vessel level was and is known by NMFS. Therefore, production of this more detailed report by the PWCC should reduce NMFS workload and cost burden.

Reporting Requirements

Federal regulations (50CFR660.113(d)(3)) detail the report requirements:

"(3) Annual coop report - (i) The designated coop manager for the C/P coop must submit an annual report to the Council for its November meeting each year. The annual coop report will contain information about the current year's fishery, including:

> "(A) The C/P sector's annual allocation of Pacific whiting;

"(B) The C/P coop's actual retained and discarded catch of Pacific whiting, salmon, Pacific halibut, rockfish, groundfish, and other species on a vessel-by-vessel basis;

"(C) A description of the method used by the C/P coop to monitor performance of cooperative vessels that participated in the fishery;

"(D) A description of any actions taken by the C/P coop in response to any vessels that exceed their allowed catch and bycatch; and

"(E) Plans for the next year's C/P coop fishery, including the companies participating in the cooperative, the harvest agreement, and catch monitoring and reporting requirements."

A. C/P Sector's Annual Allocation of Pacific Whiting

In May 2012, NMFS issued the C/P cooperative permit, which was effective on the May 15, 2012. As specified at 50 CFR 660.160(c), the C/P cooperative permit authorized the PWCC to harvest 100 percent of the Pacific whiting and non-whiting groundfish allocated to the C/P sector. For 2012, the C/P sector amounts of Pacific whiting and non-whiting groundfish species with allocations are as follows (per NMFS, :Initial Administrative Determination Notice of Right to Appeal, May 14, 2012):

2012 C/P sector allocations	mt	pounds
Pacific whiting	46,064	101,553,736.5
Pacific ocean perch	10.20	22,487.1
Widow rockfish	86.7	191,140.8
Darkblotched rockfish	8.5	18,739.3
Canary rockfish	5.0	11,023.1

On October 4, 2012, NMFS re-apportioned 28,000 mt of whiting from the Tribal Set Aside to the non-tribal fishery sectors. This action increased the 2012 C/P sector allocation to 55,584 mt.

B. C/P Cooperative's Actual Retained and Discarded Catch of Pacific Whiting, Salmon, Pacific Halibut, Rockfish, Groundfish, and Other Species on a Vessel-by-Vessel Basis

Complete catch data for 2012 is provided in Table 1 Species are grouped per the advice of NMFS.

C. Description of the Method Used by the C/P Cooperative to Monitor Performance of Cooperative Vessels that Participated in the Fishery

Each vessel in the C/P Cooperative carries two NMFS-certified observers to monitor and account for the catch of Pacific whiting and non-whiting groundfish allocations (i.e., canary rockfish, widow rockfish, darkblotched rockfish, and Pacific ocean perch), and to monitor and account for the catch of prohibited species. Observers report each vessel's catch on a daily basis to both the

NMFS Observer Program in Seattle and to Sea State, Inc. (a private, third-party catch monitoring firm).

For 2012, the C/P Cooperative contracted with Sea State, Inc. to process the catch data provided by the observer program and to provide in-season management support. Sea State regularly provides catch reports to each C/P vessel, the C/P fleet, and the C/P Cooperative. These reports may include cumulative fleet-wide and vessel-level catch data as well as tow-by-tow summaries. Fleet managers are able to reconcile the tow-by-tow catch information provided by Sea State against their own catch records to identify possible data errors and ensure accurate catch accounting throughout the fishing season. Sea State reports also provide a mechanism to identify and avoid fishing areas where incidental catch of overfished species and/or prohibited species is occurring. The C/P Cooperative has authorized Sea State, Inc. to identify specific fishing areas to be avoided as a mechanism to reduce catch of overfished species and/or prohibited species.

Catch aboard C/P vessels is weighed using flow scales and motion-compensated platform scales. The flow scale is tested daily by the vessel to ensure the accuracy of the data collected by the NMFS-certified observer. Regulations at 50 CFR 660.15(b)(3) state that the vessel operator is responsible for ensuring the vessel crew performs daily testing of all at-sea scales (belt and/or platform). The species composition of the catch is determined by the NMFS-certified observer. Because two observers are aboard each vessel the number of hauls sampled are high, at or near 100 percent. C/P vessels endeavor to provide conditions that facilitate large samples of individual hauls. The use of two observers, flow and platform scales, and high rates of sampling leads to very accurate catch accounting for Pacific whiting, non-whiting groundfish, and prohibited species.

The C/P Cooperative acknowledges and agrees that minimizing incidental catch of overfished species to the extent practicable is a primary objective of the C/P Cooperative. In general, incidental catch of overfished species in the C/P sector is very low. For 2012, each C/P Cooperative member agreed to employ bycatch avoidance techniques recommended by the PWCC Board of Directors and Sea State, Inc. Non-whiting groundfish species amounts (functionally, "bycatch limits") allocated by NMFS to the C/P sector were assigned to C/P Cooperative members proportional to their Pacific whiting allocations. These hard caps on incidental catch, if exceeded, would cause the C/P sector to cease fishing, thereby ensuring that C/P Cooperative catch of overfished species is minimized to the extent practicable.

D. Description of Any Actions Taken by the C/P Cooperative in Response to Any Vessels that Exceed Their Allowed Catch and Bycatch

In 2012, no vessels exceeded their allowed catch or bycatch amounts. Minor adjustments to the harvest schedule may be made to accommodate the inseason needs of member vessels. For example, one member company may choose to provide small amounts of their percentage of the annual catcher processor allocation of catch or bycatch to another member company if the former company has completed operations for the year and the latter is still active in the fishery.

E. Plans for the 2013 C/P Cooperative Fishery, Including the Companies Participating in the Cooperative, the Harvest Agreement, and Catch Monitoring and Reporting Requirements

For 2013, companies participating in the C/P Cooperative include:

AMERICAN SEAFOODS COMPANY LLC; GLACIER FISH COMPANY LLC; TRIDENT SEAFOODS CORPORATION

2013 C/P Cooperative Pacific Whiting Harvest Schedule:

Member	Percentage of Annual Catcher Processor Allocation
American Seafoods Company LLC	49.4%
Trident Seafoods Corporation	29.6%
Glacier Fish Company LLC	21.0%

2013 C/P Cooperative Catch Monitoring and Reporting Requirements:

Each member of the C/P Cooperative carries two NMFS-certified observers aboard each of its vessels to monitor and account for total catch, including catch of prohibited species. Observers report each vessel's daily catch to the NMFS Observer Program in Seattle and to Sea State.

For 2013, the C/P Cooperative will contract with Sea State, Inc. to process the catch data provided by the observer program and to provide in-season management support. Sea State regularly provides catch reports to each C/P vessel, the C/P fleet, and the C/P Cooperative. These reports may include cumulative fleet-wide and vessel-level catch data as well as tow-by-tow summaries. Fleet managers are able to reconcile the tow-by-tow catch information provided by Sea State against their own catch records to identify possible data errors and ensure accurate catch accounting throughout the fishing season.

Catch aboard C/P vessels is weighed using flow scales and motion-compensated platform scales. The flow scale is tested daily by the vessel to ensure the accuracy of the data collected by the NMFS-certified observer. Regulations at 50 CFR 660.15(b)(3) state that the vessel operator is responsible for ensuring the vessel crew performs daily testing of all at-sea scales (belt and/or platform). The species composition of the catch is determined by the NMFS-certified observer. Because two observers are aboard each vessel the number of hauls sampled are high, at or near 100 percent. C/P vessels endeavor to provide conditions that facilitate large samples of individual hauls. The use of two observers, flow and platform scales, and high rates of sampling leads to very accurate catch accounting for Pacific whiting, non-whiting groundfish, and prohibited species.

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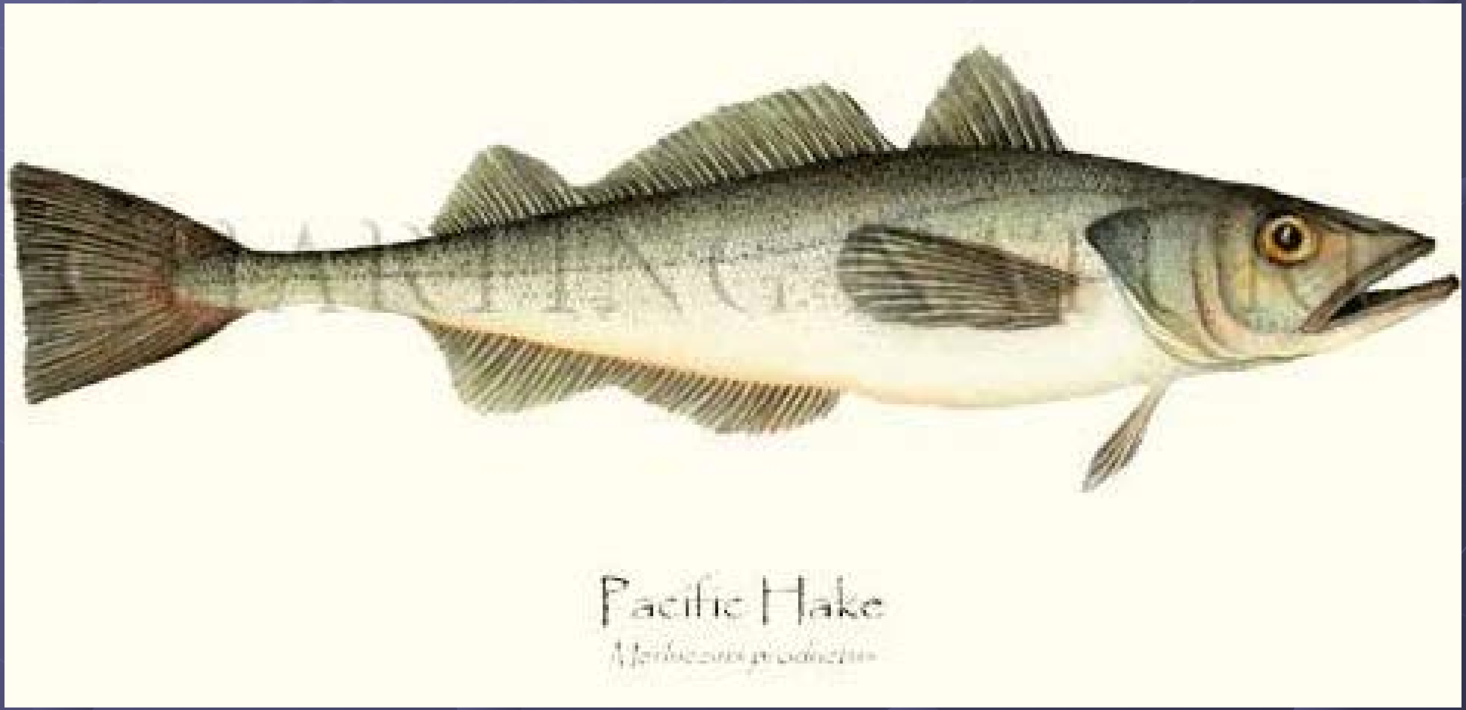
Table 1. Final C/P Cooperative 2012 Catch by Vessel

Species	Alaska Ocean	American Dynasty	American Triumph	Island Enterprise	Kodiak Enterprise	Northern Eagle	Northern Jaeger	Pacific Glacier	Seattle Enterprise	Total
ROUNDFISH (mt)										
Whiting	6,023.813	3,771.206	7,932.981	6,617.611	6,974.269	3,095.516	12,645.712	5,649.794	2,551.878	55,262.7803
Pacific Cod					0.004		0.004	0.009		0.0172
Lingcod							0.014			0.0143
Sablefish	0.363	0.323	2.525	0.031	0.231	0.016	0.807	0.034	0.011	4.3423
FLATFISH (mt)										
Arrowtooth Flounder	0.150	0.167	0.320	0.229	0.632	0.112	0.642	0.162	0.111	2.5265
Dover Sole	0.043	0.002	0.129		0.045		0.070			0.2890
English Sole			0.001	0.001		0.002			0.001	0.0060
Petrale Sole										
Starry Flounder										
Other Flatfish										
Rex Sole	0.474	0.003	1.657		0.134		0.323	0.000		2.5915
Slender Sole		0.000								0.0000
Flatfish Unidentified			0.000							0.0002
ROCKFISH (mt)										
Pacific Ocean Perch	0.002	0.006	0.171	0.092	1.321	0.736	0.287	0.159	0.349	3.1235
Shortbelly	0.000	0.010					0.009			0.0197
Widow	0.191	12.140	0.575	4.635	8.213	0.072	13.093	1.733	1.038	41.6914
Canary	0.004	0.036	0.014	0.040	0.045	0.023	0.027	0.039	0.047	0.2748
Chilipepper				0.010						0.0105
Splitnose	0.330	0.475	5.245	0.003	0.084	0.002	3.425	0.037	0.005	9.6059
Yellowtail		0.361	0.401	1.870	20.938	3.089	0.893	0.793	3.363	31.7085
Shortspine Thornyhead	0.212	0.002	0.116	0.001	0.654		0.232			1.2178
Longspine Thornyhead	0.002									0.0016
Thornyhead, Unid.										
Dark Blotched Rockfish	0.016	0.024	0.175	0.368	0.213	0.117	0.311	0.079	0.119	1.4223
Yelloweye										
Minor Shelf	0.000	0.028	0.058	0.097	0.081	0.197	0.133	0.110	0.065	0.7686
Minor Slope	0.501	0.060	5.542	4.875	18.500	3.943	5.327	2.500	1.692	42.9401
Rockfish Unidentified	0.000					0.002				0.0022
REMAINING GROUNDFISH (mt)										
Spiny Dogfish Shark	1.308	24.489	6.748	6.609	59.257	2.822	29.785	10.596	6.755	148.3694
Longnose Skate	0.028									0.0280
Other Groundfish	1.905	0.353	5.671	5.616	2.889	2.232	9.361	1.357	1.497	30.8797
PROHIBITED and PROTECTED SPP										
Chinook Salmon (numbers of fish)	12	653	62	101	43	87	545	352	70	1,925
Chum Salmon (numbers of fish)		0	6	11	6	9	2	11	6	51
Coho Salmon (numbers of fish)		0	0	3		2	3		5	13
Pink Salmon (numbers of fish)		0	0	12		2	0	8	0	22
Sockeye Salmon (numbers of fish)										
Salmon, Unid. (numbers of fish)										
Steelhead (numbers of fish)										
Pacific Halibut (mt)		0.000	0.169	0.055	0.083	0.033	0.041	0.044	0.111	0.5363
Dungeness Crab (numbers of fish)										
Eulachon (mt)		0.000	0.000		0.001			0.000		0.0011
NON-GROUNDFISH SPP (mt)										
American Shad		0.032	0.374	0.007	0.024	0.775	0.595	0.209	0.030	2.0463
Pacific Herring				0.001	0.001					0.0014
Humboldt Squid	0.010	0.019	0.003		0.006	0.012				0.0508
Squid Unidentified	5.449	5.997	8.786	6.737	5.095	2.672	19.926	8.935	2.328	65.9250
Jack Mackerel	0.181	0.043	0.023	3.124	0.809		0.245	0.136		4.5605
Pacific Mackerel	0.212	0.001	0.054	0.004	1.750	0.001	0.066	0.001		2.0875
Pacific Sardine	0.000		0.035		0.130		0.002			0.1679
All Other Non-Groundfish	0.165	0.080	0.150	0.436	0.354	0.063	0.293	0.127	0.031	1.6984

Agenda Item D.2.b
Supplemental At-Sea Co-op PowerPoint
Whiting Mothership Cooperative
April 2013

Whiting Mothership Cooperative 2012



WMC Cooperative Structure

- WMC Membership Agreement
  - Allocates Whiting to the Members
  - Catch Monitoring Protocol
  - Rules for Transfers between Members
  - Contains Agreement on Fishing Practices
  - Enforcement/Penalties

  <u>Contract between all 36 eligible permit holders</u>

- Whiting Bycatch Agreement
  - Rules for modification of fishing behaviour

2012 Allocations

- 2012 Whiting Allocation to the WMC:
  - 32,515 mt (plus 6,720 mt re-apportionment)
  - Assigned to members based on Catch History

- 2012 Bycatch Amounts
  - Canary Rockfish 3.4 mt
  - Dark Blotched 6.0 mt
  - POP 7.2 mt
  - Widow Rockfish 61.7 mt
  - Allocated to the Coop, not to individuals

WMC Bycatch Rules

- **Seasonal Pools**
- **Data Sharing**
- **Real Time Hot Spot Response**
- **Closure Areas**
- **Night Fishing Restrictions**
- **Enforcement/Sanctions**

WMC Bycatch Rules – Seasonal Pools

- Four seasonal pool allocations
- Rules for accessing rollover bycatch

WMC Bycatch Rules – Data

- Reporting <u>to</u> SeaState by the Fleet
  - NORPAC Observer Data
  - Motherships report daily to SeaState
- Reports <u>from</u> SeaState to the Fleet
  - Daily Report
  - Catch data
  - Bycatch rates for MS sector, fleet, and individual vessels, 3-day averages
  - Maps of bycatch hotspots
  - Other useful bycatch avoidance information

WMC Bycatch Rules - Data

- Mothership "**Fleet to Fleet**" Reporting Requirement
  - Total amount of whiting received in past day
  - Elevated Bycatch Tows - (between 100% to 150% of the Base Rate)
  - High Bycatch Tows – (>150% of Base Rate)

WMC Bycatch Rules – Hot Spot Response

Real Time Response to High Bycatch Rates

- Establish a Bycatch Base Rate of 4 species
  - Canary: 0.10 kg/mt *(7 lbs in a 30 ton haul)*
  - Dark Blotched 0.18 kg/mt *(12 lbs in a 30 ton haul)*
  - POP: 0.22 kg/mt *(15 lbs in a 30 ton haul)*
  - Widow: 1.88 kg/mt *(124 lbs in a 30 ton haul)*
  - Chinook 0.06 salmon/mt *(<2 per 30 ton haul)*
- Entire Fleet Must Relocate If Trigger Rates Exceeded

WMC Bycatch Rules – Hot Spot Response

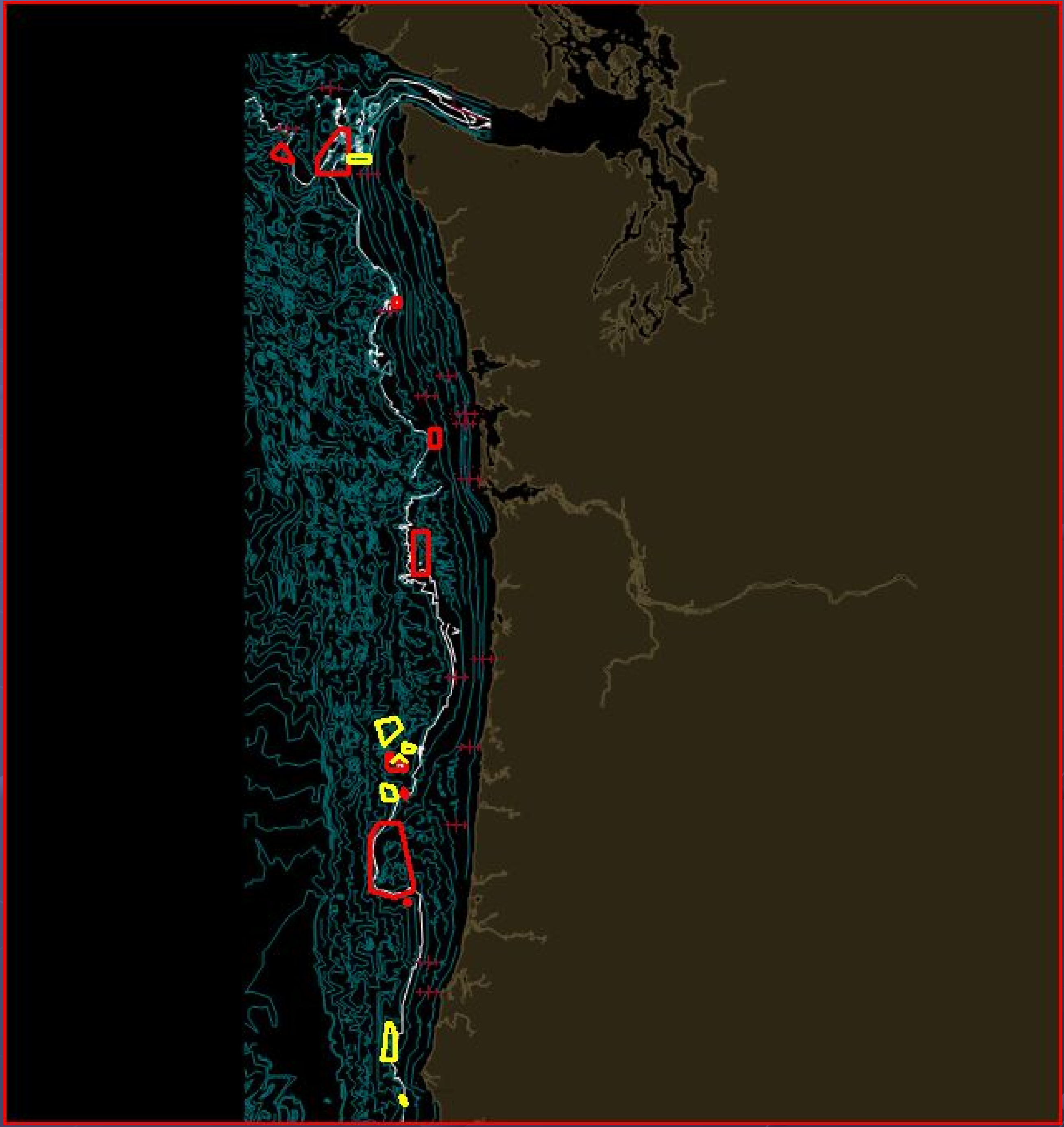
- Fleet Must Relocate IF:
  - 3 day average bycatch rate exceeds the Base Rate and the Fleet's YTD bycatch rate exceeds 50% of the Base Rate
  - 3 day average bycatch rate exceeds 125% of the Base Rate, or
  - Bycatch rate during any single day exceeds 200% of the Base Rate
- Fleet must move to an area where they can reasonably expect to achieve a lower rate.
  - Test tows required on entering new area

WMC Bycatch Rules – Closed Areas

- **Closure Areas:**
  - Pre-season Closures
  - Advisory Cautionary Areas
  - In-season Closures
  - Time Closures – Night Fishing Restrictions
  - NMFS Closures

WMC Pre-Season Closure Areas

- Nine Closures
- 2000 sq. km.
- Advisory Areas



How We Got There

- Bycatch Committee Recommends Closures to Coop Board Based On:
- Historic Observer Data 2000-2010
  - Whiting Catch/Bycatch of 4 Over-fished Species
  - GIS Layering with Detailed Bathymetry
- VMS Tracklines of "Disaster Tows"
- Captains' Input from "Local Knowledge"
- Flexibility – Commitment to Review & Adjust In-Season Based on Real Time Data

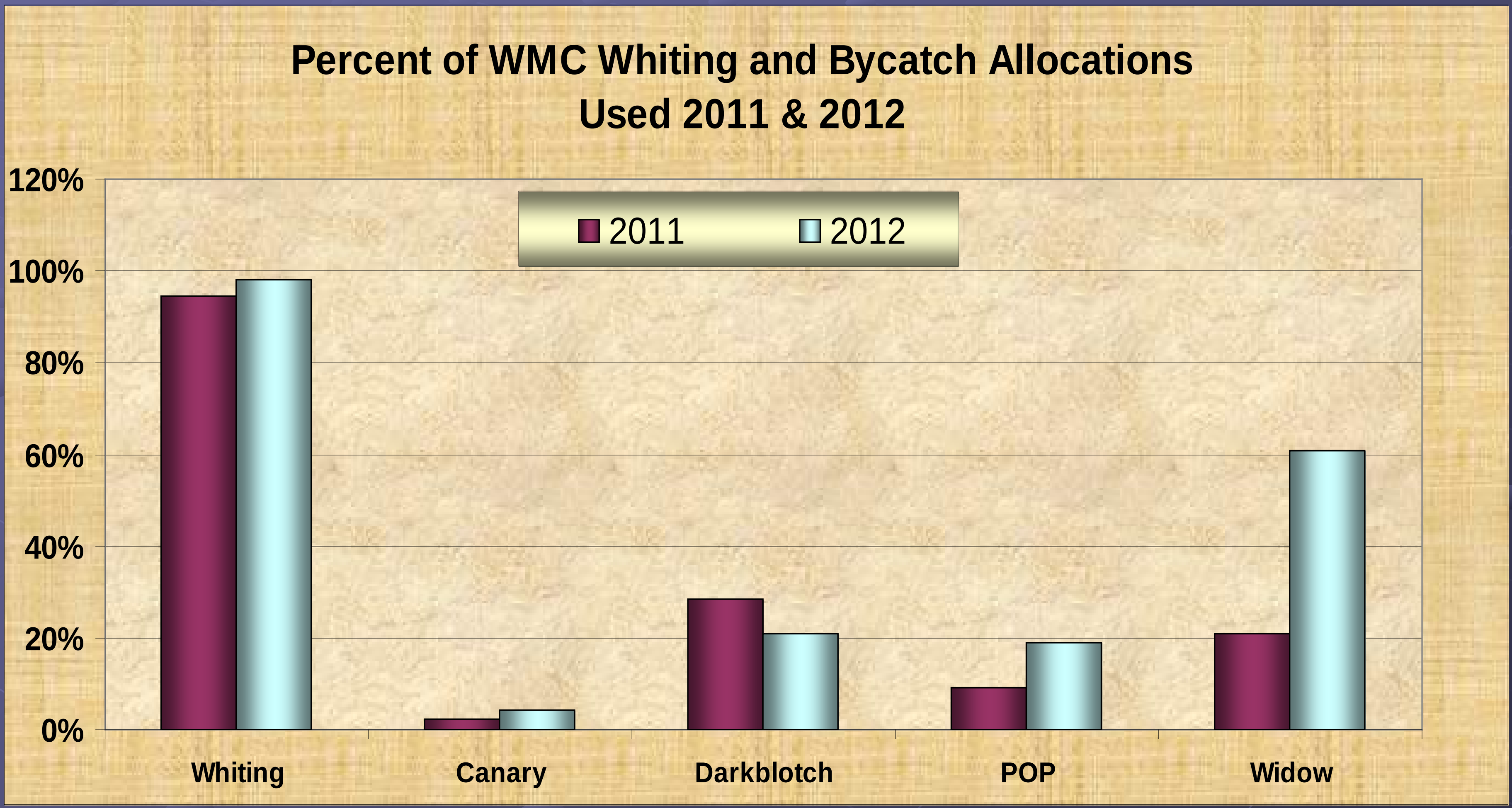
WMC Bycatch Rules – Misc.

- Other Fishing Restrictions
  - No Night Fishing- 2200-0530 hours
  - Test Tows required when entering a new fishing area
- Enforcement Actions
  - Stop Fishing Order
  - Vessel Captain Damages: $2,500 per violation
  - Owner Damages: $10,000 per violation

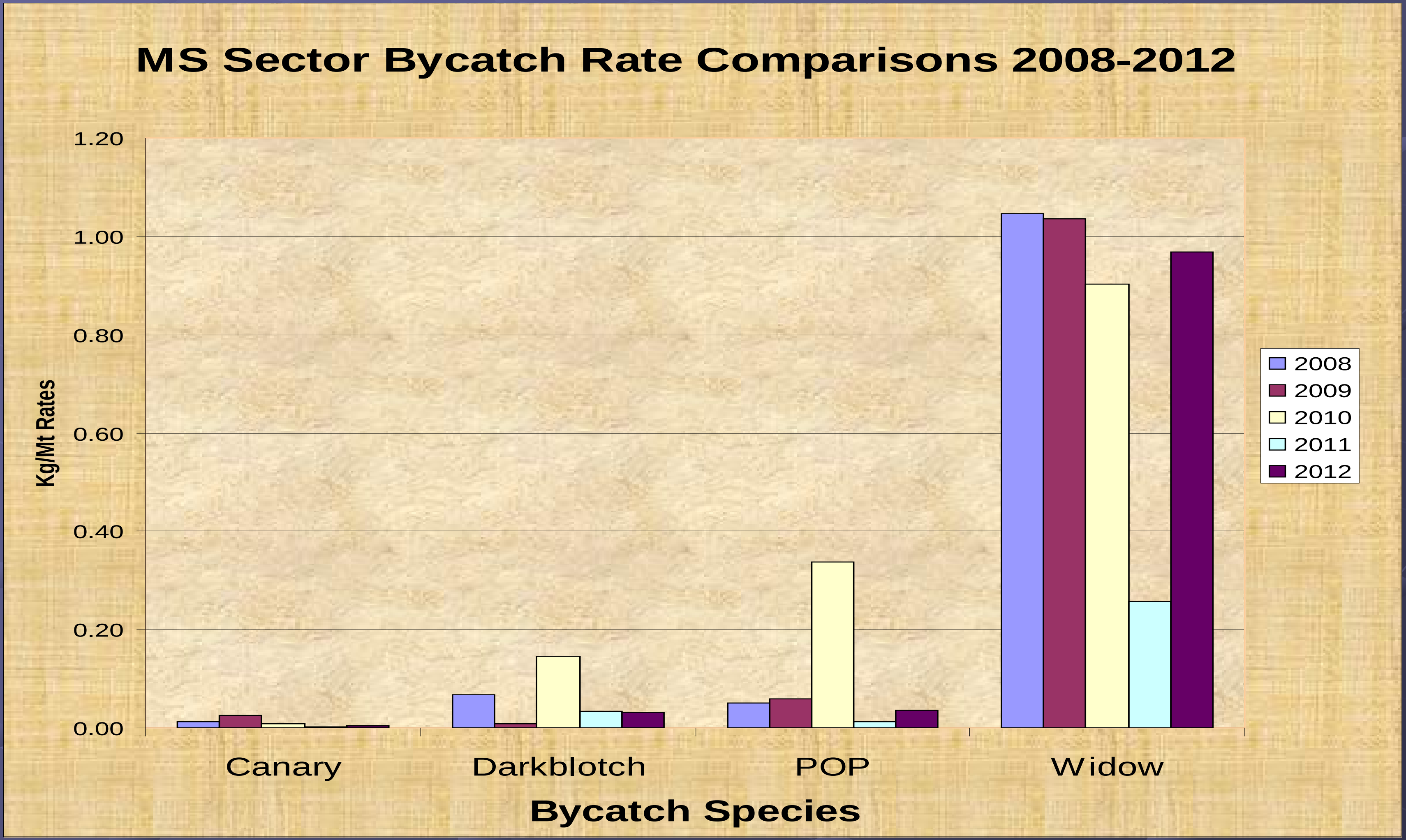
Results

In 2012, the 2nd year of the Coop, nearly 100% of the whiting was caught with a fraction of the allocated bycatch

WMC Catch and Bycatch Use
through Dec. 31st, 2012



2008 through 2012 Rates



Other Changes

- Fleet fished from May 15 until December
- Awareness that this is not a race

Questions?

Agenda Item D.2.c
NMFS Office of Law Enforcement Report
April 2013

TRAT Compliance Summary, 2012

Trat Fishery Overview*

- Shoreside IFQ Trawl
  - # of vessels: 67 in 2012 64 in 2011
  - # of trips: 1121 in 2012 989 in 2011
- Shoreside IFQ Fixed Gear
  - # of vessels: 25 in 2012 14 in 2011
  - # of trips: 281 in 2012 221 in 2011
- Shoreside IFQ Whiting
  - # of vessels: 24 in 2012 11 in 2011
  - # of trips: 736/2012 818 in 2011
- Mothership Catcher Vessel
  - # of vessels: 18 in 2012 ? in 2011
  - # of trips: 39 in 2012 29 in2011
- *2011 data is for the first 10 m0nths of 2011

2012 Trat IFQ Overview

- 138 Quota Share Holder Accounts
  - 140 in 2011
- 145 Vessel Accounts
  - 109 Fished
  - 36 did not fish
  - 149 in 2011
- 51 First Receiver Site Licenses
  - 34 purchased IFQ groundfish
  - 50 FR Site Licenses issued in 2011
- 2529 E-Fish Ticket Submittals
  - 3027 in 2011

E Fish Ticket Reporting

- 2529 E Ticket Reports in 2012
  - 96% of those ticket were submitted with 48 hours
    - (24hr reporting requirement)
  - California, 19 FRs submitted 671 E Tickets
  - Oregon, 10 FRs submitted 1576 E Tickets
  - Washington, 5 FRs submitted 282 E Tickets

- 3037 total in 2011
- Through 10/31/11, 2370 E Ticket submittals

  2122 submitted within 48 hrs (90%)

OLE Violation Investigation Summary

- VMS/RCA Investigations Opened (all fisheries)
  - SW 2010: 75 NW 2010: 171
  - SW 2011: 72 NW 2011: 162
  - SW 2012 89 NW 2012: 134

VMS/RCA (Trawl)

- Non Reporting Violations: 1 in 2012 11 in 2011
- RCA/EFH Incursions: 50 in 2012 122 in 2011
- Total Vessels: 18 in 2012 59 in 2011

OLE Violation Investigation Summary

- Gear Violations
  - 0 in 2012
  - 1 in 2011
- Declaration Violations, (including MSCV and Shoreside)
  - 7 improper declarations in 2012
  - 11 in 2011
- 30 Day Clock Violation
  - 0 in 2012
  - 0 in 2011

OLE Violation Investigation Summary

- Fishing in 2 Management Areas on the Same Trip
  - 1 in 2012
  - 2 in 2011
- Fishing Prior to establishing Vessel Account
  - 0 in 2012
  - 2 in 2011
- Fishing in Deficit
  - 13 incidents in 2012 involving 9 vessels
    - 2 vessels accounted for 6 of these incidents
    - 7 vessels had single events
  - 60 incidents in 2011 involving 30 vessels

2011 Observer Violation Investigation Summary

- 11 open cases involving Observer issues
  - Observer Harassment (8)
  - Lack of Observer Coverage (1)
  - Missing Species (3)
  - Complaints involving observer conduct (3)

2012 Observer Violation Investigation Summary

ASHOP (at-sea sector)

- 1 incident of Sexual Harassment
- 2 incidents of Sample Bias (mixing unsampled hauls/pre-sorting)
- 2 incidents of Unsafe Conditions
- 1 incident of Failure to Notify
- 1 incident of Flowscale Issue/Tampering
- Total = 7

2012 Observer Violation Investigation Summary

- WCGOP
  - 11 incidents of unsafe conditions
  - 4 incidents of Failure to Notify
  - 1 incident of Fail to return to port w/in 36 hours of unsampled haul
  - 1 incident of Unlawful Take of Seabirds
  - 6 incidents of Harassment / Intimidation
  - 1 incident of Trip Refusal
  - 1 incident of Exceeding Observer Assignment Limitations
  - 1 incident of Observer Interference/ bribery
  - 3 incidents of Industry Complaints against Observers
  - Total = 29

2012 Catch Monitor Violation Investigation Summary

- 1 incident for Failure to Complete Offload,
- 1 incident for Failure to Accurately Sort Catch
- 3 incidents of Offloading without CM present
- I Incident for Failure to Maintain Required Documents
- 1 incident for Failure to Accurately Weigh Catch
- 2 incidents of Unsafe Conditions
- 2 incidents for Data Discrepancy
- Total =11

USCG District 13/11

- 98 Groundfish Trawl vessels boarded in 2012
- No Trat Related Violations reported
- 7242 hours expended on the Living Marine Resources (LMR) mission
- Trat represents 14% of the total LMR mission

OSP / WDFW / CDF&G Activity Report for 2011

- Patrol Hours: 952
- Contacts: 709
- Violations:
  - Warnings - 7
  - Citations – 2
  - Investigations – 4

  * Funding for states available Sept. 2011

State Enforcement

- Washington Department of Fish and Wildlife
  - Hours: 1750.5
  - Contacts: 1021
  - Warnings: 8
  - Citations: 5
  - Federal Referrals: 3
- Oregon State Police
  - Hours: 1337.5
  - Contacts: 778
  - Contacts Not In Compliance: 24
  - Illegally Harvested Fish: 3
- California Fish and Game
  - Hours: 340.5
  - Contacts: 188
  - Warnings: 3
  - Citations: 12
  - Federal Referrals: 2
  - Federal Referrals to CDF&G: 2

GROUNDFISH ADVISORY SUBPANEL REPORT ON THE STATUS OF THE RATIONALIZED TRAWL FISHERY

The Groundfish Advisory Subpanel (GAP) heard a presentation from Dr. Sean Matson on the Annual Catch Report for the Shorebased Individual Fishing Quota program for 2011-2012. The report was thorough and we appreciated the information that was shared.

The GAP would like to take this opportunity to note that the attainment of many non-whiting annual catch limits (ACLs) such as Dover remains low and that the cumulative attainment for all non-whiting species combined is less than 30 percent. This report demonstrates that we are not achieving optimum yield for many of our individual quota species. The GAP believes that artifacts from previous management regime regulations are preventing higher attainment of some of the ACLs. The GAP once again encourages the Council and National Marine Fisheries Service to prioritize the trawl trailing amendments, which will result in the trawl fleet's ability to achieve higher attainments of quota and extract more value out of this fishery and to also free up time to address non-trawl management issues.

PFMC
04/06/13

Agenda Item D.2.c
Supplemental NMFS Report
April 2013

Annual Catch Report for the Pacific Coast Groundfish, Shorebased IFQ Program in 2012

Sean E. Matson, Ph.D.
National Marine Fisheries Service
NWR, Sustainable Fisheries Division

April 3, 2013

Table of Contents

A. List of Figures

B. List of Tables

1. Summary

The Shorebased Individual Fishing Quota (IFQ) Program has been in place more than two years, and there have been some notable changes during the second year of the rationalized fishery.

Non-whiting attainment increased by five percent, from 24 percent in 2011, to 29 percent in 2012. Overall attainment in the fishery decreased by two percent, accompanying a three percent decline in Pacific whiting attainment. Catch of whiting dominates the overall aggregate fishery attainment estimate; this species alone made up 78.5 percent of total catch by weight in the shorebased IFQ fishery during 2012. The reduction in attainment may be tied to reapportionment of whiting late in the season (mid-October). There was no such reapportionment in 2011.

Preliminary data indicate the use of fixed gear increased for sablefish (the most valuable species in the fishery), due to hook-and-line gear landings increasing from 13 to 19 percent of IFQ sablefish landings; the resulting revenue (hook-and-line sablefish) increased from 18 to 28 percent of all IFQ sablefish revenue. As a result, 58 percent of sablefish revenue in the IFQ program was from fixed gear in 2012, up ten percent from 2011.

Commerce-related quota pound transfers (transfers between vessel accounts for cash, barter or a combination of both) were much more evenly distributed throughout 2012 than 2011; transfers started immediately in January of 2012, and activity remained more regular throughout the rest of the year than during 2011. This suggests a greater knowledge of the IFQ management system and earlier planning on the part of participants.

Revenue distribution among species also became more even, coinciding with much lower ex-vessel prices and lower attainment of sablefish during 2012, especially south of 36° North latitude, accompanied by increases in attainment and revenue of other species (perhaps compensatory) such as petrale sole, Pacific cod, lingcod and slope rockfish.

Aggregate measures of landings, revenue, effort and catch per unit effort were very similar between 2011 and 2012. Retention rates remain high, and have changed little; aggregate estimates are up a fraction of a percent, and show relatively small fluctuations among species.

Catch of rebuilding species remains lower two years after trawl rationalization, compared with the two previous years under trip limit management. Data are preliminary and subject to change.

2. Data used in this report

The purpose of this report is to summarize and illustrate current catch data and trends for the shorebased component of the Pacific Coast Groundfish IFQ Program in 2012, and compare them with the 2011 fishery. This is an examination of current data, which divides catch estimates among strata of interest to many stakeholders. Data for 2012 are preliminary and subject to change.

Data used in this report originated from four sources, and only pertain to the shorebased non-whiting and shorebased whiting fleets, of the Pacific Coast Groundfish IFQ Program. Data from the at-sea whiting fisheries (catcher-processor and mothership) are not included. Landings and revenue data, along with the surrounding gear, area, port, and species information, were combined from electronic and paper landing receipts (fish tickets). Electronic fish ticket data were provided by the Pacific States Marine Fisheries Commission (PSMFC), for the most recent IFQ landings not yet represented in the Pacific Fisheries Information Network (PacFIN) database, which houses data from traditional, paper fish tickets. Only landings and revenue from groundfish (management group = GRND) are considered from fish ticket data in this report. Information regarding total catch of IFQ species categories, discarded catch, retention rates, participation, effort and transfers of quota pounds (QP) originated from the National Marine Fisheries Service's (NMFS) IFQ Vessel Accounts (VA) database. Only species/area groups that are managed using quotas (IFQ species/area categories) are included in NMFS vessel account data. Some historical catch data were provided from groundfish mortality reports by the West Coast Groundfish Observer Program (WCGOP) of the Northwest Fishery Science Center, within the National Marine Fisheries Service (NMFS). Only catch within the Pacific Fishery Management Council (PFMC) jurisdiction is considered in this report. Data from electronic and paper landing receipts were queried on January 18, 2013; data from the NMFS Vessel Accounts System were queried on January 8, 2013. Data from 2012 are preliminary, and may be subject to change.

Landed catch from electronic and paper fish tickets is reported as landed weight. In aggregate, across all species, where both landed and round weights were available, landed weight was equal to 99.84% of round weight. Revenue is reported as ex-vessel revenue, and is not adjusted for inflation or other factors. Discarded catch was discarded at sea, and dockside discard is not included in this report. Total catch refers simply to the sum of landed and discarded catch. Bycatch refers to fish that were caught along with the intended target species, whether they were landed or discarded. One trip was defined as a unique vessel-landing-day; this was done to avoid overestimation of counts of trips due to single landings which were reported on two separate receipts ("split tickets"). Non-whiting and shorebased directed whiting fleets were separated by the proportion of total landed trip weight that was made up by whiting in each trip. If a trip contained 50 percent Pacific whiting or greater, and was landed by trawl gear, it was considered a directed whiting trip, and those landings and revenue are presented under the shoreside whiting fleet in this report (as within PacFIN). Vessel counts shown in this report were taken from the NMFS, IFQ Vessel Accounts database. Current discarded catch estimates may in some cases be slight underestimates, due to potential lag behind landings, and are expected to be finalized during spring of 2013.

3. Landings and revenue

3.1. Landings and revenue by fleet

3.1.1. Non-whiting

Landings in the shorebased non-whiting fleet were up slightly in 2012, at 101 percent of 2011 levels (40,892,262 pounds versus 40,610,190 pounds, respectively, Table 1). Revenue in 2012 maintained 92 percent of 2011 levels (30,452,763 dollars in 2012 versus 32,935,934 dollars in 2011), despite a 56 cent per pound drop in sablefish prices, a six percent decrease in sablefish landings and a 24 percent decrease in revenue from sablefish, or 4.2 million dollars (17,614,666 dollars in 2011 versus 13,356,592 dollars in 2012).

Monthly trajectories of landings and revenue, by both the non-whiting and shorebased whiting fleets for 2012 are also very similar to the previous year, although non-whiting landings and revenue in December of 2012 returned to levels similar to pre-IFQ. Landings and revenue during December 2011 spiked much higher than typical December levels (Figure 1, Table 1).

Considering the non-whiting fleet for the two years before and the two years after trawl rationalization (Figure 2, Table 2), revenues have been 12.5 percent higher, although annual landings have on average been 24.8 percent lower. Total monthly landings and revenue have been somewhat more variable throughout the year, in the first two years following trawl rationalization, than before it.

3.1.2. Shorebased whiting

Landings within the directed shorebased whiting fleet were down in 2012, at 72 percent of 2011 levels (146,355,341 pounds, versus 203,243,752 pounds, respectively, Table 1). Revenue remained at 92 percent of 2011 levels in 2012 (20,958,679 dollars versus 22,810,819 dollars respectively), due to higher ex-vessel prices. The price of whiting increased from 11 cents per pound in 2011 to 14 cents in 2012, partially mitigating the 28 percent lower landings, along with a 26 percent lower allocation (and lower U.S. TAC). The whiting TAC is highly variable among years due to stock dynamics.

<u>3.2. Landings and revenue by port</u>

Distributions of landings and revenue by port group for 2011 and 2012 are shown in Figure 3 and Table 3, both for non-whiting and whiting trips.

3.2.1. Non-whiting

Non-whiting landings in Astoria were slightly lower than 2011 (down three percent), although revenue was slightly higher (up nine percent). Changes in landings and revenue were different across species; increases in revenue were apparent for many species, including petrale sole, Pacific cod, yellowtail rockfish, shelf rockfish, several flatfish species, and lingcod in Astoria, compared to 2011.

There was a considerable increase in non-whiting landings (three-fold) and revenue (up 51 percent) in Westport during 2012 versus 2011 (increases were seen for arrowtooth flounder, Dover sole and sablefish), and there were some substantial differences in a few other port groups. The Newport, Tillamook and Garibaldi group saw both higher landings and revenue than the same time last year (up 30 percent and nine percent, respectively). Sablefish, Dover sole, petrale sole and other species were important for increased revenue in the Newport group over the same time last year. The Bellingham (and northward) port group, as well as the Brookings/Crescent City/Port Orford group both showed increased revenue compared with 2011 (up 20 percent and eight percent, respectively). Revenue for the Charleston port group was unchanged, while Ilwaco/Chinook and the San Francisco/San Mateo/Princeton/Bodega Bay groups dropped sharply (56 percent and 54 percent of 2011 levels, respectively). The Eureka, Fort Bragg, and Moss Landing groups showed more modest decreases in revenue (82, 75, and 69 percent of 2011 levels, respectively).

3.2.2. Shorebased whiting

Looking at the shorebased whiting fleet, although total annual revenue was down eight percent from 2011, revenue for the Newport, Tillamook, Garibaldi, Charleston and Winchester Bay group was up 11 percent from 2011; in the Westport, Ilwaco, Chinook group, it was up three percent. Revenue from shorebased whiting trips in 2012 for Astoria was down, at 74 percent of 2011 levels.

3.3. Landings and revenue by gear

According to preliminary data, the proportion of sablefish landed with fixed gear has increased in the shorebased IFQ program by four percent, compared with 2011 (Figure 4, Table 4). As a result, 58 percent of the revenue from sablefish in this fishery is estimated to come from fixed gear (up ten percent from 2011), due to increases in landings using hook-and-line gear. These changes in gear use for sablefish translated in small overall changes to the distribution of aggregate landings of all groundfish species, and associated revenue among gear types for the entire non-whiting fleet (Table 5). Much lower prices were seen in 2012 for sablefish for hook-and-line, pot, and trawl gear, than during 2011 (Figure 5). Fixed gear accounts for one fourth of the non-whiting revenue in the fishery, although it currently makes up only seven percent of landings.

3.4. Landings and revenue by species

3.4.1. Non-whiting

Annual ex-vessel revenue by species/market category (those with annual revenue of more than $10,000 in 2012), for non-whiting trips during 2011 and 2012 are shown in Table 6; they are sorted from species with the highest revenue in 2012, to lowest. Sablefish generated the most non-whiting revenue in 2012, followed by Dover sole, petrale sole and shortspine thornyheads, respectively. Yellowtail rockfish was ranked fifth in revenue in 2012 with 2.8 percent of the non-whiting revenue (Figures 6 and 7, Table 6), up five places from 2011 when it was ranked tenth, with 1.1 percent. The annual ex-vessel price (Table 6) of sablefish was down 56 cents per pound, up slightly for Dover sole (up one cent), petrale sole (up four cents), and shortspine thornyheads (up six cents), and down slightly for yellowtail rockfish (down two cents).

Figures 6 and 7, and Table 6 show relative proportions of non-whiting revenue by species/market category, and changes from 2011 to 2012. The proportion of non-whiting revenue made up by sablefish dropped by 9.6 percent from 2011 to 2012, as a result of its drop in ex-vessel price, and a six percent drop in landings. A few other species increased notably in their proportion of non-whiting revenue, including petrale sole (up 3.3 percent), yellowtail rockfish (up 1.7 percent), longnose skate (up 0.8 percent), and Pacific cod (up 0.8 percent).

The distribution of revenue among non-whiting species/market categories became somewhat more even in 2012 than 2011, shown by Gini coefficient values of 0.82 versus 0.86 respectively (Table 7). This is related to the drop in sablefish prices, as well as sablefish landings, since this species is by far the most valuable species in the groundfish fishery, and thus large fluctuations in price have a pronounced effect on the relative distribution of revenue among species landed. Changes in ex-vessel prices and landings of other species are also important, such as those few mentioned earlier in this section (e.g. petrale sole, shortspine thornyheads, and yellowtail rockfish).

The total count of groundfish market categories landed in 2012 also increased by six, from 64 to 70; however the number of categories which generated any reported revenue increased by only two, from 62 to 64; many of those generated less than $10,000 annually, and are thus not shown here.

The Gini coefficient is an index of inequality for continuous data (usually economic data), with higher values indicating more inequality. Lower values indicate less inequality, or more evenness of distribution among categories. Values can range from zero (complete uniformity) to one (complete inequality). The Shannon Index of diversity was used in the mid-year IFQ report in 2012 for a similar discussion (*Agenda Item F.3.b., Supplemental NMFS Report, March 2012*); the Shannon Index combines evenness of distribution, together with richness (number of categories represented). The Gini coefficient is more comprehensible and specific for the purposes of this discussion about a constrained number of categories; it only quantifies evenness, where richness can be discussed separately.

3.4.2. Shorebased whiting

Table 8 shows landings and revenue by species, for whiting trips; Table 9 shows the relative distribution of those landings and revenue among species/market categories for 2011 and 2012. Revenue distribution among species changed little, except for a 0.9 percent decrease in the proportion of whiting fleet revenue from yellowtail rockfish, accompanying a 51 percent decrease in landings, and no change in annual yellowtail ex-vessel price, from 2011 to 2012.

4. Participation, coarse effort and catch per unit effort

Overall fishery participation, in terms of vessel counts, decreased by three vessels, from 108 in 2011 to 105 in 2012 (Table 10). Among those, the number of vessels making non-whiting trips dropped from 94 in 2011 to 88 in 2012, and vessels making whiting trips dropped from 26 to 24. The number of vessels making both whiting and non-whiting trips also dropped from 12 in 2011 to six in 2012. The monthly distribution of vessel participation is shown in Figure 8; 2011 and 2012 monthly distributions are similar, except for a conspicuous spike in whiting vessel participation in November 2012, following whiting reapportionment on October 17. There was also a dip in 2012 non-whiting participation during June and July of 2012, compared to 2011; this corresponds with a three-month lull in monthly sablefish landings, from May through July of 2012.

There has been little change in trip-level measures of non-whiting effort, and catch per unit effort between 2011 and 2012; the aggregate number of trips, total catch, and catch per trip for mid-year 2012 were all within three percent of 2011 levels (Figure 9, Table 11). Data from the NMFS Vessel Accounts Database were used for effort and participation, and cover IFQ species/area categories only.

5. Commerce-related quota pound transfer activity

5.1. Accounts

Some of the most interesting recent changes in the IFQ fishery involve transfers of quota pounds among vessel accounts. These data suggest that fishers knew better what to expect in the second year of trawl rationalization, and as a result they were utilizing tools of the program to manage their quotas earlier in the year, and more efficiently, to plan their fishing year.

Figure 10 and Table 12 show metrics used to describe monthly commerce-related transfers of quota pounds during 2011 and 2012. These include transfers that were made from vessel account to vessel account, and for cash, barter, or a combination of the two.

Commerce-related transfers began immediately in January of 2012, with 115 transfers for more than 1.3 million pounds, program-wide; in January of 2011, there were no commerce-related transfers. In 2011, transfer activity ramped up slowly. Monthly activity during 2012 was in sharp contrast with 2011 (Figure 10, Table 12); the differences can be seen in transfers per month, number of vessels transferring, and pounds transferred.

Transfer activity was much more evenly distributed through 2012 than 2011 (Figure 10). This is also shown by annual values of the Gini coefficient (Table 10), where 2011 Gini values are higher for each metric than 2012 values. Lower values indicate more even distribution among categories (less inequality). Values can range from zero (complete uniformity) to one (complete inequality). Numbers of transfers per month in 2011 yielded a Gini coefficient value of 0.42, and in 2012 the corresponding value was only 0.24. The total number of commerce-related transfers for 2012 was 18 percent lower than during 2011 (1,012 versus 1,236 respectively). For the number of vessel accounts involved in transfers per month during 2011, the Gini value was 0.42, while for 2012 it was 0.20, again showing more even temporal distribution within 2012. Monthly pounds transferred, whether including or excluding hake, was much more evenly distributed in 2012 than 2011. The Gini coefficient value for pounds transferred including hake was 0.62 in 2011 versus 0.40 in 2012; without hake, the Gini value for 2011 was 0.55, versus 0.28 in 2012. Total pounds transferred (commerce-related) was lower in 2012 than 2011, whether hake was included or not.

Together, more evenly distributed commerce-related transfer activity throughout the year (considering several metrics), lower total numbers of such transfers, and lower total pounds transferred (with and without hake) suggest that participants carried out their activities in 2012 with more knowledge, planning and familiarity with the program than in its initial year of 2011. This report does not contain data on risk pools, as that information is not currently available in conjunction with these detailed transfer data.

5.2. Species

Figure 11 and Table 13 show commerce-related trading activity of quota pounds by species/area IFQ category. During 2012, the five most frequently traded species/area IFQ category were Pacific whiting, followed by sablefish north of 36° N. lat., petrale sole, widow rockfish, and canary rockfish.

Rankings by frequency of transfer changed somewhat from 2011 to 2012, especially for a handful of species. Three of the most striking changes in rank occurred for canary rockfish, yellowtail rockfish, and sablefish south of 36° S. lat. Canary rockfish, which was the fifth most transferred species in 2012, increased by 15 ranks from 2011, when it was twentieth. Yellowtail rockfish was the seventh most transferred (commerce-related) category in 2012, up nine places from 2011, when it was eighteenth. Sablefish south of 36° S. lat. was the fourth most transferred species in 2011, but was ranked 41 in 2012. Sablefish north of 36° N. lat. was by far the most frequently transferred species during 2011; however, in 2012 it ranked second, behind Pacific whiting. Differences in the annual number of commerce-related transfers for each species between 2011 and 2012 are highlighted in Figure 11, which is sorted descending, based on numbers of transfers per species in 2012.

6. Total catch, attainment and retention rates

6.1. Total catch and attainment

Aggregate attainment of all species categories other than whiting increased by five percent in 2012, to 29 percent, from 24 percent in 2011. Although total IFQ fishery catch is lower than last year (by 56.6 million pounds), this difference is almost entirely attributable to Pacific whiting, whose catch dropped by 56.3 million pounds from 2011 to 2012. The whiting allocation was 26 percent lower in 2012 than 2011 (53.2 million pounds), due to the lower U.S. Total Allowable Catch of whiting, which fluctuates widely from year to year, according to this stock's population dynamics. Although total attainment of whiting itself was three percent lower in 2012, the reapportionment which was made late in 2012 (October 17) is important to note in making comparisons with 2011, considering there was no reapportionment in 2011. The original 2012 allocation of Pacific whiting was 125.4 million pounds, all of which was caught, as part of the 144.7 million pounds of total catch during 2012. When reapportioned pounds were added to vessel accounts on October 17, the sector allocation increased to its final amount of 151.4 million pounds. Large directed whiting trips concluded in November (>1 M pounds), and several smaller trips were made through mid-December.

There have been several notable changes in attainment by species, between 2011 and 2012 (Table 14, Figure 12). The largest increases in attainment include the following: minor slope rockfish, south of 40°10' N. lat., up 19 percent; Pacific cod, up 13 percent; canary rockfish, up 13 percent; minor shelf rockfish, south of 40°10' N. lat., up 10 percent; and minor slope rockfish, north of 40°10' N. lat., up nine percent. The largest decreases in attainment include the following: sablefish south of 36° N. lat., down 42 percent, and shortspine thornyheads south of 34°27' N. lat., down 16 percent; yelloweye rockfish attainment was down four percent.

Although attainment of petrale sole currently shows as 100.3 percent on the NOAA Pacific Coast Groundfish Individual Fishing Quota tracking page as of March 21, 2013 (https://www.webapps.nwfsc.noaa.gov/ifq/), the catch includes surplus carryover pounds from 2011, and the 2012 allocation value does not. The 2012 annual allocation itself was not exceeded.

Figure 12 shows percent changes in IFQ species total fishery attainment of their respective allocations (including both non-whiting and whiting fleets), for 2011 and 2012 (top), as well as percent changes in retention rates for the non-whiting fleet only, during the same years (bottom).

6.2. Retention

Retention rates during 2012 were very similar to the high estimates from 2011. Table 15 shows percent changes in retention rates between 2011 and 2012, along with the raw amounts landed, discarded, and total catch (including only IFQ species). Overall, retention was up 0.2 percent, from 98.6% to 98.8%. There were relatively small changes in retention for each species; only two species showed changes of greater than 10 percent (chilipepper rockfish retention decreased by 10.3 percent, from 92 percent to 81.7 percent; splitnose rockfish retention increased by 12.8 percent, from 23.8 percent to 36.6 percent, Table 15, Figure 12).

Retention of rebuilding species was generally higher in 2012 than 2011, with the exception of darkblotched rockfish, which decreased by 0.9 percent (from 98.1 to 97.2 percent). Yelloweye rockfish retention increased by 8.6 percent (from 91.4 to 100.0 percent), canary rockfish retention increased by 3.3 percent (from 96.1 to 99.4 percent). Cowcod rockfish retention was up 8.1 percent (from 82.1 to 90.2 percent), and petrale sole was up by 0.9 percent (from 98.0 to 98.9 percent). Bocaccio rockfish retention remained unchanged, at 99.9 percent.

The aggregate retention rate estimated for non-whiting trips is 95.2 percent for 2012, up 0.8 percent from 2011. For directed whiting trips, the current 2012 estimate is 99.8 percent, up 0.4 percent from 2011. Retention rate estimates may be subject to change as observer discard data for 2012 are finalized.

7. Catch of rebuilding species

Catch of current rebuilding species has been much lower on average during the first two years of the IFQ program, compared with the previous two years. Figure 13 and Table 16 show annual catch of each rebuilding species from 2009 through 2012. In addition, Table 16 shows average catch for these species during 2009-10 (pre-IFQ), and 2011-12 (post-IFQ). For yelloweye rockfish, catch under the IFQ program has been 39.3 percent of previous, while cowcod rockfish has been just 10.4 percent of pre-IFQ; canary rockfish, 62.2 percent; bococcio, 43.3 percent; darkblotched, 31.9 percent; petrale sole, 67.2 percent (Figure 14). Petrale sole is managed as a target species under its rebuilding plan.

8. Acknowledgements

I would like to thank Dave Colpo of the Pacific States Marine Fisheries Commission (PSMFC); Brad Stenberg of the Pacific Fisheries Information Network (also PSMFC); Jeff Cowen of the Northwest Fisheries Science Center (NWFSC), National Marine Fisheries Service (NMFS); Sarah Towne, Kevin Ford and Dr. Stephen Freese of the Northwest Region, NMFS; Jon McVeigh, Janell Majewski, Marlene Bellman and Melissa Mandrup of the West Coast Groundfish Observer Program, NWFSC, NMFS for their support, in supplying data for this and past reports.

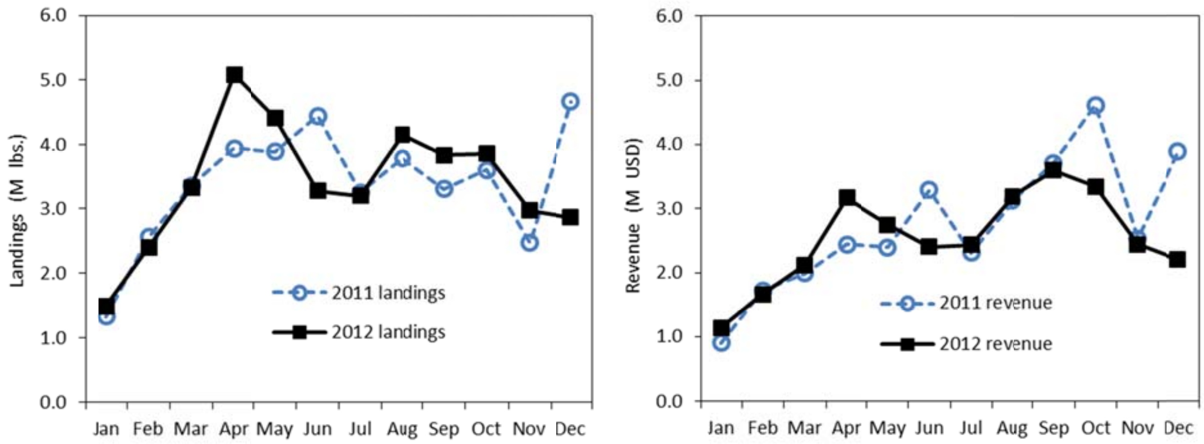


Figure 1. Monthly landings (left) and revenue (right) during 2011 and 2012, for non-whiting trips in the Shorebased IFQ Program. Source = paper and electronic landing receipt data (PacFIN and PSMFC, respectively).

Table 1. Monthly landings (left) and revenue (right) during 2011 and 2012, for non-whiting trips in the Shorebased IFQ Program. The "land % 2011" column expresses 2012 landings as a percentage of 2011 landings; the "rev % 2011" column expresses 2012 revenue in the same way. Source = paper and electronic landing receipt data (PacFIN and PSMFC, respectively).

Non-whiting trips

Month	2011 landings	2012 landings	2011 revenue	2012 revenue	Land. % 2011	Rev. % 2011
Jan	1,324,638	1,490,200	902,457	1,142,266	112%	127%
Feb	2,564,693	2,404,286	1,719,893	1,658,043	94%	96%
Mar	3,360,889	3,332,948	1,991,797	2,120,942	99%	106%
Apr	3,942,465	5,080,809	2,443,745	3,165,779	129%	130%
May	3,884,997	4,415,608	2,395,262	2,744,210	114%	115%
Jun	4,446,585	3,280,997	3,293,042	2,402,746	74%	73%
Jul	3,258,118	3,204,170	2,312,914	2,433,846	98%	105%
Aug	3,785,242	4,150,441	3,122,361	3,194,306	110%	102%
Sep	3,310,686	3,832,257	3,715,231	3,598,502	116%	97%
Oct	3,601,682	3,857,524	4,618,719	3,348,731	107%	73%
Nov	2,467,760	2,976,381	2,531,797	2,438,940	121%	96%
Dec	4,662,435	2,866,641	3,888,717	2,204,455	61%	57%
Total	40,610,190	40,892,262	32,935,934	30,452,763	101%	92%

Whiting trips

Month	2011 landings	2012 landings	2011 revenue	2012 revenue	Land. % 2011	Rev. % 2011
Jun	24,045,023	11,122,661	2,731,383	1,505,812	46%	55%
Jul	55,485,521	24,085,094	6,421,443	3,938,424	43%	61%
Aug	64,940,939	32,982,861	7,152,118	5,056,511	51%	71%
Sep	33,806,896	23,034,089	3,732,197	2,992,457	68%	80%
Oct	20,332,039	31,562,091	2,221,077	4,056,045	155%	183%
Nov	4,633,334	22,359,007	552,601	3,294,073	483%	596%
Dec	NA	1,209,538	NA	115,357	NA	NA
Sum	203,243,752	146,355,341	22,810,819	20,958,679	72%	92%

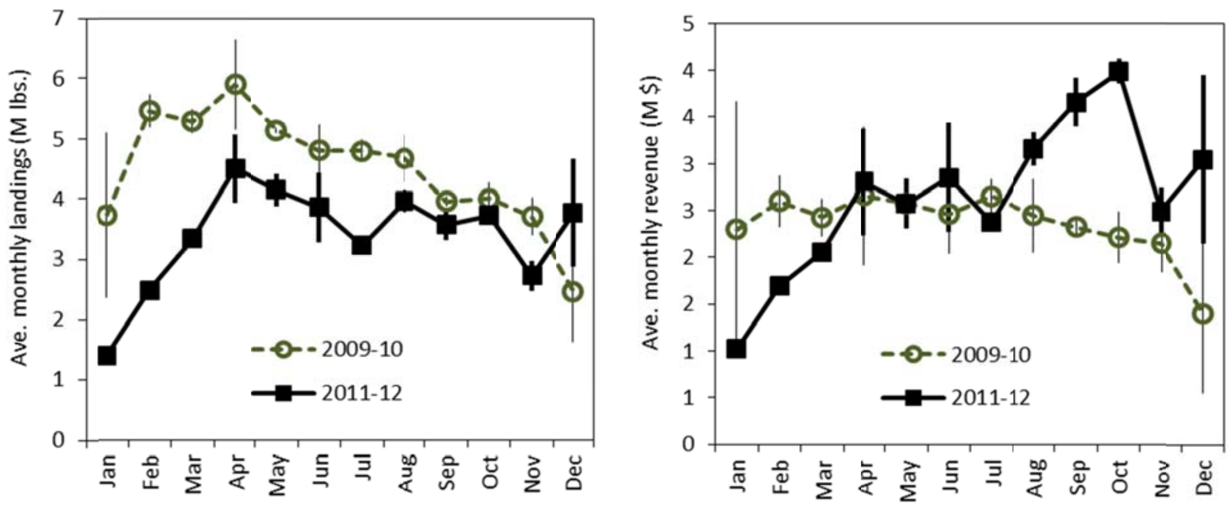
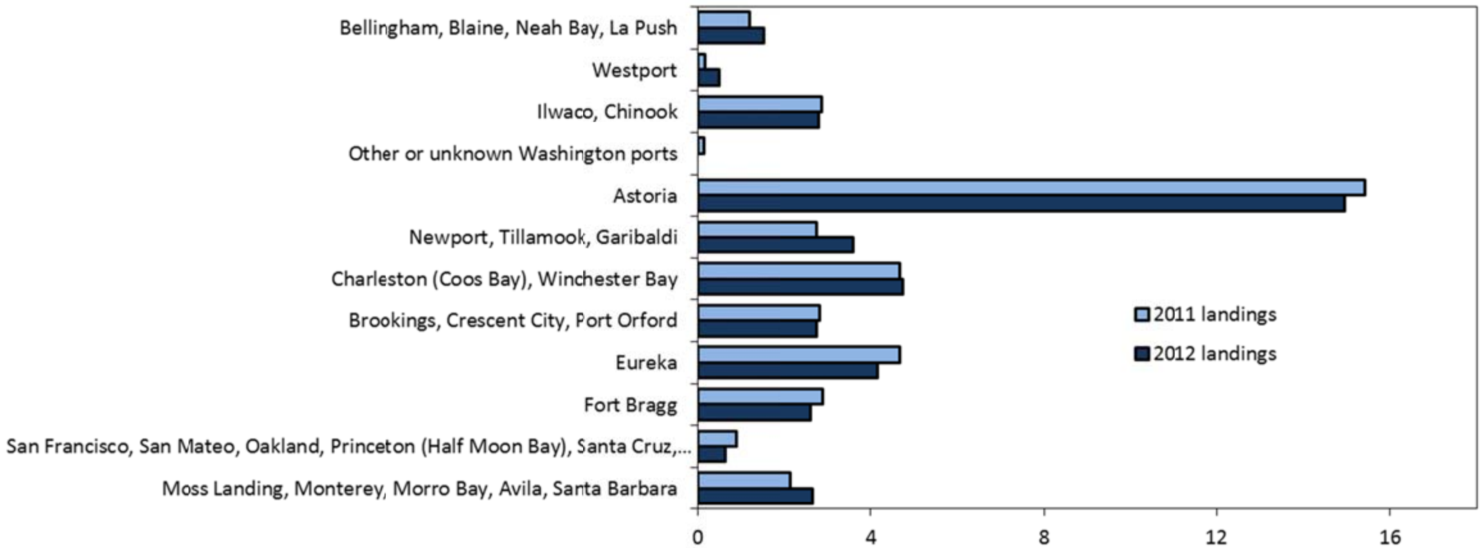


Figure 2. Average monthly landings (left) and revenue (right) during 2009-2010 (green open circles, dashed lines), versus 2011-2012 (black squares, solid lines), for non-whiting trips in the Shorebased IFQ Program (limited entry non-whiting trawl fishery during 2009-10). Source = paper and electronic landing receipt data (PacFIN and PSMFC, respectively).

Table 2. Average monthly landings (left) and revenue (right) during 2009-2010 (green open circles, dashed lines), versus 2011-2012 (black squares, solid lines), for non-whiting trips in the Shorebased IFQ Program (limited entry non-whiting trawl fishery during 2009-10). Source = paper and electronic landing receipt data (PacFIN and PSMFC, respectively).

Month	**Ave. landings**				**Ave. revenue**			
	2009-10	**2011-12**	**S.E. 09-10**	**S.E.11-12**	**2009-10**	**2011-12**	**S.E. 09-10**	**S.E. 11-12**
Jan	3,733,887	1,407,419	1,364,374	82,781	2,294,354	1,022,362	828,414	119,905
Feb	5,465,840	2,484,490	271,688	80,204	2,594,130	1,688,968	45,615	30,925
Mar	5,292,810	3,346,919	197,724	13,971	2,425,697	2,056,370	98,008	64,573
Apr	5,910,014	4,511,637	740,500	569,172	2,655,967	2,804,762	307,524	361,017
May	5,145,447	4,150,302	43,541	265,306	2,574,902	2,569,736	6,390	174,474
Jun	4,810,159	3,863,791	423,942	582,794	2,459,182	2,847,894	305,222	445,148
Jul	4,797,831	3,231,144	186,138	26,974	2,652,528	2,373,380	98,298	60,466
Aug	4,680,382	3,967,842	391,565	182,599	2,446,505	3,158,333	360,699	35,972
Sep	3,962,316	3,571,471	82,693	260,786	2,320,270	3,656,866	132,905	58,365
Oct	4,005,163	3,729,603	270,234	127,921	2,211,774	3,983,725	85,991	634,994
Nov	3,710,737	2,722,071	309,909	254,311	2,150,959	2,485,368	189,229	46,428
Dec	2,465,411	3,764,538	840,322	897,897	1,391,174	3,046,586	442,372	842,131
Annual	54,161,633	40,751,226	3,872,352	141,036	28,177,442	31,694,349	2,509,429	1,241,585



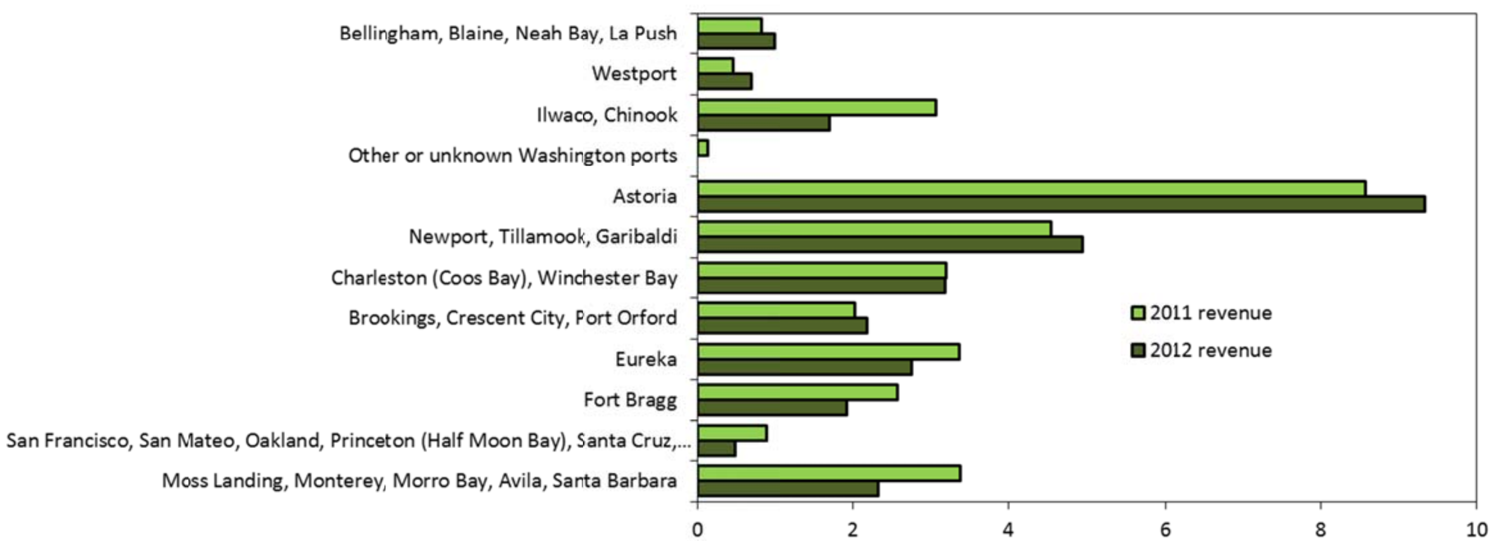


Figure 3. Landings and revenue by port group, for non-whiting trips, in the Shorebased IFQ Program. Port groups are arranged by latitude. Source = paper and electronic landing receipt data (PacFIN and PSMFC, respectively).

Table 3. Annual landings and revenue, distributed by port group, for non-whiting trips (top) and directed whiting trips (bottom), in the Shorebased IFQ Program, for 2011 and 2012. Port groups are arranged by latitude. Columns labeled "percent" express either 2012 landings or revenue (corresponding to the column appearing to left) as a percent of 2011 values. Columns labeled "dist." show the distribution of annual landings or revenue among port groups (%).

Port group (non-whiting trips)	**2011 landings**	**2012 landings**	**2011 dist.**	**2012 dist.**	**Land. difference**	**Land. percent**	**2011 revenue**	**2012 revenue**	**2011 dist.**	**2012 dist.**	**Rev. difference**	**Rev. percent**
Bellingham, Blaine, Neah Bay, La Push	1,185,687	1,500,658	3%	4%	314,971	127%	816,996	977,857	2%	3%	160,861	120%
Westport	162,774	494,278	0%	1%	331,504	304%	450,500	680,484	1%	2%	229,984	151%
Ilwaco, Chinook	2,882,683	2,809,640	7%	7%	-73,043	97%	3,051,630	1,700,006	9%	6%	-1,351,624	56%
Other or unknown Washington ports	130,220		0%	0%	-130,220	0%	127,621		0%	0%	-127,621	0%
Astoria	15,398,437	14,929,115	38%	37%	-469,322	97%	8,567,173	9,338,689	26%	31%	771,516	109%
Newport, Tillamook, Garibaldi	2,759,574	3,590,916	7%	9%	831,342	130%	4,538,783	4,935,313	14%	16%	396,530	109%
Charleston (Coos Bay), Winchester Bay	4,665,899	4,744,945	11%	12%	79,046	102%	3,187,748	3,171,837	10%	10%	-15,911	100%
Brookings, Crescent City, Port Orford	2,833,395	2,752,902	7%	7%	-80,493	97%	2,021,490	2,177,826	6%	7%	156,336	108%
Eureka	4,671,640	4,159,850	12%	10%	-511,790	89%	3,355,484	2,753,363	10%	9%	-602,120	82%
Fort Bragg	2,897,221	2,623,714	7%	6%	-273,507	91%	2,570,326	1,916,710	8%	6%	-653,616	75%
San Francisco, San Mateo, Oakland, Princeton (Half Moon Bay), Santa Cruz, Bodega Bay	869,663	621,684	2%	2%	-247,979	71%	878,513	476,211	3%	2%	-402,302	54%
Moss Landing, Monterey, Morro Bay, Avila, Santa Barbara	2,152,997	2,664,560	5%	7%	511,563	124%	3,369,670	2,324,466	10%	8%	-1,045,203	69%
Sum	40,610,190	40,892,262	100%	100%	282,072	101%	32,935,934	30,452,763	100%	100%	-2,483,170	92%

Port group (whiting trips)	**2011 landings**	**2012 landings**	**2011 dist.**	**2012 dist.**	**Land. difference**	**Land. percent**	**2011 revenue**	**2012 revenue**	**2011 dist.**	**2012 dist.**	**Rev. difference**	**Rev. percent**
Westport, Ilwaco, Chinook	50,597,855	37,654,325	25%	26%	-12,943,530	74%	5,700,215	5,848,889	25%	28%	148,674	103%
Astoria	94,478,623	52,460,824	46%	36%	-42,017,799	56%	10,537,842	7,786,722	46%	37%	-2,751,120	74%
Newport, Tillamook, Garibaldi, Charleston (Coos Bay), Winchester Bay	58,167,274	56,240,192	29%	38%	-1,927,082	97%	6,572,762	7,323,068	29%	35%	750,306	111%
Sum	203,243,752	146,355,341	100%	100%	-56,888,411	72%	22,810,819	20,958,679	100%	100%	-1,852,140	92%

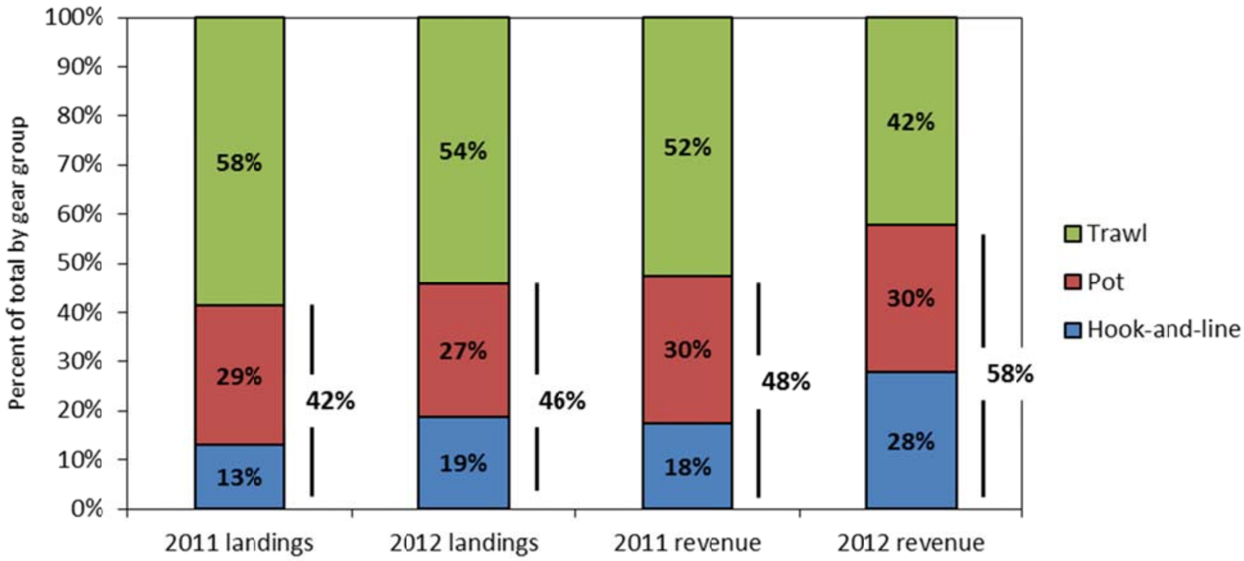


Figure 4. Landings and revenue composition of sablefish catch, by gear group, for non-whiting trips in the Shorebased IFQ Program, during 2011 and 2012. Whiskers to the right of each bar indicate the percent of annual sablefish landings or revenue from non-trawl gear. Source = combination of paper and electronic landing receipt data (PacFIN and PSMFC, respectively).

Table 4. Landings and revenue statistics of sablefish catch, by gear group, non-whiting trips in the Shorebased IFQ Program, during 2011 and 2012. Source = combination of paper and electronic landing receipt data (PacFIN and PSMFC, respectively).

Gear group	2011 landings	Land. % total	2011 revenue	Rev. % total	2011 price lb.
Hook-and-line	790,169	13%	3,091,808	18%	3.91
Pot	1,739,676	29%	5,284,804	30%	3.04
Trawl	3,562,521	58%	9,238,054	52%	2.59
Total	6,092,366	100%	17,614,666	100%	2.89

Gear group	2012 landings	Land. % total	2012 revenue	Rev. % total	2012 price lb.
Hook-and-line	1,083,978	19%	3,726,074	28%	3.44
Pot	1,553,421	27%	4,012,640	30%	2.58
Trawl	3,101,102	54%	5,617,878	42%	1.81
Total	5,738,501	100%	13,356,592	100%	2.33

Gear group	Landing % 2011	Rev. % 2011	Price % 2011	Δ land. dist.	Δ rev. dist.
Hook-and-line	137%	121%	88%	6%	10%
Pot	89%	76%	85%	-1%	0%
Trawl	87%	61%	70%	-4%	-10%
Total	94%	76%	81%	0%	0%

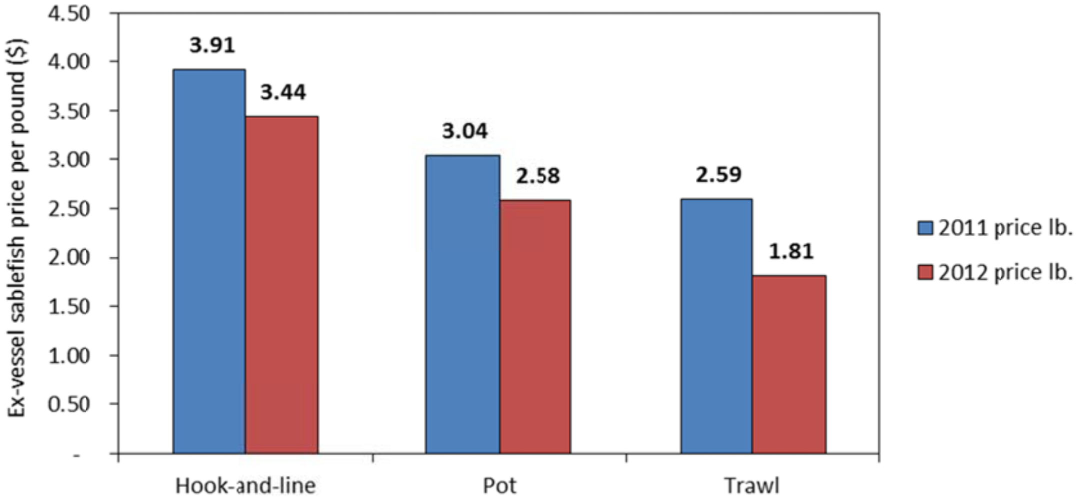


Figure 5. Annual, ex-vessel sablefish price, by gear group, for non-whiting trips in the Shorebased IFQ Program, during 2011 and 2012. Source = paper and electronic landing receipt data (PacFIN and PSMFC, respectively).

Table 5. Landings and revenue statistics of non-whiting groundfish catch, by gear group, for non-whiting trips in the Shorebased IFQ Program, during 2011 and 2012. Source = paper and electronic landing receipt data (PacFIN and PSMFC, respectively).

Gear group	2011 landings	Land. % total	2011 revenue	Rev. % total	2011 price lb.
Hook-and-line	855,569	2%	3,240,645	10%	3.79
Pot	1,763,990	4%	5,308,157	16%	3.01
Trawl	37,990,631	94%	24,387,131	74%	0.64
Total	40,610,190	100%	32,935,934	100%	0.81

Gear group	2012 landings	Land. % total	2012 revenue	Rev. % total	2012 price lb.
Hook-and-line	1,204,817	3%	3,800,194	12%	3.15
Pot	1,578,145	4%	4,043,669	13%	2.56
Trawl	38,109,206	93%	22,608,851	74%	0.59
Total	40,892,262	100%	30,452,763	100%	0.74

Gear group	Landings % 2011	Rev. % 2011	Price % 2011	Δ land. dist.	Δ rev. dist.
Hook-and-line	141%	117%	83%	1%	3%
Pot	89%	76%	85%	0%	-3%
Trawl	100%	93%	92%	1%	0%
Total	101%	92%	92%	NA	0%

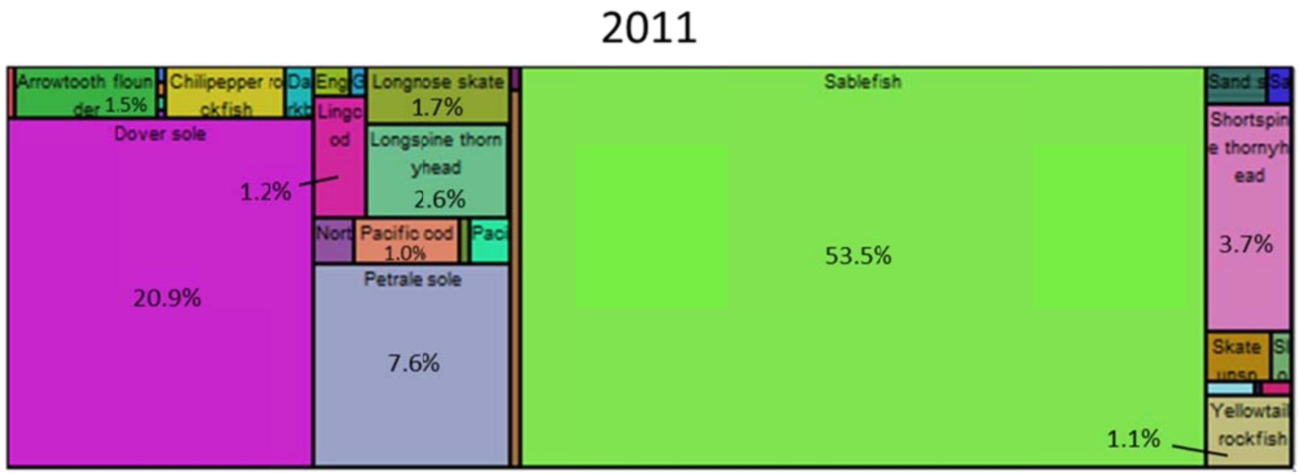


Figure 6. Treemap showing distribution of revenue among species/market categories, from non-whiting IFQ trips in the Shorebased IFQ Program, during 2011. Source = paper and electronic landing receipt data (PacFIN and PSMFC, respectively).

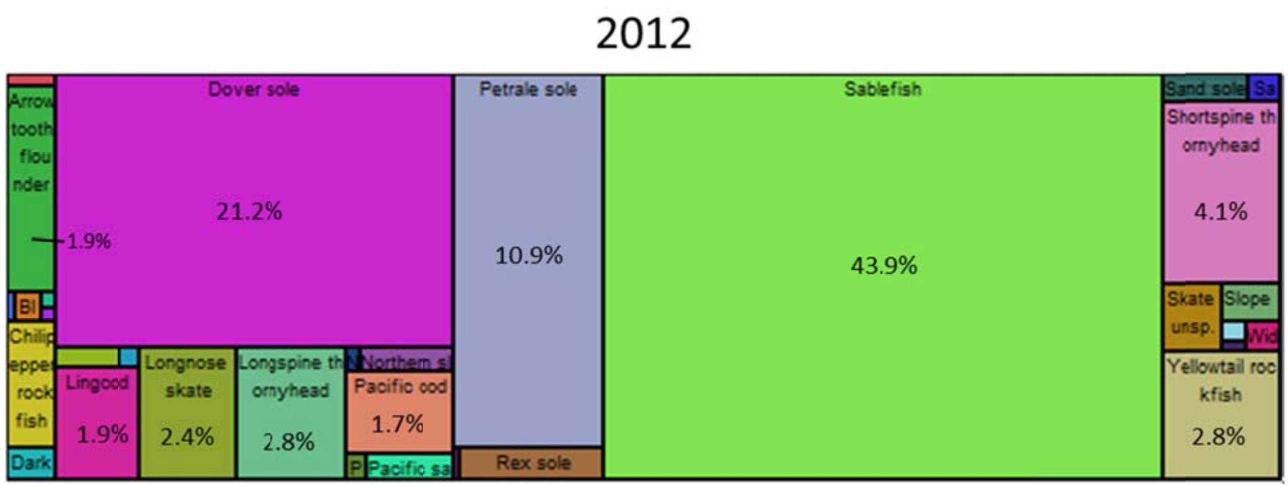


Figure 7. Treemap showing distribution of revenue among species/market categories, from non-whiting IFQ trips in the Shorebased IFQ Program, during 2012. Source = paper and electronic landing receipt data (PacFIN and PSMFC, respectively). Revenue distribution among these market categories became slightly more even in 2012 versus 2011 (Gini coefficient = 0.82 vs 0.86 respectively; lower value = less inequality), largely due to a 9.6% decrease in the representation of sablefish, and corresponding small increases in the representation of petrale sole, Dover sole, shortspine thornyheads, yellowtail rockfish, longnose skate, lingcod, etc.

Table 6. Aggregate revenue, landings, and price of groundfish market categories (categories with annual revenue > $10,000) for non-whiting trips in the Shorebased IFQ Program, during 2011 and 2012.

Species/market category	Landings 2011	Landings 2012	% of 2011	Revenue 2011	Revenue 2012	% of 2011	Price 2011	Price 2012	Δ price
Sablefish	6,092,366	5,738,501	94%	17,614,666	13,356,592	76%	2.89	2.33	-0.56
Dover sole	16,833,016	15,482,683	92%	6,880,589	6,456,137	94%	0.41	0.42	0.01
Petrale sole	1,746,901	2,254,657	129%	2,505,058	3,317,345	132%	1.43	1.47	0.04
Shortspine thornyhead	1,567,799	1,519,887	97%	1,203,433	1,254,320	104%	0.77	0.83	0.06
Yellowtail rockfish	692,841	1,667,700	241%	371,053	866,597	234%	0.54	0.52	-0.02
Longspine thornyhead	2,005,211	1,919,793	96%	844,622	849,890	101%	0.42	0.44	0.02
Longnose skate	1,680,592	1,839,038	109%	548,945	738,250	134%	0.33	0.40	0.07
Arrowtooth flounder	4,904,498	4,762,040	97%	480,174	589,725	123%	0.10	0.12	0.03
Lingcod	539,621	757,517	140%	405,065	565,473	140%	0.75	0.75	0.00
Pacific cod	554,113	871,274	157%	315,488	520,104	165%	0.57	0.60	0.03
Chilipepper rockfish	644,728	518,536	80%	411,062	356,406	87%	0.64	0.69	0.05
Rex sole	768,760	773,559	101%	261,082	270,878	104%	0.34	0.35	0.01
Skate unsp.	586,319	544,178	93%	202,326	239,188	118%	0.35	0.44	0.09
Sand sole	153,638	154,276	100%	144,397	147,890	102%	0.94	0.96	0.02
N. slope rockfish unsp.	253,748	287,133	113%	122,735	139,506	114%	0.48	0.49	0.00
Slope rockfish unsp.	101,559	202,153	199%	62,111	130,790	211%	0.61	0.65	0.04
Pacific sanddab	226,011	231,317	102%	115,984	119,286	103%	0.51	0.52	0.00
Darkblotched rockfish	194,164	176,858	91%	93,483	87,949	94%	0.48	0.50	0.02
English sole	239,084	253,600	106%	74,782	85,161	114%	0.31	0.34	0.02
Widow rockfish	57,907	111,391	192%	24,725	52,726	213%	0.43	0.47	0.05
Sanddabs unsp.	83,415	92,736	111%	56,504	52,079	92%	0.68	0.56	-0.12
Blackgill rockfish	5,225	48,399	926%	7,790	47,493	610%	1.49	0.98	-0.51
Spiny dogfish	154,052	114,107	74%	42,327	29,714	70%	0.27	0.26	-0.01
Pacific ocean perch	64,853	56,573	87%	31,742	29,482	93%	0.49	0.52	0.03
Grenadiers unsp.	198,705	186,784	94%	28,239	24,632	87%	0.14	0.13	-0.01
N. shelf rockfish unsp.	28,211	70,823	251%	10,002	22,488	225%	0.35	0.32	-0.04
Bank rockfish	11,172	20,290	182%	9,000	18,758	208%	0.81	0.92	0.12
Bocaccio rockfish	11,697	19,423	166%	7,759	13,505	174%	0.66	0.70	0.03
Splitnose rockfish	21,440	44,286	207%	7,012	12,125	173%	0.33	0.27	-0.05
POP group unsp.	34,892	22,625	65%	17,470	11,869	68%	0.50	0.52	0.02
Canary rockfish	5,914	19,718	333%	3,368	10,606	315%	0.57	0.54	-0.03
All others	147,739	130,407	88%	32,943	35,797	109%	0.22	0.27	0.05
Sum	40,610,190	40,892,262	101%	32,935,934	30,452,763	92%	0.81	0.74	-0.07
Total market category count	64	70	NA	62	64	NA	NA	NA	NA

Table 7. Distribution of revenue among species/market categories (categories with annual revenue > $10,000), from non-whiting IFQ trips in the Shorebased IFQ Program, during 2011 and 2012. Source = paper and electronic landing receipts (PacFIN and PSMFC, respectively).

Species/market category	Landings 2011	Land. dist. 2011	Landings 2012	Land. dist. 2012	Δ land. dist.	Revenue 2011	Rev. dist. 2011	Revenue 2012	Rev. dist. 2012	Δ rev. dist.
Sablefish	6,092,366	15.0%	5,738,501	14.0%	-1.0%	17,614,666	53.5%	13,356,592	43.9%	-9.6%
Dover sole	16,833,016	41.5%	15,482,683	37.9%	-3.6%	6,880,589	20.9%	6,456,137	21.2%	0.3%
Petrale sole	1,746,901	4.3%	2,254,657	5.5%	1.2%	2,505,058	7.6%	3,317,345	10.9%	3.3%
Shortspine thornyhead	1,567,799	3.9%	1,519,887	3.7%	-0.1%	1,203,433	3.7%	1,254,320	4.1%	0.5%
Yellowtail rockfish	692,841	1.7%	1,667,700	4.1%	2.4%	371,053	1.1%	866,597	2.8%	1.7%
Longspine thornyhead	2,005,211	4.9%	1,919,793	4.7%	-0.2%	844,622	2.6%	849,890	2.8%	0.2%
Longnose skate	1,680,592	4.1%	1,839,038	4.5%	0.4%	548,945	1.7%	738,250	2.4%	0.8%
Arrowtooth flounder	4,904,498	12.1%	4,762,040	11.6%	-0.4%	480,174	1.5%	589,725	1.9%	0.5%
Lingcod	539,621	1.3%	757,517	1.9%	0.5%	405,065	1.2%	565,473	1.9%	0.6%
Pacific cod	554,113	1.4%	871,274	2.1%	0.8%	315,488	1.0%	520,104	1.7%	0.8%
Chilipepper rockfish	644,728	1.6%	518,536	1.3%	-0.3%	411,062	1.2%	356,406	1.2%	-0.1%
Rex sole	768,760	1.9%	773,559	1.9%	0.0%	261,082	0.8%	270,878	0.9%	0.1%
Skate unsp.	586,319	1.4%	544,178	1.3%	-0.1%	202,326	0.6%	239,188	0.8%	0.2%
Sand sole	153,638	0.4%	154,276	0.4%	0.0%	144,397	0.4%	147,890	0.5%	0.0%
Northern slope rockfish unsp.	253,748	0.6%	287,133	0.7%	0.1%	122,735	0.4%	139,506	0.5%	0.1%
Slope rockfish unsp.	101,559	0.3%	202,153	0.5%	0.2%	62,111	0.2%	130,790	0.4%	0.2%
Pacific sanddab	226,011	0.6%	231,317	0.6%	0.0%	115,984	0.4%	119,286	0.4%	0.0%
Darkblotched rockfish	194,164	0.5%	176,858	0.4%	0.0%	93,483	0.3%	87,949	0.3%	0.0%
English sole	239,084	0.6%	253,600	0.6%	0.0%	74,782	0.2%	85,161	0.3%	0.1%
Widow rockfish	57,907	0.1%	111,391	0.3%	0.1%	24,725	0.1%	52,726	0.2%	0.1%
Sanddabs unsp.	83,415	0.2%	92,736	0.2%	0.0%	56,504	0.2%	52,079	0.2%	0.0%
Blackgill rockfish	5,225	0.0%	48,399	0.1%	0.1%	7,790	0.0%	47,493	0.2%	0.1%
Spiny dogfish	154,052	0.4%	114,107	0.3%	-0.1%	42,327	0.1%	29,714	0.1%	0.0%
Pacific ocean perch	64,853	0.2%	56,573	0.1%	0.0%	31,742	0.1%	29,482	0.1%	0.0%
Grenadiers unsp.	198,705	0.5%	186,784	0.5%	0.0%	28,239	0.1%	24,632	0.1%	0.0%
Northern shelf rockfish unsp.	28,211	0.1%	70,823	0.2%	0.1%	10,002	0.0%	22,488	0.1%	0.0%
Bank rockfish	11,172	0.0%	20,290	0.0%	0.0%	9,000	0.0%	18,758	0.1%	0.0%
Bocaccio rockfish	11,697	0.0%	19,423	0.0%	0.0%	7,759	0.0%	13,505	0.0%	0.0%
Splitnose rockfish	21,440	0.1%	44,286	0.1%	0.1%	7,012	0.0%	12,125	0.0%	0.0%
POP group unsp.	34,892	0.1%	22,625	0.1%	0.0%	17,470	0.1%	11,869	0.0%	0.0%
Canary rockfish	5,914	0.0%	19,718	0.0%	0.0%	3,368	0.0%	10,606	0.0%	0.0%
All others	147,739	0.4%	130,407	0.3%	0.0%	32,943	0.1%	35,797	0.1%	0.0%
Sum	40,610,190	100.0%	40,892,262	100.0%	0.0%	32,935,934	100.0%	30,452,763	100.0%	0.0%
Gini coefficient		0.79		0.76	NA		0.86		0.82	NA

Table 8. Aggregate revenue, landings, and price of groundfish species/market categories (categories with annual revenue > $10,000) from directed whiting trips in the Shorebased IFQ Program, during 2011 and 2012. Source = paper and electronic landing receipts (PacFIN and PSMFC, respectively).

Species/market category	Landings 2011	Landings 2012	% of 2011	Revenue 2011	Revenue 2012	% of 2011	Price 2011	Price 2012	Δ price
Pacific whiting	201,492,815	144,904,688	72%	22,029,928	20,355,436	92%	0.11	0.14	0.03
Yellowtail rockfish	960,381	474,212	49%	436,998	217,161	50%	0.46	0.46	0.00
Sablefish	66,983	104,082	155%	185,218	193,704	105%	2.77	1.86	-0.90
Widow rockfish	222,425	224,497	101%	97,128	88,624	91%	0.44	0.39	-0.04
Northern slope rockfish unsp.	24,298	158,270	651%	3,221	60,663	1883%	0.13	0.38	0.25
Spiny dogfish	406,464	351,915	87%	44,692	12,660	28%	0.11	0.04	-0.07
All others	70,386	137,677	196%	13,634	30,431	223%	0.19	0.22	0.03
Sum	203,243,752	146,355,341	72%	22,810,819	20,958,679	92%	0.11	0.14	0.03
Total market category count	28	30	NA	21	22	NA	NA	NA	NA

Table 9. Distribution of revenue among species/market categories (categories with annual revenue > $10,000), from directed whiting trips in the Shorebased IFQ Program, during 2011 and 2012. Source = paper and electronic landing receipts (PacFIN and PSMFC, respectively).

Species/market category	Landings 2011	Land. dist. 2011	Landings 2012	Land. dist. 2012	Δ land. dist.	Revenue 2011	Rev. dist. 2011	Revenue 2012	Rev. dist. 2012	Δ rev. dist.
Pacific whiting	201,492,815	99.1%	144,904,688	99.0%	-0.1%	22,029,928	96.6%	20,355,436	97.1%	0.5%
Yellowtail rockfish	960,381	0.5%	474,212	0.3%	-0.1%	436,998	1.9%	217,161	1.0%	-0.9%
Sablefish	66,983	0.0%	104,082	0.1%	0.0%	185,218	0.8%	193,704	0.9%	0.1%
Widow rockfish	222,425	0.1%	224,497	0.2%	0.0%	97,128	0.4%	88,624	0.4%	0.0%
Northern slope rockfish unsp.	24,298	0.0%	158,270	0.1%	0.1%	3,221	0.0%	60,663	0.3%	0.3%
Spiny dogfish	406,464	0.2%	351,915	0.2%	0.0%	44,692	0.2%	12,660	0.1%	-0.1%
All others	70,386	0.0%	137,677	0.1%	0.1%	13,634	0.1%	30,431	0.1%	0.1%
Sum	203,243,752	100.0%	146,355,341	100.0%	0.0%	22,810,819	100.0%	20,958,679	100.0%	0.0%

Table 10. Monthly vessel counts for non-whiting, directed whiting, and total, during 2011 and 2012 in the Shorebased IFQ Program. Source = Shorebased IFQ Program, Vessel Accounts System.

Month	2011 non-whiting	2011 whiting	2012 non-whiting	2012 whiting
Jan	23	0	27	0
Feb	31	0	32	0
Mar	41	0	46	0
Apr	45	0	43	0
May	41	0	38	0
Jun	46	15	41	13
Jul	49	22	40	19
Aug	54	22	52	20
Sep	55	18	55	15
Oct	56	15	54	17
Nov	47	7	50	21
Dec	49	0	46	3
Fleet total	94	26	88	24
Fishery total	108	NA	105	NA

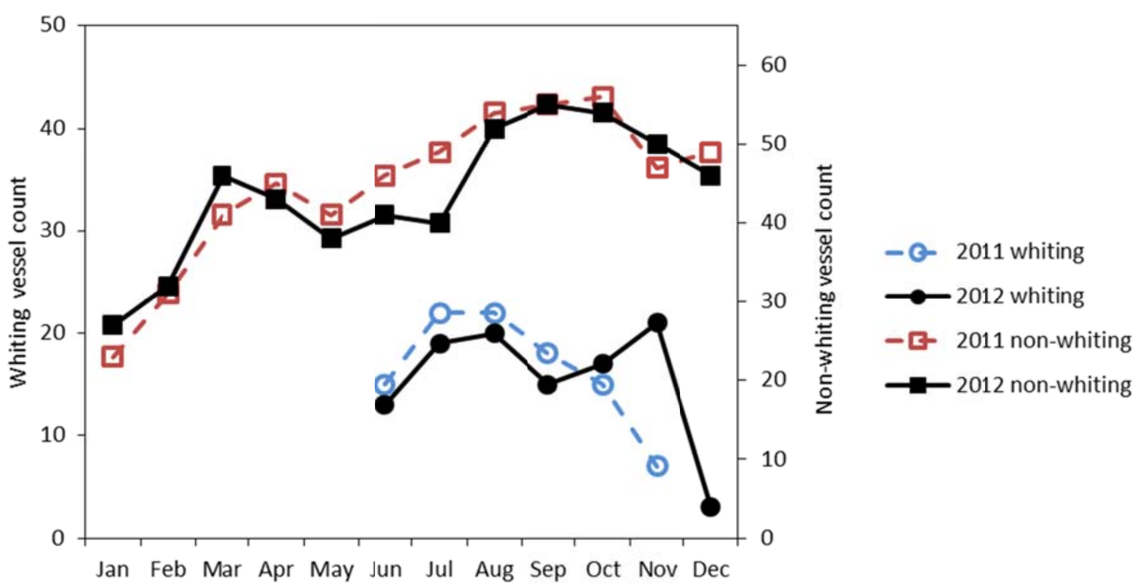


Figure 8. Monthly vessel counts for non-whiting, directed whiting, and total, during 2011 and 2012 in the Shorebased IFQ Program. Source = Shorebased IFQ Program, Vessel Accounts System.

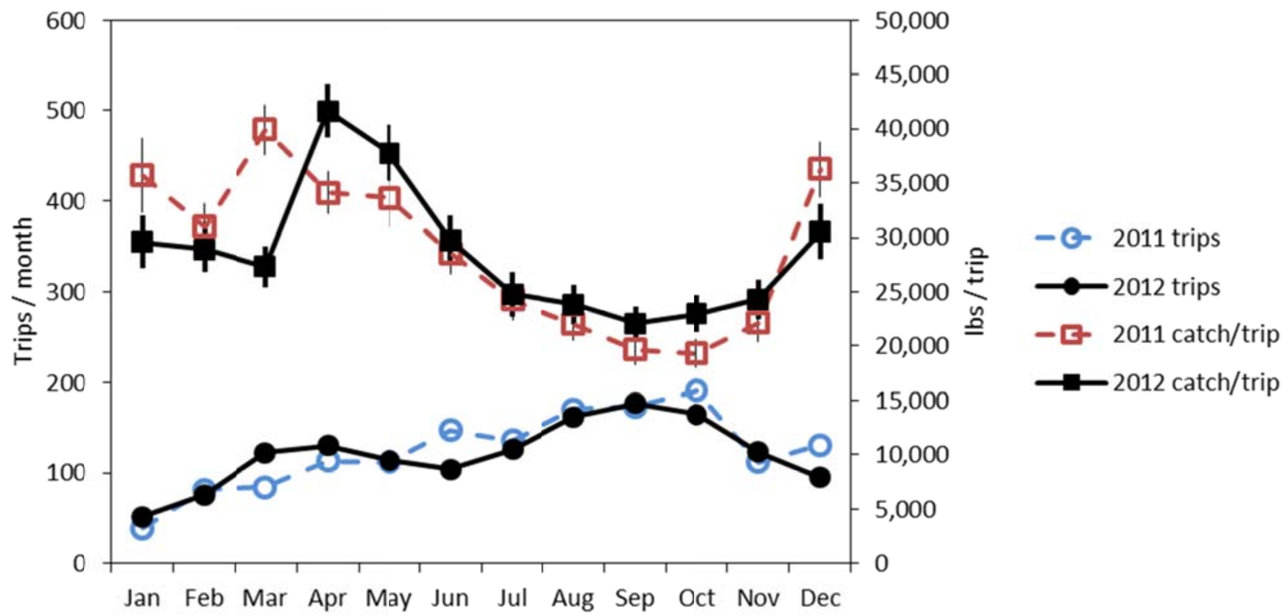


Figure 9. Monthly indicators of non-whiting fleet effort and catch per unit effort, as number of trips (bottom, circles) and catch per trip (top, squares), during 2011 and 2012. Source = Shorebased IFQ Program, Vessel Accounts System.

Table 11. Monthly total catch, and indicators of non-whiting fleet effort and catch per unit effort, as number of trips (bottom, circles) and catch per trip (top, squares), during 2011 and 2012. Source = Shorebased IFQ Program, Vessel Accounts System.

Month	**2011 trips**	**2011 catch**	**2011 catch/trip**	**2011 SE**	**2012 trips**	**2012 catch**	**2012 catch/trip**	**2012 SE**	**Trips % of 2011**	**Catch % of 2011**	**Catch/ trip % of 2011**
Jan	39	1,391,286	35,674	3,426	52	1,538,543	29,587	2,383	133%	111%	83%
Feb	81	2,507,351	30,955	2,174	76	2,198,809	28,932	2,148	94%	88%	93%
Mar	84	3,354,758	39,938	2,293	122	3,333,609	27,325	1,893	145%	99%	68%
Apr	113	3,853,779	34,104	1,957	130	5,415,141	41,655	2,478	115%	141%	122%
May	112	3,767,669	33,640	2,603	114	4,303,171	37,747	2,579	102%	114%	112%
Jun	147	4,201,535	28,582	1,958	104	3,091,065	29,722	2,332	71%	74%	104%
Jul	136	3,301,089	24,273	1,899	126	3,120,070	24,762	2,065	93%	95%	102%
Aug	170	3,744,512	22,027	1,559	162	3,858,876	23,820	1,791	95%	103%	108%
Sep	173	3,400,229	19,655	1,409	177	3,909,467	22,087	1,563	102%	115%	112%
Oct	191	3,692,915	19,335	1,301	165	3,792,556	22,985	1,691	86%	103%	119%
Nov	112	2,477,049	22,117	1,742	123	2,991,732	24,323	1,818	110%	121%	110%
Dec	131	4,753,226	36,284	2,534	95	2,895,984	30,484	2,533	73%	61%	84%
sum	1,488	40,445,398	27,181	591	1,444	40,449,023	28,012	621	97%	100%	103%

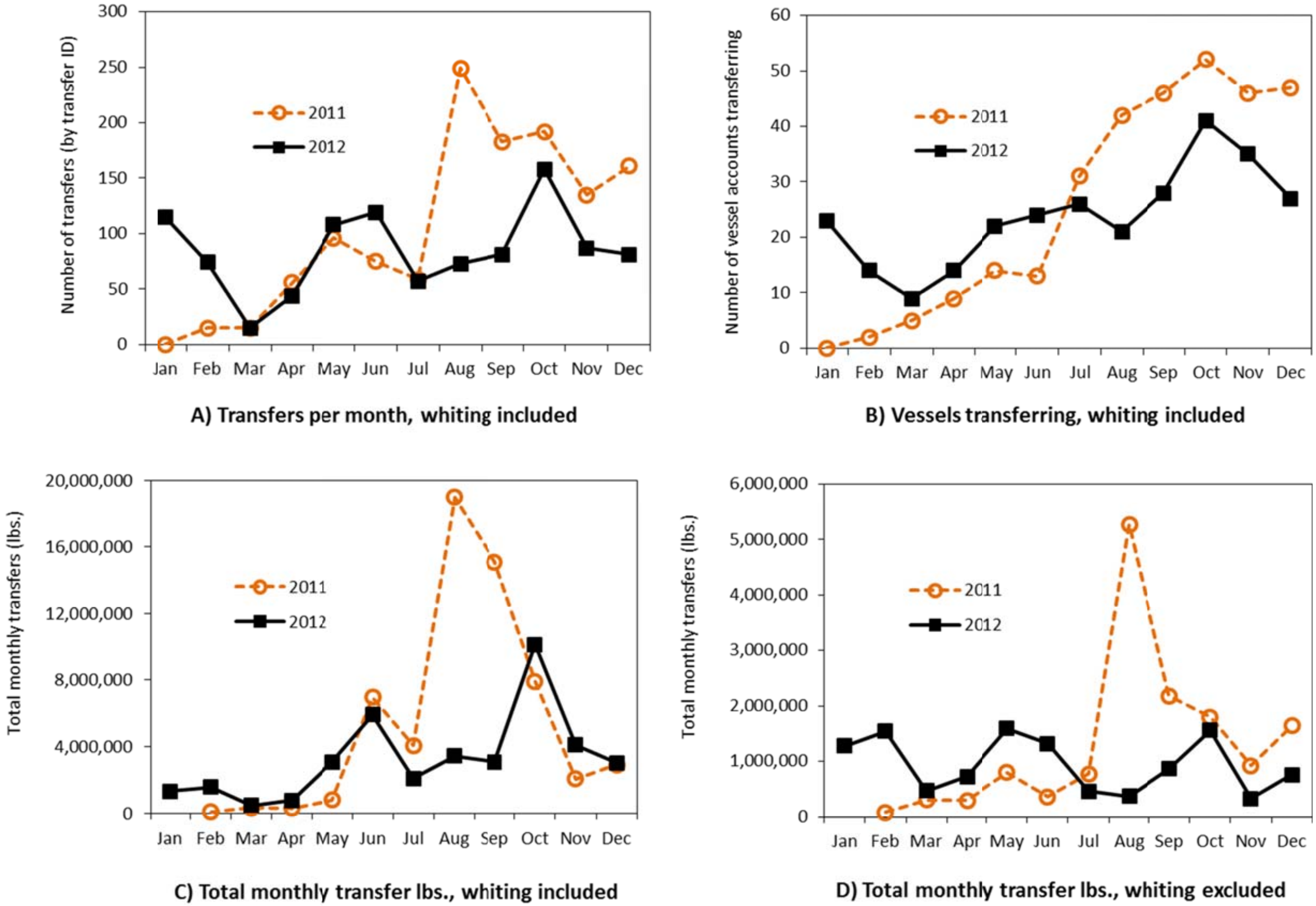


Figure 10. Metrics used to describe monthly commerce-related quota pound transfers during 2011 and 2012, including and excluding Pacific whiting. Source = Shorebased IFQ Program, Vessel Accounts System.

Table 12. Metrics used to describe monthly commerce-related quota pound transfers during 2011 and 2012 (vessel account to vessel account; cash, barter, or cash & barter only). "VA" stands for vessel account, those columns show numbers of vessel accounts from which commerce-related transfers were made. "Gini" refers to the Gini coefficient, an index of inequality of distribution, ranging from 0 to 1. Lower values mean a more uniform distribution of transfer counts or pounds transferred among months of the year, higher values mean a more unequal distribution among months. Source = Shorebased IFQ Program, Vessel Accounts System.

Month	Transfer count 2011	Transfer count 2012	VA count 2011	VA count 2012	Pounds transferred w/hake 2011	Pounds transferred w/hake 2012	Pounds transferred w/o hake 2011	Pounds transferred w/o hake 2012
Jan	0	115	0	23	0	1,304,412	0	1,281,226
Feb	15	74	2	14	78,929	1,557,237	78,929	1,541,477
Mar	15	15	5	9	304,431	469,309	304,431	469,309
Apr	56	44	9	14	293,586	756,617	293,586	722,562
May	96	108	14	22	799,756	3,080,546	799,726	1,593,759
Jun	75	119	13	24	6,956,577	5,924,327	361,664	1,318,723
Jul	59	57	31	26	4,061,293	2,078,019	775,530	455,035
Aug	249	73	42	21	18,967,104	3,434,205	5,269,413	370,086
Sep	183	81	46	28	15,091,285	3,064,483	2,179,244	867,518
Oct	192	158	52	41	7,933,128	10,114,533	1,796,003	1,559,811
Nov	135	87	46	35	2,043,484	4,085,361	918,130	328,169
Dec	161	81	47	27	2,895,998	3,016,776	1,643,813	753,431
Sum	1,236	1,012	NA	NA	59,425,571	38,885,825	14,420,469	11,261,106
Gini	0.42	0.24	0.42	0.20	0.62	0.40	0.55	0.28

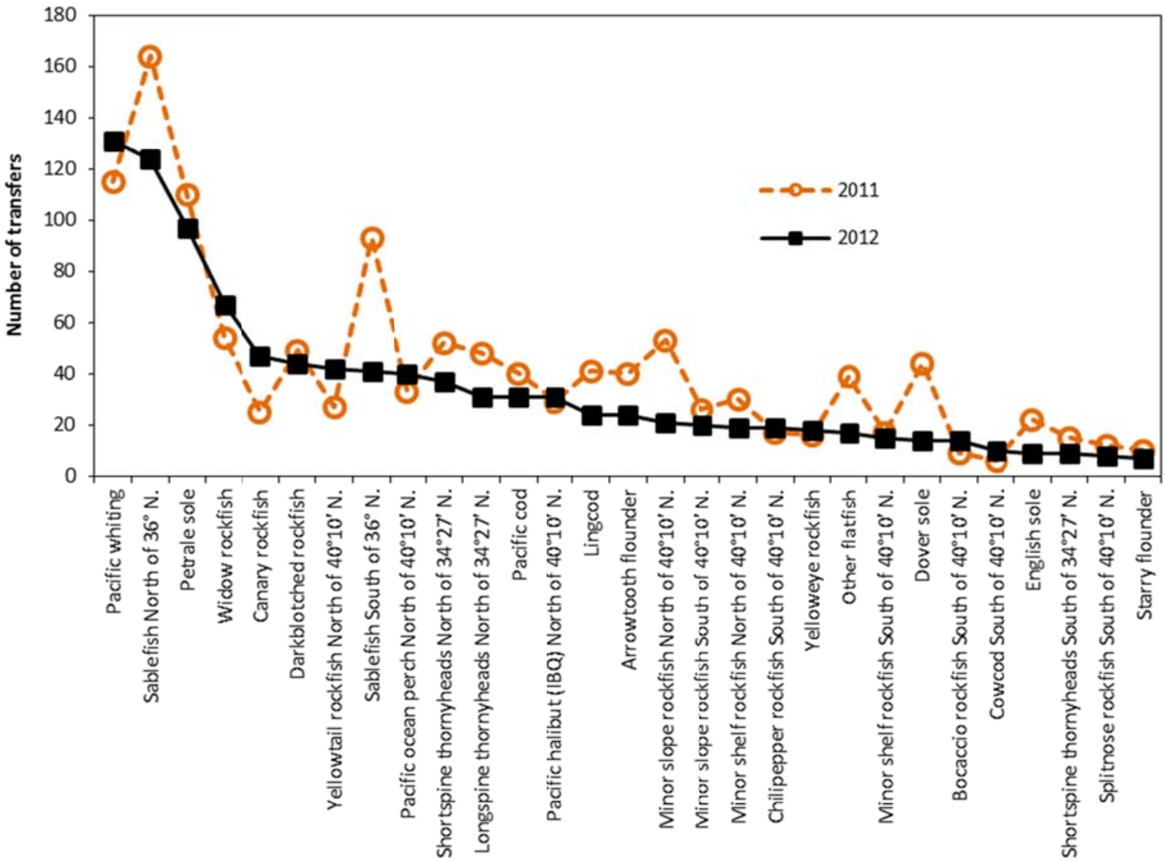


Figure 11. Numbers of commerce-related IFQ quota pound transfers by species/area category, 2011 and 2012 (vessel account to vessel account; cash, barter, or cash & barter only), including Pacific whiting. The figure is sorted by the count of transfers per species during 2012. This is not a series, markers are only connected to make the figure easier to read, and to highlight differences between years. Source = Shorebased IFQ Program, Vessel Accounts System.

Table 13. Counts, rankings, and total pounds of commerce-related IFQ quota pound (QP) transfers by species, during January through June of 2011 and 2012 (vessel account to vessel account; cash, barter, or cash & barter only), including Pacific whiting. The table is sorted descending, by the count of QP transfers during 2012. Source = Shorebased IFQ Program, Vessel Accounts System.

	2011		2012		2011	2012
Species	**Transfers**	**Rank**	**Transfers**	**Rank**	**Pounds**	**Pounds**
Pacific whiting	115	2	131	1	45,005,102	27,624,719
Sablefish North of 36° N.	164	1	124	2	1,955,920	1,562,937
Petrale sole	110	3	97	3	736,468	722,255
Widow rockfish	54	5	67	4	162,874	146,230
Canary rockfish	25	20	47	5	6,095	11,289
Darkblotched rockfish	49	8	44	6	84,962	73,287
Yellowtail rockfish North of 40°10' N.	27	18	42	7	801,814	931,811
Sablefish South of 36° N.	93	4	41	8	687,053	274,815
Pacific ocean perch North of 40°10' N.	33	15	40	9	29,969	36,111
Shortspine thornyheads North of 34°27' N.	52	7	37	10	323,735	434,168
Longspine thornyheads North of 34°27' N.	48	9	31	11	526,485	701,601
Pacific cod	40	12	31	12	714,220	605,540
Pacific halibut (IBQ) North of 40°10' N.	29	17	31	13	31,842	31,373
Lingcod	41	11	24	15	301,527	269,719
Arrowtooth flounder	40	13	24	14	2,306,575	1,283,596
Minor slope rockfish North of 40°10' N.	53	6	21	16	176,307	122,184
Minor slope rockfish South of 40°10' N.	26	19	20	17	117,443	106,388
Minor shelf rockfish North of 40°10' N.	30	16	19	19	78,608	45,495
Chilipepper rockfish South of 40°10' N.	17	22	19	18	239,349	313,739
Yelloweye rockfish	16	24	18	20	147	126
Other flatfish	39	14	17	21	530,501	516,463
Minor shelf rockfish South of 40°10' N.	17	23	15	22	6,493	25,845
Dover sole	44	10	14	24	3,215,218	2,461,662
Bocaccio rockfish South of 40°10' N.	9	28	14	23	6,010	6,884
Cowcod South of 40°10' N.	6	29	10	25	84	48
English sole	22	21	9	26	1,285,339	480,343
Shortspine thornyheads South of 34°27' N.	15	25	9	27	13,236	1,583
Splitnose rockfish South of 40°10' N.	12	26	8	28	46,435	41,640
Starry flounder	10	27	7	29	35,760	53,974
Sum	1,236	NA	1,011	NA	59,425,571	38,885,825

Table 14. Total catch and attainment by species category, in 2011 and 2012. Aggregate attainment of all species categories other than whiting was 29% in 2012, compared with 24% in 2011 (up 5%). Pacific whiting reapportionment late in the year is an important factor when considering the aggregate sector attainment rate, as well as the 2012 attainment rate of whiting, because of the large mass of the annual whiting allocation and harvest, compared with those of all other species in the shorebased IFQ sector. Source = Shorebased IFQ Program, Vessel Accounts System.

Species Category	2011 NW	2011 W	2011 Total	2011 Allocation	2011 Attain.	2012 NW	2012 W	2012 Total	2012 Allocation	2012 Attain.	Annual dif.	Attain dif. %
Arrowtooth flounder	5,547,823	28,177	5,576,000	27,406,105	20%	5,393,814	54,616	5,448,430	20,861,131	26%	-127,570	6%
Bocaccio rockfish South of 40°10' N.	11,715		11,715	132,277	9%	19,461		19,461	132,277	15%	7,746	6%
Canary rockfish	6,239	1,886	8,125	57,100	14%	13,774	2,168	15,942	57,761	28%	7,817	13%
Chilipepper rockfish South of 40°10' N.	688,187		688,187	3,252,370	21%	643,174		643,174	2,934,904	22%	-45,013	1%
Cowcod South of 40°10' N.	39		39	3,968	1%	204		204	3,968	5%	165	4%
Darkblotched rockfish	197,577	2,687	200,264	552,997	36%	188,184	9,433	197,617	548,808	36%	-2,647	0%
Dover sole	17,269,250	161	17,269,411	49,018,682	35%	16,049,785	1,319	16,051,104	49,018,682	33%	-1,218,307	-2%
English sole	302,935	1	302,936	41,166,808	1%	323,438	52	323,490	21,037,611	2%	20,554	1%
Lingcod	629,175	10,069	639,244	4,107,873	16%	831,036	8,060	839,096	3,991,800	21%	199,852	5%
Longspine thornyheads North of 34°27' N.	2,119,803	1	2,119,804	4,334,839	49%	2,013,119	116	2,013,235	4,219,648	48%	-106,569	-1%
Minor shelf rockfish North of 40°10' N.	32,934	1,291	34,225	1,150,813	3%	85,802	1,726	87,528	1,150,813	8%	53,303	5%
Minor shelf rockfish South of 40°10' N.	6,633		6,633	189,598	3%	25,069		25,069	189,598	13%	18,436	10%
Minor slope rockfish North of 40°10' N.	295,561	24,377	319,938	1,828,779	17%	326,552	158,556	485,108	1,828,779	27%	165,170	9%
Minor slope rockfish South of 40°10' N.	113,337		113,337	831,958	14%	270,847		270,847	831,958	33%	157,510	19%
Other flatfish	1,525,875	1,892	1,527,767	9,253,683	17%	1,500,933	9,673	1,510,606	9,253,683	16%	-17,161	0%
Pacific cod	554,143	2,548	556,691	2,502,247	22%	873,580	94	873,674	2,502,247	35%	316,983	13%
Pacific halibut (IBQ) North of 40°10' N.	70,063	776	70,839	257,524	28%	70,213	1,373	71,586	232,856	31%	747	3%
Pacific ocean perch North of 40°10' N.	100,884	549	101,433	263,148	39%	90,680	27,462	118,142	263,441	45%	16,709	6%
Pacific whiting	521,814	200,508,547	201,030,361	204,628,442	98%	507,336	144,207,288	144,714,624	151,373,798	96%	-56,315,737	-3%
Petrale sole	1,789,626	1	1,789,627	1,920,226	93%	2,331,478	1	2,331,479	2,324,995	100%	541,852	7%
Sablefish North of 36° N.	5,220,841	66,961	5,287,802	5,613,719	94%	4,806,019	104,082	4,910,101	5,438,797	90%	-377,701	-4%
Sablefish South of 36° N.	1,009,286		1,009,286	1,170,390	86%	499,843		499,843	1,133,352	44%	-509,443	-42%
Shortspine thornyheads North of 34°27' N.	1,569,715	4,803	1,574,518	3,156,138	50%	1,551,370	18,364	1,569,734	3,120,533	50%	-4,784	0%
Shortspine thornyheads South of 34,°27' N.	18,653		18,653	110,231	17%	808		808	110,231	1%	-17,845	-16%
Splitnose rockfish South of 40°10' N.	88,523		88,523	3,045,245	3%	117,251		117,251	3,206,513	4%	28,728	1%
Starry flounder	25,936		25,936	1,471,586	2%	18,402		18,402	1,480,404	1%	-7,534	-1%
Widow rockfish	58,010	245,693	303,703	755,348	40%	115,736	224,474	340,210	755,352	45%	36,507	5%
Yelloweye rockfish	128		128	1,323	10%	76		76	1,323	6%	-52	-4%
Yellowtail rockfish North of 40°10' N.	692,858	936,326	1,629,184	6,821,455	24%	1,729,446	464,691	2,194,137	6,850,556	32%	564,953	8%
Total	40,467,563	201,836,746	242,304,309	375,004,872	65%	40,397,430	145,293,548	185,690,978	294,855,819	63%	-56,613,331	-2%

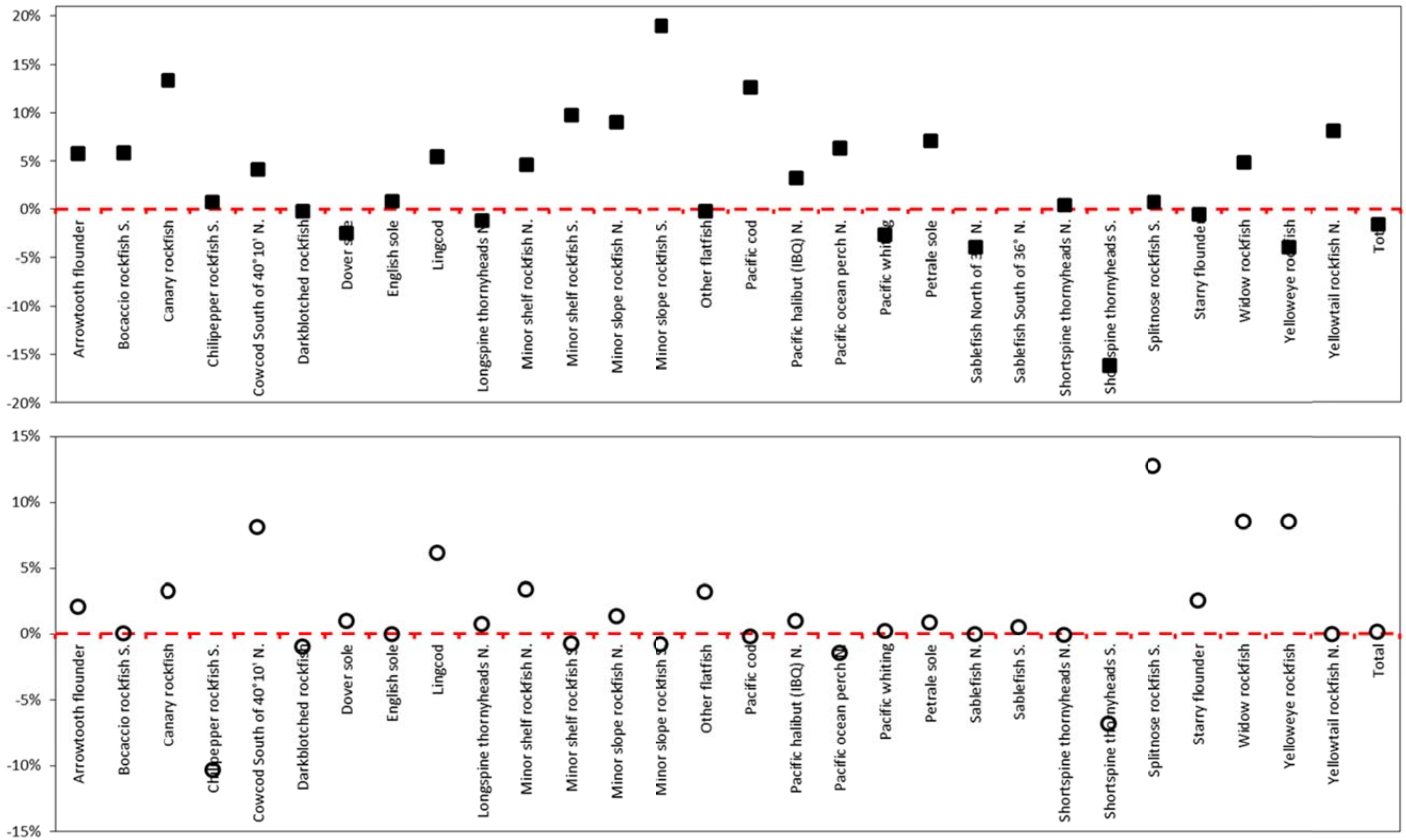


Figure 12. Percent change in attainment (top panel, filled squares), and percent change in retention rates (bottom panel, open circles) of Shorebased IFQ Program allocations, by species/area category, for 2011 and 2012. Aggregate attainment of all species categories other than whiting was 29% in 2012, compared with 24% in 2011 (up 5%). Pacific whiting reapportionment late in the year is an important factor when considering the aggregate sector attainment rate, and the 2012 attainment rate of whiting; this is due to the large mass of the annual whiting allocation and harvest, compared with those of all other species in the shorebased IFQ sector. Source = Shorebased IFQ Program, Vessel Accounts System.

Table 15. Total catch, landings, discards, and retention rates for non-whiting trips, in the Shorebased IFQ Program during 2011 and 2012. On non-whiting trips, aggregate retention increased slightly by 0.7% (from 94.5% to 95.2%), and on whiting trips it increased by 0.4% (from 99.4% to 99.8%). These rates are preliminary, as observer discard data are not final until spring. Source = Shorebased IFQ Program, Vessel Accounts System.

Species category	2011 Total catch	2011 Landed	2011 Discarded	2011 Retention	2012 Total catch	2012 Landed	2012 Discarded	2012 Retention	Retention difference
Arrowtooth flounder	5,576,000	5,028,511	547,489	90.2%	5,448,430	5,028,835	419,595	92.3%	2.1%
Bocaccio rockfish South of 40°10' N.	11,715	11,695	20	99.8%	19,461	19,433	28	99.9%	0.0%
Canary rockfish	8,125	7,809	316	96.1%	15,942	15,849	93	99.4%	3.3%
Chilipepper rockfish South of 40°10' N.	688,187	633,063	55,124	92.0%	643,174	525,422	117,752	81.7%	-10.3%
Cowcod South of 40°10' N.	39	32	7	82.1%	204	184	20	90.2%	8.1%
Darkblotched rockfish	200,264	196,530	3,734	98.1%	197,617	192,073	5,544	97.2%	-0.9%
Dover sole	17,269,411	16,921,445	347,966	98.0%	16,051,104	15,894,802	156,302	99.0%	1.0%
English sole	302,936	238,484	64,452	78.7%	323,490	254,653	68,837	78.7%	0.0%
Lingcod	639,244	549,482	89,762	86.0%	839,096	772,917	66,179	92.1%	6.2%
Longspine thornyheads North of 34°27' N.	2,119,804	2,007,704	112,100	94.7%	2,013,235	1,921,841	91,394	95.5%	0.7%
Minor shelf rockfish North of 40°10' N.	34,225	27,737	6,488	81.0%	87,528	73,908	13,620	84.4%	3.4%
Minor shelf rockfish South of 40°10' N.	6,633	361	6,272	5.4%	25,069	1,177	23,892	4.7%	-0.7%
Minor slope rockfish North of 40°10' N.	319,938	288,269	31,669	90.1%	485,108	443,700	41,408	91.5%	1.4%
Minor slope rockfish South of 40°10' N.	113,337	110,681	2,656	97.7%	270,847	262,332	8,515	96.9%	-0.8%
Other flatfish	1,527,767	1,257,341	270,426	82.3%	1,510,606	1,292,219	218,387	85.5%	3.2%
Pacific cod	556,691	556,663	28	100.0%	873,674	872,172	1,502	99.8%	-0.2%
Pacific halibut (IBQ) North of 40°10' N.	70,839	774	70,065	1.1%	71,586	1,522	70,064	2.1%	1.0%
Pacific ocean perch North of 40°10' N.	101,433	100,532	901	99.1%	118,142	115,385	2,757	97.7%	-1.4%
Pacific whiting	201,030,361	199,472,944	1,557,417	99.2%	144,714,624	143,977,021	737,603	99.5%	0.3%
Petrale sole	1,789,627	1,753,538	36,089	98.0%	2,331,479	2,305,976	25,503	98.9%	0.9%
Sablefish North of 36° N.	5,287,802	5,237,173	50,629	99.0%	4,910,101	4,861,610	48,491	99.0%	0.0%
Sablefish South of 36° N.	1,009,286	995,446	13,840	98.6%	499,843	495,781	4,062	99.2%	0.6%
Shortspine thornyheads North of 34°27' N.	1,574,518	1,560,610	13,908	99.1%	1,569,734	1,554,790	14,944	99.0%	-0.1%
Shortspine thornyheads South of 34°27' N.	18,653	18,165	488	97.4%	808	732	76	90.6%	-6.8%
Splitnose rockfish South of 40°10' N.	88,523	21,108	67,415	23.8%	117,251	42,919	74,332	36.6%	12.8%
Starry flounder	25,936	24,391	1,545	94.0%	18,402	17,781	621	96.6%	2.6%
Widow rockfish	303,703	277,506	26,197	91.4%	340,210	340,081	129	100.0%	8.6%
Yelloweye rockfish	128	117	11	91.4%	76	76	0	100.0%	8.6%
Yellowtail rockfish North of 40°10' N.	1,629,184	1,628,947	237	100.0%	2,194,137	2,193,586	551	100.0%	0.0%
Total	242,304,309	238,927,058	3,377,251	98.6%	185,690,978	183,478,777	2,212,201	98.8%	0.2%

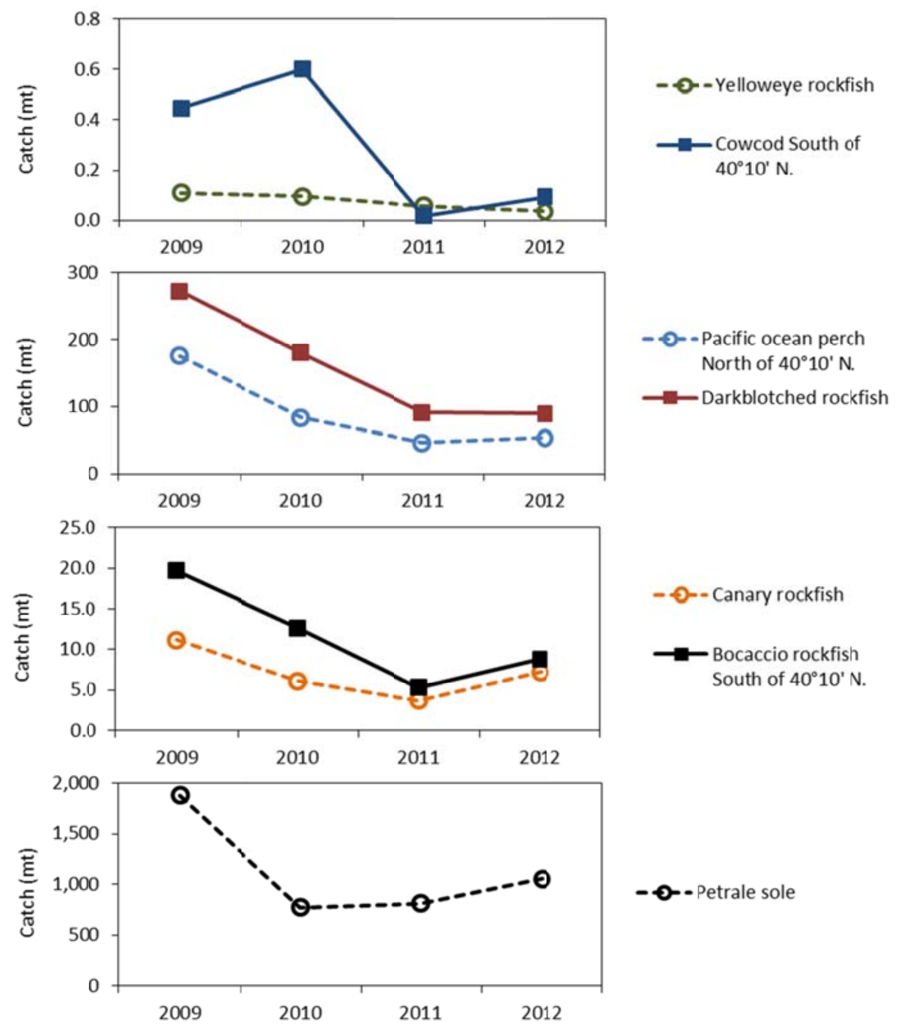


Figure 13. Total annual catch of rebuilding species from 2009 and 2010, in the limited entry trawl and shoreside whiting fisheries, as well as 2011 and 2012, in the Shorebased IFQ Program, in metric tons. Source = WCGOP Groundfish Mortality Report (2009-2010) and the Shorebased IFQ Vessel Accounts System (2011-2012).

Table 16. Total annual catch of rebuilding species from 2009 and 2010, in the limited entry trawl and shoreside whiting fisheries, as well as 2011 and 2012, in the Shorebased IFQ Program, in metric tons. Two-year average catch, and average annual catch in 2011-12 as a percentage of that of 2009-10 is presented in the far right column ("post/pre IFQ"). Source = WCGOP Groundfish Mortality Report (2009-2010) and the Shorebased IFQ Program, Vessel Accounts System (2011-2012).

Species	**2009**	**2010**	**2009-2010 ave.**	**2011**	**2012**	**2011-2012 ave.**	**Post/pre %**
Yelloweye rockfish	0.11	0.13	0.12	0.06	0.03	0.05	39.3%
Cowcod South of 40°10' N.	0.45	0.61	0.53	0.02	0.09	0.06	10.4%
Canary rockfish	11.16	6.39	8.78	3.69	7.23	5.46	62.2%
Bocaccio rockfish South of 40°10' N.	19.71	12.93	16.32	5.31	8.83	7.07	43.3%
Pacific ocean perch North of 40°10' N.	175.41	136.55	155.98	46.01	53.59	49.80	31.9%
Darkblotched rockfish	272.32	291.84	282.08	90.84	89.64	90.24	32.0%
Petrale sole	1881.91	900.37	1391.14	811.76	1057.54	934.65	67.2%

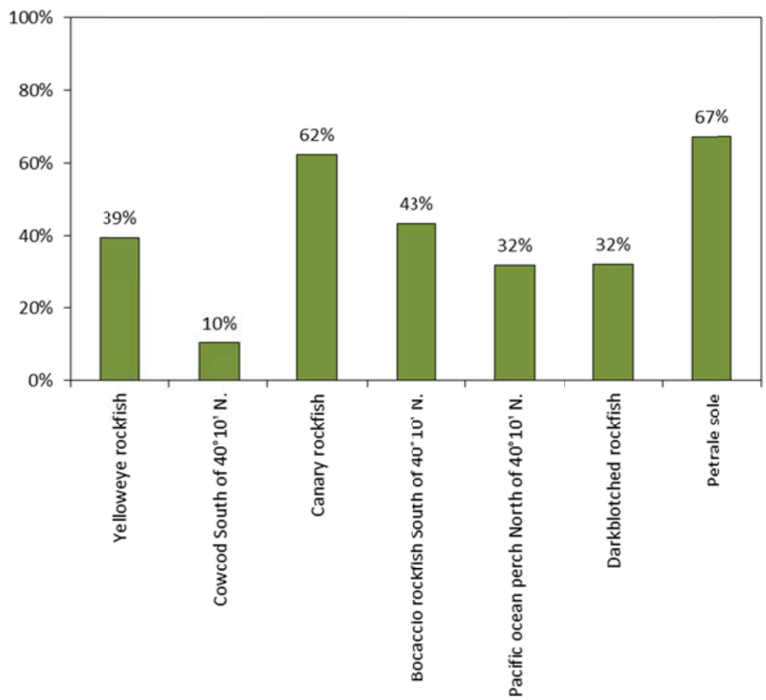


Figure 14. Two-year average catch during 2011-12 as a percentage of that of 2009-10, by species category. Source = WCGOP Groundfish Mortality Report data (2009-2010) and vessel accounts system of the Shorebased IFQ Program (2011-2012).

CENTRAL CALIFORNIA SEAFOOD MARKETING ASSOCIATION
(Previously Central Coast Sustainable Groundfish Association)
A California Fish Marketing Act Corporation

FORT BRAGG GROUNDFISH ASSOCIATION
A California Fish Marketing Act Corporation

March 19, 2013

Mr. Dan Wolford
Chairman
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, Oregon 97220 – 1384

Dear Chairman Wolford,

We appreciate this opportunity to present the attached "Fort Bragg - Central Coast Risk Pool Annual Summary Report" for 2012. This report describes the working components of the Risk Pool, provides details of its operations, and illustrates and compares our results from the first two years of operation. In contrast to 2011, the Risk Pool operated during the entire fishing season of 2012 and is pleased to present the results of these operations to the Council.

The Risk Pool is a collaborative effort along the coast of California to pool overfished species quota and minimize the risk of catching these species. Fishermen and fishery stakeholders from Fort Bragg, California and the Central Coast of California partnered with The Nature Conservancy to build and implement the Risk Pool arrangement. The management of overfished species has presented a challenge to the fishery under the Individual Fishing Quota (IFQ) system, yet the Risk Pool was able to successfully manage this challenge for the second consecutive fishing season, keeping fishermen working on the water and bringing high quality, sustainably harvested seafood to ports and consumers.

The Risk Pool is a comprehensive program, and the primary tenets of the Risk Pool are:

- A "Risk Pool Agreement" that each fishing association is a party to and that is renewable annually on a voluntary basis. The Agreement is the governing document for the Risk Pool, and prescribes the methods and means employed to minimize overfished species encounters, react to encounters when and if they occur, and facilitate transfer of overfished species quota among pool members engaged in the fishery;
- Spatial Fishing Plans that cover the regions where fishermen members operate and outline prescriptions for fishing in each region; and
- An electronic logbook and online database called eCatch (www.ecatch.org) that provides a low cost and efficient method to collect accurate information on the location, amount, and species of fish caught in near-real time and visualize that information on web-based maps.

We look forward to working with the Council and other fishery stakeholders to continue the development and implementation of innovative solutions to complex fishery problems now and into the future.

Sincerely,

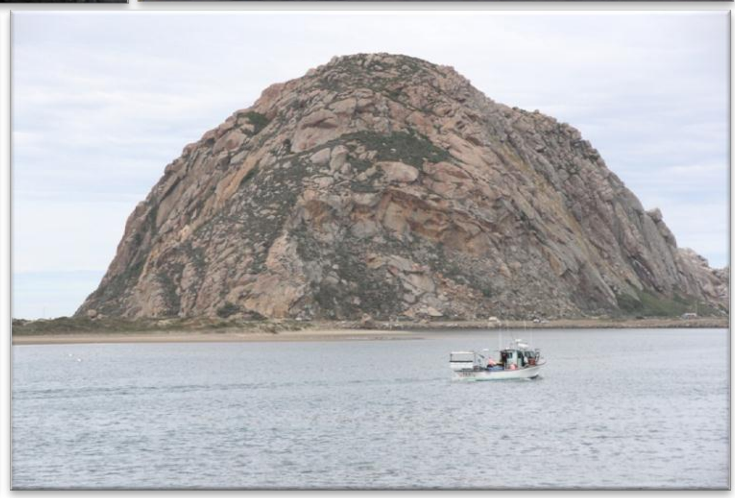
Michele Norvell
Manager, Fort Bragg Groundfish Association

Jon Griesser
Manager, Central California Seafood Marketing Association

FORT BRAGG – CENTRAL COAST RISK POOL

ANNUAL SUMMARY REPORT

2012



Report prepared by: Kate Labrum[*] and Dwayne Oberhoff[†]

Fort Bragg Groundfish Association
A California Fish Marketing Act Corporation

Central Coast Sustainable Groundfish Association
(Now: Central California Seafood Marketing Association)
A California Fish Marketing Act Corporation

The Nature Conservancy
A District of Columbia Non-profit Corporation

March 2013

[*] The Nature Conservancy
[†] Ecological Assets Management, LLC

Acknowledgements:

The authors of this report wish to acknowledge and thank the contributors whose partnership, leadership, dedication, zeal, organization, and expertise collectively make up and support the Risk Pool creating the results contained within this report. The Risk Pool has benefitted from the input and guidance from many organizations and individuals; in particular this collaboration and the 2012 Annual Summary Report are made possible by the Fort Bragg Groundfish Association and its fishermen members; the Central Coast Sustainable Groundfish Association and its members; the Central California Seafood Marketing Association and its members; Michelle Norvell; Jon Griesser; Chris Kubiak; Michael Bell; Mary Gleason; Matt Merrifield; Steve Rienecke; Chuck Cook; Joe Sullivan; Rick Algert; Merrick Burden; the Pacific Fisheries Management Council; the California Department of Fish and Wildlife; National Fish and Wildlife Foundation; and the Environmental Defense Fund.

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Contents

Introduction

In 2011 the west coast groundfish fishery transitioned into a catch share fishery, or Individual Fishing Quota management system. Under this type of management system, the annual total allowable catch is divided into shares, or quota, and allocated to individual fishermen. Fishermen are afforded some flexibility under this system as to where and when to fish, and the quota is transferable so it can be leased or bought and sold. The west coast groundfish fishery is comprised of over 90 species of flatfish, rockfish, roundfish and others; six of these species are federally designated as overfished and therefore only small amounts of quota for these species are available to the fishery on an annual basis. The overfished species present a challenge to fishermen because the limited amount of quota available constrains their ability to harvest more abundant stocks. Under the catch share system, a fisherman cannot fish if they have a quota deficit, and therefore if the harvest of any species exceeds a fisherman's quota allocation they are required to cease fishing until they have obtained adequate quota to cover the deficit. Because harvesting overfished species is not entirely predictable (i.e. these species can be caught incidentally), a fisherman could unintentionally harvest his or her entire annual quota allocation for one or more of the overfished species during one trip or set, even when taking reasonable measures necessary to avoid them.

This report describes a collaborative effort along the coast of California to pool overfished species quota and minimize the risk of catching these species during the 2012 fishing season. The Fort Bragg Groundfish Association (FBGA) and the Central Coast Sustainable Groundfish Association (CCSGA, an organization that has now evolved into the Central California Seafood Marketing Association, CCSMA) entered into an annual risk pool arrangement (the "Risk Pool") for the second consecutive year. The two associations signed a formal agreement to pool their 2012 overfished species quota pound allocations and draw on the quota pool to cover deficits incurred from harvesting overfished species. As parties to the Risk Pool agreement, the two associations developed and enforced regional fishing plans complete with fishing prescriptions designed to minimize the risk of catching overfished species in the geography between Cape Mendocino and Point Conception. Deficits of overfished species quota incurred by members of the two associations were filled at no charge, provided that all harvesting activities were conducted in compliance with the regional fishing plans. The goals of each fishing plan were to promote the long term success of the fishery and its supporting port communities by:

(i) Maximizing the harvest of target species from the fishery;
(ii) Minimizing the harvest of overfished species from the fishery;
(iii) Safeguarding sensitive fish habitat; and,
(iv) Contributing to the rebuilding of overfished stocks.

In 2012, 11 individual fishing operations were party to the Risk Pool agreement through their membership with FBGA or CCSGA. The Risk Pool was governed by a three member Advisory Committee made up of one representative from each fishing association and one representative from The Nature Conservancy (TNC). TNC owns quota in the west coast groundfish fishery and is engaged in the fishery with the goal of working with the industry to develop and implement best practices for an economically and environmentally sustainable fishery and fishing communities. TNC believes local cooperative fishing arrangements, such as the Risk Pool, hold promise for stabilizing fishery activity in our ports, bringing high quality seafood to the consumer, and protecting the health and productivity of our oceans. TNC collaborated with FBGA and CCSGA to develop regional fishing plans, implement technology solutions for sharing data, and invest quota into the Risk Pool.

Risk Pool Fishing Plans

As stipulated by the Risk Pool agreement, FBGA and CCSGA developed regional fishing plans covering 15 million acres with prescriptions to minimize the risk of catching overfished species. The regional fishing plans cover spatially explicit geographic regions and are specific to certain gear types. The fishing plans are created collaboratively by combining the best available science and technology with fishermen's knowledge, past fishing history, and habitat information to spatially delineate risk zones; fishing prescriptions – or best management practices – are then assigned to zones to reduce the risk of catching overfished species. The associations presented the regional fishing plans to the Risk Pool Advisory Committee to be approved. The fishing plans are "living documents" and are revised and updated to improve the Risk Pool's fishing performance based on information collected during the fishing season. Figure 1 provides an example of the spatial component of a regional fishing plan that identifies risk zones (note this is just an example, not an actual plan).

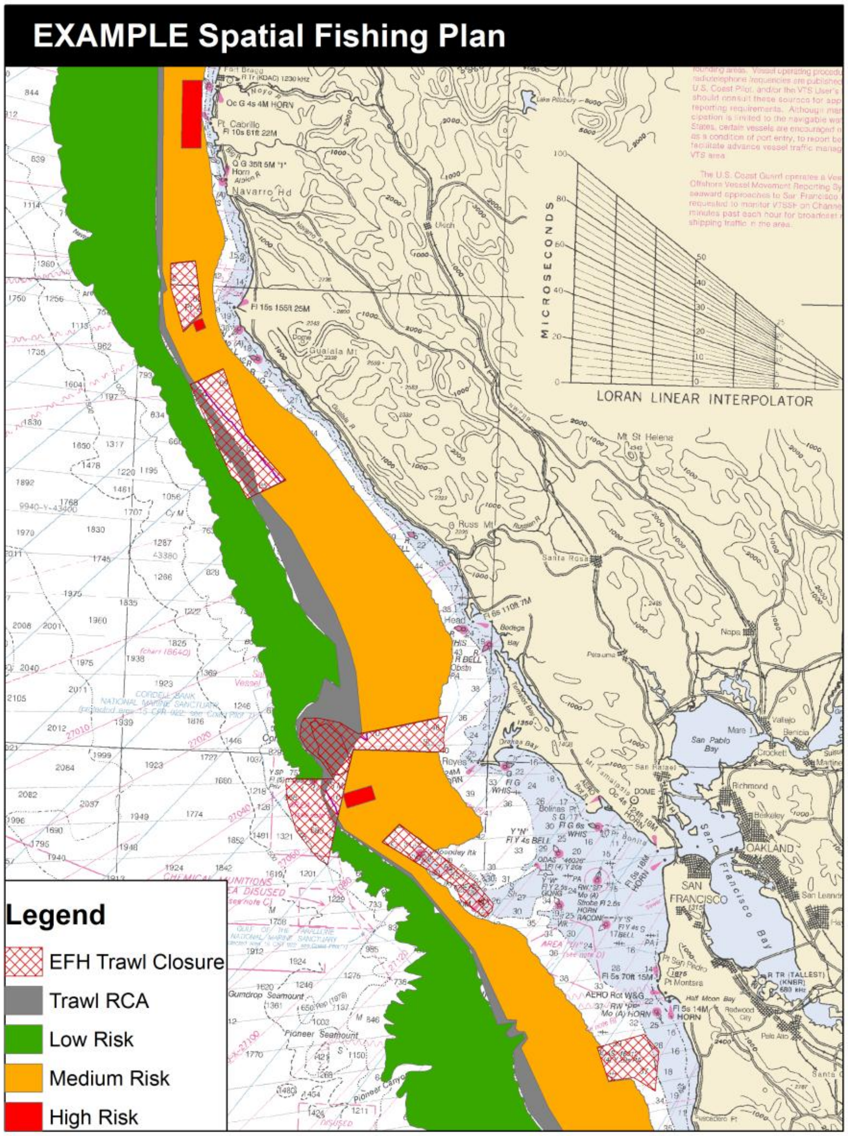

Figure 1. Example of spatial component of regional fishing plan in the central coast of California that depicts high, medium and low risk zoned areas as well as existing management closures. Each zone is paired with specific fishing prescriptions designed to reduce the risk of catching overfished species.

Technology

The act of sharing of fisheries data is a fundamental component ensuring effective operations of collaborations like the Risk Pool. Members of the Risk Pool need to know almost immediately where, when and how many overfished species were harvested in order to reduce the risk of catching more overfished species and update and adapt spatial fishing plans. Risk Pool managers also need to ensure that fishing is occurring in compliance with spatial fishing plans in order to fill deficits for overfished species quota and effectively monitor fishing operations. To achieve this, Risk Pool members share spatially accurate and near-real time data on the harvest of overfished species using a tool developed by TNC called eCatch (www.ecatch.org). This technology allows fishermen to easily capture logbook information using an iPad, visualize and query data on web-based maps, and share those maps with others if it makes sense to do so. This technology reduces the cost of data entry and enables the sharing of fishing information in near-real time. It also provides Risk Pool managers with a tool to ensure compliance with spatial fishing plans and even specific fishing prescriptions such as duration of trawl tows. During the 2011 fishing season, the Risk Pool piloted eCatch use on iPads, and in 2012 six vessels in the Risk Pool successfully logged catch data using the eCatch application on iPads. All other vessels in the Risk Pool submitted logbook data to eCatch manually through the webpage. After operating for two consecutive years and capturing data using eCatch, Risk Pool participants are building a library of valuable fisheries information that can be used to analyze long-term catch trends, optimize collective harvest planning and spatial fishing plans, and even inform predictive modeling of overfished species distributions.

Figure 2. The eCatch application (www.ecatch.org) allows fishermen to easily capture logbook data using an iPad and then query that data and visualize it on on web-based maps.

The Risk Pool has also participated in the development of an innovative fisheries tool called the Fish Hub. The Fish Hub is a software platform that provides a suite of web-based applications or tools that are designed to streamline the operations of a collaborative organization like a risk pool or permit bank. The collection and management of high volumes of complex fisheries data such as quota balances is essential for the operation of collective fishing arrangements like risk pools, but current access and tools for managing these data sources are not meeting the needs of the fishing industry involved in these collaborative arrangements. The Risk Pool engaged in a partnership with the Cape Cod Fisheries Trust to identify major obstacles surrounding data management and analysis for risk pools and permit banks and worked to develop the Fish Hub as a potential solution to these obstacles. The Fish Hub (www.fishhub.org) is an online site for managing fisheries business information and enables quota program managers to share information in near-real time using three main applications. The Risk Pool will continue to engage in this initiative to test and improve the Fish Hub as an effective fisheries data management tool.

Overfished Species Quota Holdings Summary

After signing the Risk Pool agreement, members of FBGA, CCSGA, and TNC deposited their overfished species quota into various holding accounts (*e.g.* vessel accounts) to be managed by the Risk Pool. Because of regulations governing the catch share program, the Risk Pool cannot deposit all overfished species quota into a single holding account. Instead, the Risk Pool managers distributed the overfished species quota in four separate holding accounts so as not to exceed the annual and daily associated quota pound limit on how much quota can be deposited into a single vessel account. The Pacific Fisheries Management Council approved changes to risk pool regulations under the catch share management program in late 2011 that will allow a risk pool vessel holding account to hold overfished species quota above the currently established vessel account caps. When this change is implemented it will greatly streamline Risk Pool operations and provide cost savings.

The Risk Pool's total overfished species quota holdings for 2012 are presented in Table 1 and Figure 3 below. For the purposes of this report, widow rockfish has been included in the list of overfished species in all tables, figures and analysis. The Risk Pool recognizes that widow rockfish is no longer an overfished species and considered fully rebuilt to the management target of B_{MSY} (or $\geq$ 40% of the unfished biomass) under the west coast groundfish fisheries management plan, but we have included it in this report because it was managed collectively by the Risk Pool in 2012 and also allows the Risk Pool's 2012 fishing results to be easily compared to the 2011 fishing results.

Overfished Species	2012 Risk Pool Holdings in Quota Pounds	2012 Total Allowable Catch for Fleet in Quota Pounds	2012 Risk Pool Holdings as Percentage of Total Allowable Catch
Bocaccio rockfish	77,020	132,277	58%
Canary rockfish	3,639	57,761	6%
Cowcod	2,478	3,968	62%
Darkblotched rockfish	19,012	548,808	3%
Pacific Hailibut	-	232,856	0%
Pacific ocean perch	-	263,441	0%
Widow rockfish*	69,641	755,352	9%
Yelloweye rockfish	87	1,323	7%
Total	171,876	1,995,786	9%

Table 1. Risk Pool quota holdings of overfished species in 2012 compared to the total allowable catch for the west coast groundfish fleet. **Widow rockfish is no longer an overfished species but has been included in this report because it was collectively managed by the Risk Pool in 2012.*

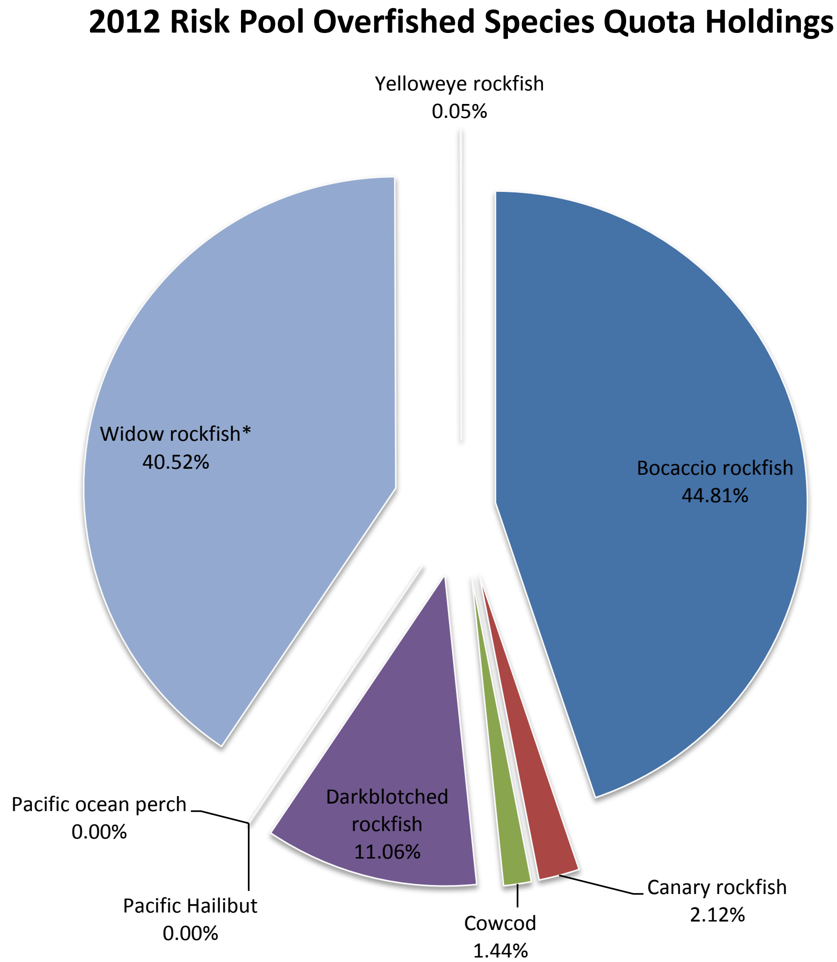

Figure 3. Pie chart showing breakdown of Risk Pool quota holdings of overfished species in 2012. **Widow rockfish is no longer an overfished species but has been included in this report because it was collectively managed by the Risk Pool in 2012*.

Risk Pool Fishing Results

In Table 2 and Figure 4, the Risk Pool's total use of overfished species quota is presented as well as the total quota balance that was retransferred pro rata back into Risk Pool members' vessel accounts at two different points during the fishing season. These quota pounds were transferred back into members accounts after projections based on collective harvest plans indicated it would be optimal to take the quota out of the Risk Pool and make it available on the open market.

Overfished Species	2012 Risk Pool Holdings in Quota Pounds	2012 Risk Pool Total Catch	2012 Risk Pool Catch as Percentage of Holdings (Utilization Rate)	2012 Total Quota Pounds Retransferred
Bocaccio rockfish	77,020	8,442	11.0%	68,578
Canary rockfish	3,639	770	21.2%	2,869
Cowcod	2,478	113	4.6%	2,365
Darkblotched rockfish	19,012	4,046	21.3%	14,966
Pacific Hailibut	-	-	0.0%	-
Pacific ocean perch	-	-	0.0%	-
Widow rockfish*	69,641	1,290	1.9%	68,351
Yelloweye rockfish	87	6	6.9%	81
Total	171,876	14,667	8.5%	157,209

Table 2. Risk Pool overfished species quota holdings, total catch, utilization rates, and total retransferred quota.

During the 2012 fishing season, Risk Pool members had available a total of 171,876 pounds of overfished species quota and collectively used a total of 14,667 pounds, or 8.5% of total holdings.

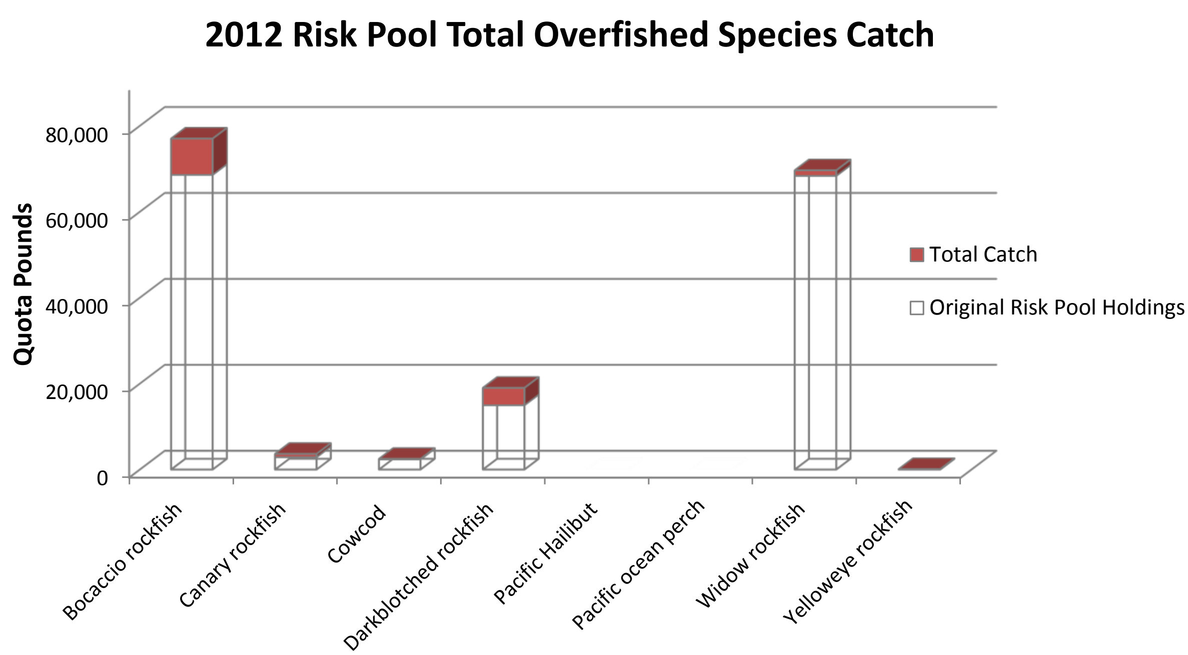

Figure 4. Total Risk Pool holdings (clear bars) and total catch of overfished species quota pounds (red bars).

The groundfish fleet (including the Risk Pool members) used a total of 773,861 pounds of the available 1,995,786 pounds of overfished species quota, or 38.8% of the total allowable catch

(Table 3). When the Risk Pool's holdings and catch are removed from the fleet at large, the overall fleet usage of the total allowable catch for overfished species increases to 41.6%.

Overfished Species	2012 Risk Pool Holdings in Quota Pounds	2012 Risk Pool Total Catch	2012 Total Allowable Catch for Fleet in Quota Pounds	2012 Total Catch for Fleet	2012 Total Allowable Catch for Fleet with Risk Pool Quota Removed	2012 Total Catch with Risk Pool Catch Removed
Bocaccio rockfish	77,020	8,442	132,277	19,461	55,257	11,019
Canary rockfish	3,639	770	57,761	15,942	54,122	15,172
Cowcod	2,478	113	3,968	204	1,490	91
Darkblotched rockfish	19,012	4,046	548,808	197,915	529,796	193,869
Pacific Hailibut	-	-	232,856	81,907	232,856	81,907
Pacific ocean perch	-	-	263,441	118,136	263,441	118,136
Widow rockfish*	69,641	1,290	755,352	340,220	685,711	338,930
Yelloweye rockfish	87	6	1,323	76	1,236	70
TOTAL	171,876	14,667	1,995,786	773,861	1,823,910	759,194
Percent Utilization of Overfishe Species Quota		8.5%		38.8%		41.6%

Table 3. Total quota holdings and total catch shown for the Risk Pool (panel 1), the entire groundfish fleet including the Risk Pool members (panel 2), and the groundfish fleet with the Risk Pool quota holdings and catch removed (panel 3).

These results from 2012 show that, similar to what was evident in 2011, the Risk Pool was able to effectively keep its utilization rate of overfished species quota to a lower level than the rest of the fleet combined (refer to Figure 5). In 2011, the FBGA and CCSGA through a similar Risk Pool agreement, were able to keep the utilization of available overfished species quota to just 2.1% within the Risk Pool, while the rest of fleet utilized 35% of overfished species quota. It was noted that results from 2011 should be evaluated with caution because it was the first year under a new management system and the Risk Pool did not begin fishing operations until part way through the calendar year; yet the results from 2012 indicate that the Risk Pool was able to keep utilization of overfished species quota lower than the rest of the fleet after fishing operations adapted to the catch share program and operated for a full fishing season.

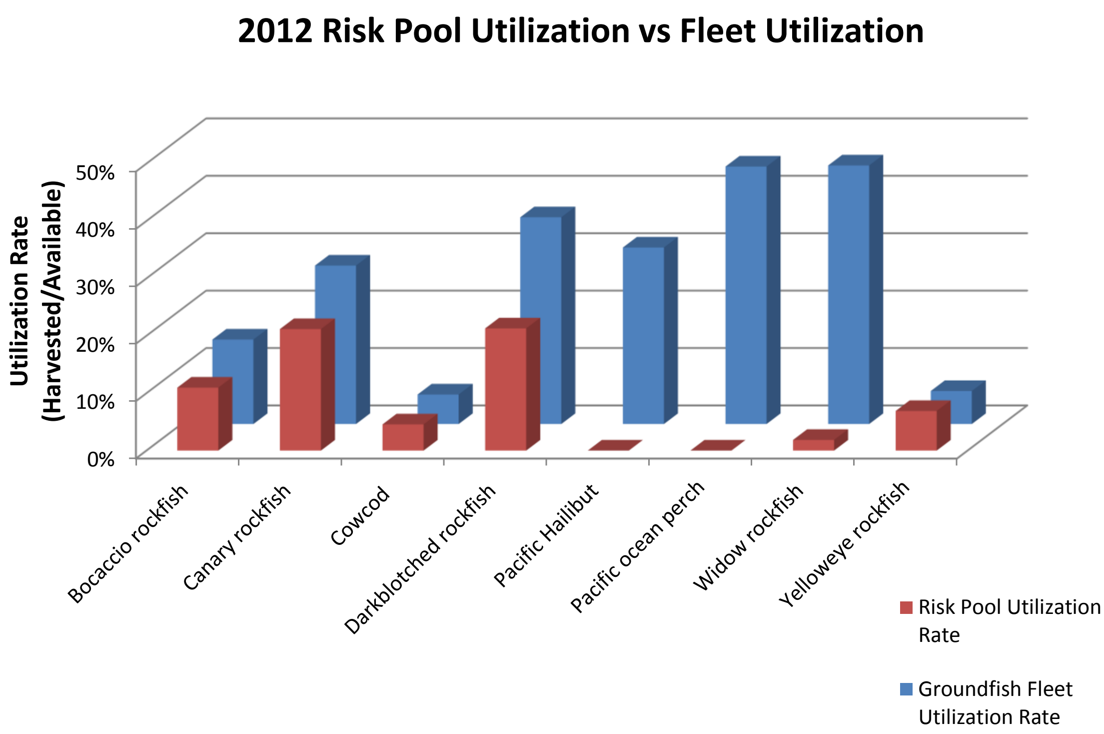

Figure 5. Utilization rates (in percent) for overfished species quota compared between the Risk Pool (red bars) and the rest of the groundfish fleet (blue bars).

Through eCatch, the Risk Pool was able to map, in near real-time, where overfished species were caught and the abundance of overfished species harvested by Risk Pool members during the 2012 fishing season. Areas of high catch intensity can indicate higher potential risk of catching overfished species over time (Figure 6), and this information is used by the Risk Pool to adaptively manage the regional fishing plans and update spatial restrictions or rules.

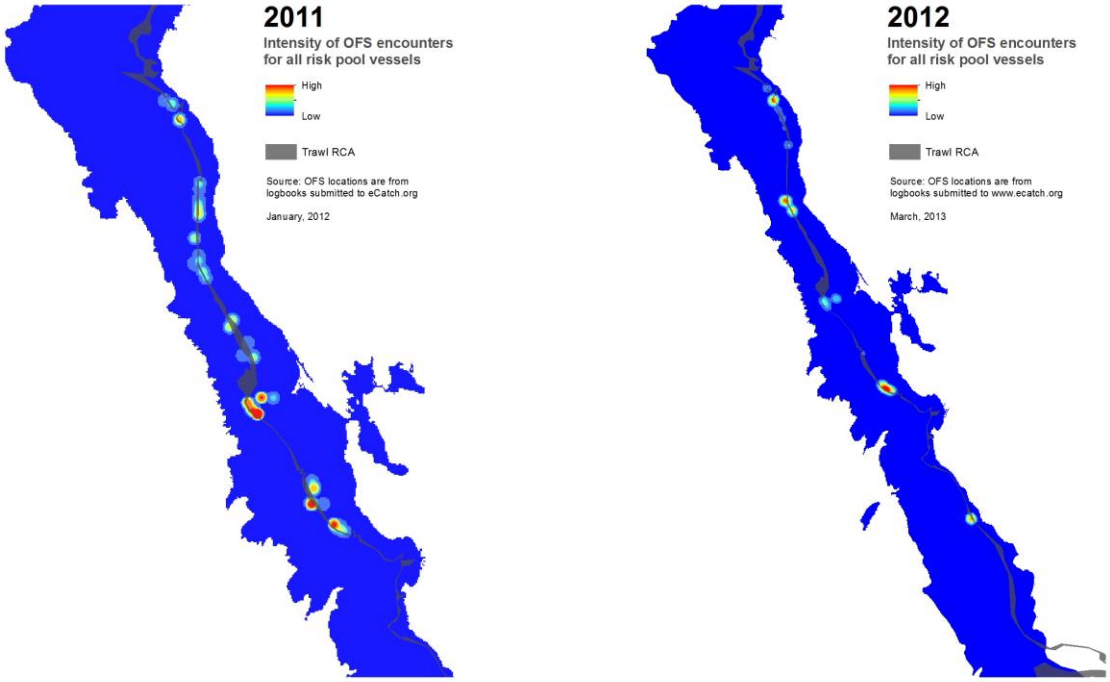

Figure 6. Maps created using eCatch data depicting the intensity of overfished species (OFS) encounters for all Risk Pool vessels during 2011 (left) and 2012 (right). Intensity is calculated as frequency of fishing sets where OFS were harvested.

A bycatch ratio is an additional metric that can be used to evaluate the performance of the Risk Pool and the groundfish fleet. Using information available on total catch of overfished species and total catch of target species (*i.e.* species other than overfished species managed under the catch share program), a simple bycatch ratio can be determined by dividing the total catch of overfished species by the total catch of target species (including discards). Overall when all species are included for 2012 the members of the Risk Pool had a bycatch ratio of 0.46%, while the rest of the groundfish fleet had a bycatch ratio of 0.42%. Whiting comprises a large amount of quota pounds landed by the west coast groundfish fleet and is not targeted by the Risk Pool members, so bycatch ratios were also calculated with whiting removed. Without whiting, the groundfish fleet had a bycatch ratio of 1.88%, while the Risk Pool has a bycatch ratio of 0.47%. This metric aligns with the utilization rates presented above and indicates that the Risk Pool reduced its bycatch of overfished species compared to the rest of the non-whiting sector of the groundfish fleet.

The data collected by Risk Pool members using eCatch makes it possible to easily evaluate bycatch ratios on a trip by trip basis. Overall, the Risk Pool members encountered overfished species in approximately 17% of all sets, which provides a measure of the risk of encounter.

Utilization of Target Species Quota

A primary goal of the Risk Pool and its associated fishing plans is to maximize the harvest of target species from the groundfish fishery. This goal is not exclusive of the other goals of the Risk Pool – to minimize the bycatch of overfished species, safeguard sensitive habitat, contribute to the rebuilding of overfished species stocks and participate in collaborative fisheries research – but the Risk Pool provides the needed insurance against deficits of overfished species that allows the fishermen members to profitably manage their fishing businesses (refer to Figure 7). In 2012, overfished species quota deficits incurred after trips where overfished species were harvested were generally filled by the Risk Pool manager within minutes to a few hours of being notified by the respective association. The result was no loss in fishing time for the members of the Risk Pool, because it was unnecessary for the fishermen to spend time searching, buying or trading for overfished species quota to fill such deficits.

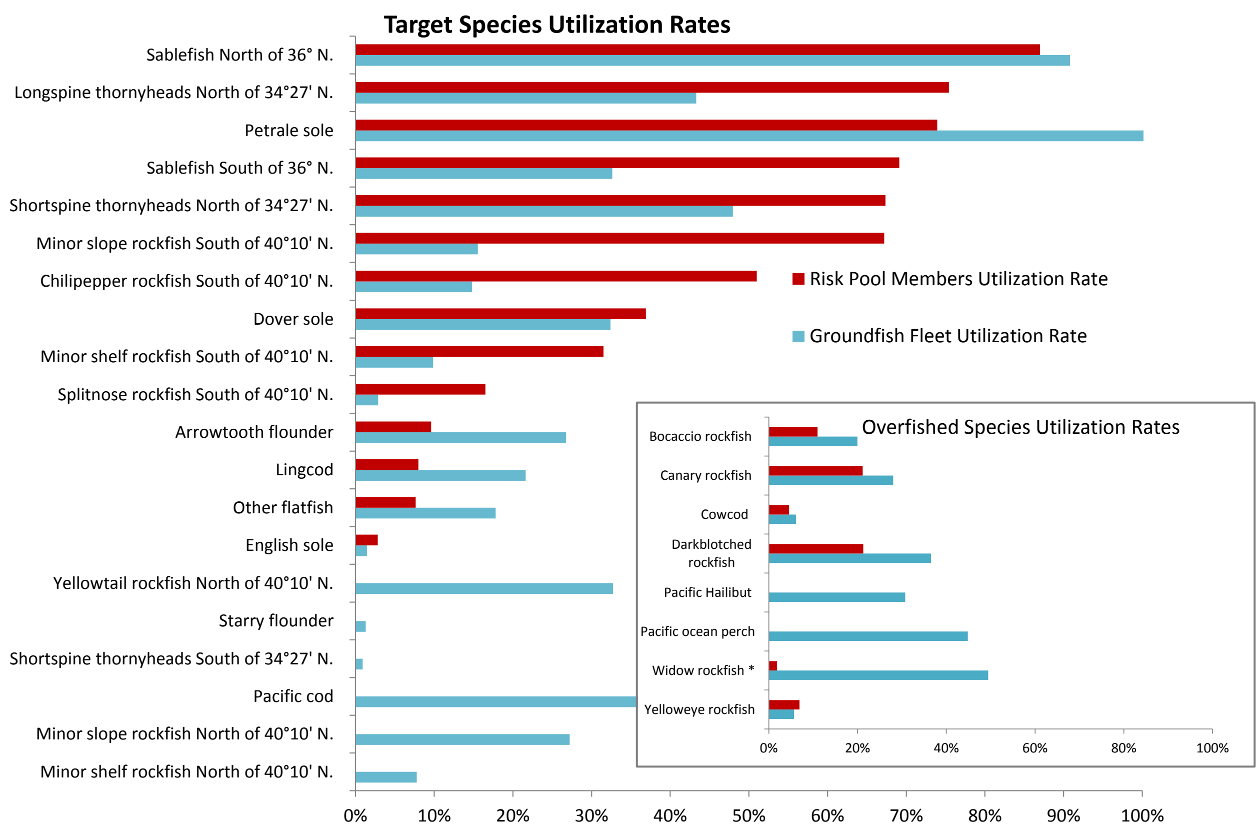

Figure 7. Utilization rates (in percent) for the 20 non-whiting target groundfish species compared between the Risk Pool (red bars) and the rest of the groundfish fleet (blue bars). Utilization rate is calculated as pounds harvested divided by quota pounds available. Inset shows overfished species utilization rates for the Risk Pool (red bars) and the rest of the groundfish fleet (blue bars).

Target species within the groundfish fishery generally depend upon the gear type being deployed by the individual fishing operation. In 2012, Risk Pool members used various gear types including trap, hook and line, Scottish seine and trawl. Typical high value target species for these gear types include petrale sole, sablefish, chilipepper rockfish, dover sole, and thornyheads. The high value associated with these target species can be a result of either the high quantity caught, high quality of the product, or higher than average ex-vessel price per pound based on consumer demand. Compared to the rest of the groundfish fleet, the Risk Pool member's combined utilization rate of quota for thornyheads, chilipepper, and dover sole was higher than the rest of the fleet (Figure 8).

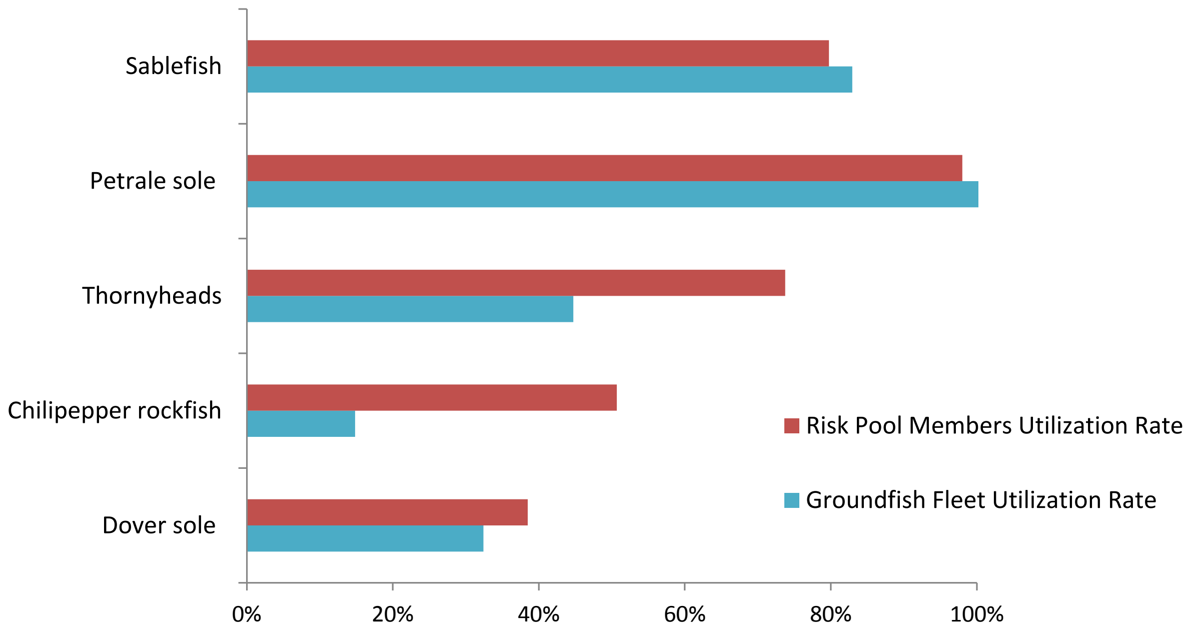

Figure 8. Utilization rates (in percent) of five high value species or species groups compared between the Risk Pool (red bars) and the rest of the groundfish fleet (blue bars). Utilization rate is calculated as pounds harvested divided by quota pounds available.

The Risk Pool members collectively caught a total of 3.2 million pounds of the 20 non-whiting target species during 2012 and landed just under 3.1 million pounds of those target species. The estimated total ex-vessel value of Risk Pool member target species landings is over $2.7 million (Figure 9). The ex-vessel value of landings is estimated based on the species-specific average price per pound received by Risk Pool members.

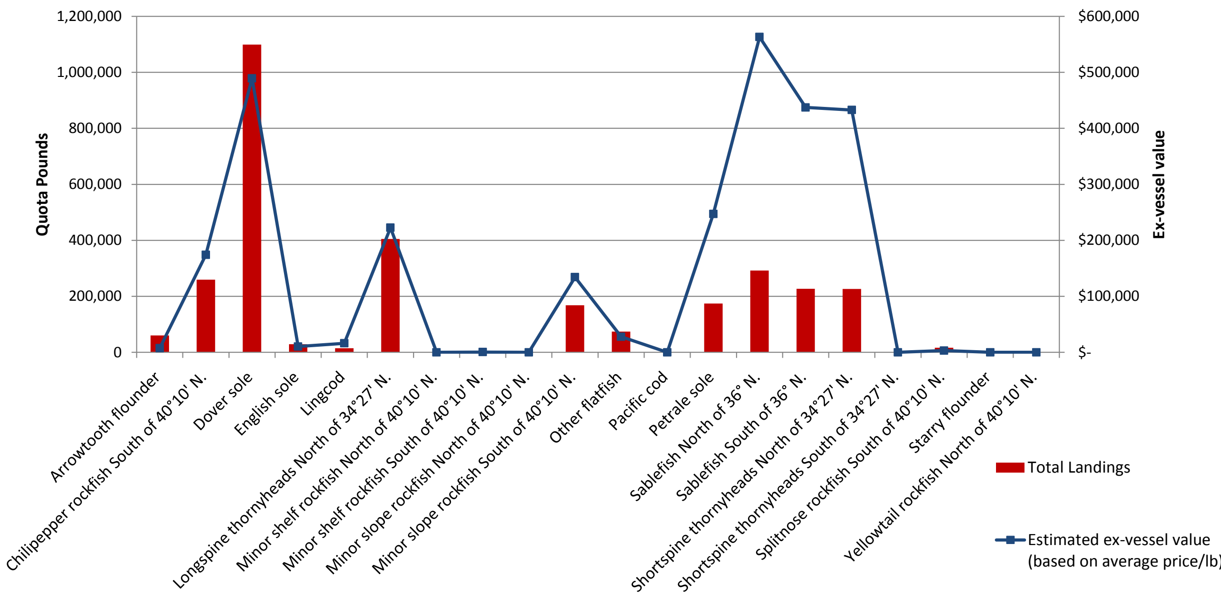

Figure 9. Total landings of 20 non-whiting target species for Risk Pool members (red bars) and estimated ex-vessel value of total landings (blue squares) based on average price per pound received by Risk Pool members.

Compliance and Monitoring

The 2012 Risk Pool agreement that was executed by the associations established steps that would be taken in the event of a compliance issue or possible violation by one of the associations' vessels of their respective fishing plan regional rules. As directed by the Advisory Committee, the Risk Pool manager was responsible for reviewing all vessel and trip specific data (i.e. spatial data, landings, etc.) with incidents of overfished species to ensure compliance with regional fishing plans. In addition, to determine compliance with spatial fishing restrictions, the Risk Pool used eCatch and the Advisory Committee reserved the right to require subsequent audits of Vessel Monitoring Systems (VMS) data from suspected or violating vessels. Because there were no incidences of non-compliance or suspected violations there were no VMS audits during 2012.

Research

The Risk Pool has actively engaged in collaborative fisheries research in the west coast groundfish fishery in order to inform local and regional management decisions. During the 2012 fishing season, the Risk Pool engaged with TNC to initiate a study investigating the Rockfish Conservation Areas (RCAs) off the west coast, which are depth-based closures that have been effective fishery management tools for reducing the catch of overfished species. However, they have also prevented access to underutilized target species that have healthy populations. Underutilized groundfish species such as yellowtail rockfish and lingcod had overall utilization rates of 32% and 21%, respectively, in 2012. The RCAs have been in place for almost ten years and yet there has been little research on the finer-scale distribution patterns of overfished species. In an effort to better understand the demographics and distributional patterns of these overfished species within the RCA, the CCSGA submitted an application to the Pacific Fishery Management Council and was granted an Exempted Fishing Permit (EFP) in 2012 to conduct the research in 2013 and 2014. The EFP authorizes a collaborative research effort that will focus on developing predictive maps of the distribution, abundance, and size of overfished species; ground-truthing the predictive maps with directed fishing efforts and visual surveys; and characterizing the abundance, length, and habitat associations of the overfished species. The Risk Pool plans to contribute overfished species quota pounds to the research effort and will review and approve directed fishing plans submitted by the research group to the Risk Pool Advisory Committee. This research project will advance understanding of the spatial distribution, size and abundance of overfished species in order to inform both fishing and management decisions that result in bycatch reduction as well as finer-scale management and enhanced profitability in the fishery.

Agenda Item D.3
Situation Summary
April 2013

STOCK COMPLEX ASSEMBLAGES

The 2006 reauthorization of the Magnuson-Stevens Act (MSA) included a mandate to end overfishing. The revised National Standard 1 (NS1) guidelines of 2009 recommended a framework for accomplishing the MSA mandate, including criteria for managing stocks in a complex to reduce the risk of overfishing. Stock complex means a group of stocks that are sufficiently similar in geographic distribution, life history, and vulnerabilities to the fishery such that the impact of management actions on the stocks is similar. The framework recommended in the revised NS1 guidelines was incorporated in the groundfish fishery management plan (FMP) under Amendment 23, which was implemented in 2011.

The Groundfish Management Team (GMT) evaluated the structure of the current groundfish stock complexes and reported to the Council in March 2010 that improvements can be made in the composition of the stock complexes and that stock complex restructuring should be done to better align stock complexes according to the revised NS1 guidelines (see Agenda Item E.4.b, Supplemental GMT Report, March 2010). The Scientific and Statistical Committee (SSC) also considered this issue and agreed with the GMT, adding that restructuring the Other Fish complex should be a top priority since that complex consists of species with different life history characteristics and depth distribution, many with poor information on historical catches (see Agenda Item I.2.b, Supplemental SSC Report, April 2010). In September 2011, a subgroup of the GMT and Council staff provided an analysis of stocks in the FMP and non-FMP stocks that are "in the fishery" in consideration of restructuring stock complexes (see Agenda Item G.5.a, Attachment 5, September 2011). The analysis evaluated each stock's relative vulnerability to overfishing and a more appropriate clustering of stocks in complexes based on their distribution and co-occurrence in the fishery. The analysis also identified nine non-FMP species that are in the fishery and caught in equivalent amounts as some of the FMP species.

The analysis presented in September 2011 has been updated with other catch statistics analyzed to better inform stock complex restructuring (Agenda Item D.3.a, Attachment 1). Strawman stock complex alternatives for six species groups (nearshore rockfish, shelf rockfish, slope rockfish, flatfish, elasmobranchs, and roundfish) are presented in Attachment 1 and it is believed that alternatives for these six groups can be considered independently.

The Council task at this meeting is to decide a range of alternatives for detailed analysis and a decision on preliminary preferred alternatives for each species group, if possible. It is recommended that the Council make adequate progress at this meeting to enable a decision on final preferred alternatives for stock complexes at the June or September meetings. This will facilitate a more orderly process for deciding 2015-2016 harvest specifications, which is slated to start in September. The Council should consider SSC advice on the analyses presented in Attachment 1, as well as the recommendations of the GMT, Groundfish Advisory Subpanel, and public before taking action on this item.

<u>Council Action</u>:

1. **Adopt a Range of Alternatives for Restructuring Stock Complexes.**
2. **Decide preliminary preferred alternatives for restructuring stock complexes, if possible.**

<u>Reference Materials:</u>

1. Agenda Item D.3.a, Attachment 1: Initial Proposal (Proposed Action, Alternatives, and Considerations) for Restructuring Groundfish Stock Complexes.

<u>Agenda Order:</u>

a. Agenda Item Overview — John DeVore
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action:** Adopt a Range of Alternatives and if Possible, Preliminary Preferred Alternatives, for Stock Complex Assemblages

PFMC
03/22/13

Initial Proposal (Proposed Action, Alternatives, and Considerations) for Restructuring Groundfish Stock Complexes

Background

The Magnuson-Stevens Act (MSA) was reauthorized in 2006 with a mandate to end overfishing. National Standard 1 (NS1) guidelines, the National Marine Fisheries Service (NMFS) guidance on how to meet the conservation objectives of the MSA, were revised in 2009 in response to the MSA reauthorization. The revised NS1 guidelines proposed a harvest management framework that specified a number of management reference points and precautionary buffers to reduce the risk of overfishing (i.e., exceeding the level of harvest estimated to achieve maximum sustainable yield (MSY)). The revised NS1 guidelines recommended specification of an overfishing limit (OFL), the MSY harvest level; a buffer between the OFL and the acceptable biological catch (ABC) to account for scientific uncertainty in estimating the OFL; and the annual catch limit (ACL), which may be set equal to the ABC or lower to accomplish other objectives. These precepts and other recommendations from the revised NS1 guidelines were incorporated in the groundfish fishery management plan (FMP) under Amendment 23, which was implemented in 2011.

The revised NS1 guidelines and Amendment 23 also incorporated a framework for managing stock complexes, which are aggregations of stocks managed in a single unit under harvest specifications decided for the complex in its entirety. Stocks managed in a complex should be sufficiently similar in geographic distribution, life history, and vulnerabilities to the fishery such that the impact of management actions on the stocks is similar. At the time a stock complex is established, the FMP should provide a full and explicit description of the proportional composition of each stock in the stock complex, to the extent possible. Stocks may be grouped into complexes for various reasons, including where stocks in a multispecies fishery cannot be targeted independent of one another and MSY cannot be defined on a stock-by-stock basis; where there is insufficient data to measure their status relative to status determination criteria (SDC); or when it is not feasible for fishermen to distinguish individual stocks among their catch. The vulnerability of stocks to the fishery should be evaluated when determining if a particular stock complex should be established or reorganized, or if a particular stock should be included in a complex.

Stock complexes may be comprised of: one or more indicator stocks, each of which has SDC and ACLs, and several other stocks; several stocks without an indicator stock, with SDC and an ACL for the complex as a whole; or one of more indicator stocks, each of which has SDC and management objectives, with an ACL for the complex as a whole. An indicator stock is a stock with measurable SDC that can be used to help manage and evaluate more poorly-known stocks that are in a stock complex. If an indicator stock is used to evaluate the status of a complex, it should be representative of the typical status of each stock within the complex, due to similarity in vulnerability. If the stocks within a stock complex have a wide range of vulnerability, they should be reorganized into different stock complexes that have similar vulnerabilities; otherwise, the indicator stock should be chosen to represent the more vulnerable stocks within the complex. In instances where an indicator stock is less vulnerable than other members of the complex, management measures need to be more conservative so that the more vulnerable members of the complex are not at risk from the fishery. More than one indicator stock can be selected to provide more information about the status of the complex. When indicator stock(s) are used, periodic re-evaluation of available quantitative or qualitative information (e.g., catch trends, changes in vulnerability, fish health indices, etc.) is needed to determine whether a stock is subject to overfishing, or is approaching (or in) an overfished condition. Under the proposed action, more consideration will be needed to understand how to best use indicator stocks in managing stock complexes.

Proposed Action

Using the "best available scientific information," the proposed action is to restructure the current groundfish stock complexes that comprise species of more equivalent ecological distributions, more equivalent vulnerabilities to overfishing, and that are caught together in the fishery. This action would align stock complexes to more closely comport with NS1 guidelines and the tenets of the FMP.

The proposed action also considers adding a few non-FMP species into the FMP. Considerations for adding new species are they are caught in the groundfish fishery in amounts that may not be considered incidental and adding species that are landed together with FMP species in general market categories facilitates estimating harvest specifications for the complex using approved catch-based methods.

The proposed action also considers designating some FMP stocks as Ecosystem Component (EC) species. EC species are not in the fishery and therefore not actively managed. EC species are not targeted in any fishery and are not generally retained for sale or personal use. EC species are not determined to be subject to overfishing, approaching an overfished condition, or overfished, nor are they likely to become subject to overfishing or overfished in the absence of conservation and management measures. While EC species are not considered to be in the fishery, the Council should consider measures for the fishery to minimize bycatch and bycatch mortality of EC species consistent with National Standard 9, and to protect their associated role in the ecosystem. EC species do not require specification of reference points but should be monitored to the extent that any new pertinent scientific information becomes available (e.g., catch trends, vulnerability, etc.) to determine changes in their status or their vulnerability to the fishery. The candidate species for an EC designation under the proposed action contribute no or negligible catch to the estimated catch-based OFLs used to determine harvest specifications.

The proposed action also considers removing some species from the FMP because they are not in the fishery. In cases where there is uncertainty whether candidate species are in the fishery or not, the proposed action is to designate such species as EC species.

The proposed action considers different ways to restructure stock complexes for six different species groups. In some cases, the relative productivity and vulnerability of component stocks is the key attribute for alternative stock complexes (e.g., nearshore and slope rockfish complexes) and in other cases, the depth distributions of component stocks is the key attribute (e.g., shelf rockfish, flatfish, elasmobranchs, and roundfish complexes). While consideration of aligning stocks managed in alternative complexes is done for all complexes, the productivity and vulnerability attributes of component stocks in the nearshore and slope rockfish complexes are the main factor in proposing alternative complexes since some of those stocks have the highest vulnerability to overfishing of all FMP stocks.

Purpose and Need

The purpose of the proposed action is to conserve and manage Pacific Coast groundfish fishery resources to prevent overfishing, to rebuild overfished stocks, to ensure conservation, to facilitate long-term protection of essential fish habitat (EFH), and to realize the full potential of the Nation's fishery resources (MSA §2(a)(6)) by restructuring current stock complexes. The harvest specifications for stock complexes are set consistent with the harvest management framework described in Chapter 4 of the Groundfish FMP.

There is a need to evaluate and consider changes to the current structure of stock complex groupings to ensure that the species in each complex are sufficiently similar in geographic distribution, life history, and vulnerabilities to the fishery such that management impacts are similar.

Potential Stock Complex Alternatives

The alternatives described here are intended to evaluate aggregations of species that represent a better management alignment of species according to their ecological distributions, interactions with the fishery, and relative vulnerabilities to overfishing. Alternatives are stratified into six major species groups (Nearshore Rockfish, Shelf Rockfish, Slope Rockfish, Flatfishes, Roundfishes, and Elasmobranchs). Considerations for restructuring stock complexes for these six groups of species can be decided independently and are thus presented and analyzed independently.

There are considerations for incorporating new species into the FMP since they are caught in the groundfish fishery in relatively high amounts analogous to catches of closely related FMP species. Incorporating these species into the FMP will also enable more accurate estimates of OFLs for some FMP species using the data-poor catch-based methods employed for unassessed species. This is because some of these species are landed in market categories representing an aggregation of similar species with little or no species composition data available to differentiate landing to species (e.g., Pacific grenadier landed in an “unspecified grenadiers” market category).

There are also considerations for designating some species as EC species, as well as removing some species from the FMP. There is a consideration for removing species from the FMP in cases where the species does not occur on the West Coast and has no catch history (e.g., dusky rockfish) or is solely caught in state-managed fisheries (e.g., leopard shark). Stocks that are not targeted and have a negligibly small catch history (e.g., calico rockfish) are candidates for an EC designation.

The Groundfish Management Team (GMT) scored the relative productivity and susceptibility of species to being caught in the fishery in a Productivity and Susceptibility Assessment (PSA) to score their relative vulnerability to potential overfishing (PFMC and NMFS 2012). Productivity and vulnerability scores from the GMT PSA analysis are used in the analysis of effects of managing FMP stocks in alternative stock complexes.

The West Coast Groundfish Observer Program also developed a database (2003-2011) and the GMT developed an analysis using that database of annual removal data to evaluate a component stock’s catch contribution to an OFL estimate for a stock complex. While there is concern for component stocks that contribute an inordinately larger catch contribution to the complex (i.e., inflator stocks), this concern is accentuated when there is high interannual variation in those catches. The presence of inflator stocks in a complex can risk overfishing of other stocks in the complex since it inflates the complex OFL. This is especially concerning for those stocks in the complex with high vulnerability to overfishing. The GMT analysis of catch data probes those effects for proposed alternative stock complexes. Two important concepts are the scale of removals and the ratio of stock removal to overall stock complex removals. An ideal stock complex would a) avoid removals above any component OFLs; b) not have large scale differences in the OFL components; therefore, allowing for potential overages; and c) if large scale differences are apparent, consistent removal ratios indicating a consistent contribution of catches to the complex is desired. The GMT identified several removal-based metrics to help evaluate these standards for status quo and proposed alternative complexes:

1) *Maximum and minimum cumulative removals of the status quo alternative*. These measures evaluate scale and are calculated as differences between stock-specific cumulative removals for years 2003-2011 and the sum of component OFLs (assumed

at the 2013 OFL value in each year). Large maximum values indicate the complex has allowed overfishing relative to the 2013 OFL. Large minimum values indicate “inflator species”— species that add a large amount of latent component OFL that could be applied to other species in the complex. Both of these are indicators that a complex is misaligned as far as catch being applied to component species. For each complex, one is looking for low maximum and minimum values.

2) *Evenness*: Evenness is another measure of scale that quantifies the inequality/imbalance among the component OFLs in a given stock complex. Pielou’s measure of evenness (Jost 2010) was used and is calculated as H'/ln(S) where H' is Shannon-Weiner diversity index (Krebs 1999) and S is the number of stocks in the complex. A value of 1 indicates every stock contributes equally; a value of 0 means one stock contributes everything. Evenness is reported for annual catches (with the median value over all years reported) and for the 2013 OFL. Values closest to 1 are desired.

3) *Slope of removal ratios*: This measure looks at how many stocks demonstrate non-significant trends in the slope of stock catch/total complex catch for each year. A simple linear model is used to fit the time series of removal ratios, with a conservative p-value < 0.1 indicating slopes significantly different than 0. The number of stocks with slope non-significantly different than 0 are reported, so values closest to 1 (1 meaning all stocks in a complex have constant removal ratios) is desired.

The analysis of effects also considers how alternative stock complexes may interact with the management system. There are formal allocations for some of these species which has a direct effect on how well the rationalized trawl sectors and other sectors of the groundfish fishery are managed to accomplish the conservation and socioeconomic objectives of the MSA and FMP.

Some of the affected stocks are scheduled for assessment this year, either as full assessments (aurora rockfish, rougheye rockfish, and Pacific Sanddabs) or as data-moderate assessments (brown rockfish, China rockfish, copper rockfish, English sole, rex sole, sharpchin rockfish, stripetail rockfish, vermilion rockfish, and yellowtail rockfish). These stocks are all managed in status quo stock complexes with the exception of English sole and yellowtail rockfish north of 40º10’ N lat., which are managed with stock-specific harvest specifications. The Council’s final preferred alternative for stock complexes could affect management of these stocks in one of three ways: 1) continue management using status quo aggregations in stock complexes, 2) move one or more of these stocks from a status quo complex to a new, reorganized complex, or 3) move one or more of these stocks out of a status quo complex to be managed with stock-specific harvest specifications. Each of these options has different management implications that are explored in this document.

Description of the Alternatives

Status Quo Rockfish

There are six status quo rockfish complexes stratified in three depth groups (nearshore, shelf, and slope) and two areas (north and south of 40º10’ N lat.) (Table 1 and Table 2, respectively).

Table 1. Status quo rockfish stocks and stock complexes north of 40º10’ N lat.

Rockfish Stocks	Stock Complexes N of 40°10’		
	Minor NS RF	**Minor Shelf RF**	**Minor Slope RF**
Overfished Stocks	Black and yellow	Bronzespotted	Aurora
Canary	Blue	Bocaccio	Bank
Darkblotched	Brown	Chameleon	Blackgill
POP N of 40º10’	China	Chilipepper	Redbanded
Yelloweye	Copper	Cowcod	Rougheye
Non-overfished Stocks	Gopher	Dusky	Sharpchin
Black rockfish (OR-CA)	Grass	Dwarf-red	Shortraker
Black rockfish (WA)	Kelp	Flag	Splitnose
Longspine thornyhead N and S of 34º27'	Olive	Freckled	Yellowmouth
Shortbelly	Quillback	Greenblotched	
Shortspine thornyhead N and S of 34º27'	Treefish	Greenspotted	
Widow		Greenstriped	
Yellowtail N of 40°10’		Halfbanded	
		Harlequin	
		Honeycomb	
		Mexican	
		Pink	
		Pinkrose	
		Puget Sound	
		Pygmy	
		Redstripe	
		Rosethorn	
		Rosy	
		Silvergray	
		Speckled	
		Squarespot	
		Starry	
		Stripetail	
		Swordspine	
		Tiger	
		Vermilion	

Table 2. Status quo rockfish stocks and stock complexes south of 40º10’ N lat.

Rockfish Stocks	Stock Complexes S of $40^{0}10'$		
	Minor NS RF	**Minor Shelf RF**	**Minor Slope RF**
Overfished Stocks	**Shallow NS Species**	Bronzespotted	Aurora
Bocaccio S of $40^{0}10'$	Black and yellow	Chameleon	Bank
Canary	China	Dusky	Blackgill
Cowcod S of $40^{0}10'$	Gopher	Dwarf-red	Pacific ocean perch
Darkblotched	Grass	Flag	Redbanded
Yelloweye	Kelp	Freckled	Rougheye
Non-overfished Stocks	**Deeper NS Species**	Greenblotched	Sharpchin
Black rockfish (OR-CA)	Blue	Greenspotted	Shortraker
Chilipepper S of $40^{0}10'$	Brown	Greenstriped	Yellowmouth
Longspine thornyhead N and S of 34º27'	Calico	Halfbanded	
Shortbelly	Copper	Harlequin	
Shortspine thornyhead N and S of 34º27'	Olive	Honeycomb	
Splitnose S of $40^{0}10'$	Quillback	Mexican	
Widow	Treefish	Pink	
		Pinkrose	
		Pygmy	
		Redstripe	
		Rosethorn	
		Rosy	
		Silvergray	
		Speckled	
		Squarespot	
		Starry	
		Stripetail	
		Swordspine	
		Tiger	
		Vermilion	
		Yellowtail	
		Swordspine	
		Tiger	
		Vermilion	

Nearshore Rockfish

One action alternative is considered for restructuring the nearshore rockfish stock complexes based on the relative productivity and vulnerability to overfishing of affected stocks (Table 3 and Table 4). Honeycomb rockfish is currently managed in the southern shelf rockfish complex. However, the depth distribution of honeycomb rockfish ranks it ecologically as a nearshore rockfish (Table 3). The proposed alternative for honeycomb rockfish is to designate it as an EC species since it contributes no historical catch to the catch-based OFL. In the event honeycomb rockfish is not designated as an EC species, there should be consideration for managing this stock in the Southern Nearshore Rockfish complex.

Table 3. Nearshore rockfish stocks ranked by relative productivity. Productivity (P) and vulnerability (V) scores are from the GMT's PSA analysis.

Stock	P	Relative P	V	Relative V
Kelp rockfish	1.94	High	1.59	Low
Black-and-yellow rockfish	1.89	High	1.7	Low
Olive rockfish	1.69	High	1.87	Med
Treefish rockfish	1.67	High	1.73	Low
Brown rockfish	1.61	High	1.99	Med
Grass rockfish	1.61	High	1.89	Med
Gopher rockfish	1.56	High	1.76	Low
Blue rockfish	1.39	Low	2.01	High
Copper rockfish	1.36	Low	2.27	Highest
Honeycomb rockfish	1.36	Low	1.97	Med
Black rockfish	1.33	Low	1.94	Med
China rockfish	1.33	Low	2.23	Highest
Quillback rockfish	1.31	Low	2.22	Highest

Table 4. Alternative 1 nearshore stocks and stock complexes aggregated by relative vulnerability (strikeout denotes a stock moving from a status quo category; italics denotes a stock moving into a new category).

Nearshore Rockfish Stocks	Stock Complexes			
	N of 40°10'		S of 40°10'	
	Nearshore RF	Vul. Nearshore RF	Nearshore RF	Vul. Nearshore RF
Non-overfished Stocks	~~Black and yellow~~ a/	*China*	**Shallow NS Species**	*China*
Black rockfish (OR-CA)	Blue	*Copper*	Black and yellow	*Copper*
Black rockfish (WA)	Brown	*Quillback*	~~China~~	*Quillback*
	~~China~~		Gopher	
	~~Copper~~		Grass	
	~~Gopher~~ a/		~~*Honeycomb*~~ b/	
	Grass		Kelp	
	~~Kelp~~ a/		**Deeper NS Species**	
	Olive		Blue	
	~~Quillback~~		Brown	
	Treefish		~~Calico~~ b/	
			~~Copper~~	
			Olive	
			~~Quillback~~	
			Treefish	

a/ Remove from complex since there is no or low presence.

b/ Specify as an Ecosystem Component species.

Analysis of the Nearshore Rockfish Alternatives

Nearshore Rockfish North of 40º10' N lat.

The catch histories of species in the status quo Minor Nearshore Rockfish North complex does not show problematic component OFL overages (Table 5), but does indicate the presence of an inflator stock. Blue rockfish is the inflator stock in the Minor Nearshore Rockfish North complex, which presents an overfishing risk for the more vulnerable stocks in the complex (i.e., China, copper, and quillback rockfish) (Figure 1). The OFL evenness is improved in the status quo complex by simply removing the species from the complex that have no or low presence north of 40º10' N lat. or are proposed for an EC species designation (Table 4 and Table 5). Alternative 1 shows a trade-off between greatly improving evenness and removal ratios for vulnerable species, while decreasing the performance of these measures in the non-vulnerable complex. Taking this species out of this complex would greatly improve complex evenness and removal ratios. Managing blue rockfish with stock-specific harvest specifications would also reduce risk of overfishing the stock which has a relatively high vulnerability. Blue rockfish has the fourth highest vulnerability score in the status quo complex behind China, copper, and quillback rockfish. Another alternative not explored in this analysis would be adding blue rockfish to the Vulnerable Northern Nearshore Rockfish Complex as described under Alternative 1. However, it would still be an inflator stock in the vulnerable complex if it were managed there and would create a greater risk of overfishing the other vulnerable species.

Nearshore Rockfish South of 40º10' N lat.

The catch histories of species in the status quo Minor Nearshore Rockfish South complex do not show problematic component OFL overages (Table 5), but does indicate the presence of inflator stocks (gopher, blue, brown, copper, and olive rockfish) (Figure 2). None of the evenness metrics are improved in the status quo complex by simply removing the species from the complex that have no or low presence north of 40º10' N lat. or are proposed for an EC species designation (Table 4 and Table 5). Overall, alternative 1 provides the best improvement in evenness and removal ratios, while taking into consideration better management of vulnerable species.

Table 5. Summary of status quo (SQ) and proposed nearshore rockfish complexes in relation to several removal-based diagnostics. See text for descriptions of each measure.

Complex	Alternative	P	Cumulative removal difference (mt)		Evenness		Ratios
			Maximum	Minimum	$Removals_{median}$	OFL	%Slope = 0
Nearshore North	SQ	-	2	-262	0.56	0.59	0.56
	SQ - EC spp.	-	1	-262	0.63	0.66	0.57
	Alt. 1	+			0.18	0.25	0.25
	Alt. 1 V	+			**0.98**	**0.88**	**0.67**
Nearshore South	SQ	-	0	-2340	0.74	0.80	0.67
	SQ - EC spp.	-	0	-2340	0.74	0.80	0.67
	Alt. 1	+			**0.79**	**0.84**	0.50
	Atl. 1 V	+			0.78	0.44	**1.00**

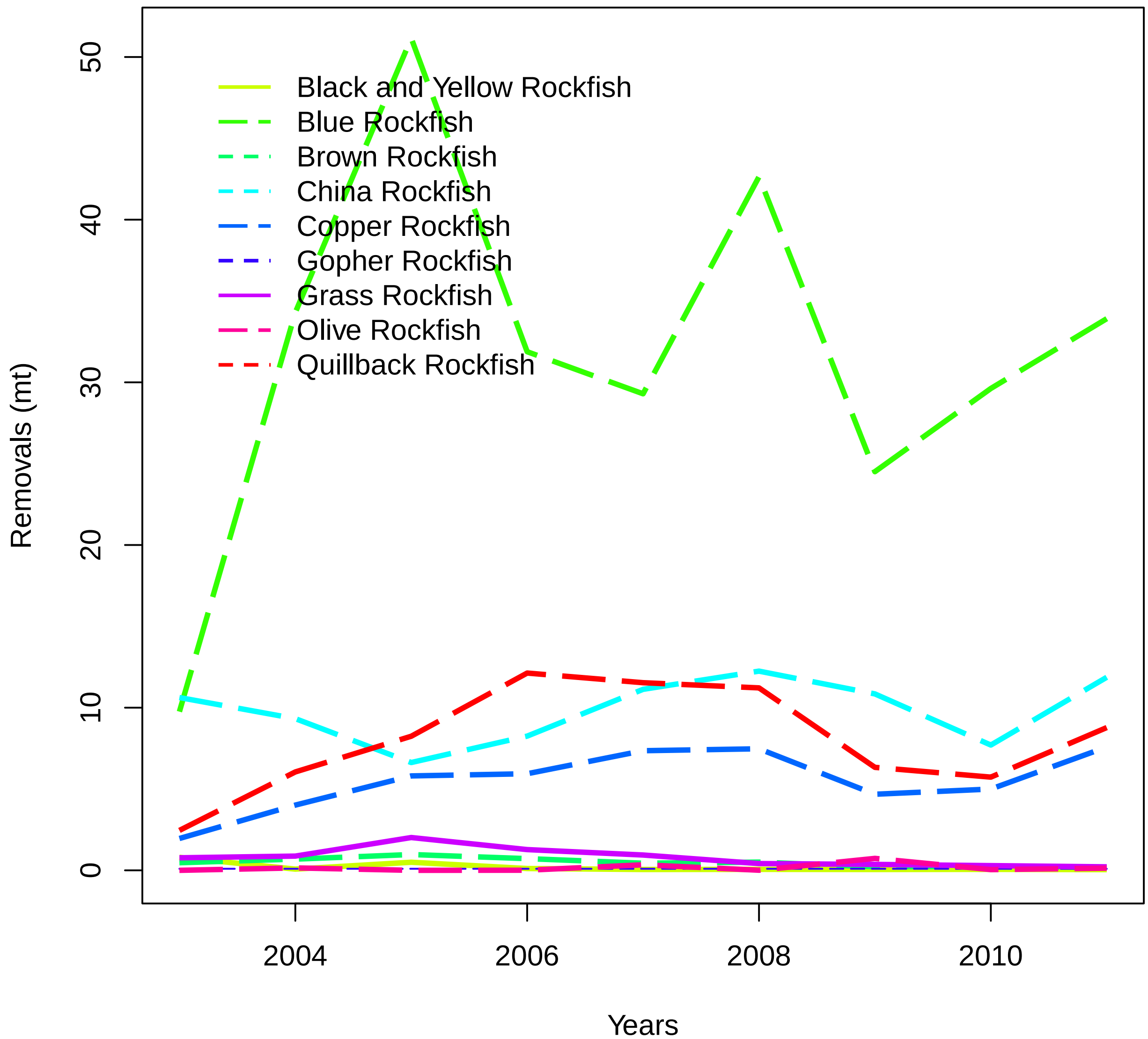

Figure 1. Annual total mortality (minus research catches) of nearshore rockfish stocks in the Minor Nearshore Rockfish North stock complex, 2003-2011.

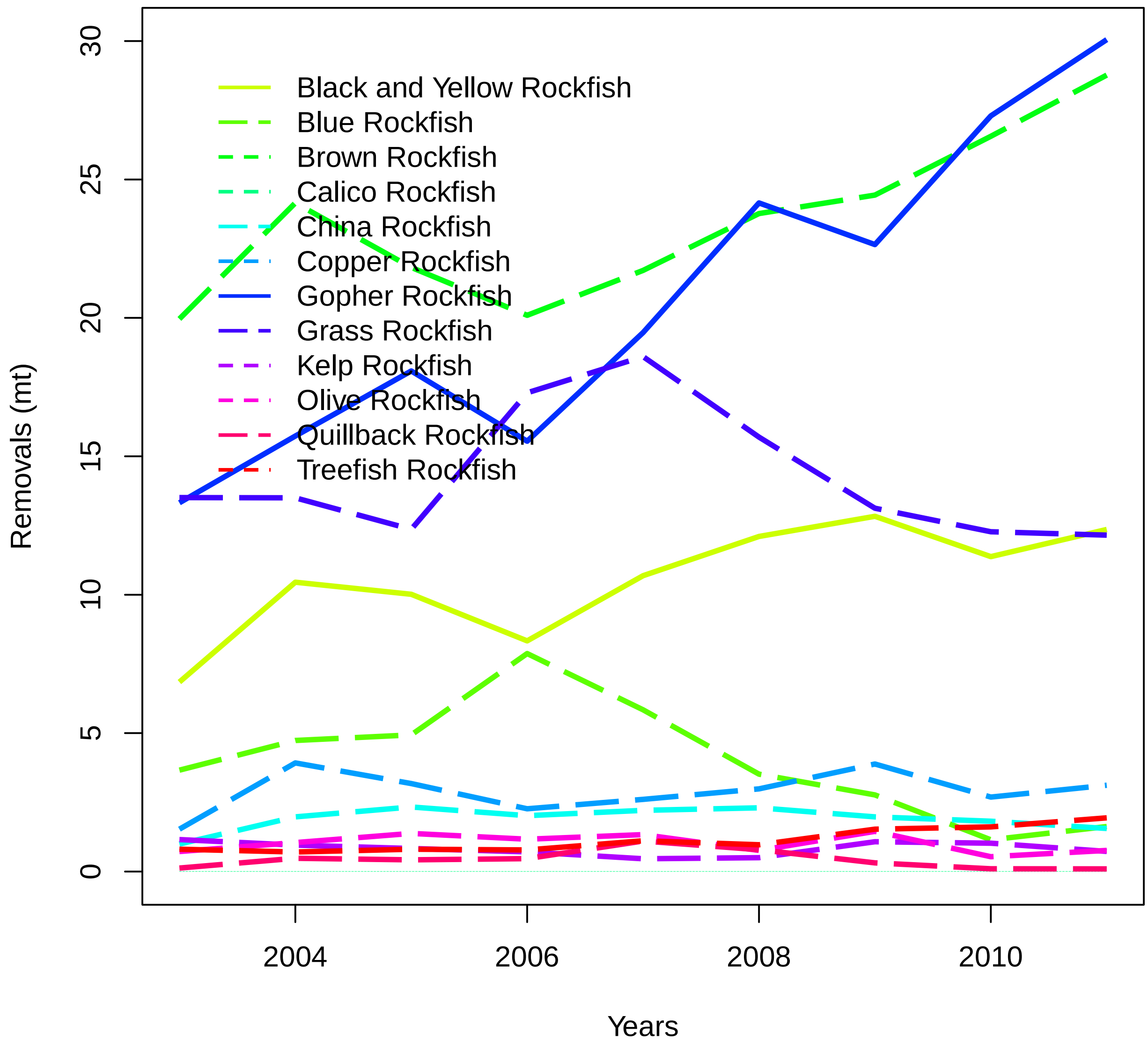

Figure 2. Annual total mortality (minus research catches) of nearshore rockfish stocks in the Minor Nearshore Rockfish South stock complex, 2003-2011.

Shelf Rockfish

One action alternative (Table 6) is considered for restructuring the shelf rockfish stock complexes based on the depth distributions of component species (Table 7 and Table 8). A number of species in the shelf rockfish complexes are proposed for an EC designation (e.g., freckled rockfish) regardless of the Council's decision to reorganize the shelf rockfish complexes by depth distribution of the component species. A few species are recommended to be removed from the northern or southern complexes (e.g., pygmy rockfish in the north) since there is no or very low presence of the species in the affected area.

Table 6. Alternative 1 shelf rockfish stocks and stock complexes (strikeout denotes a stock moving from a status quo category; italics denotes a stock moving into a new category).

Shelf Rockfish Stocks	Stock Complexes			
	N of 40^{0}10’		S of 40^{0}10’	
	Shallow Shelf RF	Deeper Shelf RF	Shallow Shelf RF	Deeper Shelf RF
Overfished Stocks	Chilipepper	~~Bank~~ a/	~~Dwarf-red~~ b/	*Bank*
Bocaccio S of 40^{0}10’	~~Dwarf-red~~ a/	~~Bronzespotted~~ a/	Flag	Bronzespotted
Canary	Flag	Bocaccio	~~Freckled~~ a/	~~Chameleon~~ a/
Cowcod S of 40^{0}10’	~~Freckled~~ a/	~~Chameleon~~ a/	Greenspotted	~~Dusky~~ a/
Yelloweye	~~Greenspotted~~ a/	~~Cowcod~~ a/	~~Halfbanded~~ a/	Greenblotched
Non-overfished Stocks	~~Halfbanded~~ a/	~~Dusky~~ b/	~~Pygmy~~ a/	Greenstriped
Chilipepper S of 40^{0}10’	~~Pygmy~~ b/	~~Greenblotched~~ a/	Rosy	~~Harlequin~~ a/
Longspine thornyhead N and S of 34º27'	Rosy	Greenstriped	Speckled	Mexican
~~Shortbelly~~ a/	Speckled	~~Harlequin~~ b/	Squarespot	Pink
Shortspine thornyhead N and S of 34º27'	Squarespot	~~Mexican~~ a/	~~Starry~~ b/	~~Pinkrose~~ b/
Widow	~~Starry~~ a/	~~Pink~~ a/	~~Swordspine~~ b/	~~Puget Sound~~ a/
Yellowtail N of 40^{0}10’	~~Swordspine~~ a/	~~Pinkrose~~ a/	Vermilion	Redstripe
	Vermilion	~~Puget Sound~~ b/	Yellowtail	Rosethorn
		Redstripe		Silvergray
		Rosethorn		Stripetail
		Silvergray		~~Tiger~~ b/
		Stripetail		
		Tiger		

a/ Remove from complex since there is no or low presence.
b/ Specify as an Ecosystem Component species.

Table 7. Shallow shelf rockfish stocks ranked by depth group and relative productivity. Productivity (P) and vulnerability (V) scores are from the GMT's PSA analysis.

Stock	P	Relative P	V	Relative V
Halfbanded rockfish	2	High	1.26	Low
Dwarf-red rockfish	1.83	High	1.54	Low
Chilipepper	1.83	High	1.35	Low
Freckled rockfish	1.78	High	1.44	Low
Pygmy rockfish	1.78	High	1.42	Low
Calico rockfish	1.75	High	1.46	Low
Rosy rockfish	1.61	High	1.89	Med
Squarespot rockfish	1.61	High	1.86	Med
Greenspotted rockfish	1.39	Low	1.98	Med
Speckled rockfish	1.33	Low	2.1	High
Flag rockfish	1.33	Low	1.97	Med
Swordspine rockfish	1.33	Low	1.94	Med
Yellowtail rockfish	1.33	Low	1.88	Med
Canary rockfish	1.28	Low	2.01	High
Starry rockfish	1.25	Low	2.09	High
Vermilion rockfish	1.22	Low	2.05	High
Yelloweye rockfish	1.22	Low	2	High

Table 8. Deeper shelf rockfish stocks ranked by depth group and relative productivity. Productivity (P) and vulnerability (V) scores are from the GMT's PSA analysis.

Stock	P	Relative P	V	Relative V
Shortbelly rockfish	1.94	High	1.13	Low
Puget Sound rockfish	1.89	High	1.35	Low
Mexican rockfish	1.5	High	1.8	Low
Chameleon rockfish	1.39	Low	2.03	High
Darkblotched rockfish	1.39	Low	1.92	Med
Stripetail rockfish	1.39	Low	1.8	Low
Sharpchin rockfish	1.36	Low	2.05	High
Pink rockfish	1.33	Low	2.02	High
Harlequin rockfish	1.31	Low	1.94	Med
Pinkrose rockfish	1.31	Low	1.82	Med
Redstripe Rockfish	1.31	Low	2.16	High
Widow rockfish	1.31	Low	2.05	High
Bocaccio	1.28	Low	1.93	Med
Dusky rockfish	1.28	Low	1.99	Med
Greenblotched rockfish	1.28	Low	2.12	High
Greenstriped rockfish	1.28	Low	1.88	Med
Bank rockfish	1.25	Low	2.02	High
Tiger rockfish	1.25	Low	2.06	High
Bronzespotted rockfish	1.22	Low	2.12	High
Silvergray rockfish	1.22	Low	2.02	High
Rosethorn rockfish	1.19	Low	2.09	High
Cowcod	1.06	Low	2.13	High

Analysis of the Shelf Rockfish Alternatives

Shelf Rockfish North of 40º10' N lat.

The catch histories of species in the status quo Minor Shelf Rockfish North complex do not show problematic component OFL overages (Table 9), but does indicate the presence of a huge inflator stock (greenstriped rockfish) (Figure 3). Evenness is improved in the status quo complex by simply removing the species from the complex that have no or low presence north of 40º10' N lat. or are proposed for an EC species designation (Table 6 and Table 9). The Alternative 1 Deep Shelf complex improves evenness and removal ratios while also aligning better with vulnerability scores, but at the expense of the Shallow Shelf complex, which shows decreased improvement in all measures because chilipepper is the overwhelming contributor to that complex.

Shelf Rockfish South of 40º10' N lat.

The catch histories of species in the status quo Minor Shelf Rockfish South complex do not show problematic component OFL overages (Table 9), but does indicate the presence of a huge inflator stock (yellowtail rockfish) (Figure 4). The removal of the proposed EC stocks from the status quo complex improves all removal-based diagnostics (Table 9). Improvement in OFL evenness and removal ratios are also seen under Alternative 1, although status quo minus the EC stocks seems to give the best overall improvement.

Alternative 1 (both north and south) is structured to consider a further stratification of rockfish complexes by depth. The further depth stratification of the current shelf rockfish complexes into Shallow Shelf and Deeper Shelf complexes might better align the shelf rockfish complexes with the current fishery. Under Rockfish Conservation Area (RCA) management, fisheries are somewhat segregated into nearshore effort shoreward of the RCA and deeper efforts seaward of the RCA. The species aggregated in the Shallow Shelf Rockfish complex are primarily caught in nearshore fisheries (e.g., recreational, nearshore commercial, and shallow "beach" trawl efforts) in association with many of the nearshore rockfish species. In this regard, it might make sense to manage nearshore and shallow shelf rockfish in a combined complex; however, this is not proposed since it may disrupt the California and Oregon state limited entry systems and allocations in place for nearshore fisheries. The species aggregated in the Deeper Shelf complex are primarily caught in deep water fisheries such as those targeting sablefish in fixed gear fisheries and trawl efforts targeting Dover sole, thornyheads, and sablefish (DTS) species. The species in the Deeper Shelf complex are often caught in association with slope rockfish in deep water fisheries along the shelf-slope break. An alternative that combines the Deeper Shelf and Slope complexes was not proposed. The harvestable surplus of the slope rockfish complexes are formally allocated with long-term sector allocations, while the shelf rockfish complexes are not (sector allocations are made every two years in the biennial process). Combining these assemblages of species may pose some allocation challenges since the Amendment 21 allocations for slope rockfish are significantly different than the 2013-14 allocations for shelf rockfish.

Table 9. Summary of status quo (SQ) and proposed shelf rockfish complexes in relation to several removal-based diagnostics. See text for descriptions of each measure.

Complex	Alternative	P	Cumulative removal difference (mt)		Evenness		Ratios
			Maximum	**Minimum**	**Removals$_{median}$**	**OFL**	**%Slope = 0**
Shelf North	SQ	-	0	-10841	0.53	0.45	0.83
	SQ - EC spp.	-			0.65	0.53	0.77
	Alt. 1 shallow	-			0.34	0.20	0.33
	Alt. 1 deep	+			**0.70**	**0.60**	**0.86**
Shelf South	SQ	-	1	-11218	0.46	0.48	0.80
	SQ - EC spp.	-			**0.50**	**0.51**	0.88
	Alt. 1 shallow	-			0.39	0.54	0.86
	Alt. 1 deep	+			0.17	0.40	**1.00**

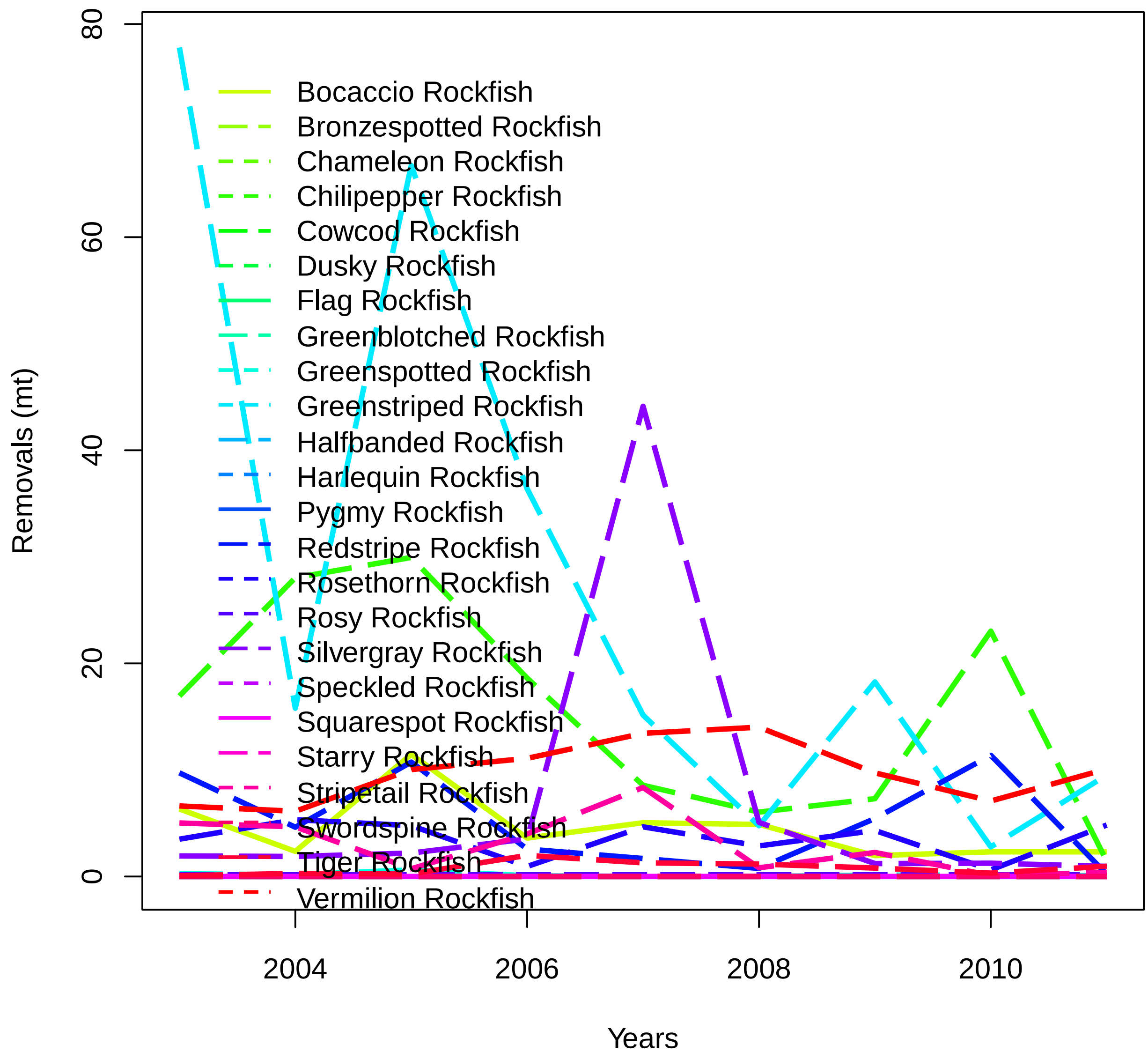

Figure 3. Annual total mortality (minus research catches) of shelf rockfish stocks in the Minor Shelf Rockfish North stock complex, 2003-2011.

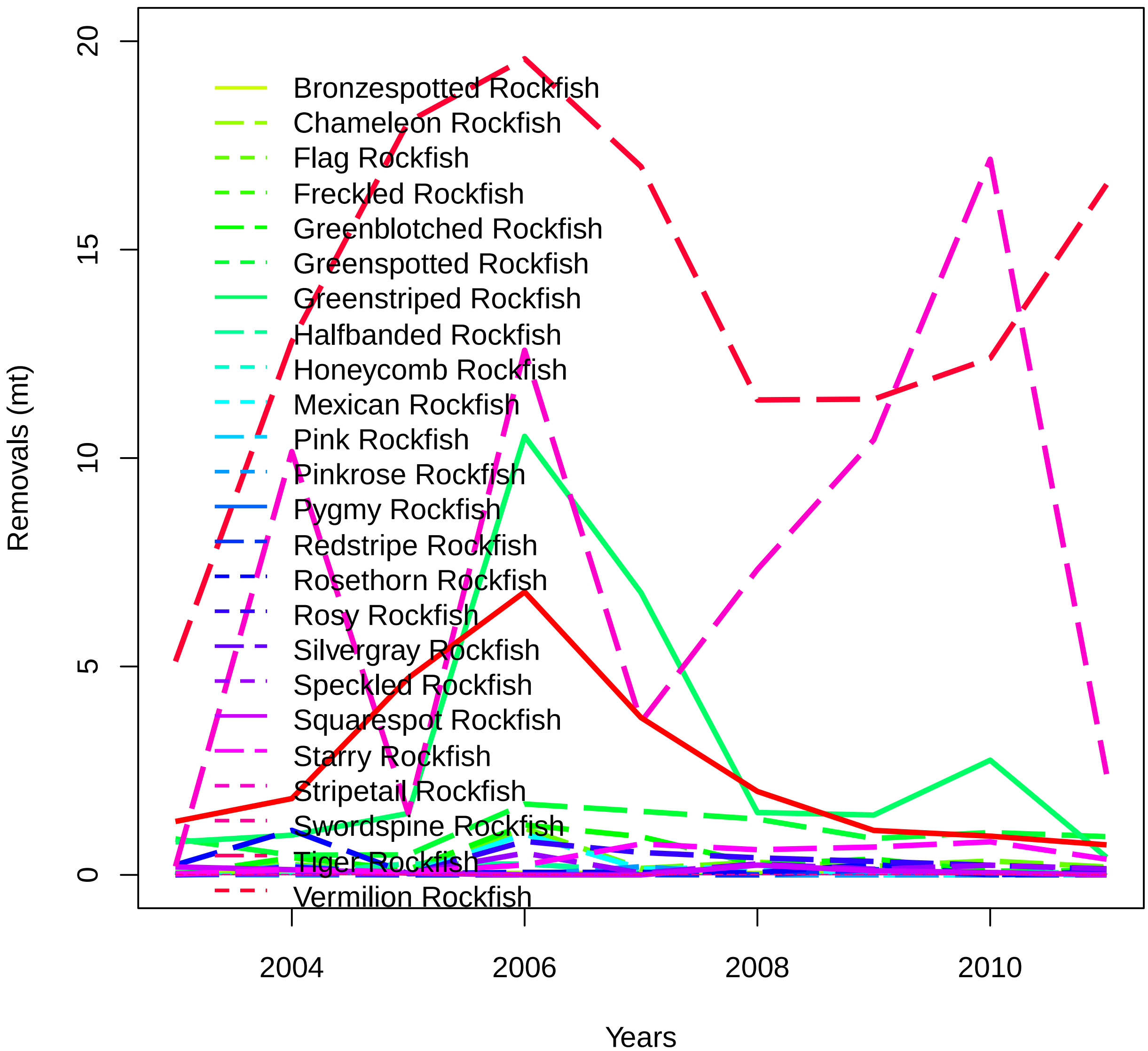

Figure 4. Annual total mortality (minus research catches) of shelf rockfish stocks in the Minor Shelf Rockfish South stock complex, 2003-2011.

Slope Rockfish

The slope rockfish complexes contain species with different relative vulnerabilities to overfishing, including two species with the highest vulnerabilities scored (rougheye and shortraker rockfish) and two species with very high vulnerabilities (aurora and blackgill rockfish) (Table 10). Two alternatives are considered to better manage these high vulnerability species in a more precautionary manner. Slope rockfish alternative 1 contemplates managing a vulnerable slope rockfish complex north of 40º10' N lat. by aggregating blackgill, rougheye, and shortraker rockfish (Table 11). Slope rockfish alternative 2 contemplates managing vulnerable slope rockfish complexes north and south of 40º10' N lat. with aurora, blackgill, rougheye, and shortraker comprising these two complexes (Table 12). Both alternatives consider removing a component species from a northern or southern complex due to lack of presence (e.g., bank rockfish in the north) regardless of whether the Council decides to restructure the slope rockfish complexes based on relative vulnerabilities of component species. Alternative 2 also contemplates removing bank rockfish from the southern slope rockfish complex and moving it to the southern shelf or southern deeper shelf rockfish complex since it is more present on the shelf than the slope (Table 7 and Table 10).

Table 10. Slope rockfish stocks ranked by relative productivity. Productivity (P) and vulnerability (V) scores are from the GMT's PSA analysis.

Stock	P	Relative P	V	Relative V
Yellowmouth rockfish	1.61	High	1.96	Med
Longspine Thornyhead	1.47	High	1.54	Low
Pacific ocean perch	1.44	High	1.69	Low
Aurora rockfish	1.33	Low	2.1	High
Shortspine thornyhead	1.33	Low	1.8	Low
Redbanded Rockfish	1.28	Low	2.02	High
Splitnose rockfish	1.28	Low	1.82	Med
Blackgill rockfish	1.22	Low	2.08	High
Shortraker rockfish	1.22	Low	2.25	Highest
Blackspotted rockfish	1.17	Low	1.97	Med
Rougheye rockfish	1.17	Low	2.27	Highest

Table 11. Alternative 1 slope rockfish stocks and stock complexes (strikeout denotes a stock moving from a status quo category).

Slope Rockfish Stocks	Stock Complexes		
	N of 40°10’		S of 40°10’
	Slope RF	Blackgill/Rougheye/Shortraker RF	Slope RF
Overfished Stocks Darkblotched POP N of 40º10’ **Non-overfished Stocks** Longspine thornyhead N and S of 34º27' Shortspine thornyhead N and S of 34º27' Splitnose S of 40°10’	Aurora ~~Bank~~ a/ ~~Blackgill~~ Redbanded ~~Rougheye~~ Sharpchin ~~Shortraker~~ Splitnose Yellowmouth	Blackgill Rougheye Shortraker	Aurora ~~Bank~~ b/ Blackgill ~~POP~~ a/ Redbanded ~~Rougheye~~ c/ Sharpchin ~~Shortraker~~ c/ Yellowmouth

a/ Remove from complex since there is no or low presence.
b/ Move to Southern Shelf Rockfish or Southern Deeper Shelf Rockfish complex.
c/ Specify as an Ecosystem Component species.

Table 12. Alternative 2 slope rockfish stocks and stock complexes aggregated by relative vulnerability (strikeout denotes a stock moving from a status quo category).

Slope Rockfish Stocks	Stock Complexes			
	N of 40°10’		S of 40°10’	
	Slope RF	Vul. Slope RF	Slope RF	Vul. Slope RF
Overfished Stocks Darkblotched POP N of 40º10’ **Non-overfished Stocks** Longspine thornyhead N and S of 34º27' Shortspine thornyhead N and S of 34º27' Splitnose S of 40°10’	~~Aurora~~ ~~Bank~~ a/ ~~Blackgill~~ Redbanded ~~Rougheye~~ Sharpchin ~~Shortraker~~ Splitnose Yellowmouth	Aurora Blackgill Rougheye Shortraker	~~Aurora~~ ~~Bank~~ b/ ~~Blackgill~~ ~~POP~~ a/ Redbanded ~~Rougheye~~ Sharpchin ~~Shortraker~~ Yellowmouth	Aurora Blackgill Rougheye Shortraker

a/ Remove from complex since there is no or low presence.
b/ Move to Southern Shelf or Southern Deeper Shelf complex.

Analysis of the Slope Rockfish Alternatives

Slope Rockfish North of 40º10’ N lat.

The catch histories of species in the status quo Minor Slope Rockfish North complex indicate big concerns in both OFL overages (e.g., aurora and rougheye rockfishes) (Table 13) and inflator species (e.g., rougheye and splitnose rockfish) (Figure 5). The removal of the proposed EC stocks from the status quo complex shows little improvement. Alternative 2 seems to give the best overall increase in performance among evenness and removal ratios.

Alternatives 1 and 2 better align the more vulnerable stocks and therefore present less risk to these stocks than status quo.

Slope Rockfish South of 40º10' N lat.

The catch histories of species in the status quo Minor Slope Rockfish South complex shows less concern over component OFL overages than the north (Table 13), but it also shows significant inflator species (e.g., bank and blackgill rockfishes) (Figure 6). The removal of the proposed EC stocks from the status quo complex species does not improve the complex. While Alternative 2 improves removal ratios, the status quo complex seems overall the best of these proposed complexes. All complexes show relatively poor evenness because of the inclusion of blackgill. Removal of blackgill could improve any of the proposed alternatives.

Alternative 2 does better align the more vulnerable stocks and therefore presents less risk to these species than status quo or Alternative 1, both of which do not aggregate the vulnerable stocks in their own complex. Since rougheye and shortraker are rarely if ever caught south of 40º10' N lat., the Alternative 2 Vulnerable Slope Rockfish complex is mainly comprised of aurora and blackgill rockfish. Blackgill would be an inflator stock in that complex compelling a precautionary ACL contribution for blackgill in the future if the Southern Vulnerable Slope Rockfish complex is created. Although it wasn't proposed in this analysis, Alternative 1 may be more informative if aurora and blackgill were pulled out of the southern complex and managed with stock-specific harvest specifications. Blackgill was assessed in 2011 with a depletion ratio placing this stock in the precautionary zone. Aurora, which has one of the highest vulnerability scores analyzed, will be assessed in 2013. Since there are concerns with both aurora and blackgill, this different structure for Alternative 1 should be considered.

Table 13. Summary of status quo (SQ) and proposed slope rockfish complexes in relation to several removal-based diagnostics. See text for descriptions of each measure.

Complex	Alternative	P	Cumulative removal difference (mt)		Evenness		Ratios
			Maximum	Minimum	Removals_{median}	OFL	%Slope = 0
Slope North	SQ	-	784	-7338	0.63	0.57	0.40
	SQ - EC spp.	-	784	-7338	0.65	0.57	0.44
	Alt. 1	-			**0.74**	0.64	0.40
	Alt 1 V	+			0.37	0.50	0.50
	Alt. 2	+			0.60	**0.70**	0.50
	Alt 2 V	+			0.51	0.62	**0.60**
Slope South	SQ	-	6	-4640	**0.47**	**0.38**	0.80
	SQ - EC spp.	-	-5	-1402	0.36	**0.38**	0.60
	Alt. 1	-			0.32	0.30	0.75
	Alt. 2	+			0.14	0.15	**1.00**
	Alt 2 V	+			0.33	0.21	0.60

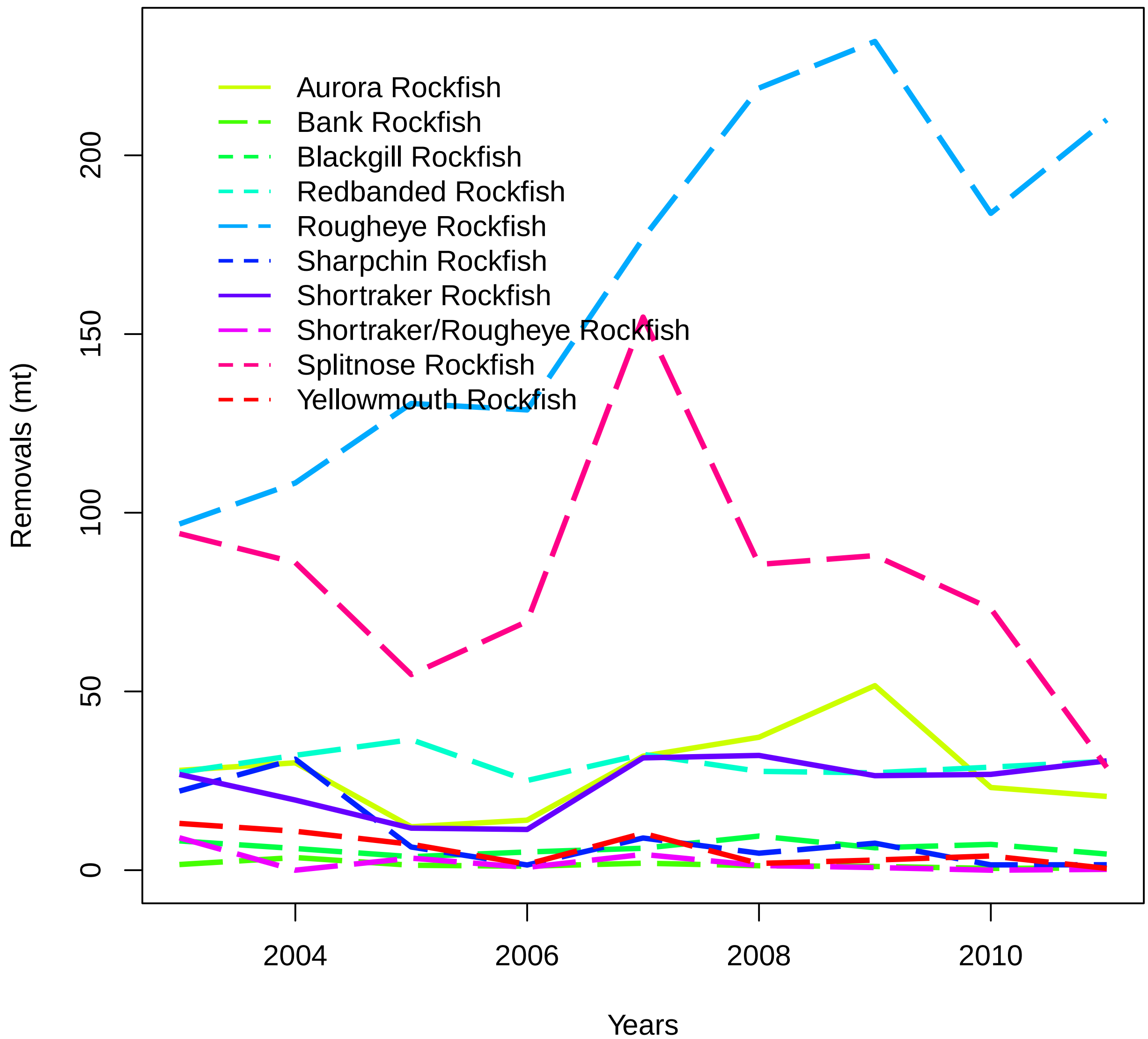

Figure 5. Annual total mortality (minus research catches) of slope rockfish stocks in the Minor Slope Rockfish North stock complex, 2003-2011.

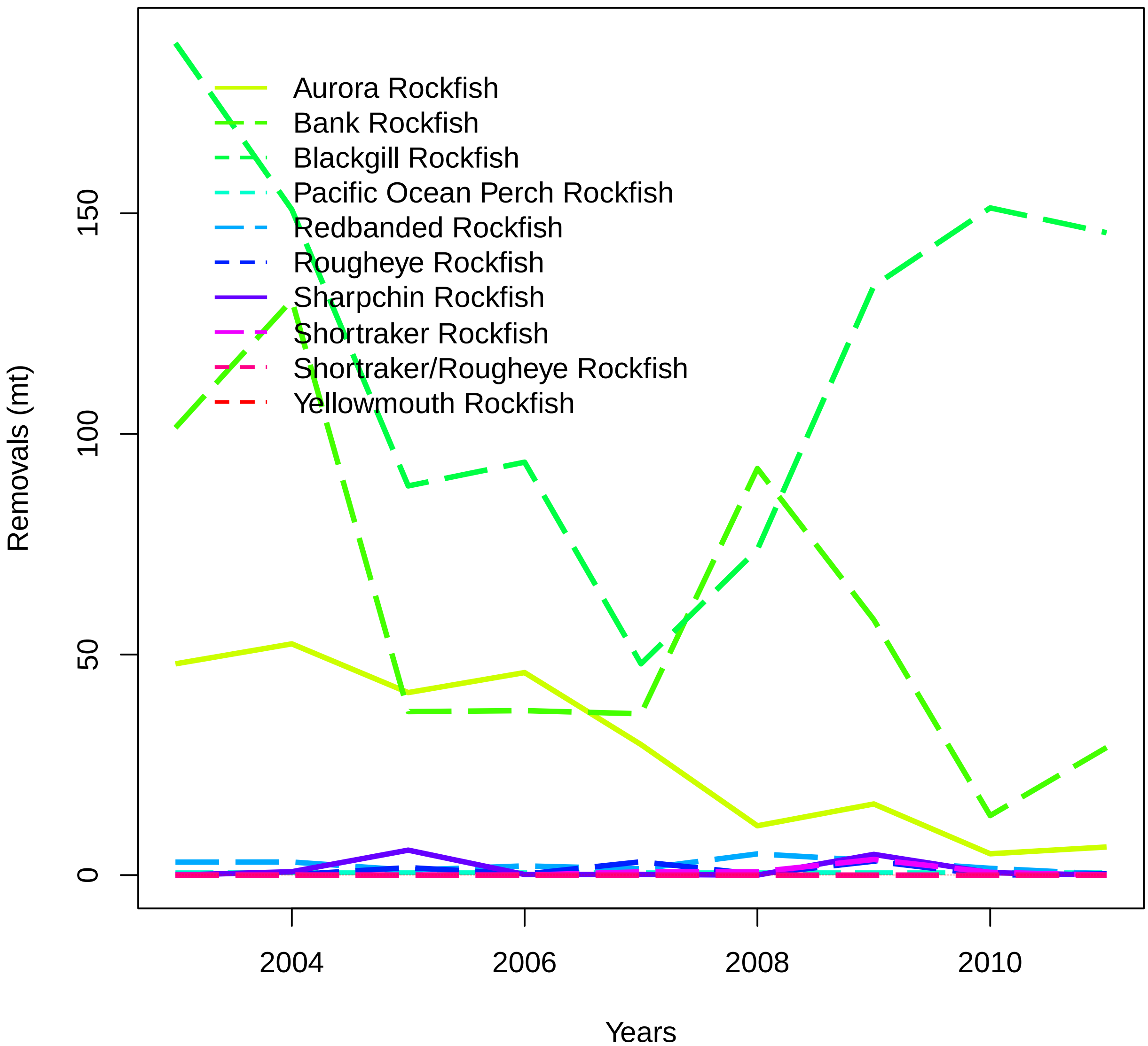

Figure 6. Annual total mortality (minus research catches) of slope rockfish stocks in the Minor Slope Rockfish South stock complex, 2003-2011.

Flatfish

Flatfish stocks are currently managed with stock-specific harvest specifications or within the Other Flatfish complex. Flatfish stocks have relatively high productivities and are therefore not as vulnerable to overfishing (Table 14). The stocks managed in the Other Flatfish complex are all of relatively close vulnerability scores but do vary in their depth distributions. Flatfish alternatives contemplate adding two non-FMP species (slender sole and deepsea sole) into the FMP and the creation of two flatfish complexes into shallow and deeper species groups.

Table 14. Flatfish stocks (non-FMP stocks in bold) ranked by depth group and relative productivity. Productivity (P) and vulnerability (V) scores are from the GMT's PSA analysis.

Depth group	Stock	P	Relative P	V	Relative V
Nearshore	Curlfin sole	2.45	High	1.23	Low
	Butter Sole	2.45	High	1.18	Low
	Pacific sanddab	2.4	High	1.25	Low
	Sand sole	2.35	High	1.23	Low
	Starry flounder	2.15	High	1.04	Low
Shelf	Flathead sole	2.3	High	1.26	Low
	Slender sole	2.25	High	1.14	Low
	English Sole	2.25	High	1.19	Low
	Rock sole	1.95	Low	1.42	Low
	Petrale sole	1.7	Low	1.94	Med
Slope	**Deepsea sole**	2.3	High	1.34	Low
	Rex sole	2.05	Low	1.28	Low
	Arrowtooth flounder	1.95	Low	1.21	Low
	Dover sole	1.8	Low	1.54	Low

Status Quo – Flatfish

There is one status quo flatfish stock complex comprised of unassessed species (Table 15).

Table 15. Status quo flatfish stocks and stock complex.

Flatfish Stocks	Stock Complex: Other Flatfish
Overfished Stocks	Butter sole
Petrale sole	Curlfin sole
Non-overfished Stocks	Flathead sole
Arrowtooth flounder	Pacific sanddab
Dover sole	Rex sole
English sole	Rock sole
Starry flounder	Sand sole

Alternative 1 – Flatfish

Flatfish alternative 1 contemplates adding two non-FMP species (deepsea sole and slender sole) to the current Other Flatfish stock complex (Table 16).

Table 16. Alternative 1 flatfish stocks and stock complex (bold denotes non-FMP stocks proposed to be incorporated in the FMP).

Flatfish Stocks	Stock Complex: Other Flatfish
Overfished Stocks	Butter sole
Petrale sole	Curlfin sole
Non-overfished Stocks	**Deepsea sole**
Arrowtooth flounder	Flathead sole
Dover sole	Pacific sanddab
English sole	Rex sole
Starry flounder	Rock sole
	Sand sole
	Slender sole

Alternative 2 – Flatfish

Flatfish alternative 2 contemplates adding two non-FMP species (deep sea sole and slender sole) to the FMP and creating two flatfish stock complexes defined by depth group (Table 17). Flatfish alternative 2 also would bring arrowtooth flounder into the Deep Flatfish stock complex as an indicator stock.

Table 17. Alternative 2 flatfish stocks and stock complexes (bold denotes non-FMP stocks incorporated in FMP, italics denotes stocks moving from stock-specific management to a complex, strikeout denotes a stock moving from a status quo category).

Flatfish Stocks	Stock Complexes	
	Shallow Flatfish	Deep Flatfish
Overfished Stocks	Butter sole	*Arrowtooth flounder*
Petrale sole	Curlfin sole	**Deep sea sole**
Non-overfished Stocks	Flathead sole	Rex sole
~~Arrowtooth flounder~~	Pacific sanddab	
Dover sole	Rock sole	
English sole	Sand sole	
Starry flounder	**Slender sole**	

Analysis of the Flatfish Alternatives

The status quo Other Flatfish complex has small overages (Table 18), but massive inflator species (rex sole and sand sole) (Figure 7). Alternative 1 has the most overall improvement in removal-based diagnostics over status quo, although the Alternative 2 Shallow Flatfish complex shows the best improvement in removal ratios. Evenness is generally poor for all complexes.

The status quo and action flatfish alternatives are satisfactory in terms of relatively close correspondence of estimated productivities and vulnerabilities of component stocks (Table 14 and Table 18). However, the ecological and depth distributions of component stocks are dissimilar. Flatfish alternative 2 seeks to stratify new complexes by depth distribution by creating a Shallow Flatfish and a Deep Flatfish complex . Arrowtooth flounder would be added to the Deep Flatfish complex as an indicator stock for managing that complex since it is an assessed stock. Two other stocks (rex sole and Pacific sanddabs) are scheduled for assessment in 2013 and, if the assessments are endorsed and adopted, could be indicator stocks for alternative flatfish complexes.

Both flatfish alternatives contemplate adding two non-FMP species (slender sole and deepsea sole) into the FMP. Both species have relatively high west coast catches (Figure 7) and are thus considered to be in the groundfish fishery. Managing these two stocks in the FMP would reduce the risk of potential overfishing of these two stocks.

The depth-based complexes under alternative 2 may be more risk-averse in preventing potential overfishing. Harvest specifications in each complex could be better tailored to the fishery with Shallow Flatfish catches primarily occurring shoreward of RCAs and Deep Flatfish catches primarily occurring seaward of the RCA.

Flatfish stocks managed in the status quo Other Flatfish complex are trawl-dominant with over 90 percent of historical landings from bottom trawl gear (PFMC 2010). The formal sector allocations for the Other Flatfish complex decided under Amendment 21 are 90 percent trawl and 10 percent non-trawl, with a set-aside from the trawl allocation specified biennially for the at-sea whiting sectors. The Amendment 21 allocations are the default for restructured flatfish complexes and should meet the needs of the fishery under the proposed flatfish stock complex alternatives since the two species proposed for FMP management under the action alternatives are also predominantly caught in bottom trawls. There could be consideration for a different initial allocation of quota shares to IFQ permits than used to allocate quota for the Other Flatfish complex under alternative 2 since vessels specializing in shallow water efforts (i.e., beach trawlers) are more likely to catch shallow flatfish than deep flatfish and vessels specializing in deep water efforts are more likely to catch deep flatfish. However, once quota share trading and sales are allowed, quota shares will distribute according to the needs of the permit holders.

Table 18. Summary of status quo (SQ) and proposed flatfish complexes in relation to several removal-based diagnostics. See text for descriptions of each measure.

Alternative	P	Cumulative removal difference (mt)		Evenness		Ratios
		Maximum	Minimum	$\text{Removals}_{\text{median}}$	OFL	%Slope = 0
SQ	+	61	-39730	0.51	**0.50**	0.43
Alt 1	+			**0.52**	0.44	0.56
Alt 2 shallow	+			0.46	0.26	**0.71**
Alt 2 deep	+			0.43	0.49	0.33

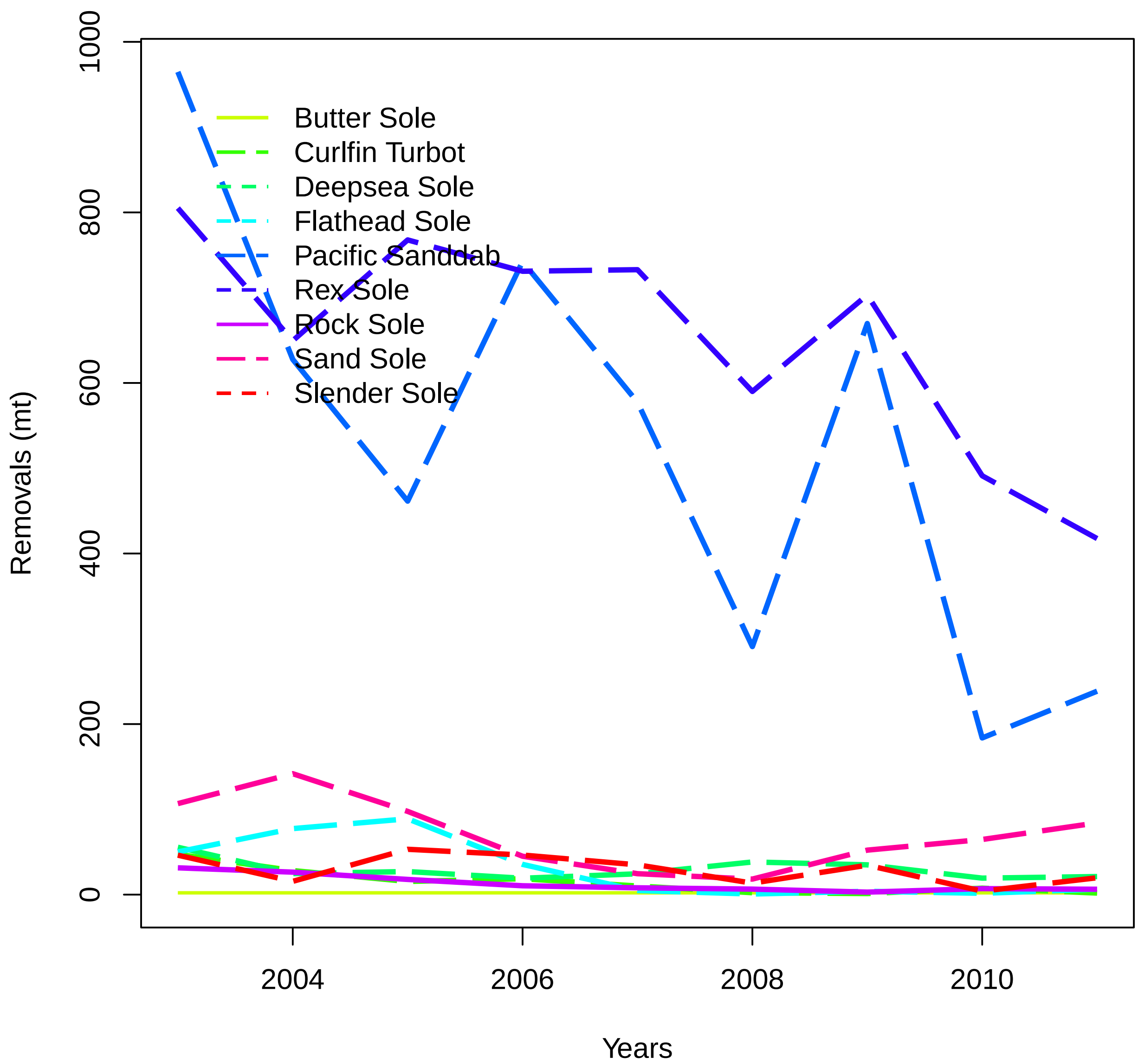

Figure 7. Annual total mortality (minus research catches) of flatfish stocks in the Other Flatfish stock complex, including the two non-FMP species (deepsea sole and slender sole) proposed to be added under the action alternatives, 2003-2011.

Elasmobranchs

The species comprising the Other Fish complex have disparate life histories, ecological relationships, distributions, and vulnerabilities to overfishing (Table 19). All the action alternatives contemplate a complete restructuring of the status quo Other Fish complex since that aggregation of disparate stocks does not meet the purpose and need to manage stocks with similar distributions, similar fishery interactions, similar life histories, and similar vulnerabilities to potential overfishing.

The elasmobranch alternatives contemplate managing elasmobranchs either in separate skate and miscellaneous elasmobranch complexes (Alternatives 1 and 2) or together in aggregate complexes

(Alternatives 3 and 4). Skates and the other miscellaneous elasmobranch species are further managed in shallow and deep groups (Alternatives 2 and 4) according to the depth groups shown in Table 19.

The elasmobranch alternatives also offer consideration for specifying some of the component species as EC species (e.g., soupfin shark) or removing some stocks from the FMP (e.g., leopard shark). The alternatives also contemplate moving some species from stock-specific harvest management into a complex to serve as an indicator stock for managing the complex (e.g., longnose skate) and moving a stock from management in a complex to single stock management (e.g., spiny dogfish).

Table 19. Elasmobranch stocks (non-FMP stocks in bold) ranked by depth group and relative productivity. Productivity (P) and vulnerability (V) scores are from the GMT's PSA analysis.

Depth group	Stock	P	Relative P	V	Relative V
Shallow	Longnose skate	1.53	High	1.68	Low
	Aleutian skate	1.42	High	1.71	Low
	Big skate	1.37	High	1.99	Med
	Brown catshark	1.37	High	1.84	Med
	Leopard shark	1.26	High	2	High
	Spiny dogfish	1.11	Low	2.13	High
	Soupfin shark	1.11	Low	2.02	High
Deep	**Black/roughtail skate**	1.45	High	1.68	Low
	Bering/sandpaper skate	1.37	High	1.8	Low
	California skate	1.21	Low	2.12	High

Status Quo – Elasmobranchs

The elasmobranch stocks in the FMP, including those managed in the status quo Other Fish complex, are depicted in Table 20.

Table 20. Status quo elasmobranch stocks and stock complex.

Elasmobranch Stocks	Stock Complex: Elasmobranchs in the Other Fish Complex
Non-overfished Stocks Longnose skate	Big skate California skate Leopard shark Ratfish Soupfin shark Spiny dogfish

Alternative 1 – Elasmobranchs

Elasmobranch alternative 1 contemplates eliminating the Other Fish complex and managing those stocks in two complexes (Skate and Miscellaneous Elasmobranchs) (Table 21). Alternative 1 also contemplates adding non-FMP species to the FMP (Aleutian skate, Bering/sandpaper skate, black/roughtail skate, and all other endemic skates to the Skates complex). Longnose skate would be added to the Skates complex as an indicator stock. All endemic skates other than Aleutian skate, Bering/sandpaper skate, big skate, black/roughtail skate, California skate, and longnose skate would be designated EC species. Soupfin shark would also be designated an EC species.

Table 21. Alternative 1 elasmobranch stocks and stock complexes (bold denotes non-FMP stocks proposed to be incorporated in the FMP, italics denotes stocks moving from stock-specific management to a complex, strikeout denotes a stock moving from a status quo category).

Elasmobranch Stocks	Stock Complexes		
	~~**Elasmobranchs in the Other Fish Complex**~~	**Skates**	**Misc. Elasmobranchs**
Non-overfished Stocks ~~Longnose skate~~	~~Big skate~~ ~~California skate~~ ~~Leopard shark~~ a/ ~~Ratfish~~ ~~Soupfin shark~~ b/ ~~Spiny dogfish~~	**Aleutian skate** **Bering/sandpaper skate** Big skate **Black/roughtail skate** California skate *Longnose skate* **All other skates**	Ratfish Spiny dogfish

a/ Remove from FMP.
b/ Specify as an Ecosystem Component species.

Alternative 2 – Elasmobranchs

Elasmobranch alternative 2 is the same as alternative 1, except the Skates complex is divided into two depth-based complexes (Shallow Skates and Deep Skates) (Table 22).

Table 22. Alternative 2 elasmobranch stocks and stock complexes (bold denotes non-FMP stocks proposed to be incorporated in the FMP, italics denotes stocks moving from stock-specific management to a complex, strikeout denotes a stock moving from a status quo category).

<table>
<tr><th rowspan="2">Elasmobranch Stocks</th><th colspan="4">Stock Complexes</th></tr>
<tr><th>~~Other Fish~~</th><th>Shallow Skates</th><th>Deep Skates</th><th>Misc. Elasmobranchs</th></tr>
<tr><td>Non-overfished Stocks
~~Longnose skate~~
-
-</td><td>~~Big skate~~
~~California skate~~
~~Leopard shark~~ a/
~~Ratfish~~
~~Soupfin shark~~ b/
~~Spiny dogfish~~</td><td>Aleutian skate
Big skate
Longnose skate
All other skates</td><td>Bering/sandpaper skate
Black/roughtail skate
California skate</td><td>Ratfish
Spiny dogfish</td></tr>
</table>

a/ Remove from FMP.
b/ Specify as an Ecosystem Component species.

Alternative 3 – Elasmobranchs

Elasmobranch alternative 3 contemplates eliminating the Other Fish complex and managing those stocks in one Elasmobranch complex (Table 23). Elasmobranch alternative 3 also contemplates adding non-FMP species to the FMP (Aleutian skate, Bering/sandpaper skate, black/roughtail skate, all other endemic skates, and brown catshark to the Elasmobranch complex). All endemic skates managed in the Elasmobranchs complex other than Aleutian skate, Bering/sandpaper skate, big skate, black/roughtail skate, and California skate would be designated EC species. Soupfin shark would also be designated an EC species. Spiny dogfish would be managed with stock-specific harvest specifications.

Table 23. Alternative 3 elasmobranch stocks and stock complexes (bold denotes non-FMP stocks proposed to be incorporated in the FMP, italics denotes stocks moving from stock-specific management to a complex or vice versa, strikeout denotes a stock moving from a status quo category).

<table>
<tr><th rowspan="2">Elasmobranch Stocks</th><th colspan="2">Stock Complexes</th></tr>
<tr><th>~~Elasmobranchs in the Other Fish Complex~~</th><th>Elasmobranchs</th></tr>
<tr><td>Non-overfished Stocks
Longnose skate
Spiny dogfish
-</td><td>~~Big skate~~
~~California skate~~
~~Leopard shark~~ a/
~~Ratfish~~
~~Soupfin shark~~ b/
~~Spiny dogfish~~</td><td>Aleutian skate
Bering/sandpaper skate
Big skate
Black/roughtail skate
California skate
All other skates
Brown catshark
Ratfish</td></tr>
</table>

a/ Remove from FMP.
b/ Specify as an Ecosystem Component species.

Alternative 4 – Elasmobranchs

Elasmobranch alternative 4 is the same as alternative 3, except the Elasmobranchs complex is divided into two depth-based complexes (Shallow Elasmobranchs and Deep Elasmobranchs) (Table 24).

Table 24. Alternative 4 elasmobranch stocks and stock complexes (bold denotes non-FMP stocks proposed to be incorporated in the FMP, italics denotes stocks moving from stock-specific management to a complex, strikeout denotes a stock moving from a status quo category).

Elasmobranch Stocks	Stock Complexes		
	~~Elasmobranchs in the Other Fish Complex~~	**Shallow Elasmobranchs**	**Deep Elasmobranchs**
Non-overfished Stocks Longnose skate *Spiny dogfish* -	~~Big skate~~ ~~California skate~~ ~~Leopard shark~~ a/ ~~Ratfish~~ ~~Soupfin shark~~ b/ ~~Spiny dogfish~~	**Aleutian skate** Big skate **All other skates** **Brown catshark** Ratfish	**Bering/sandpaper skate** **Black/roughtail skate** California skate

a/ Remove from FMP.
b/ Specify as an Ecosystem Component species.

Analysis of the Elasmobranch Alternatives

The actual status quo alternative for this group of species is the Other Fish complex. However, this complex is so misaligned and poorly constructed with disparate species of different life histories, different distributions, different productivities, and different vulnerabilities that analyzing the Other Fish complex as a viable alternative was not even contemplated. Therefore, the status quo complex alternative for elasmobranchs analyzed in this document is comprised of only the elasmobranchs that are currently managed in the Other Fish complex (Table 20). Given this, status quo shows huge overages of component OFLs (e.g., big skate and ratfish, and species with OFL contributions of 0) (Table 25) and one huge inflator species (spiny dogfish) (Figure 8). As a result, evenness is poor in any alternative that contains either spiny dogfish or species with no OFL contribution (i.e., most of the skates). Alternative 1 shows the best improvement in removal ratios, while Alternative 3 shows the best improvement in removal evenness. Overall, Alternatives 1 and 4 arguably provide the best balance of improvement in both evenness and removal ratios over status quo.

In terms of aggregating stocks with similar productivities (and vulnerabilities), status quo and Alternative 3 fail in that the component stocks are mismatched for those attributes (Table 25). Alternative 1 matches the Miscellaneous Elasmobranchs suitably, but aggregating all the endemic skates in one complex mismatches their relative productivities and vulnerabilities. Alternatives 2 and 4 aggregate elasmobranchs by their depth distributions and better align component stocks with similar productivities and vulnerabilities.

Table 25. Summary of status quo (SQ) and proposed elasmobranch complexes in relation to several removal-based diagnostics. See text for descriptions of each measure.

Alternative	P	Cumulative removal difference (mt)		Evenness		Ratios
		Maximum	**Minimum**	**Removals$_{median}$**	**OFL**	**%Slope = 0**
SQ	-	1881	-6800	0.43	**0.20**	0.17
Alt 1 skates	-			0.43	0.00	**0.55**
Alt 1 ratdog	+			0.31	0.00	0.33
Alt 2 shallow skates	+			0.39	0.00	0.50
Alt 2 deep skates	+			0.53	0.00	0.33
Alt 2 ratdog	+			0.31	0.00	0.33
Alt 3	-			**0.62**	0.00	0.42
Alt 4 shallow elasmos	+			0.57	0.00	0.44
Alt 4 deep elasmos	+			0.53	0.00	0.33

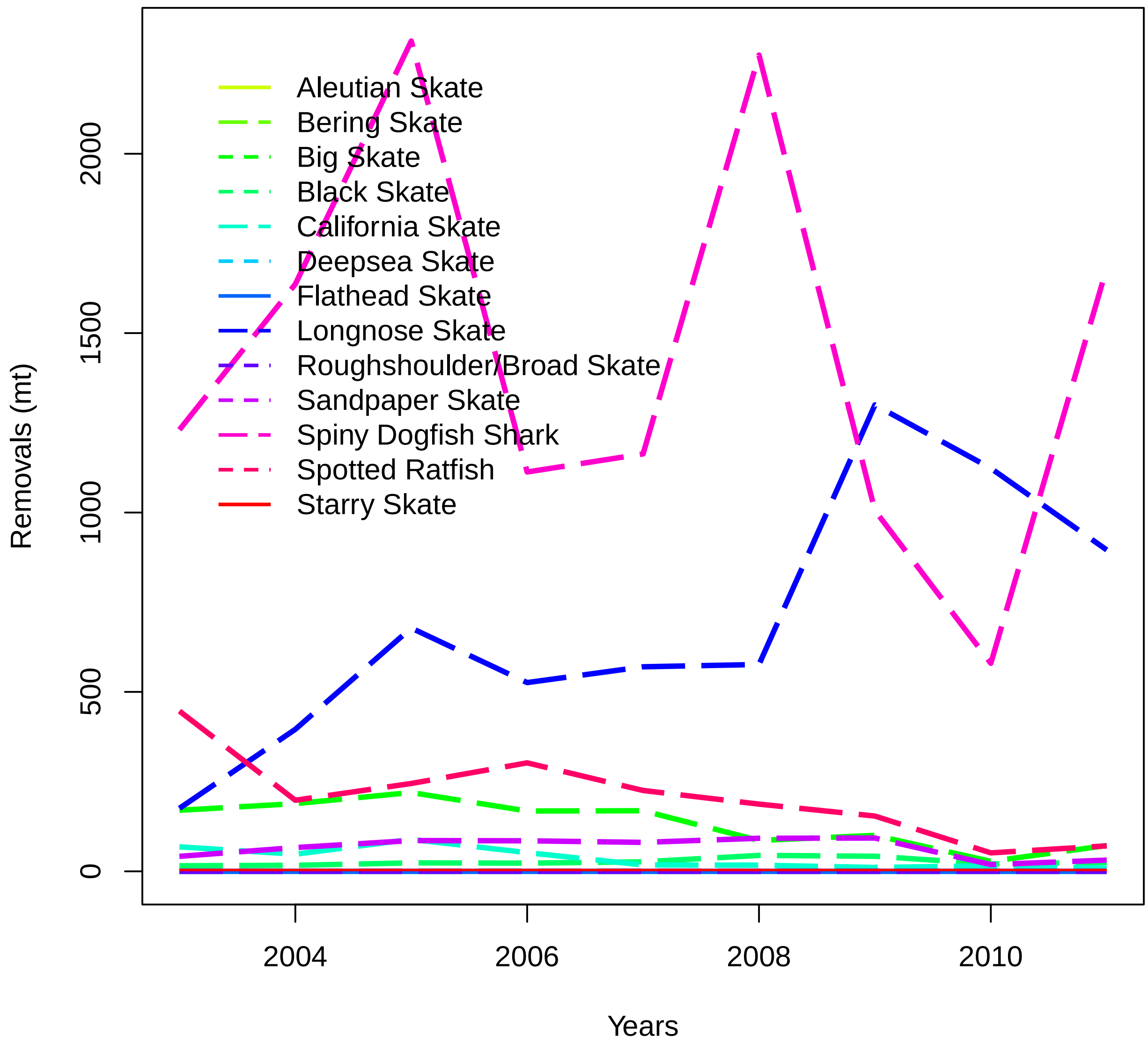

Figure 8. Annual total mortality (minus research catches) of elasmobranch stocks in the Other Fish stock complex, including the addition of the non-FMP species proposed under the action alternatives, 2003-2011.

Roundfish

The species comprising the Other Fish complex have disparate life histories, ecological relationships, distributions, and vulnerabilities to overfishing (Table 26). All the action alternatives contemplate a complete restructuring of the status quo Other Fish complex since that aggregation of disparate stocks does not meet the purpose and need to manage stocks with similar distributions, similar fishery interactions, similar life histories, and similar vulnerabilities to potential overfishing.

The roundfish alternatives contemplate managing roundfish stocks in separate groups that vary by depth and vulnerability to potential overfishing. The roundfish alternatives also offer consideration for specifying some of the component species as EC species (e.g., finescale codling).

Table 26. Roundfish stocks (non-FMP stocks in bold) ranked by depth group and relative productivity. Productivity (P) and vulnerability (V) scores are from the GMT's PSA analysis.

Depth group	Stock	P	Relative P	V	Relative V
Nearshore	California scorpionfish	1.83	High	1.41	Low
	Kelp greenling	1.83	High	1.62	Low
	rock greenling	1.78	High	1.77	Low
	Cabezon	1.72	High	1.68	Low
Shelf	Pacific cod	2.11	High	1.34	Low
	Pacific whiting	2	High	1.69	Low
	Lingcod	1.75	Low	1.55	Low
	Ratfish	1.63	Low	1.72	Low
Slope	**California slickhead**	2.06	High	1.14	Low
	Finescale codling	1.72	High	1.48	Low
	Sablefish	1.61	High	1.64	Low
	Pacific grenadier	1.44	Low	1.82	Med
	Giant grenadier	1.33	Low	1.87	Med

Status Quo – Roundfish

The roundfish stocks in the FMP, including those managed in the status quo Other Fish complex, are depicted in Table 27.

Table 27. Status quo roundfish stocks and stock complexes.

Roundfish Stocks	Stock Complex: Roundfish in the Other Fish Complex
Non-overfished Stocks Cabezon (CA) Cabezon (OR) California scorpionfish Lingcod N and S of 40º10' Pacific cod Pacific whiting Sablefish N and S of 36º	Cabezon (WA) Finescale codling Kelp greenling Pacific grenadier

Alternative 1 – Roundfish

Roundfish alternative 1 contemplates eliminating the Other Fish complex and managing the component roundfish stocks in two complexes (Grenadiers and Nearshore Roundfish) (Table 28). Roundfish alternative 1 also contemplates adding non-FMP species to the FMP (giant grenadier and all other endemic grenadiers to the Grenadiers complex). All endemic grenadiers other than Pacific and giant grenadiers would be specified as EC species. Finescale codling would also be designated an EC species. The Oregon substock of cabezon would be added to the Nearshore Roundfish complex as an indicator stock.

Table 28. Alternative 1 roundfish stocks and stock complexes (bold denotes non-FMP stocks to be incorporated in the FMP, strikeout denotes a stock moving from a status quo category).

Roundfish Stocks	Stock Complexes		
	~~Roundfish in the Other Fish Complex~~	**Grenadiers**	**Nearshore Roundfish**
Non-overfished Stocks Cabezon (CA) ~~Cabezon (OR)~~ California scorpionfish Lingcod N and S of 40º10' Pacific cod Pacific whiting Sablefish N and S of 36º	~~Cabezon (WA)~~ ~~California skate~~ ~~Finescale codling~~ a/ ~~Kelp greenling~~ ~~Pacific grenadier~~ - -	Pacific grenadier **Giant grenadier** **All other grenadiers**	Cabezon (WA) *Cabezon (OR)* Kelp greenling **All other greenlings**

a/ Specify as Ecosystem Component species.

Alternative 2 – Roundfish

Roundfish alternative 2 contemplates eliminating the Other Fish complex and managing those stocks in two complexes (Nearshore Roundfish and Deep Roundfish) (Table 29). Roundfish alternative 2 also contemplates adding non-FMP species to the FMP (giant grenadier, all other endemic grenadiers, and California slickhead to the Deep Roundfish complex). Finescale codling would be managed in the Deep Roundfish complex. The California and Oregon substocks of cabezon and California scorpionfish would be added to the Nearshore Roundfish complex as indicator stocks. All endemic grenadiers other the Pacific and giant grenadiers would be designated EC species.

Table 29. Alternative 2 roundfish stocks and stock complexes (bold denotes non-FMP stocks proposed to be incorporated in the FMP, italics denotes stocks moving from stock-specific management to a complex, strikeout denotes a stock moving from a status quo category).

Roundfish Stocks	Stock Complexes		
	~~Roundfish in the Other Fish Complex~~	**Nearshore Roundfish**	**Deep Roundfish**
Non-overfished Stocks ~~Cabezon (CA)~~ ~~Cabezon (OR)~~ ~~California scorpionfish~~ Lingcod N and S of 40º10' Pacific cod Pacific whiting Sablefish N and S of 36º	~~Cabezon (WA)~~ ~~California skate~~ ~~Finescale codling~~ ~~Kelp greenling~~ ~~Pacific grenadier~~ -	*Cabezon (CA)* *Cabezon (OR)* Cabezon (WA) *California scorpionfish* Kelp greenling **All other greenlings**	Pacific grenadier **Giant grenadier** **All other grenadiers** **California slickhead** Finescale codling

Analysis of the Roundfish Alternatives

The actual status quo alternative for this group of species is the Other Fish complex. However, this complex is so misaligned and poorly constructed with disparate species of different life histories, different distributions, different productivities, and different vulnerabilities that analyzing the Other Fish complex as a viable alternative was not even contemplated. Therefore, the status quo complex alternative for roundfish analyzed in this document is comprised of only the roundfish stocks that are currently managed in the Other Fish complex (Table 27). Given this, status quo complex demonstrates large inflator species (e.g., Pacific grenadier) (Figure 9). Alternatives 2 and 3 demonstrate the best improvement over status quo, although this group is still a bit of a mixed species assemblage. The evenness in the Grenadier or Deep Roundfish complex is poor because Pacific grenadier dominates.

All roundfish alternatives consider the addition of non-FMP species, including all grenadiers and all greenlings. Most grenadiers and greenlings landed in West Coast fisheries are landed in general market categories of "unspecified grenadiers" and "unspecified greenlings", respectively; therefore, adding all endemic grenadiers and greenlings to the FMP will allow more accurate OFL estimates using approved catch-based methods. Of the non-FMP grenadiers contemplated for inclusion in the FMP, giant grenadier is present in greater densities than the other endemic grenadiers according to trawl survey CPUEs.

The status quo assemblage of roundfish stocks does not align the relative productivities (and vulnerabilities) of component stocks well due to the lower productivity and higher vulnerability of grenadier (Table 26 and Table 30). All of the action alternatives better align the productivities and vulnerabilities of component stocks since the grenadiers are either managed in their own complex (Alternative 1) or included in an assemblage of deeper roundfish (Alternative 2).

Table 30. Summary of status quo (SQ) and proposed roundfish complexes in relation to several removal-based diagnostics. See text for descriptions of each measure.

Alternative	P	Cumulative removal difference (mt)		Evenness		Ratios
		Maximum	Minimum	$\text{Removals}_{\text{median}}$	OFL	%Slope = 0
SQ	-	87	-9955	**0.83**	0.48	0.25
Alt 1 cab-greenlings	+			0.36	0.39	0.40
Alt 1 grenadiers	+			0.30	0.00	**0.73**
Alt 2 NS roundfishes	+			0.41	**0.59**	0.67
Alt 2 deep roundfishes	+			0.34	0.00	0.67

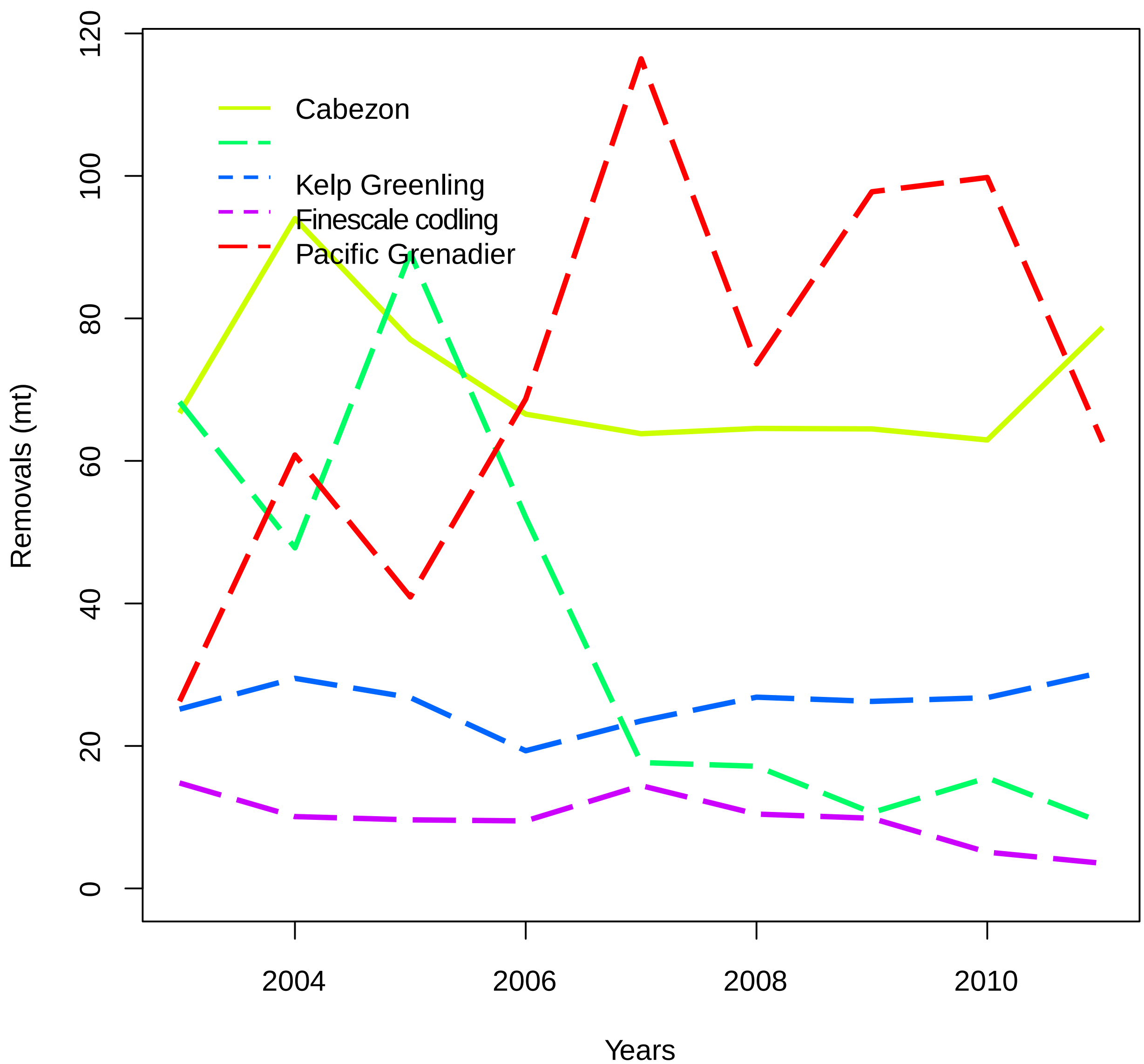

Figure 9. Annual total mortality (minus research catches) of roundfish stocks in the Other Fish stock complex, 2003-2011.

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Agenda Item D.3.a
Supplemental Agenda Item Overview PowerPoint
(DeVore/Cope)
April 2013

Considerations for Restructuring Groundfish Stock Complexes

Pacific Fishery Management Council

April 2013

National Standards and FMP Guidelines for Stock Complexes

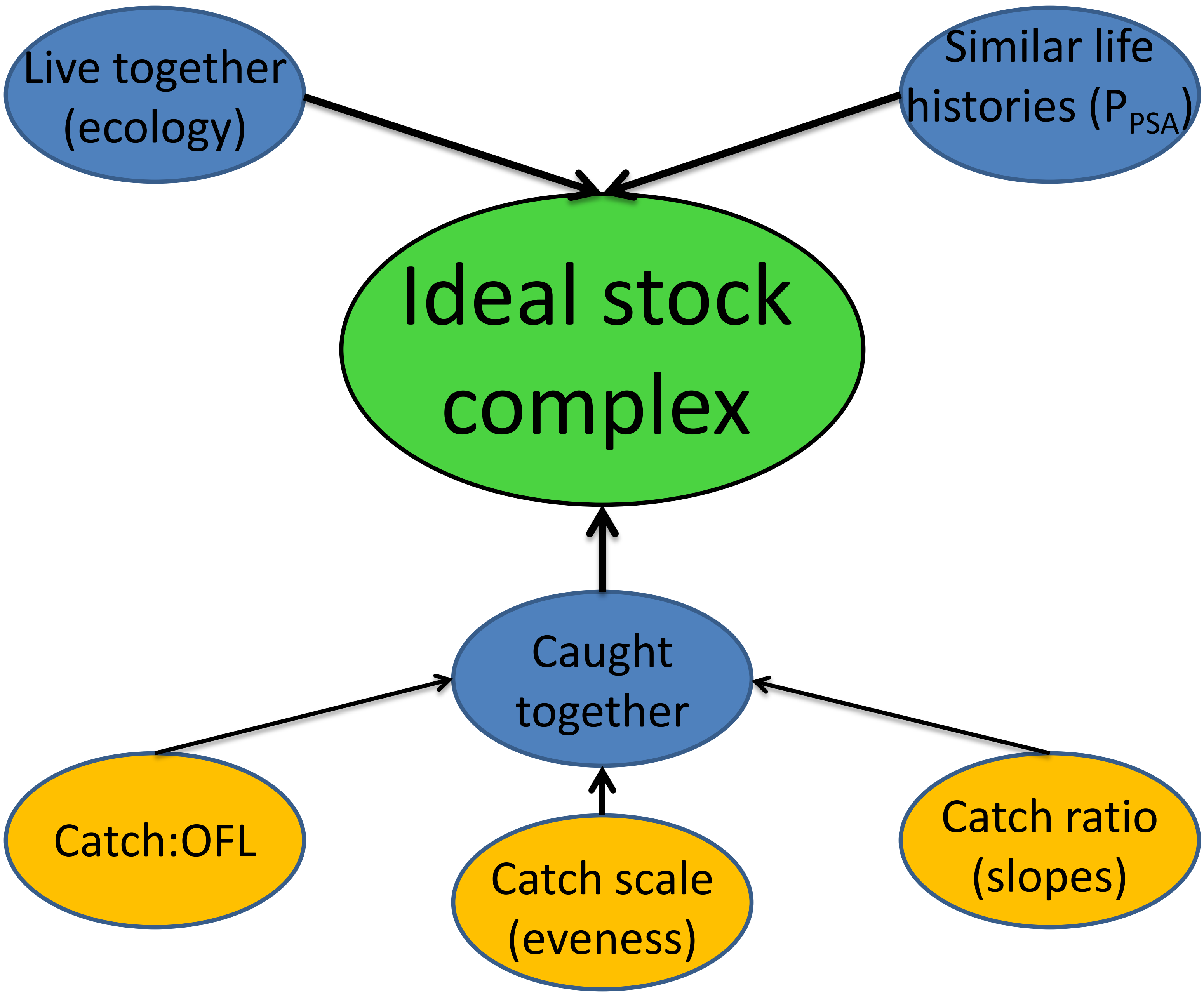
- Management impacts on stocks in a complex should be similar
- Stocks in a complex must be similar in geographic distribution, life history, and vulnerabilities to the fishery

Problems with current stock complexes

- Disparate vulnerabilities
  - E.g., Slope Rockfish complexes
- Disparate distributions
  - E.g., Shelf Rockfish complexes
- Removals exceeding component OFLs
  - E.g., rougheye in Slope Rockfish North
- Inflator stocks
  - E.g., greenstriped rockfish in Shelf Rockfish North complex
- No catch contribution
  - E.g., cabezon (WA) in Other Fish complex
- Disparate life histories
  - E.g., Other Fish (most poorly constructed complex)

Strawman Alternatives

- Alternatives for 6 species groups
  - Nearshore RF, Shelf RF, Slope RF, Flatfish, Elasmobranchs, and Roundfish
  - Can be decided independently
- Addition of some non-FMP species
- Designation of EC stocks
- Removal of leopard shark from FMP


Live together (ecology)
Similar life histories (P_{PSA})
Ideal stock complex
Caught together
Catch:OFL
Catch scale (eveness)
Catch ratio (slopes)

Matching life histories

- PSA (P & S = V)
- V not stable (S)
- P used
- 2 groups: high and low P
- Cutoff = 1.4 for rockfish

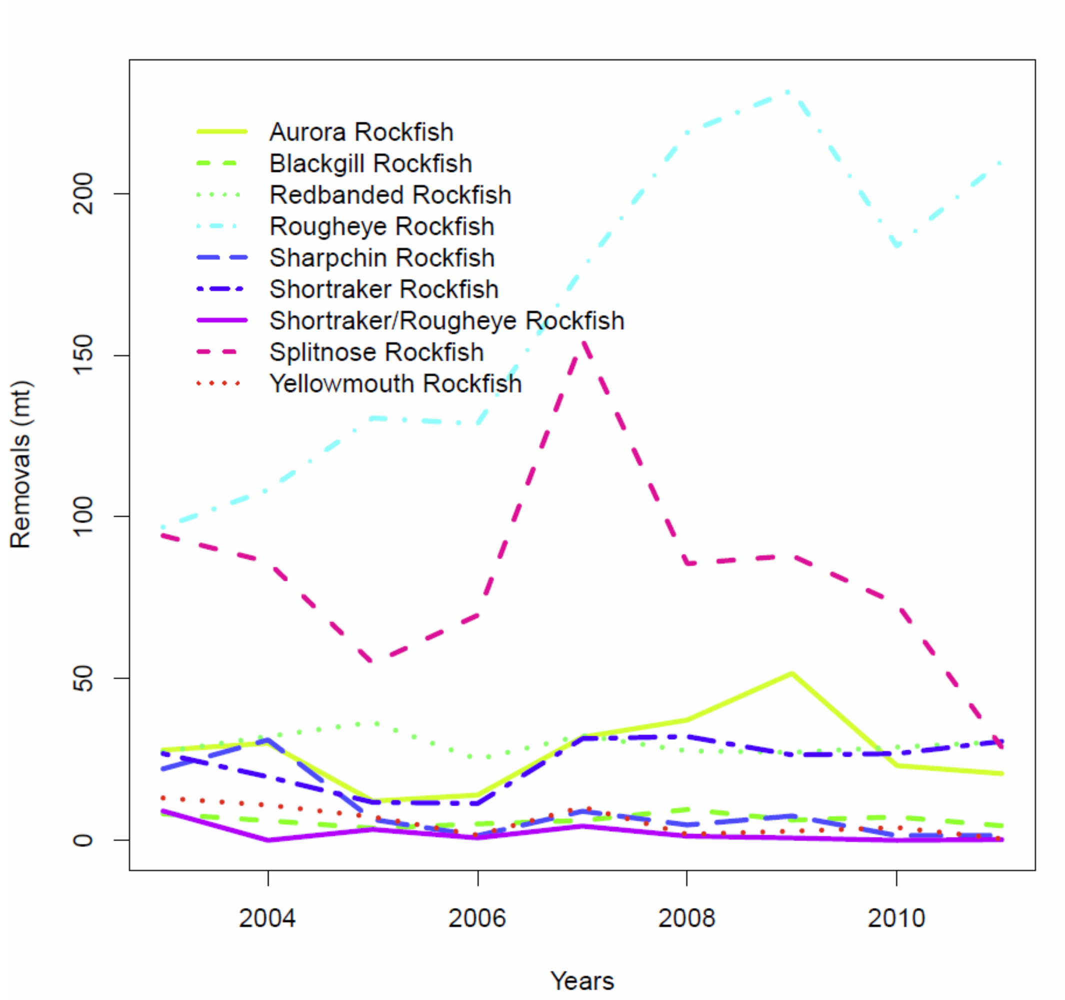
Nearshore rockfishes

	P	V
Kelp rockfish	1.94	1.59
Black-and-yellow rockfish	1.89	1.7
Olive rockfish	1.69	1.87
Treefish rockfish	1.67	1.73
Brown rockfish	1.61	1.99
Grass rockfish	1.61	1.89
Gopher rockfish	1.56	1.76
Blue rockfish	1.39	2.01
Copper rockfish	1.36	2.27
Honeycomb rockfish	1.36	1.97
Black rockfish	1.33	1.94
China rockfish	1.33	2.23
Quillback rockfish	1.31	2.22

High	Mod	High
Low	Low	X-hi

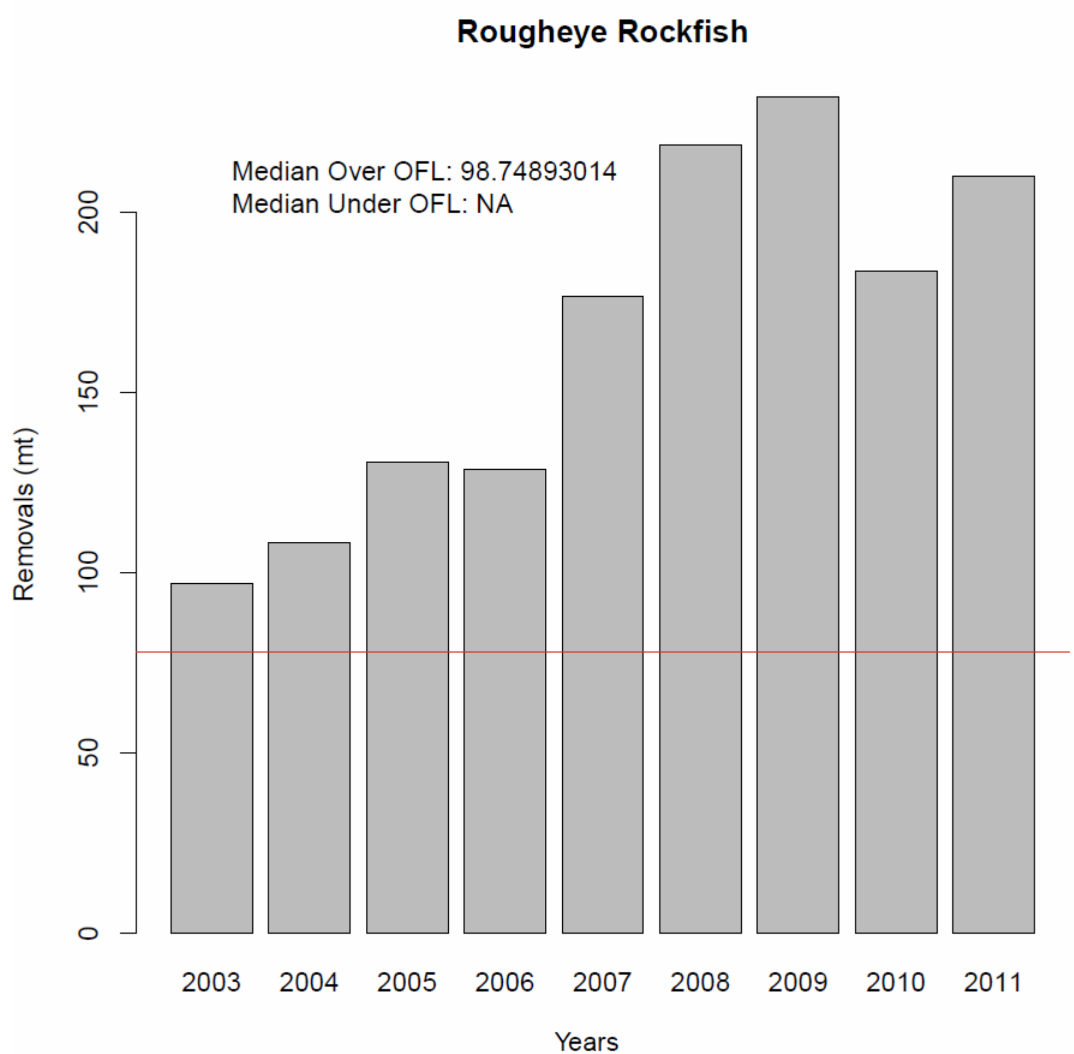
Comparing removals

- Diff. cum catch from OFL
  - If max > 0, OFL exceeded
  - If min large -#, inflator stock



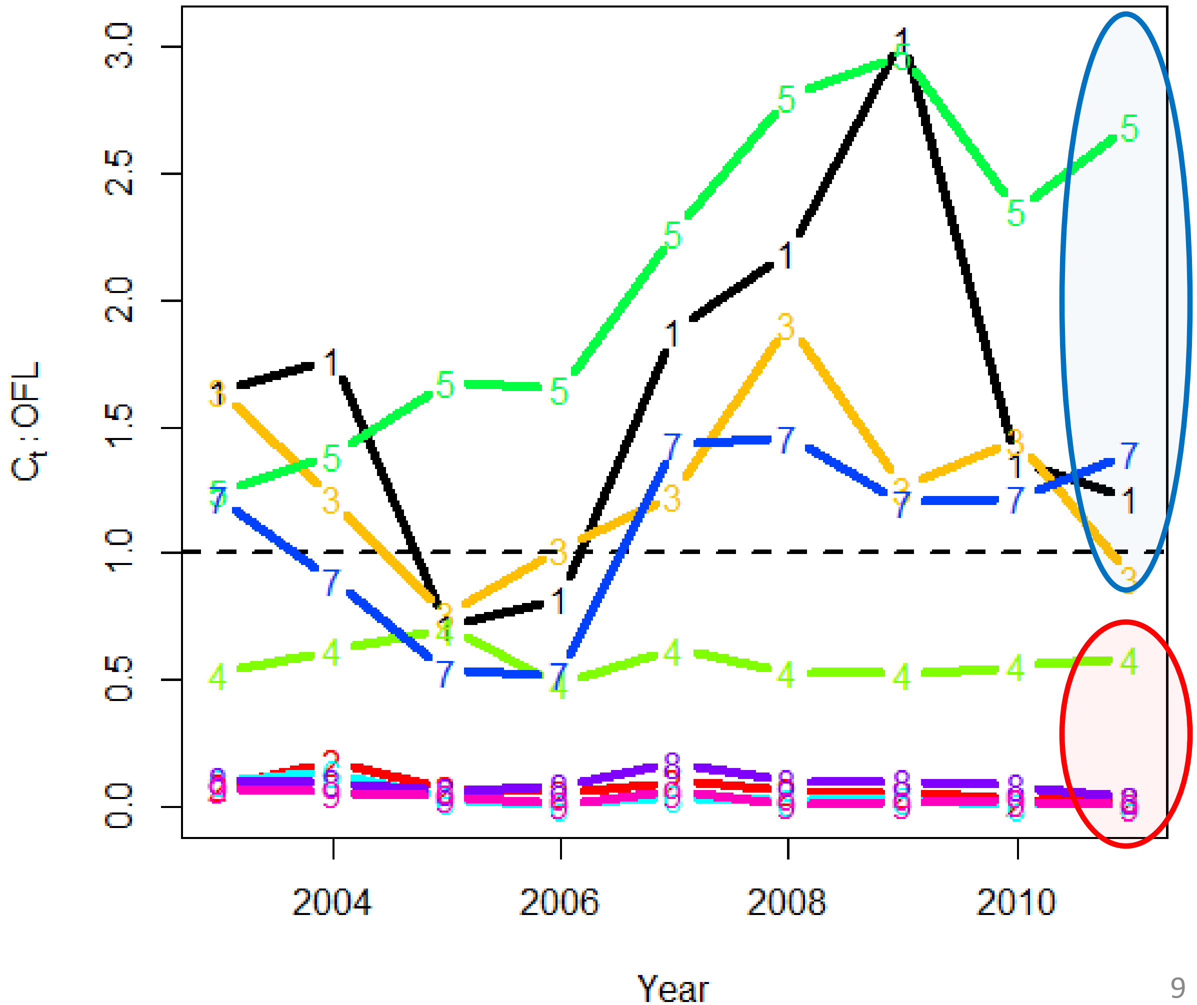
Removals relative to OFL

- Diff. cum catch from OFL
  - If max > 0, OFL exceeded
  - If min large -#, inflator stock

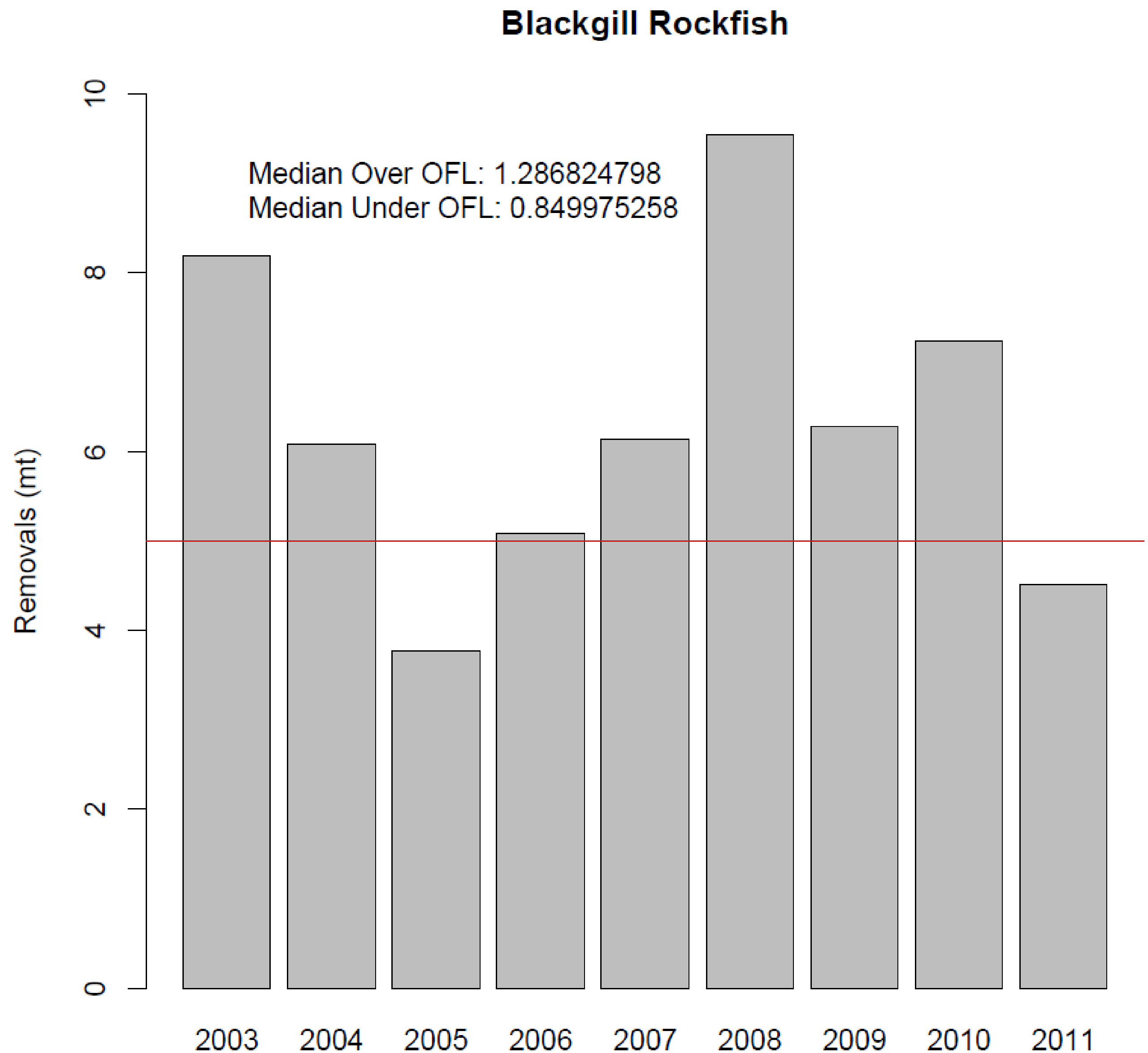


Clustering Catch:OFL ratios:
Ex: Slope Minor Rockfish North

1. Aurora
2. Bank
3. Blackgill
4. Redbanded
5. Rougheye
6. Sharpchin
7. Shortraker
8. Splitnose
9. Yellowmouth



Why scale matters

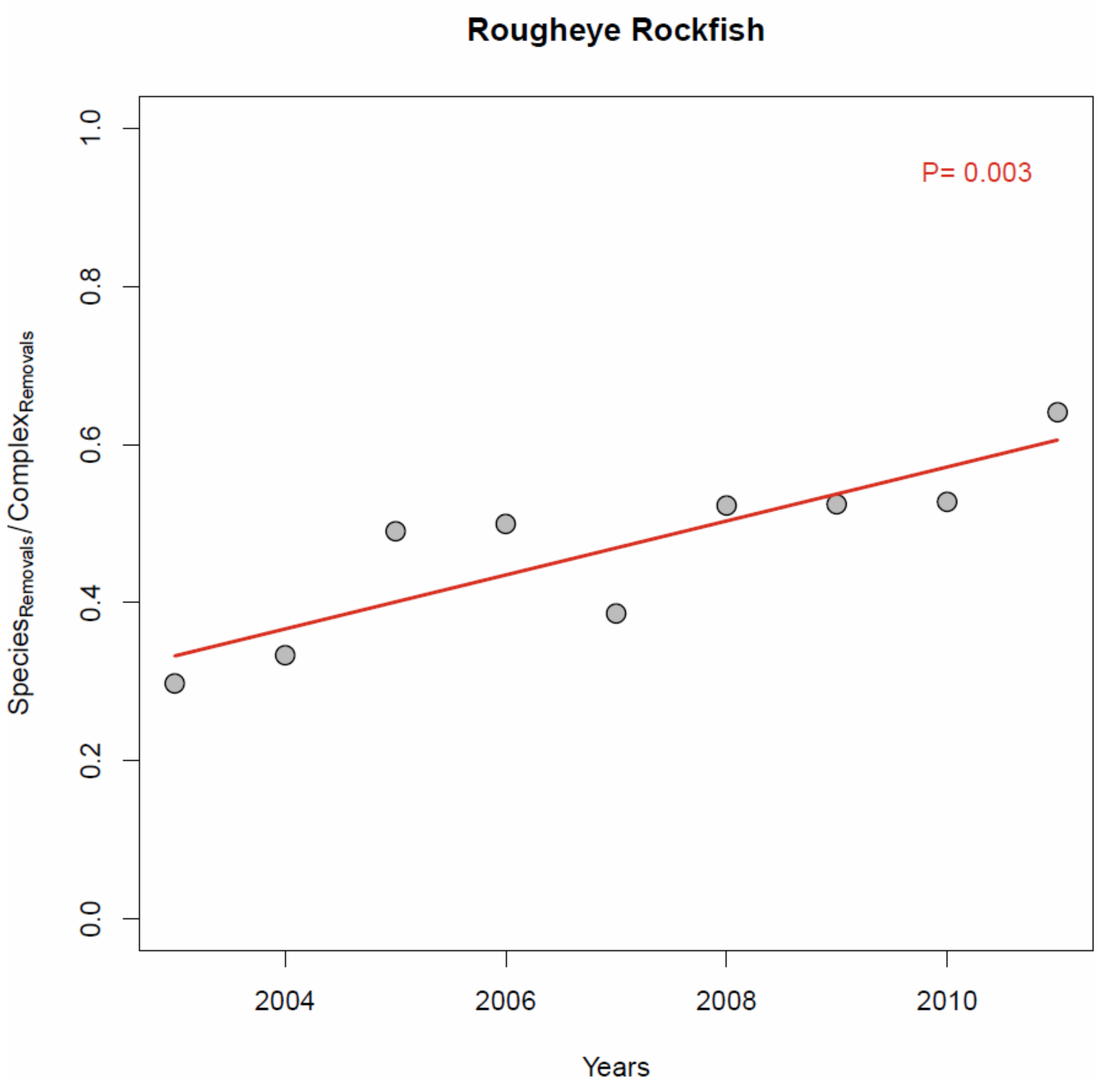


Matching catch scales

- Similar contributions to stock complex OFLs and removals
- "Evenness" (0-1: least to most even)

Stock complex OFL = 100				
	Uneven		Even	
Species	OFL	Removal	OFL	Removal
A	90	5	25	24
B	2	70	25	22
C	3	10	25	20
D	5	5	25	24
Evenness	0.309	0.549	1.000	0.998

Constant catch ratios



Steps in analyzing SQ & alternatives

- Analyze Status Quo:
  - Productivity grouping (+: common Ps; -: mixed Ps)
  - Calculate min.-max. cumulative catches
- Analyze alternatives relative to Status Quo:
  - Productivity grouping
  - Evenness (catch and OFLs)
  - % Removal ratios

			Measures to evaluate Status Quo		Measures to evaluate alternatives relative to Status Quo		
Complex	**Alternative**	**P**	**Cumulative removal difference (mt)**		**Evenness**		**Ratios**
			Maximum	**Minimum**	**Removals$_{median}$**	**OFL**	**%Slope = 0**
Slope North	SQ	-	784	-7338	0.63	0.57	0.40
	SQ - EC spp.	-	784	-7338	0.65	0.57	0.44
	Alt. 1	-			**0.74**	0.64	0.40
	Alt 1 V	+			0.37	0.50	0.50
	Alt. 2	+			0.60	**0.70**	0.50
	Alt 2 V	+			0.51	0.62	**0.60**

Steps in analyzing alternatives

- Develop alternative (based on ecology, P, etc.)
- Calculate min.-max. cumulative catches
- Evenness (catch and OFLs)
- Removal ratios

Analytical Methods

- Core ecological distribution from PACOOS and published species ranges
- Productivity from PSA
- Catch analysis using PacFIN, RecFIN, NorPAC, and WCGOP databases
  – Scale of catches (Pielou's evenness measure)
  – Slope of catch ratios

Considerations for Nearshore Rockfish

- Should vulnerable stocks (China, copper, and quillback) be managed in their own complexes?
  - China and copper data-moderate assessments this year – could be indicator stocks or managed as single species
- Should species (black and yellow, gopher, and kelp in north) be removed from complex?
- Should honeycomb and calico be designated EC stocks in the south?

Considerations for Shelf Rockfish

- Should complexes be stratified into Shallow and Deep Shelf complexes?
- Should species (e.g., freckled) be removed from complexes due to low or no presence?
- Should species (e.g., harlequin) be designated as EC species?

Considerations for Slope Rockfish

- Should vulnerable stocks (aurora, blackgill, rougheye, and shortraker) be managed in their own complexes?
  - Aurora and rougheye assessments this year; blackgill assessment in 2011 – could be indicator stocks or managed as single species
- Should species (e.g., POP in the south) be removed from complex?

Considerations for Flatfish

- Should non-FMP species (deepsea sole and slender sole) be added to complex?
  - In the fishery (caught in same amounts as some FMP species)
  - More accurate OFL estimates for some species
  - Alt. 1 & 2
- Should complex be stratified into Shallow and Deep Flatfish complexes?
  - Alt. 2

Considerations for Elasmobranchs

- Should skates be managed separately from other elasmobranchs?
  - Different productivities and vulnerabilities
  - Different distributions
  - Alt. 1 & 2
- Should complex be stratified by depth distributions of species?
  - Alt. 2 for skates; alt. 4 for all elasmobranchs

Considerations for Roundfish

- Should grenadiers be managed separately from other roundfish?
  - Different productivities and vulnerabilities
  - Different distributions
  - Alt. 1
- Should complex be stratified by depth distributions of species?
  - Alt. 2

Agenda Item D.3.b
Supplemental GAP Report
April 2013

Groundfish Advisory Subpanel Report on
Stock Complex Assemblages

The Groundfish Advisory Subpanel (GAP) received a briefing from Mr. John DeVore on restructuring groundfish stock complexes and offers the following comments and recommendations.

The GAP is generally concerned this initiative will receive a higher priority than other initiatives that the GAP believes are of more immediate importance. The GAP is concerned the trawl trailing actions already addressed by the Council are not being implemented in a timely fashion by NMFS due to competing workload. The GAP believes other initiatives that are more important to GAP members, such as widow rockfish reallocation, an issue of permit ownership and control in the fixed gear sablefish primary fishery, and other actions may be unnecessarily delayed to accommodate stock complex restructuring.

The GAP is also very concerned analysis presented is insufficient to adequately decide preliminary preferred alternatives or to recommend a full range of alternatives for detailed analysis. For instance, there is no analysis of the socioeconomic effects of restructuring complexes, any discussion of the management implications of restructuring complexes, nor any analysis of conservation effects of the proposed changes. The GAP is nervous that these important analyses may be given short shrift under the proposed timeline to decide a final preferred alternative by September. GAP members emphasize it will be extremely important to provide these analyses before an informed decision can be made.

Notwithstanding these provisos, the GAP explored the initial range of alternatives and offers the following recommendations for each of the six species groups identified in Attachment 1.

Nearshore Rockfish

The GAP recommends an additional alternative for analysis in which brown, China, and copper rockfish are removed from the complex and managed with stock-specific harvest specifications. These three stocks will be assessed for the first time this year with data-moderate assessments. This alternative is necessary in the analysis to preserve a wide range of options for managing these stocks. In the event one or more of these stocks is determined to be overfished, an option for managing these stocks outside of a complex may be needed.

Shelf Rockfish

The GAP recommends there be no detailed analysis of alternatives to status quo for the shelf rockfish complexes. The current configuration of the Rockfish Conservation Areas (RCAs) has significantly limited access to shelf rockfish reducing any conservation concerns for these stocks. In the event there is a substantial reduction or elimination of RCAs in the future, alternatives for managing shelf rockfish can then be considered in a subsequent action.

The GAP further recommends that starry and honeycomb rockfish *not* be designated Ecosystem Component (EC) species south of 40º10' N latitude. The GAP notes these species are caught in recreational fisheries and are caught incidentally in commercial fisheries in the Southern California Bight. While these species are not targeted, they are caught in amounts that may be considered greater than incidental and would therefore not meet the criteria for EC species.

Slope Rockfish

The GAP recommends an alternative for analysis in which aurora and rougheye rockfish are removed from the slope rockfish complexes. Both of these stocks will be assessed this summer and the Council may desire the flexibility to manage these stocks with stock-specific harvest specifications. In the event one or both of these stocks is determined to be overfished, an option for managing these stocks outside of a complex may be needed.

The GAP further recommends that bank rockfish *not* be removed from the slope rockfish complexes and re-categorized as a shelf species. The GAP notes that bank rockfish are caught on the shelf-slope break south of Pt. Conception and on the slope north of Pt. Conception.

Flatfish

The GAP recommends there be no detailed analysis of alternatives to status quo for the Other Flatfish complex. This is the most balanced and well structured complex in the fishery management plan (FMP) and the GAP sees no need to change the structure.

The GAP further recommends that slender sole *not* be added to the FMP. Slender sole are a diminutive flatfish species that are not readily caught in the trawl fishery. While they may be caught in the NMFS trawl survey, the survey nets use codend liners with smaller mesh sizes than allowed in the fishery. The fishery gear selectivity for slender sole is such that the catch is *de minimus*. The GAP therefore concludes that slender sole are not in the fishery and do not warrant inclusion in the FMP.

Elasmobranchs

The GAP is not recommending any change to the elasmobranch alternatives presented in Attachment 1. The GAP does recommend that leopard shark be removed from the FMP. Leopard shark are only caught within state waters in California and are not targeted in any federal fisheries. Further, leopard shark is a species with a different life history, distribution, and fishery interaction than any of the other FMP species making it difficult to design any complex that includes the species. Therefore, the GAP recommends delegating management authority for leopard shark to the state of California.

Roundfish

The GAP recommends an alternative for analysis that removes Pacific grenadier from the FMP. Pacific grenadier, as well as the other endemic grenadier species, are caught incidentally in West

Coast fisheries and are not targeted. Furthermore, since these are deepwater species, catch of grenadiers are restricted since the prohibition on trawling deeper than 700 fm went into effect in 2006 with the final rule implementing Amendment 19. Since 2006, the average annual landings of grenadiers is 127.7 mt. Finally, the GAP notes the core distribution of grenadiers is much deeper than the 700 fm limit for West Coast trawl fisheries. Therefore, if harvest were to increase from the recent year average, there would be no biological effect of any significance since the fishery cannot access the core population.

Lastly, the GAP recommends against adding California slickhead to the FMP. The GAP notes this species is not targeted nor is it incidentally caught in west coast groundfish fisheries. The GAP further notes this species is a deepwater smelt species and, if there is a need to manage California slickhead in a federal FMP, then this species should be managed under the coastal pelagic species FMP.

PFMC
04/06/13

GROUNDFISH MANAGEMENT TEAM REPORT ON STOCK COMPLEX ASSEMBLAGES

The Groundfish Management Team (GMT) reviewed the Initial Proposal for Restructuring Groundfish Stock Complexes (Agenda Item D.3, Attachment 1) and had a joint discussion with the Scientific and Statistical Committee (SSC). We thank Dr. Jason Cope and Council staff for the detailed and informative presentation that guided the GMT and SSC through the intricacies of this complicated and important issue, and for the analyses already completed.

The GMT notes the stock complex alternatives provided in Agenda Item D.3, Attachment 1 are a very good start at a first look at potential complex restructuring. **This range of alternatives likely includes complexes that are close to optimal and should be retained for future consideration.** However, the current range of alternatives may not yet include all options of interest as discussed below.

The GMT concluded that many details need to be resolved and understood before alternatives can be effectively evaluated. Further, more time is needed to make consistent and logical refinements and evaluations of the alternatives shown in Attachment 1. The consensus of the GMT was that more time is needed to adopt a range of alternatives. As discussed below, we could provide additional alternatives and tools for evaluating the alternatives at the June meeting.

The GMT also discussed whether September is the best time in the process for a final decision on stock complex structures. The reorganization of stock complexes involves aspects of both harvest specifications and management measures. Harvest specifications, including overfishing limits (OFLs) and acceptable biological catch (ABCs), are not finalized until November. The results of certain stock assessments, like rougheye and aurora rockfishes which are scheduled for adoption in September, will be key to informing the Council's preferred stock complex structure. Likewise, the management measures and the associated socio-economic impacts that would be expected to accompany changes to stock complexes is another important factor in the analysis and decision-making. Under the initial proposed schedule for the 2015-2016, the major analysis of management measures occurs between the November and April meetings. The Council is scheduled to adopt the final schedule for 2015-2016 decision-making, including stock complexes, in June. Based on this reasoning, **the GMT recommends that Council staff evaluate the impacts of a June and September process (current proposal) as well as a June, September, and November process.** Regardless of when the Council's final decision is made, we recommend accomplishing as much analysis and discussion as possible between now and June, and June and September. A lot could be accomplished by September even if the Council does not make its final recommendations until later.

The GMT reminds the Council that guidance to date from the National Marine Fisheries Service (NMFS) is to make progress aligning stock complexes with the current National Standards (NS) (see Appendix 1, below). As such, the Council may not need to reorganize all complexes at the same time. Instead, the Council could prioritize the order in which to reorganize the complexes based on various criteria such as vulnerability and productivity of individual species within the complex. Further, as discussed below and displayed in Figure 1, progress has been made.

Prioritization

Based on the materials reviewed and produced to date, the GMT developed the following prioritization based on the Productivity and Susceptibility Assessment (PSA) results and historical harvest levels. An alternative approach for prioritization could be based on the ease of application and least impact to fisheries (see section below on the costs of changing stock complexes).

1. Slope Rockfish. This complex consists of species that are difficult to discern from one another (e.g., aurora rockfish from splitnose rockfish; shortraker rockfish from rougheye rockfish) and contains species for which vulnerability is high (e.g., rougheye and shortraker rockfish). In addition, evidence suggests that some components of this complex may have been harvested at levels much higher than their ABC contributions to the complex.[1] **The GMT recommends that the slope rockfish complex be given high priority for restructuring, taking into account information from the upcoming aurora and rougheye stock assessments.**

2. Other Fish. The Other Fish complex clearly consists of species that have very disparate life histories, ecological associations, vulnerabilities, and susceptibility to fisheries. Some of the individuals within this complex (e.g., California skate, spiny dogfish) received high vulnerability scores from the productivity and susceptibility analysis (PSA; Agenda Item E.2.b, Supplemental GMT Report, March 2010, Agenda Item G.5.b, Supplemental GMT Report, September 2011, and Agenda Item D.3.a, Attachment 1, April 2013). Some of these species may not be adequately accounted for or protected within the current stock complex structure. **The GMT recommends that the Other Fish complex should be given high priority for restructuring.**

3. Nearshore Rockfish: Although some species within the nearshore rockfish complex received highest vulnerability rankings in the PSA (e.g., copper, quillback, and China rockfish), the GMT proposes a lower priority to the nearshore complex reorganization relative to slope and Other Fish complexes. Reasons include: (a) all species within the complex are easily identifiable, (b) California and Oregon already require their commercial fisheries to sort and report all species in the nearshore complex, (c) recreational catches in all three states are estimated and uploaded to RecFIN at the species level, and (d) both recreational and the commercial nearshore fishery are managed by the states. Catch accounting on at the species level is likely more accurate than for the shelf rockfish complex and the Other Fish complex. Therefore, no improvements to data quality would be expected if the complex was restructured. The ability for accurate inseason tracking of each species within this complex is high, for both recreational and commercial fisheries. Harvest guidelines and associated management measures to control catch (like trip limits, bag limits, etc.) could be implemented for species for which component ABCs may be reached or approached during inseason. Based on these considerations and other considerations provided below, **the GMT recommends that reorganizing the nearshore rockfish complex be given lower priority.**

[1] Dick, E. J., and A. MacCall. 2010. Estimates of sustainable yield for 50 data-poor stocks in the Pacific Coast Groundfish Fishery Management Plan. NOAA Technical Memorandum NMFS NOAA-TM-NMFS-SWFSC-460.
1

4 Shelf Rockfish: Vulnerabilities for many of the shelf rockfish ranked high. Nonetheless, many of these species are protected from overfishing given the Rockfish Conservation Areas (RCAs). Therefore, as long as the RCA remains intact and/or change only with minor alterations (e.g., routine adjustments in discrete areas), **the GMT recommends that reorganizing the shelf rockfish complex be given lower priority.** If redesigning the shelf rockfish complex goes forward, priority should be given to evaluating the trawl-dominant species, given the expectation that the future trawl RCA configuration may change under rationalization (e.g., coastwide wholesale changes).

The remainder of this statement provides additional details from the GMT discussion, as well as attempts to clarify goals and objectives of restructuring stock complexes.

Stock Complex Reorganization Background

The purpose of stock complexes and much of the background were well explained in previous documents, including the initial proposal for restructuring groundfish stock complexes (Agenda Item D.3.a, Attachment 1), GMT statements (e.g., Agenda Item E.4.b, Supplemental GMT Report, March 2010; Agenda Item E.4.b, Supplemental GMT Report, March 2010; Agenda Item G.5.a, Attachment 5, September 2011), and SSC reports (e.g., Agenda Item I.2.b, Supplemental SSC Report, April 2010). In the following sections, we clarify and highlight a few points regarding stock complexes.

What is the main policy goal?

One of the primary goals and a requirement of National Standard 1 (NS1) is to prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry. While achieving this and other goals, National Standards 6, 8, and 9 also provide important standards for consideration related to the stock complex decision:

- National Standard 6 (NS6): requires that conservation and management measures, where practicable, minimize costs and avoid unnecessary duplication. In the final rule implementing the revised NS1 guidelines, NMFS said they believe that Councils should retain the discretion to determine which fisheries require specific conservation and management measures.
- National Standard 8 (NS8): specifies that decision makers take into account importance of fishery resources to fishing communities to provide sustained participation and minimize adverse economic impacts.
- National Standard 9 (NS9): requires that FMPs, to the extent practicable, minimize bycatch, and to the extent it cannot be avoided minimize bycatch mortality.

The GMT primarily speaks to the NS1 herein, and provides some discussion on NS8 and NS9. The remaining NS Guidelines are provided for reference at the end of the document. We understand that the Groundfish Advisory Subpanel (GAP) may provide input regarding fishing community and economic considerations.

Why Stock Complexes?

Some of the principal reasons for organizing stock complexes include:

- Where stocks in a multi-species fishery cannot be targeted independent of one another and MSY cannot be defined on a stock by stock basis;
- Where there is insufficient data to measure their status relative to status determination criteria (SDC); and

- When it is difficult for fishermen, observers, plant monitors, port biologists, and others to distinguish individuals among stocks.

It is clear that in most cases, stock complexes are necessary comport with the NS1 guidelines. For example, the slope rockfish complex consists of species that are difficult to distinguish from one another (i.e., shortraker and rougheye rockfish), therefore having a slope rockfish complex is logical. However, the current complex consists of species that received high vulnerability rankings by the PSA analysis. As such, an examination of the species that compose complex is recommended by the GMT.

However, the question arose during the GMT discussions about whether the nearshore complex was necessary. Stocks within this complex are easily identifiable, and Oregon and California require that all nearshore species be sorted in the commercial fisheries. In addition, status determination criteria (SDC) are possible for all species within this complex using data moderate assessments. Nonetheless, the GMT concluded that there is merit for continuing to manage this group of species within a complex rather than managing each component separately. Reasons include: (a) the recreational fishery in California and Oregon manages the nearshore species as a complex and makes projections at the complex level, (b) there may be a cost at the state level (see section below) to make such regulatory changes, and (c) component species within the complex can be managed using harvest guidelines for some species and fisheries to prevent exceeding the component ABC (see more discussion below).

How Should Stock Complexes be Assembled?

The GMT briefly discussed the history of stock complex development and concluded that the status quo complexes were created more by evolution than by design. Although the primary purpose of the status quo complexes may have been to group species that were caught together, the GMT agrees that Agenda Item D.2.b, Attachment 1 provides sound reasoning and some tools for reassembling complexes to better align with NS1, NS8, and NS9. The GMT suggests that other tools could be developed to evaluate the alternatives (e.g., ratios of catch relative to ABCs) and may bring forward such tools at the June Council meeting. The GMT did not have sufficient time to provide detailed comment on how the complexes should be assembled at this point. We agree with points shown in Attachment 1 but emphasize that species within a complex would ideally have similar life histories, vulnerabilities, and susceptibilities to fishing operations. We plan to provide more detail on this subject in June.

Choice of species in the FMP or as Ecosystem Components

The Council staff paper (Agenda Item D.3.a, Attachment 1) addresses the possibility of adding or removing species from the Fishery Management Plan (FMP) or designating some as Ecosystem Component (EC) species in line with the NS1 on the classification of stocks. As we described last cycle, we see this as a first step in the stock complex analysis.[2] These steps were outlined in Agenda Item G.5.b, Supplemental GMT Report, 2011 during the last cycle and reproduced in a Figure 1. For this first step the Council would need to consider each species proposed for re-designation and provide a rationale for the classification of each. We continue to recommend that the Council base those decisions on the PSA vulnerability scores, which we have done for some non-FMP species and are shown in the Council staff paper, and on the relative magnitude of catch. The issue is essentially one of relative conservation and management need, and as we pointed out last cycle, the PSA and catch data suggest that a few stocks not in the FMP now have a similar

[2] Agenda Item G.5.b, Supplemental GMT Report September 2011

conservation and management need to stocks that are in the FMP (e.g., deepsea sole). They also suggest that some FMP stocks are not vulnerable to the fishery. We write here just to emphasize the issue. We expect the team and Council staff to bring more analysis in June to help the Council weigh the FMP classification of stocks. Lastly, while the question about what species are to be managed as "in the fishery" comes first logically speaking, we think the analysis and Council's decision process can occur concurrently with the evaluation of the stock complexes. The methods we see being used to evaluate stock complex alternatives are flexible enough to add or remove a species from the alternatives with little extra work involved. Moreover, as shown in the Council staff paper, there are only a handful of species proposed for re-classification.

Costs Associated with Changes to Stock Complexes

The GMT discussed the potential costs and benefits for creating new stock complexes or restructuring. Regarding possible costs, the GMT did not have strong agreement or discussion on specific costs but some GMT members suggested the following: 1) increasing the number of market categories may increase the sampling burden on port samplers, 2) additional sorting requirements may decrease the number of samples that port samplers can handle in a given amount of time (e.g., each sample may take more time to sort), and 3) if species that are similar in appearance are in separate complexes, then incorrect sorting may occur on the vessel and at the fish plant, resulting in less accurate data. Possible costs to observers and port monitors were not discussed specifically but may face similar tradeoffs. It was also acknowledged that some of these issues have been noted in earlier documents, for example on pages C-42 through C-46 of Appendix C of the 2013-2014 FEIS for the Pacific Coast Groundfish Fishery (FEIS 2013). **The GMT recommends the analysis detail the anticipated costs of the alternatives compared to status quo.**

However, it should be emphasized that if costs were to increase, the magnitude of these costs are not clear at this time but who will bear the brunt of these possible increases can be inferred. For example, some ports and state agencies may be more impacted by newly constructed or restructured stock complexes than other ports or states agencies. That is, the costs of these changes may have differential impact due to the geographic distribution of those stocks. Specifically, the nearshore stock complex was cited as one where costs of restructuring may not be evenly distributed across states.

If greater specificity of the types and the magnitudes of these costs to port samplers, observers, and port monitors is of interest, the GMT discussed the possibility of designing and implementing a survey of these groups to collect information that may include questions on which species are difficult to differentiate, how much time is needed to differentiate them, what tools are used to differentiate them (e.g., identification keys), and the potential tradeoffs between time, number of samples, and accuracy of identification. **The GMT recommends the feasibility of this survey to be discussed with the appropriate parties to inform the stock complex analysis and decision making.**

Tools and Indicators

Analysis to date can be found in the Council staff paper (Agenda Item D.3.a, Attachment 1). This analysis provides a potential tool that could be used, in tandem with other tools or analysis, to evaluate stock complex alternatives. In addition, we intend to provide more analysis of how stocks may be restructured, or how various existing management tools or some of the new tools described in NS1 may be used to improve complexes and prevent overfishing of the components within them. For example there may be existing complexes that accurately reflect the co-occurrence of species and their susceptibility to the fishery. In those cases it might be advisable to lower the harvest specification for the complex based on indicator stocks (i.e., the most vulnerable stocks within the complex) to prevent overfishing any component. Alternatively there may be existing complexes where it might not be desirable to change the assemblage (e.g., due to disruption to existing fisheries or data collection) but where vulnerable component stocks can be managed differently with harvest guidelines or lower trip limits, bag limits, etc.

In other cases it may be possible to reconfigure a complex or complexes to allow for differential specification and management (e.g., splitting an existing complex into vulnerable and less vulnerable complexes). This could allow for targeting on the less vulnerable complex while avoiding the more vulnerable complex. In all of these cases we will be looking at what stocks need to be included in the FMP and in alternative complexes as well as which stocks might more appropriately be considered EC species.

Progress Towards Reconfiguring Stock Complexes
The Situation Summary (Agenda Item D.3) provides links to some statements that describe progress towards reconfiguring stock complexes. In addition to these statements, the GMT provided a detailed overview of work towards this goal in Appendix C of the 2013-2014 FEIS Harvest Specifications and Management Measures (FEIS 2013). In addition to this overview, Appendix C of the FEIS (2013) provides information regarding some costs and benefits of moving aurora, shortraker, and rougheye rockfish out of complexes and managing to their own ACL. This information will be considered as the GMT moves forward with creating new alternatives and tools to evaluate the alternatives.

A sample schedule for achieving the goal of reconfiguring stock complexes was shown in Agenda Item G.5.b, Supplemental GMT Report, 2011, and reproduced in Figure 1. Even though progress has been delayed relative to the original plan, this figure clearly illustrates the amount of work accomplished by the Council, Council Staff, and advisory bodies towards achieving this objective. It also illustrates what remains to be done. This figure shows that we are near the end and that most of the necessary background work and analyses have been accomplished.

GMT recommendations:

1. **Retain the range of alternatives provided in Agenda Item D.3.a, Attachment 1 for future consideration.**

2. **Task Council staff with evaluating the impacts of a June, September process (current proposal) as well as a June, September, November process.**

3. **Priorities (in time) for reorganizing complexes**
   - a **The slope rockfish complex = high**
   - b **The Other Fish complex = high**
   - c **The nearshore rockfish complex = lower**
   - d **The shelf rockfish complex= lower**

4. **The analysis detail the anticipated costs of the alternatives compared to status quo.**

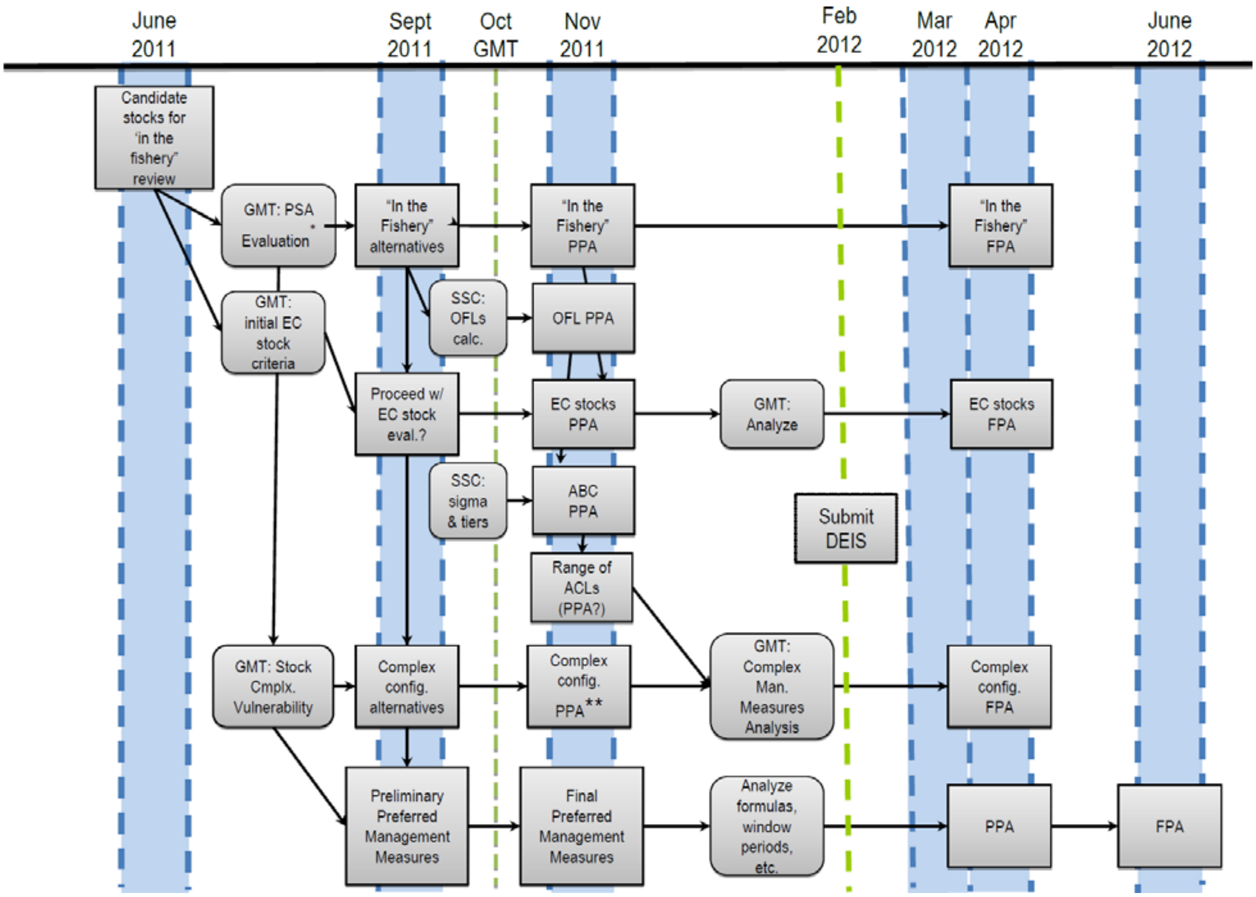


Figure 1. Stock complex analytical framework and timeline, from September 2011 G.5.b Supplemental GMT report.

Appendix 1. National Standards in the Magnuson-Stevens Fisheries Conservation and Management Act Reauthorized

(http://www.nmfs.noaa.gov/msa2007/docs/act_draft.pdf)

Standard 1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield (OY) from each fishery for the U.S. fishing industry.

Standard 2. Conservation and management measures shall be based upon the best scientific information available.

Standard 3. To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

Standard 4. Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various U.S. fishermen, such allocation shall be:

(1) Fair and equitable to all such fishermen.

(2) Reasonably calculated to promote conservation.

(3) Carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.

Standard 5. Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.

Standard 6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.

Standard 7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

Standard 8. Conservation and management measures shall, consistent with the conservation requirements of the Magnuson-Stevens Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to:

(1) Provide for the sustained participation of such communities; and

(2) To the extent practicable, minimize adverse economic impacts on such communities.

Standard 9. Conservation and management measures shall, to the extent practicable:

(1) Minimize bycatch; and

(2) To the extent bycatch cannot be avoided, minimize the mortality of such bycatch.

Standard 10. Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

PFMC
04/07/13

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON STOCK COMPLEX ASSEMBLAGES

Mr. John DeVore and Dr. Jason Cope gave a summary of "Initial Proposal (Proposed Action, Alternatives, and Considerations) for Restructuring Groundfish Stock Complexes" (Agenda Item D.3.a Attachment 1). The report describes a proposed action to restructure the current groundfish stock complexes into groupings that comprise species of more equivalent ecological distributions, of more equivalent vulnerabilities to overfishing, and that are caught together in the fishery. The Scientific and Statistical Committee (SSC) appreciates the efforts of the authors of the report, agrees that restructuring stock complexes is important, and anticipates reviewing a revised document in June.

The SSC focused on methodology for identifying stock complexes that could be restructured and for evaluating the performance of proposed stock complexes.

The SSC supports approaches that group similar stocks on the basis of their productivity and spatial distribution. The distribution data used were not described in sufficient detail to fully evaluate. The SSC recommends developing and presenting explicit measures of the concordance between spatial groupings and the groupings of stocks into stock complexes.

Several potential metrics for evaluating proposed stock complexes were discussed. All proposed metrics depend to some degree on predicting future fishing behavior. It is very difficult to evaluate whether a new stock complex structure will achieve the desired goals without actually implementing changes in an iterative, adaptive-management approach.

The SSC recommends refining the metrics used to evaluate current stock complexes to focus on the ratio of total cumulative catch to total cumulative component overfishing limit (OFL) and the mean difference between total catch and total component OFL. Plots of trends over time in catch relative to component OFL provide a useful graphical summary of potential concerns with current stock complexes.

The SSC also raised concerns about the reliability of species composition data used in retrospective analyses, an issue often encountered in groundfish management. Some stock restructurings may provide benefits by aligning species complexes with market categories, e.g. grenadier and greenlings. However, increasing the number of market categories could create data quality issues, and the SSC recommends this be evaluated more thoroughly in the next version of this analysis.

The current report contains adequate information for the SSC to reiterate its endorsement of reorganizing the present "other fish" stock complex.

PFMC
04/07/13

IMPLEMENTATION OF THE 2013 PACIFIC WHITING FISHERY UNDER THE U.S.-CANADA PACIFIC WHITING AGREEMENT

A new stock assessment for Pacific whiting has been conducted (Agenda Item D.4.a, Attachment 1), reviewed, and used for decision-making in the international whiting treaty process. The Joint Management Committee (JMC) met on March 18-19 to formalize their recommendations on the 2013 coastwide total allowable catch for Pacific whiting (Agenda Item D.4.b, JMC Report). Mr. Phil Anderson and Mr. Frank Lockhart will brief the Council on the JMC's recommendations.

The Council should consider advisory body and public comment before deciding on any actions necessary regarding the 2013 U.S. annual catch limit for Pacific whiting and other associated issues.

Council Action:

1. Consider any necessary action for implementation of the 2013 Pacific whiting fishery.

Reference Materials:

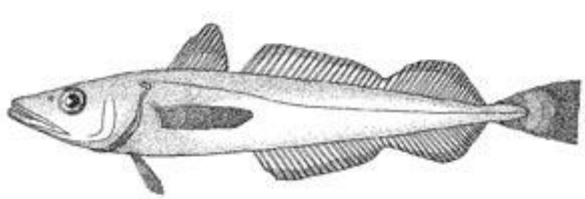
1. Agenda Item D.4.a, Attachment 1: Executive Summary of Status of the Pacific hake (Whiting) stock in U.S. and Canadian Waters in 2013. (*Full Version Available on Briefing Book Website and CD Only*).
2. Agenda Item D.4.b, JMC Report: March 19, 2013 Letter from the Joint Management Committee detailing their recommendations on the 2013 total allowable catch of Pacific whiting.

Agenda Order:

a. Agenda Item Overview — John DeVore
b. Joint Management Committee Report — Phil Anderson and Frank Lockhart
c. Reports and Comments of Advisory Bodies and Management Entities
d. Public Comment
e. **Council Action:** Consider any Necessary Action for Implementation of the 2013 Pacific Whiting Fishery

PFMC
03/22/13

Status of the Pacific hake (whiting) stock in U.S. and Canadian waters in 2013



International Joint Technical Committee for Pacific hake

Final Document
3/4/2013

This document reports the collaborative efforts of the official U.S. and Canadian JTC members.

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Table of Contents

Executive Summary

Stock

This assessment reports the status of the coastal Pacific hake (or Pacific whiting, *Merluccius productus*) resource off the west coast of the United States and Canada. This stock exhibits seasonal migratory behavior, ranging from offshore and generally southern waters during the winter spawning season to coastal areas between northern California and northern British Columbia during the spring, summer and fall when the fishery is conducted. In years with warmer water temperatures the stock tends to move farther to the North during the summer and older hake tend to migrate farther than younger fish in all years. Separate, and much smaller, populations of hake occurring in the major inlets of the northeast Pacific Ocean, including the Strait of Georgia, Puget Sound, and the Gulf of California, are not included in this analysis.

Catches

Coast-wide fishery landings of Pacific hake averaged 222,000 mt from 1966 to 2012, with a low of 90,000 mt in 1980 and a peak of 363,000 mt in 2005. Prior to 1966 the total removals were negligible relative to the modern fishery. The fishery in U.S. waters has averaged 166,000 mt, or 74.7% of the average total landings over the time series, with the catch from Canadian waters averaging 56,000 mt. During the fishery's first 25 years, the majority of removals were from foreign or joint-venture fisheries. In this stock assessment, the terms catch and landings are used interchangeably; estimates of discard within the target fishery are included, but discarding of Pacific hake in non-target fisheries is not. Discard from all fisheries is estimated to be less than 1% of landings and therefore is likely to be negligible with regard to the population dynamics.

Recent coast-wide landings from 2008–2012 have been above the long term average, at 243,000 mt. Landings between 2001 and 2008 were predominantly comprised of fish from the very large 1999 year class, with the cumulative removal from that cohort exceeding an estimated 1.2 million mt. In 2008, the fishery began harvesting considerable numbers of the then emergent 2005 year class. Catches in 2009 were again dominated by the 2005 year class with some contribution from an emergent 2006 year class and relatively small numbers of the 1999 cohort. The 2010 and 2011 fisheries encountered very large numbers of the 2008 year-class, while continuing to see some of the 2005 and 2006 year-classes as well as a small proportion of the 1999 year class. In 2012, U.S. fisheries caught mostly 2 and 4-year old fish from the 2008 and 2010 year classes, while the Canadian fisheries encountered older fish from the 2005, 2006, and 2008 year classes. A considerable number of 2-year old fish were caught by the U.S. at-sea fleet later in the year.

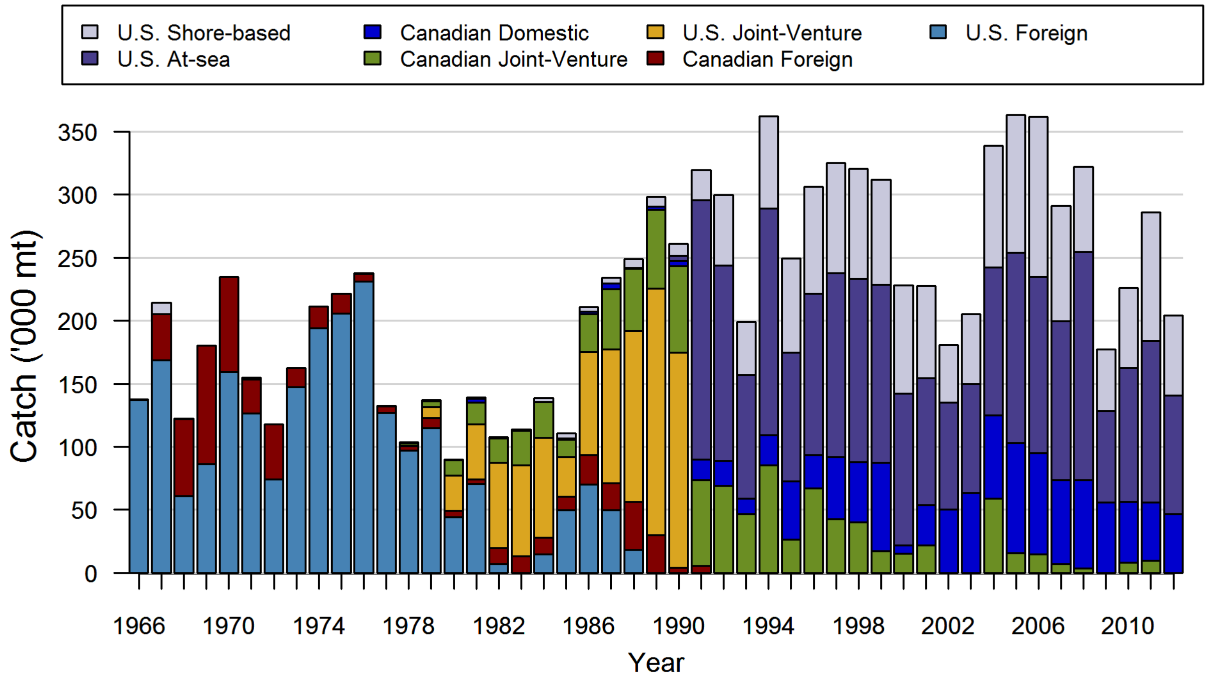

Figure a. Total Pacific hake catch used in the assessment by sector, 1966-2012. Tribal catches are included.

Table a. Recent commercial fishery catch (1,000's mt). Tribal catches are included where applicable.

Year	US at-sea	US shore-based	US total	Canadian joint-venture	Canadian domestic	Canadian total	Total
2003	87	55	142	0	63	63	205
2004	117	97	214	59	66	125	339
2005	151	109	260	16	87	103	363
2006	140	127	267	14	80	95	362
2007	126	91	218	7	67	73	291
2008	181	68	248	4	70	74	322
2009	72	49	122	0	56	56	177
2010	106	64	170	8	48	56	217
2011	128	102	230	10	46	56	286
2012	94	63	157	0	47	47	204

Data and assessment

Data have been updated for the 2013 assessment with the addition of new ages into the 2011 age distribution, the addition of a new age distribution from the 2012 fishery and acoustic survey, and addition of the 2012 acoustic survey biomass estimate to the abundance index.

This assessment reports a single base-case model representing the collective work of the Joint Technical Committee (JTC), and depends primarily upon nine years of an acoustic survey biomass index as well as catches for information on the scale of the current hake stock. The 2011 survey index value is the lowest in the time-series, and the 2012 index is more than 2.5 times greater. The age-composition data from the aggregated fisheries (1975-2012) and the acoustic survey contribute to the assessment model's ability to resolve strong and weak cohorts. Both sources indicate a strong 2008 cohort in the 2011 and 2012 data, and a strong 2010 cohort in the 2012 data, which may partially explain the recent increase in the survey index.

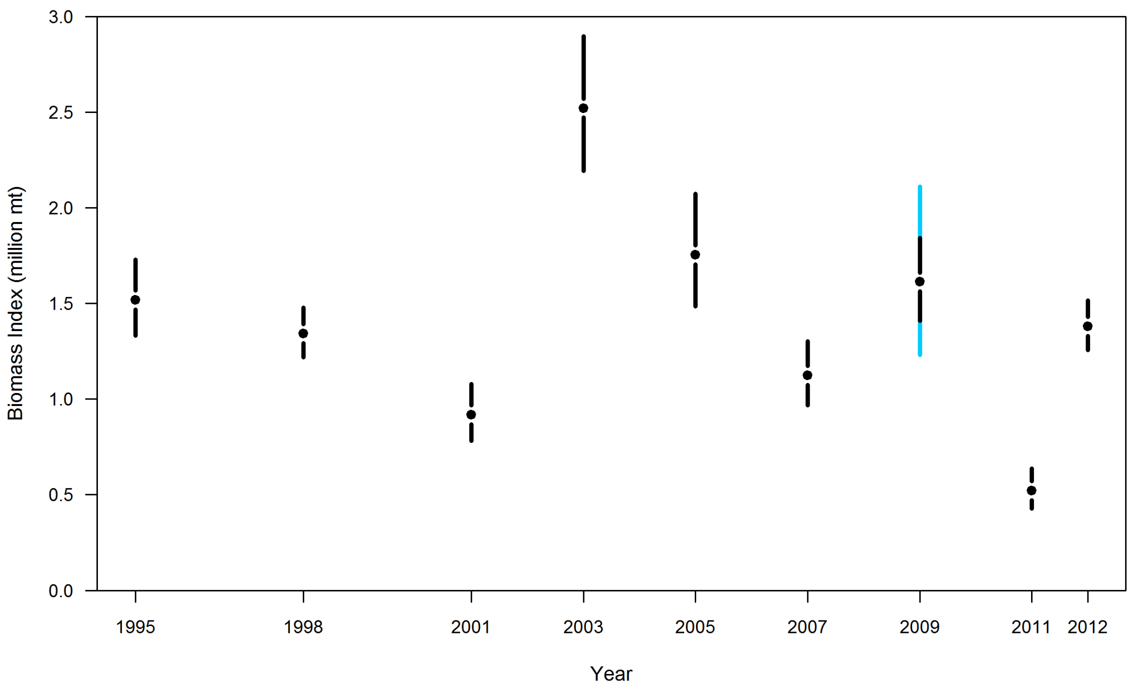

Figure b. Acoustic survey biomass index (millions of metric tons). Approximate 95% confidence intervals are based on only sampling variability (1995–2007, 2011–2012) in addition to squid/hake apportionment uncertainty (2009, in blue).

The assessment uses Bayesian methods to incorporate prior information on two key parameters (natural mortality, *M*, and steepness of the stock-recruit relationship, *h*) and integrate over parameter uncertainty to provide results that can be probabilistically interpreted. The exploration of uncertainty is not limited to parameter uncertainty as structural uncertainty is investigated through sensitivity analyses.

Stock biomass

The base-case stock assessment model indicates that Pacific hake female spawning biomass was below the unfished equilibrium in the 1960s and 1970s. The stock is estimated to have increased rapidly after two or more large recruitments in the early 1980s, and then declined steadily after a peak in the mid- to late-1980s to a low in 2000. This long period of decline was followed by a brief increase to a peak in 2003 (a median female spawning biomass estimate of 1.34 million mt in the SS model) as the large 1999 year class matured. The stock is then estimated to have declined with the aging 1999 year class to a female spawning biomass time-series low of 0.42 million mt in 2009. This recent decline is similar to that estimated in the 2012 assessment, but at a slightly greater absolute value. The current (2013) median posterior spawning biomass is estimated to be 72.3% of the estimated unfished equilibrium level (SB_0) with 95% posterior credibility intervals ranging from 34.7% to 159.7%. The estimate of 2013 female spawning biomass is 1.50 million mt, which is more than double the projected spawning biomass from the 2012 assessment (0.64 million mt). The difference in projected biomass is largely driven by increases in the estimated size of the 2008 and 2010 year classes.

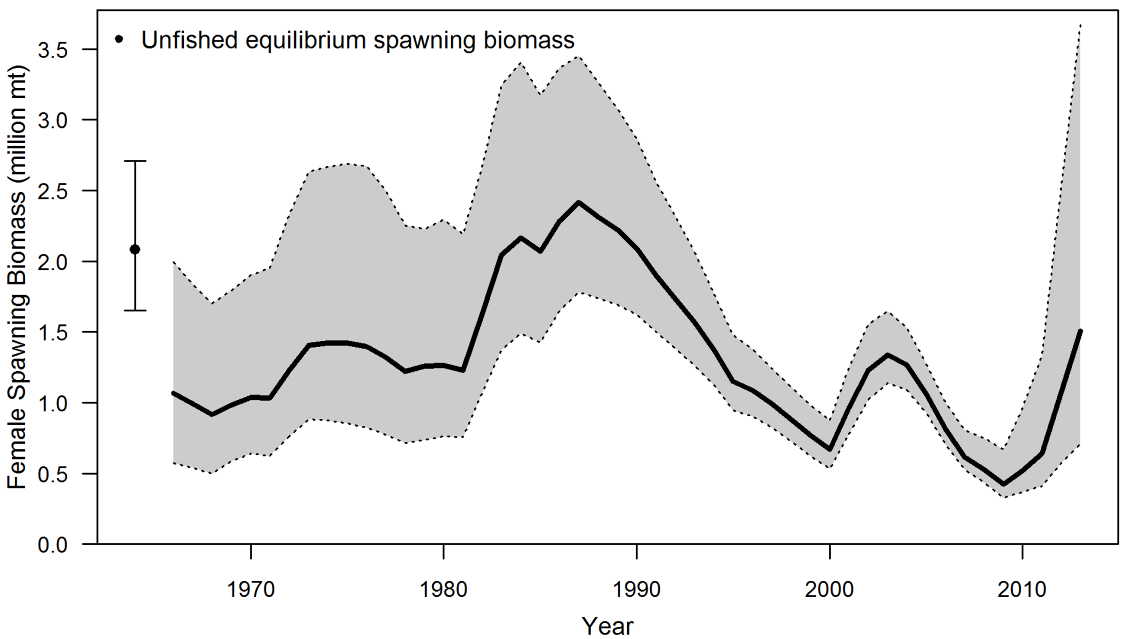

Figure c. Median of the posterior distribution for female spawning biomass through 2013 (solid line) with 95% posterior credibility intervals (shaded area).

Table b. Recent trends in estimated Pacific hake female spawning biomass (million mt) and depletion level relative to estimated unfished equilibrium.

	Spawning biomass (mt)			Depletion (SB_t/SB_0)		
Year	2.5th percentile	Median	97.5th percentile	2.5th percentile	Median	97.5th percentile
2004	1.093	1.268	1.530	0.475	0.605	0.769
2005	0.929	1.064	1.277	0.401	0.508	0.640
2006	0.705	0.811	1.000	0.307	0.390	0.491
2007	0.527	0.617	0.808	0.236	0.297	0.384
2008	0.436	0.529	0.751	0.199	0.255	0.345
2009	0.327	0.424	0.670	0.152	0.204	0.303
2010	0.371	0.520	0.964	0.172	0.255	0.418
2011	0.409	0.642	1.333	0.194	0.315	0.579
2012	0.575	1.078	2.542	0.275	0.516	1.109
2013	0.709	1.504	3.676	0.347	0.723	1.597

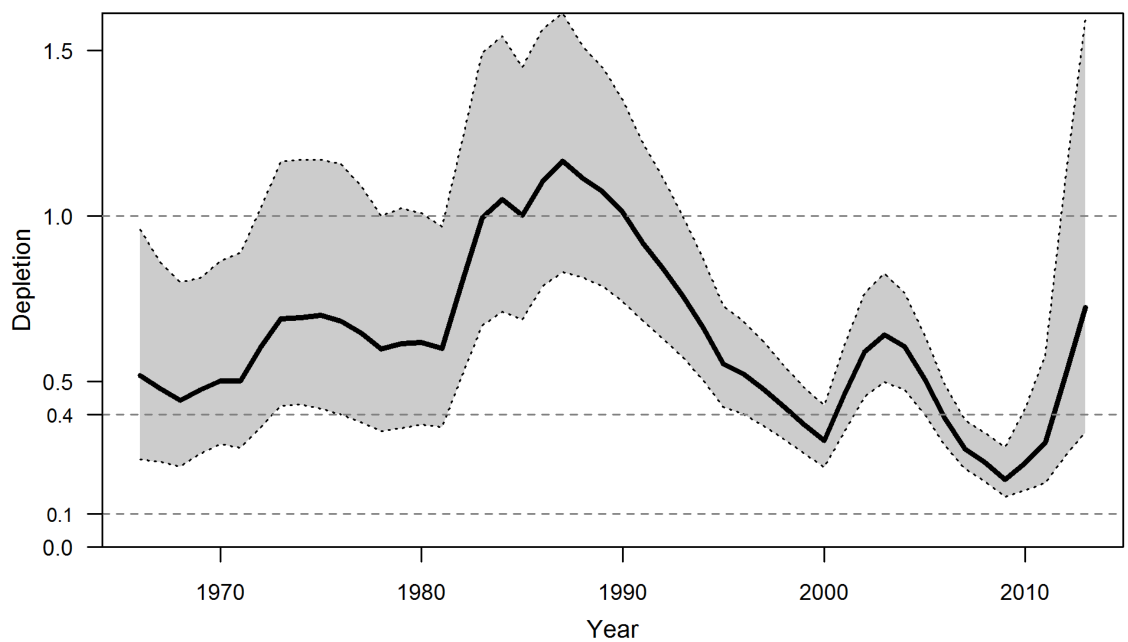

Figure d. Median (solid line) of the posterior distribution for spawning depletion (SB_t/SB_0) through 2013 with 95% posterior credibility intervals (shaded area). Dashed horizontal lines show 10%, 40% and 100% depletion levels.

Recruitment

Recruitment is highly variable for Pacific hake. Large year classes in 1980, 1984, and 1999 have been a major component of the fishery in the 1980's and early 1990's, and the early 2000's. Recently, strong year classes are estimated in 2008 and 2010, although the uncertainty about 2010 year class strength is large given the limited exposure to fisheries. In the last decade, estimated recruitment has been at some of the lowest values in the time-series as well some of the highest.

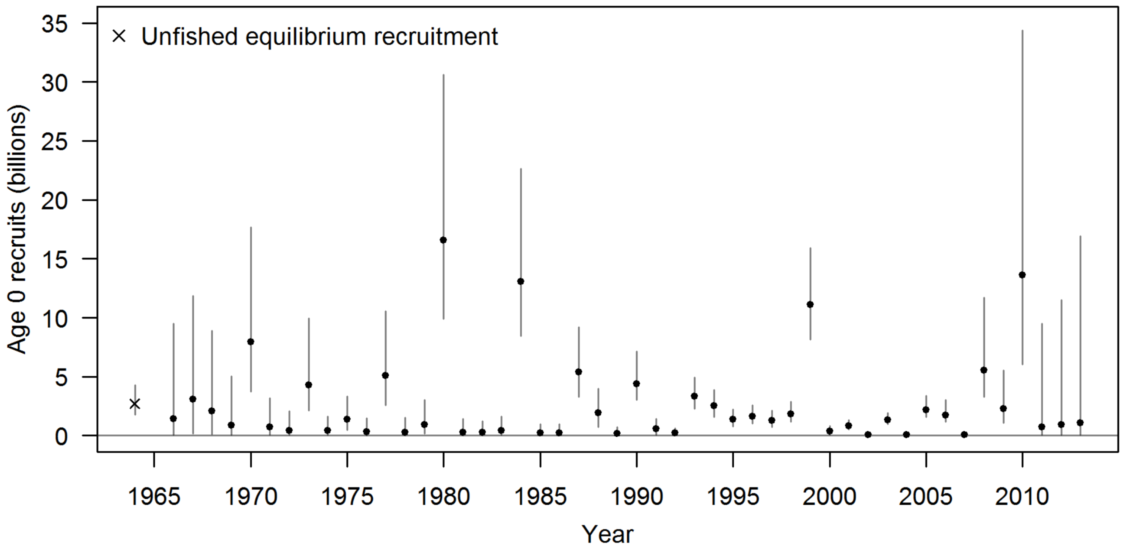

Figure e. Medians (solid circles) of the posterior distribution for recruitment (billions of age-0) with 95% posterior credibility intervals (gray lines). Unfished equilibrium recruitment is shown as an X.

Table c. Estimates of recent Pacific hake recruitment (billions of age-0).

Year	2.5th percentile	Median	97.5th percentile
2004	0.012	0.069	0.228
2005	1.557	2.172	3.379
2006	1.151	1.721	3.048
2007	0.017	0.088	0.295
2008	3.288	5.526	11.720
2009	1.088	2.269	5.519
2010	6.037	13.606	34.396
2011	0.060	0.737	9.509
2012	0.054	0.916	11.500
2013	0.054	1.061	16.926

Exploitation status

Fishing intensity on the Pacific hake stock is estimated to have been below the $F_{40\%}$ target until 2007. The base-case model estimates of prior fishing intensity indicate that the target was likely exceeded in three of the last five years. (It should be noted, however, that the harvest in those years did not exceed the catch limits that were specified, based on the best available science at the time.) The exploitation fraction does not necessarily correspond to fishing intensity because fishing intensity accounts for the age-structure of the population. For example, the fishing intensity remained nearly constant and above target from 2010 to 2011. However, the exploitation fraction declined in these years because of many estimated 1 year old fish.

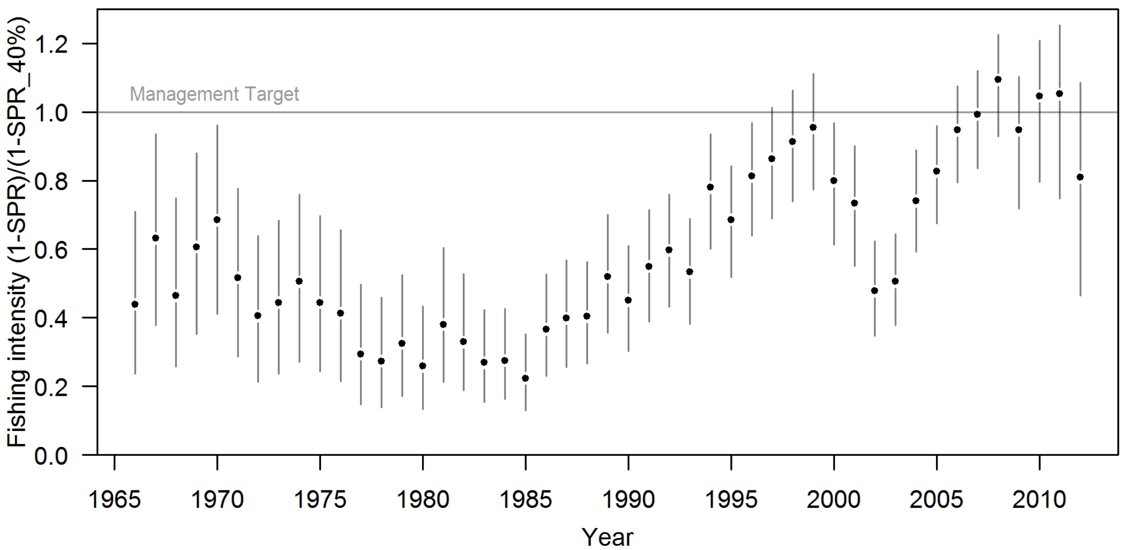

Figure f. Trend in median fishing intensity (relative to the SPR management target) through 2012 with 95% posterior credibility intervals. The management target define in the Agreement is shown as a horizontal line at 1.0.

Table d. Recent trend in fishing intensity (relative spawning potential ratio; (1-SPR)/(1-SPR$_{40\%}$)) and exploitation rate (catch divided by vulnerable biomass).

	Fishing intensity			Exploitation fraction		
Year	2.5th percentile	Median	97.5th percentile	2.5th percentile	Median	97.5th percentile
2003	37.8%	50.6%	64.4%	5.1%	6.3%	7.5%
2004	59.2%	74.1%	88.9%	10.6%	12.8%	14.8%
2005	67.5%	82.7%	96.0%	15.6%	18.7%	21.4%
2006	79.4%	94.7%	107.6%	18.3%	22.7%	26.0%
2007	83.5%	99.3%	112.0%	21.2%	27.5%	32.2%
2008	92.8%	109.4%	122.5%	20.8%	29.2%	35.2%
2009	71.7%	94.7%	110.3%	11.7%	18.4%	23.8%
2010	79.6%	104.7%	120.9%	18.2%	30.7%	42.3%
2011	74.8%	105.2%	125.3%	10.5%	21.5%	33.5%
2012	46.4%	81.0%	108.5%	6.3%	14.5%	26.4%

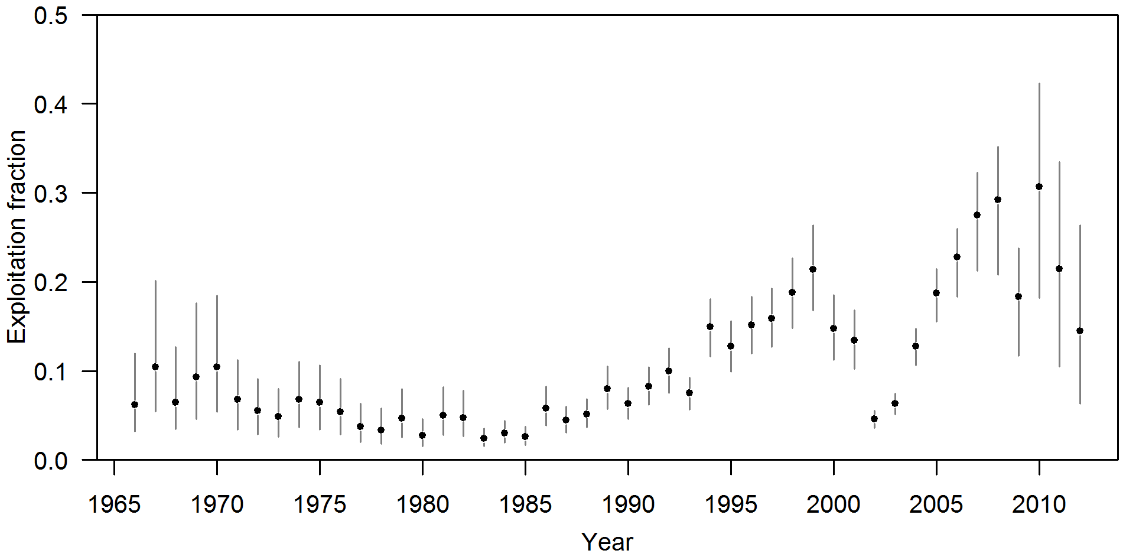

Figure g. Trend in median exploitation fraction through 2012 with 95% posterior credibility intervals.

Management Performance

Since implementation of the Magnuson-Stevens Fishery Conservation and Management Act in the U.S. and the declaration of a 200 mile fishery conservation zone in both countries in the late 1970s, annual quotas (or catch targets) have been used to limit the catch of Pacific hake in both zones by foreign and domestic fisheries. During the 1990s, however, disagreement between the U.S. and Canada on the division of the total catch led to quota overruns; 1991-1992 quotas summed to 128% of the limit and overruns averaged 114% from 1991-1999. Since 1999, catch targets have been determined using an $F_{40\%}$ default harvest rate with a 40:10 control rule (the default harvest policy) that decreases the catch linearly from a depletion of 40% to a depletion of 10%. Further considerations have often resulted in catch targets to be set lower than the recommended catch limit. The Agreement between the United States and Canada, establishes U.S. and Canadian shares of the coast-wide allowable biological catch at 73.88% and 26.12%, respectively, and this distribution has been adhered to since ratification of the Agreement.

Total catches last exceeded the coastwide catch target in 2002, when landings were 112% of the catch target. Over the last ten years, the average utilization has been 87%. From 2009 to 2012 much of the U.S. tribal allocation remained uncaught and Canadian catches have also been below the limit even though in retrospect the target harvest rate was surpassed in some years. The exploitation history in terms of both the biomass and *F*-target reference points, portrayed graphically via a phase-plot in Figure h, shows that historically the fishing intensity has been low and the biomass has been high. Recently, the estimated depletion level has been below 40% and the fishing intensity high, until 2012 when fishing intensity was below target and depletion was above 40%. Uncertainty is the 2012 estimates of fishing intensity and depletion show a 9% joint probability of being above the target fishing intensity and below 40% depletion.

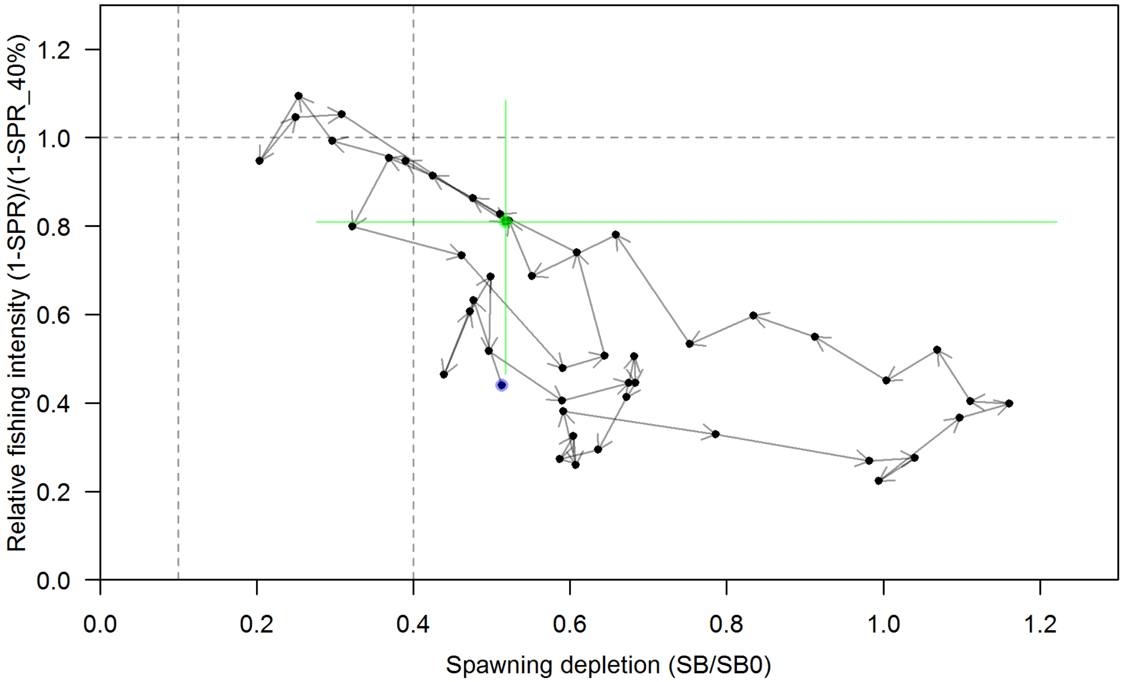

Figure h. Temporal pattern (phase plot) of posterior median fishing intensity vs. posterior median depletion through 2012. The blue circle indicates 1966 and the green circle denotes 2012. Green bars indicatethe 95% posterior credibility intervals along both axes. Arrows indicate the temporal progression of years and the dashed lines indicate the fishing intensity target (vertical) and the 40:10 control rule limits (vertical, 10% and 40%).

Table e: Recent trends in Pacific hake landings and management decisions.

Year	Total Landings (mt)	Coast-wide (US+Canada) catch target (mt)
2003	205,177	228,000
2004	338,654	501,073
2005	363,157	364,197
2006	361,761	364,842
2007	291,129	328,358
2008	322,145	364,842
2009	177,459	184,000
2010	226,202	262,500
2011	286,055	393,751
2012	204,040	251,809

Reference points

The estimated unfished equilibrium spawning biomass estimate was 2,081 thousand mt, which is 10% greater than the estimate reported in the 2012 stock assessment. The 95% posterior credibility interval ranges from 1,653 to 2,709 thousand mt and encompasses the estimate from the 2012 assessment. The spawning biomass that is 40% of the unfished equilibrium spawning biomass ($SB_{40\%}$) is estimated to be 833 thousand mt, which is slightly larger than the equilibrium spawning biomass implied by the $F_{40\%}$ default harvest rate target, 36% of SB_0 (744 thousand mt). *MSY* is estimated to occur at 24% of SB_0 (500 thousand mt) with a yield of 357 thousand mt; only slightly higher than the equilibrium yield at the biomass target ($SB_{40\%}$), 328 thousand mt, and at the $F_{40\%}$ target, 337 thousand mt. The full set of reference points, with posterior credibility intervals for the base case is reported in Table f.

Table f.. Summary of Pacific hake reference points for the base-case model.

Quantity	2.5^{th} percentile	Median	97.5^{th} percentile
Unfished female *SB* (SB_0, thousand mt)	1,653	2,081	2,709
Unfished recruitment (R_0, billions)	1.761	2.687	4.303
Reference points based on $F_{40\%}$			
Female spawning biomass ($SB_{F40\%}$ thousand mt)	556	744	942
$SPR_{MSY\text{-}proxy}$	–	40%	–
Exploitation fraction corresponding to SPR	18.4%	21.8%	25.9%
Yield at $SB_{F40\%}$ (thousand mt)	243	337	479
Reference points based on $SB_{40\%}$			
Female spawning biomass ($SB_{40\%}$ thousand mt)	661	833	1,084
$SPR_{SB40\%}$	40.6	43.2	51.4
Exploitation fraction resulting in $SB_{40\%}$	14.4%	19.2%	23.3%
Yield at $SB_{40\%}$ (thousand mt)	238	328	469
Reference points based on estimated MSY			
Female spawning biomass (SB_{MSY} thousand mt)	328	500	840
SPR_{MSY}	18.3%	28.2%	46.5%
Exploitation fraction corresponding to SPR_{MSY}	17.6%	34.5%	59.5%
MSY (thousand mt)	248	357	524

Unresolved problems and major uncertainties

Measures of uncertainty in this assessment underestimate the true uncertainty in current stock status and future projections because they do not account for alternative structural models for hake population dynamics and fishery processes (e.g., selectivity), the effects of data-weighting schemes, and the scientific basis for prior probability distribution choices.

The JTC investigated a broad range of alternative models, and we present a subset of key sensitivity analyses in the main document. A major source of uncertainty in the 2013 status and target catch is in the estimate of the size of the 2010 year class. The posterior distribution of derived parameters from the base model encompasses the median estimates of most sensitivity models.

Pacific hake displays the highest degree of recruitment variability of any west coast groundfish stock, resulting in large and rapid changes in stock biomass. This volatility, coupled with a dynamic fishery, which potentially targets strong cohorts resulting in time-varying selectivity, and little data to inform incoming recruitment until the cohort is age 2 or greater, will, in most circumstances, continue to result in highly uncertain estimates of current stock status and even less-certain projections of future stock trajectory. Uncertainty in this assessment is largely a function of the potentially large 2010 year class being observed once in the acoustic survey and twice in the fishery, although with low and uncertain selectivity. The supplemental acoustic survey performed in 2012 helped reduce the uncertainty of the strength of this year class, which is an expected result of increasing the survey frequency. However, with recruitment being a main source of uncertainty in the projections and the survey not quantifying hake until they are 2 years old, short term forecasts are very uncertain.

At the direction of the JMC, the JTC developed a Management Strategy Evaluation (MSE) in 2012 to explore the basic performance of the default harvest policy in the context of annual vs. biennial surveys. The results of these explorations showed that biomass levels and average catch are variable, mainly because of the high recruitment variability seen with Pacific hake coupled with potentially large stock assessment estimation biases. Even though the Pacific hake fishery is relatively data-rich, with a directed fishery-independent survey program, substantial biological sampling for both commercial fisheries and the acoustic survey, and reliable estimates of catch, the data are less informative about incoming recruitment which is partially responsible for large differences between the simulated abundance and the estimated abundance.

The MSE simulations show two main results. First, the current $F_{40\%}$-40:10 management strategy with perfect knowledge of current biomass resulted in a median long-term average depletion of less than 30%. Second, there was little difference in median values between strategies involving annual and biennial surveys. At the present time, we consider these conclusions preliminary because our simulations involved a limited range of uncertain processes that are known or suspected to occur for Pacific hake. For example, the structure and assumptions of the stock assessment model used in the annual the assessment-management cycle matched the assumptions of the operating model used to generate stock dynamics and assessment data. Such a match typically underepresents the potential range of future outcomes possible under any combination of harvest policy and survey frequency. In the MSE (Appendix A), we identify several factors that may lead to incorrect assumptions in the stock assessment model.

The JTC recommends continuing work on the MSE by expanding the operating model to investigate the performance of a suite of assessment models with more complicated hypotheses about actual Pacific hake life-history and fishery dynamics. Furthermore, the JTC would like to continue the involvement of the JMC, SRG, and AP to further refine management objectives, as well as, determine scenarios of interest, management actions to investigate, and hypotheses to simulate.

Forecast decision table

A decision table showing predicted status and fishing intensity relative to target fishing intensity is presented with uncertainty represented from within the base-case model. The decision table (split into Tables g.1 and g.2) is organized such that the projected outcomes for each potential catch level (rows) can be evaluated across the quantiles (columns) of the posterior distribution. The first table (g.1) shows projected depletion outcomes, and the second (g.2) shows projected fishing intensity outcomes relative to the target fishing intensity (based on SPR; see table legend). Fishing intensity exceeding 100% indicates fishing in excess of the $F_{40\%}$ default harvest rate.

An additional table is presented containing a set of management metrics that were identified as important to the Joint Management Committee (JMC) and the Advisory Panel (AP) in 2012. These metrics summarize the probability of various outcomes from the base case model given each potential management action. Although not linear, probabilities can be interpolated from this table for intermediate catch values. Figure i shows the depletion trajectory through 2015 for several of these management actions.

The median spawning stock biomass is projected to remain constant with a 2013 catch of 650,000 mt, which is greater than the catch determined using the default harvest rate (626,364 mt). A catch of approximately 603,000 mt results in an equal probability of the stock increasing or decreasing from 2013 to 2014, based on individual trajectories from samples of the posterior distribution. The median values show slightly different results than the individual trajectories, which is not unexpected. Catches of less than 600,000 mt result in a slight increase in the median 2014 spawning biomass. However, the posterior distribution is highly uncertain, and either increasing or decreasing trends are possible over a broad range of 2012 catch levels. A 2013 catch of 696,000 mt results in the same projected catch of 696,000 mt in 2014 when applying the default harvest policy ($F_{40\%}$ – 40:10).

Table g.3 shows the same catch alternatives for 2013 and probabilities based on individual samples from the posterior distribution. The probability that the spawning stock biomass in 2014 remains above the 2013 level is 50% with a catch of 603,000 mt, the probability that the fishing intensity is above target in 2013 is 50% with a catch of 626,364 mt, and the probability that the predicted 2014 catch target is the same as a set value in 2013 is 50% for a set value of 696,000 mt in 2013. There is less than a 12% probability that the spawning stock will drop below 40% in 2014 for all catch levels considered.

Until cohorts are five or six years old, the model's ability to resolve cohort strength is poor. For many of the recent above average cohorts (2005, 2006, and 2008), the size of the year class was overestimated when it was age 2, compared to updated estimates as the cohort aged and more observations were available from the fishery and survey. Given this trend, a very uncertain 2010 year class, and a projected 2013 catch target that is both more than 1.5 times the highest catch in the time series and 1.75 times the median MSY, additional forecast decision tables were created given three states of nature about the size of the 2010 year class. These states of nature are low 2010 recruitment, medium 2010 recruitment, and high 2010 recruitment, and each state of nature is defined to have a probability of 10%, 80%, and 10%, respectively. Table g.4 shows the median depletion and fishing intensity within each state of nature, and it can be seen that in the low-recruitment state of nature the fishing intensity would be at target with a 2013 catch between 300,000 and 350,000 mt. Table g.5 shows the probability metrics for each state of nature. In the low-recruitment state of nature there is an equal probability that the spawning biomass in 2014 will be less than or greater than the spawning biomass in 2013 with a catch between 300,000 and 350,000 mt. There is an equal probability that the spawning biomass will be below 40% of unfished equilibrium spawning biomass with a catch near 400,000 mt.

Table g.1. Posterior distribution quantiles for forecasts of Pacific hake relative depletion (at the beginning of the year before fishing takes place) from the base model. Catch alternatives are based on: 1) arbitrary constant catch levels (rows a–g), 2) the catch level that results in an equal probability of the population increasing or decreasing from 2013 to 2014 (row h), 3) the median values estimated via the default harvest policy ($F_{40\%}$ – 40:10) for the base case (row i), 4) the catch level that results in the median spawning biomass to remain unchanged from 2013 to 2014 (row j), and 5) the catch level that results in a 50% probability that the median projected catch will remain the same in 2014 (row k).

Within model quantile			5%	25%	50%	75%	95%
Management Action			**Beginning of year depletion**				
	Year	Catch (mt)					
a	2013	0	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	0	47.7%	68.3%	88.1%	114.4%	169.8%
b	2013	250,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	250,000	41.8%	62.5%	82.1%	108.8%	163.2%
c	2013	300,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	300,000	40.5%	61.5%	81.1%	107.7%	162.1%
d	2013	350,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	350,000	39.3%	60.3%	79.9%	106.6%	161.0%
e	2013	400,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	400,000	38.3%	59.2%	78.6%	105.6%	159.7%
f	2013	450,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	450,000	37.0%	58.0%	77.3%	104.4%	158.7%
g	2013	500,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	500,000	35.8%	56.8%	76.0%	103.2%	157.7%
h	2013	603,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	603,000	33.9%	54.3%	73.5%	100.7%	155.7%
i	2013	626,364	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	715,041	33.4%	53.8%	72.9%	100.2%	155.3%
j	2013	650,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	650,000	32.8%	53.2%	72.4%	99.7%	154.8%
k	2013	696,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	696,000	31.7%	52.1%	71.3%	98.7%	153.9%

Table g.2. Posterior distribution quantiles for forecasts of Pacific hake fishing intensity (spawning potential ratio; (1-SPR)/(1-SPR$_{40\%}$); values greater than 100% denote fishing in excess of the $F_{40\%}$ default harvest rate) from the base model. Catch alternatives are explained in Table g.1.

Within model quantile			5%	25%	50%	75%	95%
Management Action			Fishing Intensity				
	Year	Catch (mt)					
a	2013	0	0%	0%	0%	0%	0%
	2014	0	0%	0%	0%	0%	0%
b	2013	250,000	37%	50%	63%	75%	91%
	2014	250,000	29%	42%	53%	64%	82%
c	2013	300,000	42%	57%	70%	82%	98%
	2014	300,000	34%	48%	61%	72%	90%
d	2013	350,000	47%	63%	76%	88%	105%
	2014	350,000	38%	54%	67%	80%	98%
e	2013	400,000	52%	68%	82%	94%	110%
	2014	400,000	42%	59%	74%	86%	104%
f	2013	450,000	57%	73%	87%	98%	114%
	2014	450,000	47%	64%	79%	92%	110%
g	2013	500,000	61%	77%	91%	102%	117%
	2014	500,000	50%	69%	84%	97%	115%
h	2013	603,000	68%	85%	99%	109%	123%
	2014	603,000	58%	78%	93%	106%	123%
i	2013	626,364	69%	87%	100%	111%	124%
	2014	715,041	65%	85%	100%	112%	129%
j	2013	650,000	71%	88%	101%	112%	125%
	2014	650,000	61%	81%	97%	109%	127%
k	2013	696,000	74%	91%	104%	114%	127%
	2014	696,000	64%	84%	100%	113%	129%

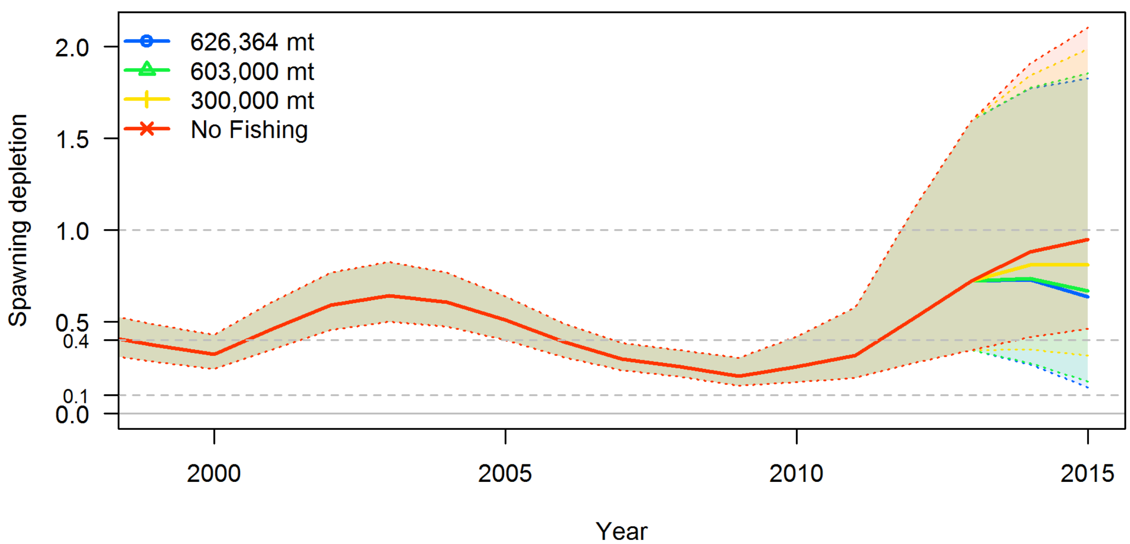

Figure i. Time-series of estimated spawning depletion to 2013 from the base-case model, and forecast trajectories to 2015 for several several management options from the decision table, with 95% posterior credibility intervals. The 2013 catch of 626,364 mt was calculated using the default harvest policy, as defined in the Agreement, which updates future catches (see Table g.1).

Table g.3. Probabilities of various management metrics given different catch alternatives. Catch alternatives are explained in Table g.1.

Catch	Probability $SB_{2014}<SB_{2013}$	Probability $SB_{2014}<SB_{40\%}$	Probability $SB_{2014}<SB_{25\%}$	Probability $SB_{2014}<SB_{10\%}$	Probability Fishing intensity in 2013 > 40% Target	Probability 2014 Catch Target < 2013 Catch
0	0%	2%	0%	0%	0%	0%
250,000	2%	4%	0%	0%	2%	1%
300,000	6%	5%	1%	0%	4%	2%
350,000	11%	6%	1%	0%	9%	4%
400,000	18%	6%	1%	0%	15%	9%
450,000	25%	7%	1%	0%	22%	14%
500,000	33%	8%	1%	0%	30%	20%
603,000	50%	9%	2%	0%	45%	36%
626,364	53%	10%	2%	0%	50%	39%
650,000	57%	10%	2%	0%	55%	42%
696,000	62%	11%	3%	0%	59%	50%

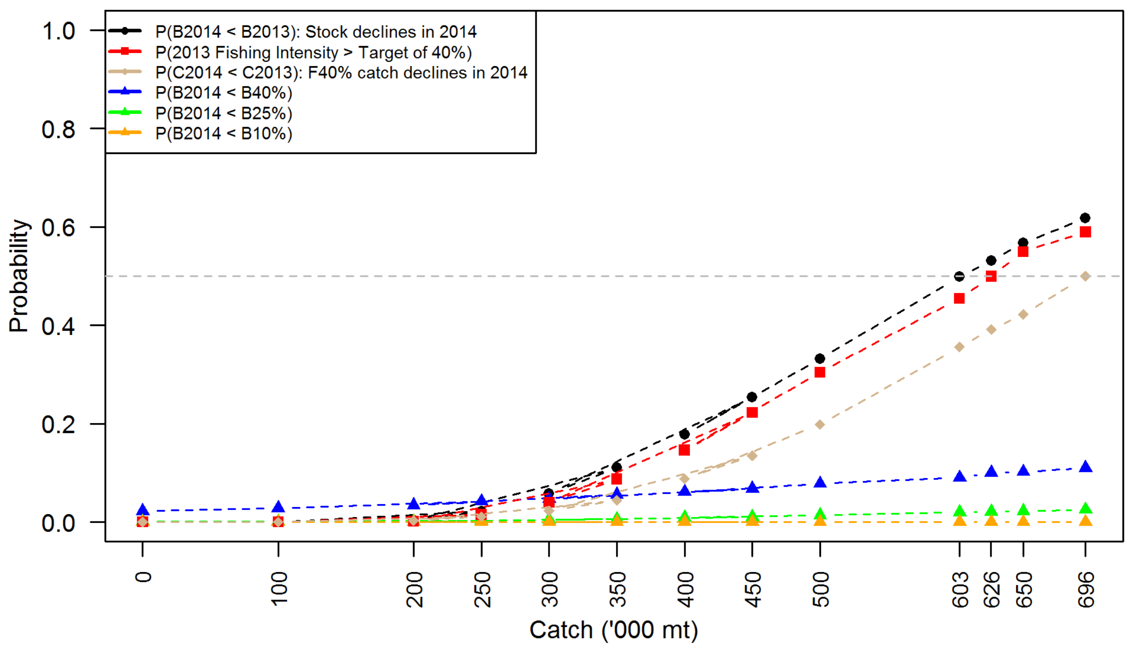

Figure j: Probabilities of various management metrics given different catch alternatives as defined in Table g.3. The points show these specific catch levels and lines interpolate between the points.

Table g.4. Median forecasts of Pacific hake depletion and fishing intensity (FI) for three different states of nature based on 2010 recruitment: 1) Low 2010 recruitment uses the lowest 10% of 2010 recruitment estimates, 2) Mid 2010 recruitment uses the middle 80% of 2010 recruitment estimates, and 3) High 2010 recruitment uses the highest 10% of 2010 recruitment estimates. Catch alternatives are explained in Table g.1.

	State Probability	Low 2010 recruitment 10%		Mid 2010 recruitment 80%		High 2010 recruitment 10%	
Year	Catch	Depletion	FI	Depletion	FI	Depletion	FI
2013	0	41.1%	0%	72.4%	0%	141.0%	0%
2014	0	49.3%	0%	88.2%	0%	165.8%	0%
2013	250,000	41.1%	91%	72.4%	63%	141.0%	37%
2014	250,000	43.9%	82%	82.2%	53%	160.3%	29%
2013	300,000	41.1%	98%	72.4%	70%	141.0%	42%
2014	300,000	42.8%	90%	81.1%	61%	159.3%	34%
2013	350,000	41.1%	104%	72.4%	76%	141.0%	47%
2014	350,000	41.6%	98%	79.9%	67%	158.3%	38%
2013	400,000	41.1%	109%	72.4%	82%	141.0%	52%
2014	400,000	40.3%	104%	78.6%	73%	157.2%	42%
2013	450,000	41.1%	113%	72.4%	87%	141.0%	57%
2014	450,000	39.0%	110%	77.3%	79%	156.2%	47%
2013	500,000	41.1%	117%	72.4%	91%	141.0%	61%
2014	500,000	37.6%	115%	76.0%	84%	155.1%	51%
2013	603,000	41.1%	123%	72.4%	98%	141.0%	68%
2014	603,000	35.1%	123%	73.5%	93%	153.0%	58%
2013	626,364	41.1%	124%	72.4%	100%	141.0%	69%
2014	626,364	34.6%	128%	73.0%	100%	152.5%	65%
2013	650,000	41.1%	125%	72.4%	101%	141.0%	71%
2014	650,000	34.0%	126%	72.4%	97%	152.0%	61%
2013	696,000	41.1%	127%	72.4%	104%	141.0%	74%
2014	696,000	32.9%	129%	71.3%	100%	151.0%	64%

Table g.5. Probabilities of various management metrics given different catch alternatives for three different states of nature based on 2010 recruitment: 1) the lower 10% of 2010 recruitment estimates, 2) the middle 80% of 2010 recruitment estimates, and 3) the highest 10% of 2010 recruitment estimates.. Catch alternatives are explained in Table g.1.

Catch	Probability $SB_{2014}<SB_{2013}$	Probability $SB_{2014}<SB_{40\%}$	Probability $SB_{2014}<SB_{25\%}$	Probability $SB_{2014}<SB_{10\%}$	Probability Fishing intensity in 2013 > 40% Target	Probability 2014 Catch Target < 2013 Catch
			Lower 10% of 2010 recruitment			
0	0%	21%	1%	0%	0%	0%
250,000	16%	34%	3%	0%	15%	11%
300,000	31%	39%	5%	0%	40%	23%
350,000	56%	46%	6%	0%	74%	42%
400,000	65%	49%	9%	0%	93%	74%
450,000	69%	54%	10%	0%	99%	90%
500,000	77%	59%	14%	0%	100%	97%
603,000	89%	64%	20%	0%	100%	100%
626,364	91%	68%	20%	0%	100%	100%
650,000	92%	68%	21%	0%	100%	100%
696,000	93%	71%	24%	0%	100%	100%
			Middle 80% of 2010 recruitment			
0	0%	0%	0%	0%	0%	0%
250,000	1%	1%	0%	0%	0%	0%
300,000	3%	1%	0%	0%	0%	0%
350,000	7%	1%	0%	0%	2%	0%
400,000	14%	2%	0%	0%	7%	2%
450,000	23%	2%	0%	0%	15%	6%
500,000	32%	2%	0%	0%	26%	13%
603,000	51%	3%	0%	0%	44%	32%
626,364	55%	4%	0%	0%	50%	36%
650,000	59%	4%	0%	0%	56%	40%
696,000	65%	5%	0%	0%	61%	50%
			Upper 10% of 2010 recruitment			
0	0%	0%	0%	0%	0%	0%
250,000	0%	0%	0%	0%	0%	0%
300,000	0%	0%	0%	0%	0%	0%
350,000	0%	0%	0%	0%	0%	0%
400,000	0%	0%	0%	0%	0%	0%
450,000	0%	0%	0%	0%	0%	0%
500,000	0%	0%	0%	0%	0%	0%
603,000	0%	0%	0%	0%	0%	0%
626,364	1%	0%	0%	0%	0%	0%
650,000	2%	0%	0%	0%	0%	0%
696,000	3%	0%	0%	0%	0%	0%

Research and data needs

There are many areas of research that could improve stock assessment efforts, however we focus here on those efforts that might appreciably reduce the uncertainty (both perceived and unknown) in short-term forecasts of Pacific hake for management decision-making. This list is in prioritized order:

1. Continue development of the management strategy evaluation (MSE) tools to evaluate major sources of uncertainty relating to data, model structure and the harvest policy for this fishery and compare potential methods to address them. Work with the JMC, SRG, and AP to develop scenarios to investigate, management performance metrics to evaluate the scenarios, and hypotheses related to the life-history, fishery, spatial dynamics, and management of Pacific hake.

2. Review the proposed design of the joint hake/sardine (SaKe) acoustic survey to determine whether an optimized survey design could satisfy the needs of management for both Pacific hake and sardines. Included in this review should be a list of necessities that must be met to provide a consistent, accurate, and useful survey for Pacific hake.

3. Continue to explore alternative indices for juvenile or young (0 and/or 1 year old) Pacific hake. Initially, the MSE should be used to investigate whether an age-0 or -1 index could reduce stock assessment and management uncertainty enough to improve overall management performance.

4. Analyze recently collected maturity samples and explore ways to include new data in the assessment.

5. Routinely collect and analyze life-history data, including maturity and fecundity for Pacific hake. Explore possible relationships among these life history traits as well as with body growth and population density. Currently available information is limited and outdated.

6. Conduct research to improve the acoustic survey estimates of age and abundance. This includes, but is not limited to, species identification, target verification, target strength and alternative technologies to assist in the survey, as well as improved and more efficient analysis methods.

7. Conduct an annual acoustic survey if the necessary research to continue advancing acoustic survey techniques is not compromised (e.g., see item 6 above).

8. Apply bootstrapping methods to the acoustic survey time-series in order to bring more of the relevant components into the variance calculations. These factors include the target strength relationship, subjective scoring of echograms, thresholding methods, the species-mix and demographic estimates used to interpret the acoustic backscatter, and others.

9. Continue to explore process-based assessment modeling methods that may be able to use the large quantity of length observations to reduce model uncertainty and better propagate life-history variability into future projections.

10. Evaluate the quantity and quality of historical biological data (prior to 1988 from the Canadian fishery, and prior to 1975 from the U.S. fishery) for use in developing age-composition data.

11. Conduct further exploration of ageing imprecision and the effects of large cohorts via simulation and blind source age-reading of samples with differing underlying age distributions – with and without dominant year classes.

12. Investigate meta-analytic methods for developing a prior on degree of recruitment variability (σ_r), and for refining existing priors for natural mortality (M) and steepness of the stock-recruitment relationship (h).

1 Introduction

Prior to 1997, separate Canadian and U.S. assessments for Pacific hake were submitted to each nation's assessment review process. This practice resulted in differing yield options being forwarded to each country's managers. Multiple interpretations of Pacific hake status made it difficult to coordinate an overall management policy. Since 1997, the Stock Assessment and Review (STAR) process for the Pacific Fishery Management Council (PFMC) has evaluated assessment models and the Pacific Council process, including NOAA Fisheries, has generated management advice that has been largely utilized by both nations.

The Joint US-Canada Agreement for Pacific hake (called the Agreement) was formally ratified in 2006 (signed in 2007) by the United States as part of the reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act. Although the Agreement has been considered to be in force by Canada since June 25, 2008, an error in the original U.S. text required that the Agreement be ratified again before it could be implemented. This second ratification occurred in 2010. Under the Agreement, Pacific hake stock assessments are to be prepared by the Joint Technical Committee (JTC) comprised of both U.S. and Canadian scientists and reviewed by the Scientific Review Group (SRG), with national representatives to both groups appointed by their respective governemnts. Additionally, the Agreement calls for both of these bodies to include industry- nominated scientists, who are selected and appointed jointly by both nations..

This stock assessment document represents the work of a joint U.S. and Canadian JTC and their associates. Extensive modeling efforts conducted from 2010 to 2012, as well as highly productive discussions among analysts have resulted in unified documents for the assessments from 2011 to the present (2013).

This assessment reports a single base-case model representing the collective work of the JTC. The assessment depends primarily upon the acoustic survey biomass index (1995, 1998, 2001, 2003, 2005, 2007, 2009, 2011 and 2012) for information on the scale of the current hake stock. The 2011 index was the lowest in the time-series but the 2012 index was much greater. The aggregate fishery age-composition data (1975–2012) and the age-composition data from the acoustic survey contribute to the models ability to resolve strong and weak cohorts. Both sources show a somewhat strong 2008 cohort and a strong 2010 cohort, but the 2011 and 2012 age compositions differ slightly regarding the relative magnitude of the weaker 2005 and 2006 cohorts.

The assessment is fully Bayesian, with the base-case model incorporating prior information on two key parameters (natural mortality, M, and steepness of the stock-recruit relationship, h) and integrating over estimation and parameter uncertainty to provide results that can be probabilistically interpreted. From a range of alternate models investigated by the JTC, a subset of sensitivity analyses are also reported in order to provide a broad qualitative comparison of structural uncertainty with the base case. These sensitivity models are thoroughly described in this assessment document.

The current document highlights progress made during 2012, residual areas of needed research, as well as ongoing scientific uncertainties in modeling choices, such that future technical working groups will enjoy a much easier working environment which fosters collaborative solutions to these difficult issues.

1.1 Stock structure and life history

Pacific hake (*Merluccius productus*), also referred to as Pacific whiting, is a semi-pelagic schooling species distributed along the west coast of North America generally ranging from 25° N. to 55° N. latitude. It is among 18 species of hake from four genera (being the majority of the family *Merluccidae)*, which are distributed worldwide in both hemispheres of the Atlantic and Pacific oceans which have generated recent catches of around 1.25 million mt, annually (Alheit and Pitcher 1995, Lloris et al. 2005). The coastal stock of Pacific hake is currently the most abundant groundfish population in the California Current system. Smaller populations of this species occur in the major inlets of the Northeast Pacific Ocean, including the Strait of Georgia, Puget Sound, and the Gulf of California. Genetic studies indicate that Strait of Georgia and the Puget Sound populations are genetically distinct from the coastal population (Iwamoto et al. 2004; King et al. 2012). Genetic differences have also been found between the coastal population and hake off the west coast of Baja California (Vrooman and Paloma 1977). The coastal stock is also distinguished from the inshore populations by larger body size and seasonal migratory behavior.

The coastal stock of Pacific hake typically ranges from the waters off southern California to southern Alaska, with the northern boundary related to fluctuations in annual migration. However, a recent genetic and parasite-load study found evidence of some summer mixing with inshore stocks in Queen Charlotte Sound (King et al. 2012). Distributions of eggs, larvae, and infrequent observations of spawning aggregations indicate that Pacific hake spawning occurs off south-central California during January–March. Due to the difficulty of locating major offshore spawning concentrations, details of hake spawning behavior remains poorly understood (Saunders and McFarlane 1997). In spring, adult Pacific hake migrate onshore and northward to feed along the continental shelf and slope from northern California to Vancouver Island. In summer, Pacific hake often form extensive mid-water aggregations in association with the continental shelf break, with highest densities located over bottom depths of 200–300 m (Dorn 1991, 1992). Pacific hake feed on euphausiids, pandalid shrimp, and pelagic schooling fish (such as eulachon and Pacific herring) (Livingston and Bailey 1985). Larger Pacific hake become increasingly piscivorous, and Pacific herring are commonly a large component of hake diet off Vancouver Island. Although Pacific hake are cannibalistic, the geographic separation of juveniles and adults usually prevents cannibalism from being an important factor in their population dynamics (Buckley and Livingston 1997).

Older Pacific hake exhibit the greatest northern migration each season, with two- and three-year old fish rarely observed in Canadian waters north of southern Vancouver Island. During El Niño events (warm ocean conditions, such as 1998), a larger proportion of the stock migrates into Canadian waters, apparently due to intensified northward transport during the period of active migration (Dorn 1995, Agostini et al. 2006). El Niño conditions also result in range extensions to the north, as evidenced by reports of hake off of southeast Alaska during these warm water years. Throughout the warm period experienced in 1990s, there were changes in typical patterns of hake distribution. Spawning activity was recorded north of California. Frequent reports of unusual numbers of juveniles off of Oregon to British Columbia suggest that juvenile settlement patterns also shifted northwards in the late 1990s (Benson et al. 2002, Phillips et al. 2007). Because of this shift, juveniles may have been subjected to increased cannibalistic predation and fishing mortality. However, the degree to which this was significant, and the proportion of the spawning and juvenile settlement that was further north than usual is unknown. Subsequently, La Nina conditions (colder water) in 2001 resulted in a southward shift in the stock's distribution, with a much smaller proportion of the population found in Canadian waters in the 2001 survey. Hake were distributed across the entire range of the survey in 2003, 2005, 2007 (Figures 1 and 2) after displaying a very southerly distribution in 2001. Although a few adult hake (primarily from the 1999 cohort) were observed north of the Queen Charlotte Islands in 2009 most of the stock appears to have been distributed off Oregon and Washington. The 2011 acoustic survey observed what appears to have been the most southerly distribution of Pacific hake since 2001. Some adult hake were observed in the

Quatsino area (northwest Vancouver Island), but most of the stock was found off the coasts of Washington, Oregon, and California (Figure 2).

1.2 Ecosystem Considerations

Pacific hake are an important contributor to ecosystem dynamics in the Eastern Pacific due to their relatively large total biomass and potentially large role as both prey and predator in the Eastern Pacific Ocean. The role of hake predation in the population dynamics of other groundfish species is likely to be important (Harvey et al. 2008), although difficult to quantify. Hake migrate farther north during the summer during relatively warm water years and their local ecosystem role therefore differs year-to-year depending on environmental conditions. Recent research indicates that hake distributions may be growing more responsive to temperature, and that spawning and juvenile hake may be occurring farther North (Phillips et al. 2007; Ressler et al. 2007). Given long-term climate-change projections and changing distributional patterns, considerable uncertainty exists in any forward projections of stationary stock productivity and dynamics.

Hake are also important prey items for many piscivorous species including lingcod (*Ophiodon elongatus*) and Humboldt squid (also known as jumbo flying squid, *Dosidicus gigas*). In recent years, the coastal U.S. lingcod stock has rebuilt rapidly from an overfished level and jumbo flying squid have intermittently extended their range northward from more tropical waters to the west coast of North America. Recent Humboldt squid observations in the hake fishery, recreational fisheries, and scientific surveys in the U.S. and Canada reflect a very large increase in squid abundance as far north as southeast Alaska (e.g., Gilly et al., 2006; Field et al., 2007) during the same portions of the year that hake are present, although the number and range vary greatly between years. While the relative biomass of these squid and the cause of such range extensions are not completely known, squid predation on Pacific hake is likely to have increased substantially in some years. There is evidence from the Chilean hake (a similar gadid species) fishery that squid may have a large and adverse impact on abundance, due to direct predation on individuals of all sizes (Alarcón-Muñoz et al., 2008). Squid predation as well as secondary effects on schooling behavior and distribution of Pacific hake may become important for future assessments. However, it is unlikely that the current data sources will be able to detect squid-related changes in hake population dynamics (such as an increase in natural mortality) until well after they have occurred, if at all. There is considerable ongoing research to document relative abundance, diet composition and habitat utilization of Humboldt squid in the California current ecosystem (e.g., J. Field, SWFSC, and J. Stewart, Hopkins Marine Station, personal communication, 2010; Gilly et al., 2006; Field et al., 2007) which should be considered in future assessments. However, there were few Humboldt squid present in the California Current during 2010, 2011, and 2012, despite the great abundance in 2009. Given the volatility of squid populations, future presence and abundance trends are impossible to predict.

1.3 Fisheries

The fishery for the coastal population of Pacific hake occurs along the coasts of northern California, Oregon, Washington, and British Columbia primarily during June–November in recent years. The fishery is conducted almost exclusively with mid-water trawls. Most fishing activity occurs over bottom depths of 100-500 m, while offshore extensions of fishing activity have occurred in recent years to reduce bycatch of depleted rockfish and salmon. The history of the coastal hake fishery is characterized by rapid changes brought about by the development of substantial foreign fisheries in 1966, joint-venture fisheries by the early 1980s, and domestic fisheries in 1990s (Table 1, Figure 3).

Large-scale harvesting of Pacific hake in the U.S. zone began in 1966, when factory trawlers from the Soviet Union began targeting Pacific hake. During the mid-1970s, factory trawlers from Poland, Federal Republic of Germany, the German Democratic Republic and Bulgaria also participated in the fishery. During 1966-1979, the catch in U.S. waters is estimated to have averaged 137,000 t per year (Table 1, Figure 3). A joint-venture fishery was initiated in 1978 between two U.S. trawlers and Soviet factory trawlers acting as mother-ships (the practice where the catch from several boats is brought back to the larger, slower ship for processing and storage until the return to land). By 1982, the joint-venture catch surpassed the foreign catch, and by 1989, the U.S. fleet capacity had grown to a level sufficient to harvest the entire quota, and no further foreign fishing was allowed, although joint-venture fisheries continued for another two years. In the late 1980's, joint ventures involved fishing companies from Poland, Japan, the former Soviet Union, the Republic of Korea and the People's Republic of China.

Historically, the foreign and joint-venture fisheries produced fillets as well as headed and gutted products. In 1989, Japanese mother-ships began producing surimi from Pacific hake using a newly developed process to inhibit myxozoan-induced proteolysis. In 1990, domestic catcher-processors and mother ships entered the Pacific hake fishery in the U.S. zone. These vessels had previously engaged in Alaskan walleye pollock (*Theragra chalcogramma*) fisheries, and have continued to do so ever since. The development of surimi production techniques for pollock was expanded to include Pacific hake as a viable alternative. Similarly, shore-based processors of Pacific hake had been constrained by a limited domestic market for Pacific hake fillets and headed and gutted products. The construction of surimi plants in Newport and Astoria, Oregon, led to a rapid expansion of shore-based landings in the U.S. fishery in the early 1990's, when the Pacific Council set aside an allocation for that sector. In 1991, the joint-venture fishery for Pacific hake in the U.S. zone ended because of the increased level of participation by domestic catcher-processors and mother ships, and the growth of shore-based processing capacity. In contrast, Canada, at its discretion, allocates a portion of the Pacific hake catch to joint-venture operations once shore-side capacity is filled.

The sectors involved in the Pacific hake fishery in Canada exhibit a similar historical pattern, although phasing out of the foreign and joint-venture fisheries has proceeded more slowly relative to the U.S. (Table 1). Since 1968, more Pacific hake have been landed than any other species in the groundfish fishery on Canada's west coast. Prior to 1977, the fishing vessels from the former Soviet Union caught the majority of Pacific hake in the Canadian zone, with Poland and Japan accounting for much smaller landings. After declaration of the 200-mile extended fishing zone in 1977, the Canadian fishery was divided among shore-based, joint-venture, and foreign fisheries. In 1992, the foreign fishery ended, but the demand of Canadian shore-based processors remained below the available yield, thus the joint-venture fishery continues today, although no joint-venture fishery took place in 2002, 2003, 2009 or 2012. The majority of the shore-based landings of the coastal hake stock is processed into fillets for human consumption, surimi, or mince by processing plants at Ucluelet, Port Alberni, and Delta, British Columbia. Although significant aggregations of hake are found as far north as Queen Charlotte Sound, in most years the fishery has been concentrated below 49° N. latitude off the south coast of Vancouver Island, where there have been sufficient quantities of fish in proximity to processing plants.

1.4 Management of Pacific hake

Since implementation of the Magnuson-Stevens Fishery Conservation and Management Act in the U.S. and the declaration of a 200 mile fishery conservation zone in both countries in the late 1970s, annual quotas (or catch targets) have been used to limit the catch of Pacific hake in both zones by foreign and domestic fisheries. Scientists from both countries historically collaborated through the Technical Subcommittee of the Canada-U.S. Groundfish Committee (TSC), and there were informal agreements on the adoption of annual fishing policies. During the 1990s, however, disagreements between the U.S. and

Canada on the allotment of the catch limits between U.S. and Canadian fisheries led to quota overruns; 1991-1992 quotas summed to 128% of the limit, while the 1993-1999 combined quotas were 107% of the limit on average. The Agreement between the United States and Canada, establishes U.S. and Canadian shares of the coast-wide allowable biological catch at 73.88% and 26.12%, respectively, and this distribution has been adhered to since ratification of the Agreement.

Throughout the last decade, the total coast-wide catch has tracked the harvest targets reasonably closely (Table 2). Since 1999, catch targets have been determined using an $F_{SPR=40\%}$ default harvest rate with a 40:10 control rule that decreases the catch linearly from a depletion of 40% to a depletion of 10% (called the default harvest policy in the Agreement). Further considerations have often resulted in catch targets to be set lower than the recommended catch limit. In 2002, after Pacific hake was declared overfished by the U.S., the catch of 181 thousand mt exceeded the target; however it was still below the limit of 208 thousand mt. In 2004, after Pacific hake was declared rebuilt, and when the large 1999 cohort was near-peak biomass, the catch fell well short of the catch target of 501 thousand mt, which is larger than the largest catch ever realized. Constraints imposed by bycatch of canary and widow rockfishes limited the commercial U.S. catch target to 259 thousand mt. Neither the U.S. portion nor the total catch has substantially exceeded the harvest guidelines in any recent year, indicating that management procedures have been effective.

1.4.1 United States

In the U.S. zone, participants in the directed fishery are required to use pelagic trawls with a codend mesh that is at least 7.5 cm (3 inches). Regulations also restrict the area and season of fishing to reduce the bycatch of Chinook salmon and several depleted rockfish stocks. More recently, yields in the U.S. zone have been restricted to levels below optimum yields due to bycatch of overfished rockfish species, primarily widow and canary rockfishes, in the Pacific hake fishery. At-sea processing and night fishing (midnight to one hour after official sunrise) are prohibited south of 42° N. latitude. Fishing is prohibited in the Klamath and Columbia River Conservation zones, and a trip limit of 10,000 pounds is established for Pacific hake caught inside the 100-fathom contour in the Eureka INPFC area. During 1992-1995, the U.S. fishery opened on April 15; however in 1996 the opening date was changed to May 15. Shore-based fishing is allowed after April 1 south of 42° N. latitude, but is limited to 5% of the shore-based allocation being taken prior to the opening of the main shore-based fishery. The main shore-based fishery opens on June 15. Prior to 1997, at-sea processing was prohibited by regulation when 60 percent of the harvest guideline was reached. The current allocation agreement, effective since 1997, divides the U.S. non-tribal harvest guideline among factory trawlers (34%), vessels delivering to at-sea processors (24%), and vessels delivering to shore-based processing plants (42%). Since 1996, the Makah Indian Tribe has conducted a separate fishery with a specified allocation in its "usual and accustomed fishing area”, and beginning in 2009 there has also been a Quileute tribal allocation. Since 2011, the non-tribal U.S. fishery has been fully rationalized with allocations in the form of IFQs to the shore-based sector and to cooperatives in the at-sea mothership and catcher-processor sectors.

1.4.2 Industry actions

Shortly after the 1997 allocation agreement was approved by the PFMC, fishing companies owning factory trawlers with U.S. west coast groundfish permits established the Pacific Whiting Conservation Cooperative (PWCC). The primary role of the PWCC is to distribute the factory trawler allocation among its members in order to achieve greater efficiency by the member fishing companies in their resource allocation, processing efficiency and product quality, as well aspromoting reductions in waste and bycatch rates relative to the former “derby” fishery in which all vessels competed for a fleet-wide quota. The PWCC also initiated recruitment research to support hake stock assessment. As part of this effort, PWCC sponsored a juvenile recruit survey for a number of years. In 2009, the PWCC contracted a review of the 2009 stock assessment which was discussed in the 2010 stock assessment and was one of the contributing factors to the extensive re-analysis of historical data and modeling methods subsequent to that assessment.

1.5 Overview of recent fisheries

1.5.1 United States

In 2005 and 2006, the coast-wide ABCs were 531,124 and 661,680 mt respectively. The OYs for these years were set at 364,197 and 364,842 and were nearly fully utilized with the abundant 1999 year-class comprising a large proportion of the catch. For the 2007 fishing season the PFMC adopted a 612,068 mt ABC and a coast-wide OY of 328,358 mt. This coast-wide OY continued to be set considerably below the ABC in order to avoid exceeding bycatch limits for overfished rockfish. In 2008, the PFMC adopted an ABC of 400,000 mt and a coast-wide OY of 364,842 mt, based upon the 2008 stock assessment. This ABC was set below the overfishing level indicated by the stock assessment, and therefore the difference between the ABC and OY was substantially less than in prior years. However, the same bycatch constraints caused a mid-season closure in the U.S. in both 2007 and 2008 and resulted in final landings being below the OY in both years. Based on the 2009 assessment, the Pacific Council adopted a U.S.-Canada coast-wide ABC of 253,582 mt, and a U.S. ABC of 187,346 mt. The Pacific Council adopted a U.S.-Canada coast-wide OY of 184,000 mt and a U.S. OY of 135,939 mt, reflecting the agreed-upon 73.88% of the OY apportioned to U.S. fisheries and 26.12% to Canadian fisheries. Bycatch limits were assigned to each sector of the fishery for the first time in 2009, preventing the loss of opportunity for all sectors if one sector exceeded the total bycatch limit. This greatly reduced the ‘race for fish’ as bycatch accumulated during the season. In total, the 2009 U.S. fishery caught 121,110 mt, or 89.1% of the U.S. OY, without exceeding bycatch limits. In 2010 the Pacific Council adopted a U.S.-Canada coast-wide ABC of 455,550 mt, a U.S.-Canada coast-wide OY of 262,500 mt and a U.S. OY of 190,935 mt, reflecting the agreed-upon apportionment. As in 2009, tribal fisheries did not harvest the full allocation granted to them (49,939 mt in 2010), and two reapportionments were made to other sectors during the fishing season. In total, the 2010 U.S. fishery caught 170,109 mt, or 89.1% of the U.S. OY. Bycatch rates were generally not a problem, although known areas of high historical bycatch were still (anecdotally) being avoided. In certain areas of the coasts, many fishermen found it difficult to avoid the large schools of age-2 hake (200-300 grams) present off the U.S. coast. The shore-side fishery opted for a voluntary stand-down between June 30 to July 20 due to the presence of these small fish and to avoid bycatch of canary rockfish.

The Pacific Council adopted a U.S.-Canada coast-wide overfishing level (OFL) of 973,700 mt in 2011, with an annual catch limit (ACL) of 393,751 mt. The U.S. annual catch limit was 290,903 mt, after apportioning the coast-wide ACL by the agreed upon U.S.-Canada apportionment. The 2011 U.S. fisheries caught 78.7% of their catch limit (229,067 mt) and were below the 2011 catch limit mainly due to smaller tribal catches. This year was the first time that motherships participated under the co-op system, thus were able to pool bycatch limits. Remaining mothership bycatch allocations were transferred to the catcher/processor sector in mid-December. This was also the first year that the shore-based fleet operated under the new catch shares program with individual fishing quotas (IFQ). All U.S. sectors encountered smaller fish in the 35–40 cm range, dominated by the 2008 year class. In previous years, the fishery may have avoided these small fish, but markets for smaller fish were developing in 2011. The at-sea fleet encountered larger fish in May, which were encountered less often in June and rarely after then. The at-sea fleet additionally encountered even smaller fish in October through December, ranging in size from 24–34 cm, corresponding to the 2009 and 2010 year classes.

The Joint Management Committee (JMC) decided on a coastwide catch target of 251,809 mt for 2012, with a U.S. allocation of 186,037 mt. After the tribal allocation of 17.5% plus 16,000 mt, and a 2,000 mt allocation for research catch and bycatch in non-groundfish fisheries, the 2012 non-tribal U.S. catch limit of 135,481 mt was allocated to the catcher/processor (34%), mothership (24%), and shore-based (42%) commercial sectors. Therefore, the at-sea fleet (catcher/processors and motherships) was allocated 78,579 mt and the shore-based fleet was allocated 56,902 mt. The at-sea fleet encountered larger fish in May and mainly smaller fish from the 2010 year class late in the year. The shore-based fleet mainly caught a combination of the 2008 and 2010 year classes. Area closures and bycatch limits limited kept the at-sea fleet from fishing the locations where the shore-based fleet was encountering larger fish from the 2008 year class. Tribal fisheries had very few landings (less than 1,000 mt) because Pacific hake were not present in large numbers in tribal areas. Therefore, 28,000 mt were reapportioned from the tribal fisheries to the non-tribal fisheries on October 4, 2012. Both the at-sea and shore-based fleets nearly caught their respective total catch targets, leaving 28,773 mt, 84.5%, of the catch target uncaught.

1.5.2 Canada

The Canadian fishery has operated under an Individual Vessel Quota (IVQ) management system since 1997. Groundfish trawl vessels are allocated a set percentage of the Canadian TAC that is fully transferable among vessels within the trawl sector. Additionally, the IVQ management regime allows an opportunity for vessel owners to exceed license holding by up to 15% and have these overages deducted from their quota for the subsequent year. Conversely, if less than the quota is taken, up to 15% can be carried over into the next year. The maximum 15% overage allowance for the 2012 fishery, 15,427 mt, was allotted due to the 2011 fishery failing to capture its allocation. The assessment-based allocation for 2012 was 50,345 mt; with the additional overage carried forward from 2011 this became 65,772 mt. The fishery caught 46,776 mt, 92.9% of the 2012 allocation or 71.1% of the total allocation including the overages from 2011. Since the catch was only 71.1% of the total, the fishery will again be allowed the maximum 15% overage for the 2013 season. The 2012 catch was taken solely by the shore-based fishery; the JV fishery was not opened. The 2012 fishery followed the same spatial pattern as in the last several years with older, larger fish caught in Queen Charlotte Sound later in the year and a large portion of the total caught in the vicinity of La Perouse Sound throughout the summer and fall months. Quatsino Sound and Brooks Peninsula have also become popular hotspots for the fishery in the last two years.

For an overview of all catch and allocations by year, country, and fleet, see Table 1 and Table 2. For 2002, 2003, 2009, and 2012 there was no JV fishery opened and this is reflected as zero catch for those years in Table 1.

2 Data

Nearly all of the data sources available for Pacific hake were re-evaluated during 2010. That process included obtaining the original raw data, reprocessing the entire time-series with standardized methods, and summarizing the results for use in the 2011 and 2012 stock assessments. These sources have been updated with all newly available information in 2013. Primary fishery-dependent and -independent data sources used here (Figure 4) include:

- Total catch from all U.S. and Canadian fisheries (1966-2012).
- Age compositions composed of data from the U.S. fishery (1975-2012) and the Canadian fishery (1990-2012).
- Biomass indices and age compositions from the Joint U.S. and Canadian integrated acoustic and trawl survey (1995, 1998, 2001, 2003, 2005, 2007, 2009, 2011 and 2012).

The assessment model also used biological relationships derived from external analysis of auxiliary data. These include:

- Mean observed weight-at-age from fishery and survey catches, 1975-2012.
- Aging-error matrices based on cross-read and double-blind-read otoliths.
- Proportion of individual female hake mature by size and/or age from a sample collected in 1995.

Some sources were not included but have been explored, used for sensitivity analyses, or discarded in recent stock assessments (these data are discussed in more detail below):

- Fishery and acoustic survey length composition information.
- Fishery and acoustic survey age-at-length composition information.
- Biomass indices and age compositions from the Joint U.S. and Canadian integrated acoustic and trawl survey (1977, 1980, 1983, 1986, 1989, 1992).
- NWFSC/SWFSC/PWCC coast-wide juvenile hake and rockfish survey (2001-2009).
- Bycatch of Pacific hake in the trawl fishery for pink shrimp off the coast of Oregon, 2004-2005, 2007-2008.
- Historical biological samples collected in Canada prior to 1990, but currently not available in electronic form.
- Historical biological samples collected in the U.S. prior to 1975, but currently not available in electronic form or too incomplete to allow analysis with methods consistent with more current sampling programs.
- CalCOFI larval hake production index, 1951-2006. The data source was previously explored and rejected as a potential index of hake spawning stock biomass, and has not been revisited since the 2008 stock assessment.
- Joint-U.S. and Canada acoustic survey index of age-1 Pacific hake.
- Histological analysis of ovary samples collected during the 2010 & 2012 NWFSC bottom trawl surveys, and the 2012 acoustic survey.

2.1 Fishery-dependent data

2.1.1 Total catch

The catch of Pacific hake for 1966-2012 by nation and fishery sector is shown in Table 1. Catches in U.S. waters prior to 1978 are available only by year from Bailey et al. (1982) and historical assessment documents. Canadian catches prior to 1989 are also unavailable in disaggregated form. For more recent catches, haul or trip-level information was available to partition the removals by month, during the hake fishing season, and estimate bycatch rates from observer information at this temporal resolution. This has allowed a more detailed investigation of shifts in fishery timing (See Figure 5 in Stewart et al. 2011). Although the application of monthly bycatch rates differed from previous, simpler analyses, it resulted in less than a 0.3% change in aggregate catch over the time-series. The U.S. shore-based landings are from the Pacific Fishery Information Network (PacFIN), foreign and joint-venture catches for 1981–1990 and domestic at-sea catches for 1991–2012 are estimated from the AFSC’s and, subsequently, the NWFSC's at-sea hake observer programs stored in the NORPAC database. Canadian joint-venture catches from 1989 are from the Groundfish Biological (GFBio) database, the shore-based landings from 1989 to 1995 are from the Groundfish Catch (GFCatch) database, from 1996 to March 2007 from the Pacific Harvest

Trawl (PacHarvTrawl) database, and from April 2007 to present from the Fisheries Operations System (FOS) database. Discards are nominal relative to the total fishery catch. The majority of vessels in the U.S. shore-based fishery have operated under experimental fishing permits that required them to retain all catch and bycatch for sampling by plant observers. All U.S. at-sea vessels and Canadian joint-venture catches are monitored by at-sea observers. Observers use volume/density methods to estimate total catch. Domestic Canadian landings are recorded by dockside monitors using total catch weights provided by processing plants.

One of the concerns identified in recent assessments has been the presence of shifts in the within-year distribution of catches during the time series. Subsequent to the ascension of the domestic fleet in the U.S. and both the domestic and Joint-Venture fleets in Canada, the fishery shifted most of the catch to the early spring during the 1990s (Table 1). This fishery gradually spread out over the summer and fall, and in recent years has seen some of the largest catches in the fall through early winter (Figure 5). This pattern has allowed the fishery to reduce the impact of some bycatch constraints and is likely to continue in U.S. waters under the individual trawl quota system adopted in 2011, as long as bycatch quotas remain stable.

2.1.2 Fishery biological data

Biological information from the U.S. at-sea commercial Pacific hake fishery was extracted from the NORPAC database. This included length, weight and age information from the foreign and joint-venture fisheries from 1975-1990, and from the domestic at-sea fishery from 1991–2012. Specifically these data include sex-specific length and age data which observers collect by selecting fish randomly from each haul for biological data collection and otolith extraction. Biological samples from the U.S. shore-based fishery, 1991–2012, were collected by port samplers located where there are substantial landings of Pacific hake: primarily Eureka, Newport, Astoria, and Westport. Port samplers routinely take one sample per offload (or trip) consisting of 100 randomly selected fish for individual length and weight and from these, 20 fish are randomly selected for otolith extraction. The Canadian domestic fishery is subject to 100% observer coverage on the two processing vessels *Viking Enterprise* and *Osprey*, which together make up 25% of the coast-wide catch. The joint-venture fishery has 100% observer coverage on their processing vessels, which in 2011 made up 16% of the Canadian catch, but was non-existent in 2012. On observed trips, otoliths (for ageing) and lengths are sampled from Pacific hake caught in the first haul of the trip, with length samples taken on subsequent hauls. Sampled weight from which biological information is collected must be inferred from year-specific length-weight relationships. For unobserved trips, port samplers obtain biological data from the landed catch. Observed domestic haul-level information is then aggregated to the trip level to be consistent with the unobserved trips that are sampled in ports. For the Canadian joint-venture fishery, an observer aboard the factory ship estimates the codend weight by measuring the diameter of the codend and doing a spherical volume calculation for each delivery from a companion catcher boat. Length samples are collected every second day of fishing operations, and otoliths are collected once a week. Length and age samples are taken randomly from a given codend. Since the weight of the sample from which biological information is taken is not recorded, sample weight must be inferred from a weight-length relationship applied to all lengths taken and summed over haul.

The sampling unit for the shore-based fisheries is the trip, while the haul is the primary unit for the at-sea fisheries. Since detailed haul-level information is not recorded on trip landings documentation in the shore-based fishery, and hauls sampled in the at-sea fishery cannot be aggregated to a comparable trip level, there is no least common denominator for aggregating at-sea and shore-based fishery samples. As a result, samples sizes are simply the summed hauls and trips for fishery biological data. The magnitude of this sampling among sectors and over time is presented in Table 3.

Biological data were analyzed based on the sampling protocols used to collect them, and expanded to estimate the corresponding statistic from the entire landed catch by fishery and year when sampling occurred. In general, the analytical steps can be summarized as follows:

1. Count the number of fish (or lengths) at each age (or length bin) within each trip (or haul), generating "raw" frequency data.
2. Expand the raw frequencies from the trip (or haul) based on the fraction of the total haul sampled.
3. Weight the summed frequencies by fishery sector landings and aggregate.
4. Calculate sample sizes (number of trips or hauls) and normalize to proportions that sum to unity within each year.

To complete step (2), the expansion factor was calculated for each trip or haul based on the ratio of the total estimated catch weight divided by the total weight from which biological samples were taken. In cases where there was not an estimated sample weight, a predicted sample weight was computed by multiplying the count of fish in the sample by a mean individual weight, or by applying a year-specific length-weight relationship to the length of each fish in the sample, then summing these predicted weights. Anomalies can emerge when very small numbers of fish are sampled from very large landings; these were avoided by constraining expansion factors to not exceed the 95th percentile of all expansion factors calculated for each year and fishery. The total number of trips or hauls sampled is used as either the initial multinomial sample size input to the SS stock assessment model (prior to iterative reweighting) or as a relative weighting factor among years. Motivated by a recent downward trend in fishery sampling for ages in the Canadian sector, the method of weighting the fleet-specific proportions (Step 3) was revised in 2012 to be based on the estimated numbers in the total sector catch using mean weight-at-age across many years, rather than the number of samples collected from that catch. This allows for adequate representation of even sparsely sampled sectors. In 2013, this was further revised to use year specific mean weight-at-age to determine the estimated numbers in the total sector catch, resulting in consistent historical age compositions that do not need to be updated in future years unless new data for that year are added.

The aggregate fishery age-composition data (1975–2012) confirm the well-known pattern of very large cohorts born in 1980, 1984 and 1999, with a small proportion from the 1999 year class (13 years old in 2012) still present in the fishery (Figure 6). The more recent age-composition data consisted of high proportions of 2008 and 2010 year classes in the 2012 fishery (Figure 6). The previously strong 2005 and 2006 year classes declined in proportion in the 2011 fishery samples, but remained persistent in the 2012 fishery. We caution that proportion-at-age data contains information about the relative numbers-at-age, and these can be affected by changing recruitment, selectivity or fishing mortality. The absolute size of incoming cohorts cannot be precisely determined until they have been observed several times.

Both the weight- and length-at-age information suggest that hake growth has changed markedly over time. This is particularly evident in the frequency of larger fish (> 55 cm) before 1990 and a shift to much smaller fish in more recent years. The treatment of length-at-age and weight-at-length are described in more detail in section 2.3.3 and 2.3.4 below. Although length composition data are not fit explicitly in the base case assessment models presented here, the presence of the 2008 and 2010 year classes are clearly observed in both of the U.S. fishery sectors.

2.1.3 Catch per unit effort

Catch-per-unit-effort (CPUE) is a common source of information about relative population trend in stock assessments world-wide, although numerous studies question its utility. Calculation of a reliable CPUE metric is particularly problematic for Pacific hake and it has never been used as a tuning index for assessment of this stock. This is mainly because the basic concept of "effort" is difficult to define for the hake fishery, as the use of acoustics, communication among vessels, extensive time spent searching and transit time between fishing ports and known areas of recurrent hake aggregations means that, by the time a trawl net is put in the water, catch rates can be predicted by the fishing vessel reasonably well. Factory trawlers may continue to fish the same aggregation for days, while shore-based sectors may be balancing running time with hold capacity and therefore opt for differing catch rates. Further, during the last decade, the hake fishery has been severely constrained in some areas due to avoidance of rockfish bycatch. Periodic voluntary 'stand-downs', and temporary in-season closures have resulted from high bycatch rates, and in some years fishermen have changed their fishing behavior and fishing areas, in order to reduce bycatch of overfished rockfish species. Furthermore, the US at-sea fleet generally leaves the hake fishing grounds for a period during the season to participate in the Bering Sea pollock fishery. It is unlikely that such fleet dynamics and inter-species effects can be dealt with adequately in order to produce a reliable index for Pacific hake based on fishery CPUE data.

2.2 Fishery-independent data

2.2.1 Acoustic survey

The joint U.S. and Canadian integrated acoustic and trawl survey has been the primary fishery-independent tool used to assess the distribution, abundance and biology of coastal Pacific hake, along the West coasts of the United States and Canada. Coast-wide surveys were carried out jointly by the Alaska Fisheries Science Center (AFSC) and the Pacific Biological Station (PBS) of the Canadian Department of Fisheries and Oceans (DFO) in 1995, 1998, and 2001. Following 2001, the responsibility for the U.S. portion of the survey was transferred to the Fishery Resource Analysis and Monitoring (FRAM) Division of NOAA's Northwest Fisheries Science Center (NWFSC). The survey was scheduled on a biennial basis, with joint acoustic surveys conducted by NWFSC and PBS from 2003 to 2011. In 2012 a supplemental survey was added due to concerns about the depletion level of the stock and to investigate the size of the incoming 2008 year class. Between 1977 and 1992, acoustic surveys of Pacific hake were conducted every three years by the AFSC. However, these early surveys (1977–1992) covered only a reduced depth range and focused on U.S. waters. Therefore, they are not used in the current assessment because of concerns over bias due to arbitrary expansion factors used to extrapolate findings to the entire depth and latitudinal range of the survey. More details are given in Stewart et al (2011). Only acoustic surveys performed in 1995, 1998, 2001, 2003, 2005, 2007, 2009, 2011, and 2012 were used in this assessment (Table 4). The acoustic survey includes all waters off the coasts of the U.S. and Canada thought to contain all portions of the hake stock older than age-1. Age-0 and age-1 hake have been historically excluded from the survey efforts, due to largely different schooling behavior relative to older hake and concerns over markedly different catchability by the trawl gear.

The distribution of Pacific hake can vary greatly between years. It appears that northward migration patterns are related to the strength of subsurface flow of the California Current (Agostini et al. 2006) and upwelling conditions (Benson et al. 2002). Distributions of hake backscatter plotted for each acoustic survey since 1995 illustrate the variable spatial patterns of age-2+ hake among years (Figure 1). The 1998 acoustic survey is notable because it shows an extremely northward occurrence that is thought to be related to the strong 1997-1998 El Nino. In contrast, the distribution of hake during the 2001 survey was compressed into the lower latitudes off the coast of Oregon and Northern California. In 2003, 2005 and 2007 the distribution of Pacific hake did not show an unusual coast-wide pattern, but in 2009, 2011, and 2012 the majority of the hake distribution was again found in U.S. waters. Pacific hake also tend to migrate farther north as they age.

Figure 2 shows the mean location of Pacific hake observed in the acoustic survey by age and year. Age-2 hake are located in the southern portion of the summer range, while older age classes are found in more northerly locations within the same year. The mean locations of Pacific hake age-6 and older tend to be more similar among years than those for the younger ages. With the aging of the strong 1999 year class causing a reduction in the number of older fish, and the presence of recent strong cohorts, a more southerly distribution of the hake stock has been observed in recent surveys.

Acoustic survey data from 1995 onward have been analyzed using geostatistical techniques (kriging), which accounts for spatial correlation to provide an estimate of total biomass as well as an estimate of the year-specific sampling variability due to patchiness of hake schools and irregular transects (Petitgas 1993; Rivoirard et al. 2000; Mello & Rose 2005; Simmonds and MacLenann, 2005). Advantages to the kriging approach are: 1) it simultaneously provides the estimates of the hake biomass and associated sample variability while properly accounting for spatial correlation along and between transects; 2) it provides biomass estimates in the area beyond transect lines but within the correlation distance; 3) it provides maps of hake biomass and estimation variance that take into account the heterogeneous and patchy hake distribution; and 4) it allows for greater flexibility (and potentially efficiency) in survey transect design, in that transects do not need to be parallel to each other. A comparison of the kriged estimates to previous conventional design-based estimates was presented in Stewart et al. (2011), and showed a reasonable degree of consistency between the two methods. During the acoustic surveys, mid-water trawls are made opportunistically to determine the species composition of observed acoustic sign and to obtain the length data necessary to scale the acoustic backscatter into biomass (see Table 4 for the number of trawls in each survey year).

Biological samples collected from these trawls are post-stratified, based on similarity in size composition. Results from research done in 2010 on representativeness of the biological data (i.e. repeated trawls on the same aggregation of hake) and sensitivity analyses of stratified data showed that trawl sampling and post-stratification is only a small source of variability among all of the sources of variability inherent to the acoustic analysis (see Stewart et al 2011). The composite length frequency developed from the biological sampling was used to characterize the hake size distribution along each transect and to predict the expected backscattering cross section for Pacific hake based on the fish size-target strength (TS) relationship $TS_{db} = 20\log L - 68$ at 38 kHz (Traynor 1996). Recent target strength work (Henderson and Horne 2007), based on in-situ and ex-situ measurements, estimated a regression intercept of 4–6 dB lower than that of Traynor (1996), suggesting that an individual hake reflects less acoustic energy, resulting in a larger estimated biomass than when using Traynor's (1996) equation. This difference would be accounted for directly in estimates of acoustic catchability within the assessment model, but variability in the estimated biomass due to uncertainty in target strength is not explicitly accounted for.

The 2012 acoustic survey was a supplemental survey that was implemented based on recommendations from the JTC, SRG, and JMC after observing results from the 2012 assessment. To acquire enough ship time for a coastwide survey similar to past surveys, the SWFSC and NWFSC developed a joint design to survey Pacific hake and Pacific sardine (*Sardinops sagax*). The NOAA Ship *Bell M. Shimada* was to survey from central California to the north end of Vancouver Island and the Canadian Coast Guard Ship *W.E. Ricker* surveyed the northern areas in Canada (Figure 7). Additionally, it was necessary to use a catcher vessel to sample backscatter for species identification and the collection of biological samples, for which industry volunteered the F/V *Forum Star*. The *Forum Star* is a 29 meter long, 7.8 meter wide commercial trawler, and there were many times when weather did not permit it to meet up with the 63.8 meter long, 15 meter wide *Bell Shimada* in a timely fashion to perform the required hauls on backscatter aggregations. In addition to weather, having the *Forum Star* stop to fish while the *Bell Shimada* continued sounding resulted in the ships sometimes being rather far apart, which at times also made it difficult to perform the required hauls The Forum Star has an ES60 echo sounder system (38 and 120 kHz) on board which allowed for comparable identification of aggregations with the Bell Shimada, which has an EK60 (18, 38, 70, 120, 200 kHz).

The *W.E. Ricker* was slated to take over the survey at the North end of Vancouver Island this year instead of central Vancouver Island. This was due to the SWFSC's requirement to survey the entire west coast sardine stock, which is believed to extend to Northern Vancouver Island. However, the *Forum Star* had some mechanical and safety issues which did not allow it to continue into Canadian waters, and the Chief Scientists on the *Bell Shimada* and the *W.E. Ricker* decided during the survey that the *W.E. Ricker* would start at the U.S./Canadian border. Therefore, transects in Canada were redesigned to allow coverage of the additional area off Vancouver Island. If the *Bell Shimada* were to catch up to it, the plan was to have the *Bell Shimada* run the acoustic transects and the *W.E. Ricker* to convert to a fishing vessel only to be called upon by the *Bell Shimada* to trawl on aggregations seen by the echo sounders. The *Bell Shimada* did not catch up to the *W.E. Ricker* during its voyage up the West Coast of Vancouver Island, so the *W.E. Ricker* acoustic data and ground-truth (haul) data were used for this part of the survey. The extra transects that the *W.E. Ricker* had to run on the West Coast of Vancouver Island resulted in dropping of some transects in the north, mainly in Queen Charlotte Sound and Dixon Entrance.

The 2012 survey was successful at providing a useful biomass estimate of Pacific hake as well as age composition, but because of joint hake and sardine operations there were the following major differences from the past survey protocols.

- *Some planned transects were randomly selected for removal from the survey design in order to make up time lost to weather delays.* The hake biomass is estimated using spatial kriging which interpolates a biomass for these omitted areas using spatial correlation, and the variability is appropriately increased to account for this.

- *A change in ping rate and vessel speed resulted in false indication of the bottom and it was not always possible to confirm hake at the end of transects. Twelve transects were stopped while hake was still present.* The change in ping rate and vessel speed was to allow for the detection of small sardine schools in shallow water. While this worked for the hake program much of the time, there were quite often false bottoms generated on the echograms at the shelf drop-off. These false bottoms were due to the high ping rate which worked fairly well for shallow depths (<750m) but as the depth increased, the pings could not make it back to the ship before the next ping was sent, resulting in ping interference which manifested itself as a false bottom in the water column. These artifacts appeared as strong backscatter on the echogram and on several transects they overlaid actual hake aggregations. In past surveys the hake acoustic team changed the ping rate to avoid these artifacts but the sardine program was resistant to changing this as it would result in 'No Data' areas for their analysis. While at-sea it was believed that the transects were all stopped after the end of the hake school, upon further inspection post-survey, it was determined that hake were still present. The kriging estimates biomass beyond the end of the transect and appropriately inflates the variance, therefore the biomass estimate used in this assessment is the best possible estimate given the data available. To investigate the possible worst-case bias, data were sampled from nearby transects and arbitrarily inserted onto the end of these twelve transect, extending them from 1 to 12 nautical miles. This worst-case scenario resulted in a 5% increase in the biomass for the 1 mile extension, up to a 30% increase with a 12 mile extension. The length of schools of hake was commonly less than 6 nm, and this analysis suggests that the potential bias is likely to be small, especially when compared to other potential sources of uncertainty and bias.

- *The identification of hake was performed using a catcher vessel for the U.S. portion of the survey*. The JTC is grateful to the U.S. hake industry for supplying a catcher vessel to the survey and ensuring that a valid design could be completed. This was the first year that a separate catcher vessel has been used in this acoustic survey, and many challenges were faced and overcome. Ideally the *Bell Shimada* and *Forum Star* would be in close proximity to identify and ensure that the correct aggregation was fished upon, but the difference in size and speed did not always allow for this. At times, the Forum Star was many hours behind the Shimada and recorded a different backscatter signal than what the Forum Star did. The Forum Star also had significant pitch and roll which resulted in the dropping out of signal, which may have made the aggregations appear differently to the acousticians on board. In addition, the difference in number of echo sounder frequencies also made the identification of fish aggregation more difficult on Forum Star. In addition to issues such as communication and identifying the echo that was to be trawled on, there may be differences from previous surveys, such as vessel catchability. However, a large number of tows were performed relative to recent surveys and standardization of nets and methods reassures the JTC that mark identification was valid. The JTC does recommend that more research is done on mark identification and verification, though (see research recommendations).

- *Performing a joint survey results in the loss of some data collection.* Accomplishing two objectives in one survey means that some data collection will be lost and there may be sacrifices made to one or both objectives. The NWFSC and SWFSC are commended for their hard work in coming up with a design that satisfied the objective of both species, and the JTC is grateful for a valid Pacific hake survey biomass estimate in 2012. However, the JTC realizes that additional research and ecosystem data collection were sacrificed, both of which mmight have proven to be useful in the future. Additionally, the 2012 joint survey did not have the time to survey as far south for age-1 hake, as has been done in the past, and personnel and other resources were not available, due to necessary staffing of the supplemental survey, to convert and continue the age-1 index. Preliminary analyses, discussed below, of an age-1 index of hake developed from the surveys in past years showed that it may be useful to predict incoming year classes. This is a high priority research recommendation that would likely improve the assessment and management of Pacific hake.

Figure 7 shows the relative backscatter of age-2+ hake as observed in the 2012 survey. Many hake observed between Monterey Bay and Cape Mendocino, and off of the Oregon coast. There were few locations in Canada with assigned hake backscatter, mainly off of the northern portion of West Vancouver Island, Quatsino Sound, Brooks Peninsula, and Northeast Queen Charlotte sound. Although small numbers of hake were sampled in some trawls in areas far north of Vancouver Island, it was determined that, as in the 2011 survey, these hake were a very small part of the observed backscatter due to mixing with smaller species such as euphausiids or eulachon, and occasionally no backscatter was assigned to the regions on these transects (Figure 7). Comparing the distribution of backscatter in 2011 and 2012 to the distribution of backscatter in previous surveys (Figure 1) shows that the stock was distributed more southerly in 2011 and 2012. The distribution of hake in 2011 and 2012 was most similar to the distribution of hake in 2001, when the population was also dominated by young fish. The 2012 survey biomass estimate is 1,380,724 metric tons, which is approximately 2.65 times the 2011 acoustic survey biomass estimate of 521,476 metric tons (Figure 8). Only 8.69% of this biomass was observed in Canadian waters in 2012. No Humboldt squid were observed in 2012, although considerable numbers were caught in both the survey and fishery in 2009.

The variability of the 2012 biomass estimate, measured as a coefficient of variance (CV), is 4.75%, half of the 10.2% calculated for the 2011 survey (Figure 8 and Table 4). These estimates of uncertainty account for sampling variability (and the variability due to squid in 2009), but several additional sources of observation error are also possible. For example, haul-to-haul variation in size and age, target strength uncertainty of hake as well as the presence of other species in the backscatter and inter-annual differences in catchability likely comprise additional sources of uncertainty in the acoustic estimates. In the future, it is possible that a bootstrapping analysis that incorporates of many of these sources of variability can be conducted and the estimation of variance inflation constants in the assessment may become less important (O'Driscoll 2004). At present, though, there is strong reason to believe that all survey variance estimates are underestimated relative to the true variability.

As it was with the fishery data, age-composition data were used to describe the age structure of hake observed by this survey. Proportions-at-age for the eight acoustic surveys are summarized in Figure 6 and show large proportions of the 1999, 2008, and 2010 year classes. The 2012 survey attributed 63.7% of the estimated number of hake observed to the 2010 year-class. The acoustic survey data in this assessment do not include age-1 fish, although a separate age-1 index has been developed in the past.

2.2.2 Bottom trawl surveys

The Alaska Fisheries Science Center conducted a triennial bottom trawl survey along the west coast of North America from 1977 to 2001 (Wilkins et al. 1998). This survey was repeated for a final time by the Northwest Fisheries Science Center in 2004, but did not go into Canadian waters. In 1999, the Northwest Fisheries Science Center began to take responsibility for bottom trawl surveys off of the U.S. west coast, and, in 2003, the Northwest Fisheries Science Center survey was extended shoreward to a depth of 55 m to match the shallow limit of the triennial survey (Keller et al., 2008). Despite similar seasonal timing of the two surveys, the 2003 and subsequent annual surveys differ from the triennial survey in size/horsepower of the chartered fishing vessels and bottom trawl gear used. As such, the two were determined (at a workshop on the matter in 2006) to be separate surveys which cannot be combined into one. In addition, the presence of significant densities of hake, both offshore and to the North of the area covered by the trawl survey, coupled with the questionable effectiveness of bottom trawls in catching mid-water schooling hake, limits the usefulness of this survey to assess the hake population. For these reasons neither the triennial, nor the Northwest Fisheries Science Center shelf trawl survey, have been used in recent assessments. With the growing time-series length of the NWFSC survey (now 9 years), future assessments should re-evaluate the use of the survey as an index of the adult and/or juvenile (age 0-1) hake population.

2.2.3 Pre-recruit survey

From 1999-2009, the NWFSC and Pacific Whiting Conservation Cooperative (PWCC), in coordination with the SWFSC Rockfish survey have conducted an expanded survey (relative to historical efforts) targeting of juvenile hake and rockfish. The SWFSC/NWFSC/PWCC pre-recruit survey used a mid-water trawl with an 86' headrope and ½" codend with a 1/4" liner to obtain samples of juvenile hake and rockfish (identical to that used in the SWFSC Juvenile Rockfish Survey). Trawling was done at night with the head rope at 30 m at a speed of 2.7 kt. Some trawls were made before dusk to compare day/night differences in catch. Trawl tows of 15 minutes duration at target depth were conducted along transects at 30 nm intervals along the coast. Stations were located along each transect, at bottom depths of 50, 100, 200, 300, and 500 m. Since 2001, side-by-side comparisons were made between the vessels used for the survey.

Trends in the coast-wide index have shown very poor correlations with estimated year-class strengths in recent assessment models for year classes that were consistently observed in the fishery and survey. Therefore, this index has not been used in any assessment. Because the pre-recruit survey has not been conducted since 2009, it has not been revisited in subsequent stock assessments.

2.2.4 Age-1 Index from the acoustic survey

The acoustic survey has historically focused its at-sea and analysis efforts on the age-2+ portion of the Pacific hake stock. The rationale for this included: inshore and southerly distribution of age-1 fish required additional survey time to provide adequate geographic coverage; relatively lower catchability of age-1 fish in the trawl net used by the survey; and perhaps greater difficulty in identifying these schools from other small pelagic fish. This choice was also consistent with the needs of early stock assessments, where recruitments were modeled as at age-2. Despite these reasons for excluding age-1 fish historically, a reliable index of age-1 hake would now be extremely valuable for this stock assessment. An age-1 index could potentially reduce uncertainty around the strength of incoming cohorts much more rapidly than only the biennial survey estimates for age-2+ fish and the annual commercial fishery data.

During 2011, the acoustic survey team re-processed all echogram data available, spanning the period from 1995 to 2011. All age-1 aggregations were identified and the backscatter integrated following the simple polygon methods that were used for the adult stock prior to development of the kriging method currently employed. The number of data points is currently very small. Unfortunately, correlation analysis for the index and assessment-estimated year-class strengths is hampered by low variability among the years for which age-1 hake have been enumerated by the acoustic survey. However, the results are generally consistent with large 2008 and 2010 cohorts (Figure 9). This index was not used in the 2013 assessment, but the JTC encourages a continuation of this effort, which, in addition to an annual survey could reduce assessment model uncertainty in the future.

2.3 Externally analyzed data

2.3.1 Maturity

The fraction mature, by size and age, is based on data reported in Dorn and Saunders (1997) and has remained unchanged since the 2006 stock assessment. These data consisted of 782 individual ovary collections based on visual maturity determinations by observers. The highest variability in the percentage of each length bin that was mature within an age group occurred at ages 3 and 4, with virtually all age-one fish immature and age 4+ hake mature. Within ages 3 and 4, the proportion of mature hake increased with larger sizes, such that only 25% were mature at 31 cm while 100% were mature at 41 cm. Less than 10% of the fish smaller than 32 cm are predicted to be mature, while 100% maturity is predicted by 45 cm.

Histological samples have been collected during the 2009 U.S. bottom trawl survey and were analyzed in early 2012. Preliminary analysis of the 2009 data suggest the presence of yearly variation and that some larger fish may skip spawning, although they are likely mature. Additional ovaries were collected from the 2012 bottom trawl survey and the 2012 acoustic survey to investigate differences between hake caught in mid-water and those caught near the bottom, as well as variability between years. The number of samples by length bin is shown in Table 5. The JTC expects to complete the analysis of 2012 samples in 2013 for consideration in the 2014 hake assessment.

2.3.2 Aging error

The large inventory of Pacific hake age determinations include many duplicate reads of the same otolith, either by more than one laboratory, or by more than one age-reader within a lab. Recent stock assessments have utilized the cross- and double-reads to generate an ageing error vector describing the imprecision and bias in the observation process as a function of fish age. New data and analysis were used in the 2009 assessment to address an additional process influencing the ageing of hake: cohort-specific ageing error related to the relative strength of a year-class. This process reflects a tendency for uncertain age determinations to be assigned to predominant year classes. The result is that the presence of strong year classes is inflated in the data while neighboring year-classes are under-represented.

To account for these observation errors in the model, year-specific ageing-error matrices (or vectors of standard deviations of observed age at true age) are applied, where the standard deviations of strong year classes were reduced by a constant proportion. For the 2009 and 2010 assessments this proportion was determined empirically by comparing double-read error rates for strong year classes with rates for other year classes. In 2010, a blind double-read study was conducted using otoliths collected across the years 2003-2009. One read was conducted by a reader who was aware of the year of collection, and therefore of the age of the strong year classes in each sample, while the other read was performed by a reader without knowledge of the year of collection, and therefore with little or no information to indicate which ages would be more prevalent. The resulting data were analyzed via an optimization routine to estimate both ageing error and the cohort effect. The resultant ageing error was similar to the ageing error derived from the 2008 analysis. This approach has been unchanged since the 2011 assessment and has been retained for 2013, with the ageing-error reduced for the 1980, 1984, 1999, 2008, and 2010 cohorts.

2.3.3 Weight-at-age

A matrix of empirically derived population weight at age is required as input for the current assessment models. Mean weight at age was calculated from samples pooled from all fisheries and the acoustic survey for the years 1975 to 2012 (Figure 10). Ages 15 and over were pooled and assumed to have the same weight at age. For ages 2 to 15+, 99% of the combinations of year and age had samples from which to calculate mean weight at age. At age 1, 58% of the years had samples available. The combinations of age and year with no observations were assumed to change linearly over time between observations at any given age. For those years before and after all the observations at a given age, mean weights were assumed to remain constant prior to the first observation and after the last observation. The number of samples is generally proportional to the amount of catch, so the combinations of year and age with no samples should have relatively little importance in the overall estimates of the population dynamics. The use of empirical weight at age is a convenient method to capture the variability in both the weight-at-length relationship within and among years, as well as the variability in length-at-age, without requiring parametric models to represent these relationships. However, this method requires the assumption that observed values are not biased by strong selectivity at length or weight and that the spatial and temporal patterns of the data sources provide a representative view of the underlying population.

2.3.4 Length-at-age

In 2011 assessment models, and in models used for management prior to the 2006 stock assessment, temporal variability in length-at-age was included in stock assessments via the calculation of empirical weight-at-age. In the 2006 and subsequent assessments that attempted to estimate the parameters describing a parametric growth curve, strong patterns have been identified in the observed data indicating sexually dimorphic and temporally variable growth. Von Bertalanffy growth models fit externally to data collected prior to 1990 and afterward show the same dramatically different rates of growth when it has been estimated inside the assessment model in recent years. Hake show very rapid growth at younger ages, and the length-at-age trajectories of individual cohorts also vary greatly, as has been documented in previous assessments. In addition, there are bioenergetic effects (Walters and Essington 2010), the interactions of selectivity at length, fishing and natural mortality that can make estimating unbiased growth curves difficult (Taylor et al. 2005). Most statistical methods for estimating growth curves perform poorly (Gwinn et al. 2010).

In aggregate, these patterns result in a greater amount of process error for length-at-age than is easily accommodated with parametric growth models, and attempts to explicitly model size-at-age dynamics have not been very successful for hake. Models have had great difficulty in making predictions that mimic the observed data. This was particularly evident in the residuals to the length-frequency data from models prior to 2011. We have not revisited the potential avenues for explicitly modeling variability in length- and weight-at age in this model, but retain the empirical approach to weight-at-age described above.

2.4 Estimated parameters and prior probability distributions

The estimated parameters and prior probability distributions used in this stock assessment are reported in Table 6. Several important distributions are discussed in detail below.

2.4.1 Natural Mortality

In recent stock assessments, the natural mortality rate for Pacific hake has either been fixed at a value of 0.23 per year, or estimated using an informative prior to constrain the probability distribution to a reasonable range of values. The 0.23 estimate was originally obtained via tracking the decline in abundance of individual year classes (Dorn et. al 1994). Pacific hake longevity data, natural mortality rates reported for Merluciids in general, and previously published estimates for Pacific hake natural mortality indicate that natural morality rates in the range 0.20-0.30 could be considered plausible for Pacific hake (Dorn 1996).

Beginning in the 2008 assessment, Hoenig's (1983) method for estimating natural mortality (*M*), was applied to hake, assuming a maximum age of 22. The relationship between maximum age and *M* was recalculated using data available in Hoenig (1982) and assuming a log-log relationship (Hoenig, 1983), while forcing the exponent on maximum age to be -1. The recalculation was done so that uncertainty about the relationship could be evaluated, and the exponent was forced to be -1 because theoretically, given any proportional survival, the age at which that proportion is reached is inversely related to M (when free, the exponent is estimated to be -1.03). The median value of *M* via this method was 0.193. Two measures of uncertainty about the regression at the point estimate were calculated. The standard error, which one would use assuming that all error about the regression is due to observation error (and no bias occurred) and the standard deviation, which one would use assuming that the variation about the regression line was entirely due to actual variation in the relationship (and no bias occurred). The truth is likely to be between these two extremes (the issue of bias not withstanding). The value of the standard error in log space was 0.094, translating to a standard error in normal space of about 0.02. The value of the standard deviation in log space was 0.571, translating to a standard deviation in normal space of about 0.1. Thus Hoenig's method suggests that a prior distribution for *M* with mean of 0.193 and standard deviation between 0.02 and 0.1 would be appropriate if it were possible to accurately estimate *M* from the data, all other parameters and priors were correctly specified, and all correlation structure was accounted for.

In several previous assessments (2008-2010) natural mortality has been allowed to increase with age after age 13, to account for the relative scarcity of hake at age 15+ in the observed data. This choice was considered a compromise between using dome-shaped selectivity - and assuming the oldest fish were extant but unavailable to the survey or fishery - and specifying increasing natural mortality over all ages, which tended to create residual patterns for ages with far more fish in them. The reliability of this approach has been questioned repeatedly, and it makes little difference to current assessment results, so in the interest of parsimony, natural mortality is considered to be constant across age and time for all models reported in this assessment document.

Since the 2011 assessment and again this year, a combination of the informative prior used in recent Canadian assessments and the results from Hoenig's method described above support the use of a log-normal distribution with a median of 0.2 and a log-standard deviation of 0.1. Sensitivity to this prior is evaluated by examination of the posterior distribution, as updated by the data, as well as the use of alternate priors, specifically a larger standard deviation about the point estimate (see Section 3.4.7).

2.4.2 Steepness

The prior for steepness is based on the median (0.79), 20th (0.67) and 80th (0.87) percentiles from Myers et al. (1999) meta-analysis of the family Gadidae, and has been used in previous U.S. assessments since 2007. This prior is distributed $\beta(9.76,2.80)$ which translates to a mean of 0.777 and a standard deviation of 0.113. Sensitivity to this prior was evaluated using various values for the mean (see Section 3.4.7).

3 Assessment

3.1 Modeling history

Age-structured assessment models of various forms have been used to assess Pacific hake since the early 1980s, using total fishery landings, fishery length and age compositions, and abundance indices. Modeling approaches have evolved as new analytical techniques have been developed. Initially, a cohort analysis tuned to fishery CPUE was used (Francis et al. 1982). Later, the cohort analysis was tuned to NMFS triennial acoustic survey estimates of absolute abundance at age (Francis and Hollowed 1985, Hollowed et al. 1988a). In 1989, the hake population was modeled using a statistical catch-at-age model (Stock Synthesis) that utilized fishery catch-at-age data and survey estimates of population biomass and age-composition data (Dorn and Methot, 1991). The model was then converted to AD Model Builder (ADMB; Fournier et al. 2012) in 1999 by Dorn et al. (1999), using the same basic population dynamics equations. This allowed the assessment to take advantage of ADMB's post-convergence routines to calculate standard errors (or likelihood profiles) for any quantity of interest. Beginning in 2001, Helser et al. (2001, 2003, and 2004) used the same ADMB model to assess the hake stock and examine important assessment modifications and assumptions, including the time-varying nature of the acoustic survey's selectivity and catchability. The acoustic survey catchability coefficient (q) was one of the major sources of uncertainty in the model. The 2004 and 2005 assessments presented uncertainty in the final model result as a range of biomass. The lower end of the biomass range was based upon the conventional assumption that the acoustic survey q was equal to 1.0, while the higher end of the range represented a q=0.6 assumption.

In 2006, the coastal hake stock was modeled using the SS2, an earlier version of the Stock Synthesis (SS) modeling framework written in AD Model Builder (Methot and Wetzel 2012). Conversion of the previous hake model into SS2 was guided by three principles: 1) incorporate less *derived* data, favoring the inclusion of unprocessed data where possible, 2) explicitly model the underlying hake growth dynamics, and 3) pursue parsimony in model complexity. "Incorporating less *derived* data" entailed fitting observed data in their most elemental form. For instance, no pre-processing to convert length data to age-compositional data was performed. Also, incorporating conditional age-at-length data for each fishery and survey allowed explicit estimation of expected growth, dispersion about that expectation, and its temporal variability, all conditioned on selectivity. In both 2006 and 2007, as in 2004 and 2005, assessments presented two models (which were assumed equally likely) in an attempt to bracket the range of uncertainty in the acoustic survey catchability coefficient, q. The lower end of the biomass range was again based upon the conventional assumption that the acoustic survey q was equal to 1.0, while the higher end of the range allowed estimation of q with a fairly tight prior about q = 1.0 (estimated q = 0.6 - 0.7). The 2006 and 2007 assessments were collaborative, including both U.S. and Canadian scientists.

During 2008, three separate stock assessments were prepared independently by U.S. and Canadian scientists. The U.S. model was reviewed during the STAR panel process, and both the VPA and TINSS models were presented directly to the SSC, but were not formally included in the U.S. assessment review and management process. The post-STAR-panel U.S. model freely estimated q for the first time, and this resulted in very large relative stock size and yield estimates. In 2009, the U.S. assessment model incorporated further uncertainty in the degree of recruitment variability (σ_R), more flexible time-varying fishery selectivity, and a separate *M* for older hake. Additionally, the 2009 assessment incorporated further refinements to the ageing-error matrices, including both updated data and cohort-specific reductions in ageing error to reflect "lumping" effects due to strong year classes. The 2009 U.S. model continued to integrate uncertainty in acoustic survey *q* and selectivity and in *M* for older fish. Residual patterns that had been present in the age and length data were discussed at length, and efforts were undertaken to build the tools necessary to re-evaluate input data to allow more flexibility in potential modeling approaches.

In 2010, two competing models (one built using TINSS, Martell 2010; and one in SS, Stewart and Hamel 2010) were presented to the STAR panel. The SS model was similar in structure to the 2009 assessment. Estimates of absolute stock size and yields differed greatly between the two models, and the causes of these differences went largely unidentified. The SSC recommended that the Pacific Council base management advice on both models.

In 2011, two models were again put forward by a joint stock assessment team comprised of U.S. and Canadian scientists collaborating in the spirit of the as-yet unimplemented Agreement. Results from both models were presented in a single document (Stewart et al. 2011). Considerable efforts were made to refine both models to better understand the reasons for previous differences among models and to better present the uncertainty in current stock status. The exercise resulted in two models that were structurally very similar, although they still contained some fundamental differences in underlying assumptions about certain likelihood components and prior assumptions about the productivity and scale of the population. During model development, a wide range of model complexities were explored, which led to the conclusion that relatively simple model structures were able to provide results consistent with more complex models. The final models achieved a much greater degree of parsimony compared with some earlier assessments. Notably, neither model attempted to fit to observed lengths at age. Annual variability in length at age was instead captured through use of empirically-derived estimates of weight at age in the data files (discussed above). Both models were deemed equally plausible by the STAR panel, in terms of their ability to capture the dynamics of the Pacific hake stock and provide advice for management in the face of considerable scientific uncertainty.

In 2012 the Pacific whiting Agreement was officially enacted and members of a provisional Joint Technical Committee (JTC), comprised of Canadian and U.S. scientists, continued to collaborate in the production of a single stock assessment document. Members of the provisional JTC agreed on a single base-case model, using the SS modeling platform configured almost identically to that used in the 2011 assessment. Sensitivity to structural and parameter uncertainty was analyzed using this model and a new statistical catch at age model (CCAM), originally developed at the University of British Columbia (Martell 2011) and customized by members of the JTC.

The 2013 stock assessment presented here carries on the collaboration between U.S. and Canadian scientists making up the JTC. As in 2012, the SS model was used to represent a base model, but a separate Canadian model was not developed and SS was also used to characterize structural and parameter uncertainty.

3.2 Response to recent review recommendations

3.2.1 2013 Scientific Review Group (SRG) review

The Scientific Review Group was held in Vancouver, British Columbia from February 19–22, 2013. The SRG investigated many aspects of the model, but the base model presented by the JTC was unchanged and endorsed by the SRG for use by the JMC when considering the 2013 catch quota. The SRG also reviewed the Management Strategy Evaluation (MSE), and felt that it was a great start to this important process, but was limited in scope and in its current state was not completely adequate to provide management guidance.

Many recommendations were made by the SRG and three were given high priority: 1) continue work on the MSE, 2) improve our understanding of Pacific hake life-history by collecting and analyzing data related to growth, maturity, and fecundity, and 3) continue acoustic research, especially with regard to an age-1 index and target identification.

3.2.2 2012 SRG review

The 2012 SRG panel (21–24 February, 2011) conducted a thorough review of the data, analyses and modeling conducted by the JTC (a full summary can be found in the STAR panel report). The SRG endorsed the use of these revised models for 2012. Other recommendations for this assessment made during the SRG review were: inclusion of a table of management metrics that were of particular interest to meeting participants and several adjustments to some technical terms to improve the readability of the assessment results. These suggestions are incorporated in this document as well and an additional column was added to the table of metrics. Specific responses are given below.

3.2.3 2012 SRG recommendations and responses from the JTC

High priority recommendations

1. Increase frequency of survey to annual

    Response: The JTC supports this recommendation, and especially supported an interim survey in 2012. However, the results from the MSE show that on average, there is little difference in average catch, average annual variability of the catch, and stock status between an annual and a biennial survey. Furthermore, there is concern that an annual survey would jeopardize future research on improving survey techniques. On the other hand, the 2012 assessment incorporated an acoustic survey biomass estimate from 2009 that was very high, and an acoustic survey biomass estimate in 2011 that was very low. Along with the incoming 2008 year class and signs of a potentially strong 2010 year class, the 2013 assessment benefited from a supplemental 2012 acoustic survey. Results below present a hypothetical assessment where there was no 2012 survey to determine the usefulness of this interim survey.

2. Management strategy evaluation (MSE)

    Response: The JTC supports this recommendation, and began work on an MSE in the summer of 2012. Results of this MSE are provided in Appendix A and the JTC recommends future work on the MSE with input from the JMC, SRG, and AP.

Other recommendations

- Inter-vessel calibrations

  Response: Inter-vessel calibration has not been performed at this time. However, transects off of Vancouver Island in the 2012 survey were done by both the Bell Shimada and the CCGS W.E Ricker. It is uncertain if this data may be used to investigate the differences between vessels due to timing, but it may be possible.

- Age-1 or -0 index development

  Response: The JTC supports the development of an age-1 index, especially because the preliminary age-1 index from the acoustic survey indicates recent strong year classes estimated by the base model (Figure 9).

- Life-history data improvements

  Response: Ovaries have been collected from hake caught during the 2012 bottom trawl and 2012 acoustic surveys. These collections are currently being analyzed and will hopefully be available for consideration in the 2014 assessment. Numbers of samples collected are shown in Table 5.

- Survey extent

  Response: One long transect in 2012 was performed on the W.E. Ricker with an industry representative on board to investigate the presence of hake in deep water. No conclusive evidence of hake in deep water was found.

- Survey variance

  Response: There has been no additional work on the inclusion of additional sources of error in the survey estimate. Work on this topic was halted due to time constraints given a supplemental 2012 survey.

- The use of commercial vessels in acoustic or biological sampling be explored as one way to expand sampling

  Response: A catcher vessel was used in the 2012 acoustic survey, and many challenges were identified. No additional work has been done to determine the utility of acoustic sampling with commercial vessels, but as learned from the 2012 survey and the use of a catcher vessel, calibration of echo sounders would be necessary.

- Target characterization and verification

  Response: The use of a catcher vessel in the 2012 survey increased the number of hauls that typically occur in a normal survey year. However, other difficulties may negate the benefits seen from the increased number of tows. No additional work has been done due to time constraints imposed by the supplemental 2012 survey.

- Exploration of separability assumption in the assessment model; i.e., the assumption that selectivity is constant over time.

  Response: Two sensitivities are presented in this document showing the effect of introducing a flexible form of time-varying selectivity. Little difference in the results was seen.

3.3 Model Description

3.3.1 Base model

The base-case model reported in this assessment uses SS version 3.24j (Methot and Wetzel 2012), which provides a general framework for modeling fish stocks that permits the complexity of population dynamics to vary in response to the quantity and quality of available data. In the base model, both the complexity of the data and the dynamics of the model are intended to be quite simple, and efforts have been made to be as consistent with the 2012 assessment and with the model structure that was tested this year using the MSE. Additional complexity is explored via sensitivity analysis using the SS platform.

The basic model structure, aggregation-level, treatment of data, as well as parameterizations for key processes remain unchanged from the 2011 and 2012 assessments. The Pacific hake population is assumed to be a single coast-wide stock along the Pacific coast of the United States and Canada. Sexes are combined within all data sources, including fishery and survey age compositions, as well as in the model dynamics. The accumulator age for the internal dynamics of the population is set at 20 years, well beyond the expectation of asymptotic growth. The modeled period includes the years 1966–2012 (the last year of available data), with forecasts extending to 2015. The population was assumed to be in unfished equilibrium 20 years prior to the first year of the model, allowing a 'burn-in' of recruitment estimates such that the age structure in the first year of the model was free of equilibrium assumptions. Since there were no large-scale commercial fisheries for hake until the arrival of foreign fleets in the mid- to late 1960s, no fishing mortality is assumed prior to 1966.

The base model structure, including parameter specifications, bounds and prior distributions (where applicable) is summarized in Table 6. The assessment model includes a single fishery representing the aggregate catch from all sectors in both nations). The effect of modeling the U.S. foreign, joint-venture, at-sea and shore-based fisheries, as well as the Canadian foreign, joint-venture and domestic fisheries as separate fleets was explored in the 2011 assessment. It was assumed that selectivity for both the acoustic survey and commercial fishery does not change over time, but time-varying selectivity was explored as part of the sensitivity analysis. Selectivity curves were modeled as non-parametric functions estimating age-specific values for each age beginning at age 2 for the acoustic survey (since age-1 fish are excluded included from the design) and age-1 for the fishery as small numbers are observed in some years. Selectivity is forced to be constant after age-6, although this assumption is also explored in the sensitivity analysis.

Growth is represented via the externally derived matrix of weight-at-age described above. Alternate models, including a time-varying von Bertalanffy function, dimorphic growth and seasonally explicit growth within years were compared via sensitivity analyses during the 2011 assessment but did not provide substantially different results.

For the base model, the instantaneous rate of natural mortality (*M*) is estimated with a lognormal prior having a median of 0.2 and σ (in log-space) of 0.1 (described above). The stock-recruitment function is a Beverton-Holt parameterization, with the log of the mean unexploited recruitment freely estimated. This assessment uses the Beta-distributed prior for stock-recruit steepness (*h*) applied to previous assessments and described above. Year-specific recruitment deviations were estimated from 1946–2012. The standard deviation, σ_r, for recruitment variability, serving as both a recruitment deviation constraint and bias-correction, is fixed at a value of 1.4 in this assessment. This value is based on consistency with the observed variability in the time-series of recruitment deviation estimates, and is the same as assumed in 2012. Maturity and fecundity relationships are assumed to be time-invariant and fixed values remain unchanged from recent assessments.

The acoustic survey index of abundance was fit via a log-normal likelihood function, using the observed sampling variability, estimated via kriging as year-specific weighting (and additional uncertainty in 2009 due to the presence of Humboldt squid). An additional constant and additive log(SD) component is included, which was freely estimated to accommodate unaccounted for sources of process and observation error. Survey catchability was freely estimated with a uniform (noninformative) prior in log-space. A Multinomial likelihood was applied to age-composition data, weighted by the sum of the number of trips or hauls actually sampled across all fishing fleets, and the number of trawl sets in the research surveys. Input sample sizes were then iteratively down-weighted to allow for additional sources of process and observation error. This process resulted in tuned input sample sizes roughly equal to the harmonic mean of the effective sample sizes after model fitting, and tuning quantities were unchanged from the 2012 assessment.

3.4 Modeling results

3.4.1 Changes from 2012

A set of 'bridging' models in SS was constructed to clearly illustrate the component-specific effects of all changes to the base-case model from 2012 to 2013. The first link in this bridge analysis was to update to the most recent version of the Stock Synthesis software (version 3.24j; 27 November, 2012). This change produced no observable differences in the model results (not shown).

The second change involved updating the 2011 catches and data to reflect any changes in the underlying databases and to get final estimates of catch and age compositions for 2011 to replace the preliminary estimates available at the time the 2012 stock assessment. The 2011 catch decreased slightly and due to late arriving ages collected late in 2011, the proportions at ages 1 and 2 increased slightly while the proportions at ages older than 3 decreased slightly (Figure 11). Other changes in this step were to update the mean weight-at-age matrix using 2012 data and to combine the fleet specific age compositions using year-specific mean weight-at-age (discussed above). This produced very small differences throughout the time series of fishery compositions. These changes resulted in similar historical trends, but a slightly more depleted stock in recent years mainly due to fewer 2005, 2006, and 2008 recruits (Table 7 and Figure 12).

The third change included adding the 2012 fishery age-composition data and 2012 catches. This is basically an assessment without a 2012 acoustic survey. The stock status improved greatly in 2012 due to a larger estimate of 2008 recruitment and a much larger, but uncertain, estimate of 2010 recruitment (Table 7 and Figure 12). The uncertainty interval on 2012 depletion is quite large, extending from just below 10% to slightly less than 100%.

The final change in the bridging was to add in the 2012 acoustic survey biomass estimate and age-compositions. The MLE estimates of spawning biomass, depletion, and recruitment showed little change, except for a slight reduction in the 2010 year class, indicating that the 2012 fishery and 2012 survey predict similar trends, which has not always been the case in past years. The largest change was that uncertainty was reduced, especially at the lower end (although MLE estimates may not accurately estimate the tails of uncertainty due to asymmetry). Without the acoustic data, the 2013 assessment would be much more uncertain.

3.4.2 Model selection and evaluation

The JTC focused on a small subset of structural choices for 2013. There were extensive structural explorations conducted during the 2011 stock assessment (see Stewart et al. 2011 for a thorough description of these analyses, ranging from simple production models to seasonal, sex- fleet/sector-specific approaches incorporating time-varying growth). The JTC devoted their efforts instead to a few structural uncertainties, and to the development of a management strategy evaluation in 2012. Of the models investigated, only a small subset representing those with the best estimation behavior was selected for sensitivity analyses, which are reported below.

Iterative reweighting of the composition data in the base case SS model did not produce large changes in the results, and the JTC found that the same down-weighting values for fishery and acoustic survey age compositions as used in the 2012 assessment produced reasonable results (12% and 94%, respectively, of the observed number of trips/hauls, while retaining the relative differences in sampling among years). As noted in the 2012 assessment, this is consistent with the high degree of correlation among fishery tows for the at-sea fleet and the much greater temporal and spatial spread of the acoustic hauls. The additional variance component for the acoustic survey was estimated to be 0.42 at the median of the posterior distribution, indicating substantial additional process error beyond simple sampling variability was present (as expected). This estimate is slightly less than the median estimate in the 2012 assessment (0.46), but much larger than that from the 2011 assessment (0.26) reflecting the *post hoc* deduction that the 2009 survey observation is largely inconsistent with the trend over adjacent years. Despite the relatively large amount of combined process and observation error for the acoustic time-series, fit to this data source still provides the strongest information available in the assessment on the scale of the current Pacific hake stock.

A summary of the fit to the age-composition data (for the base case) and survey index (for both models) can be found in the model results section below

3.4.3 Assessment model results

For the base model, the MCMC chain was run for 10,000,000 iterations with the first 10,000 discarded to eliminate 'burn-in' effects. Each 10,000th value thereafter was retained, resulting in 999 samples from the posterior distributions for model parameters and derived quantities. Stationarity of the posterior distribution for model parameters was assessed via a suite of standard diagnostic tests. The objective function, as well as all estimated parameters and derived quantities, showed good mixing during the chain, no evidence for lack of convergence, and low autocorrelation (Figure 13 and Figure 14). Correlation-corrected effective sample sizes were sufficient to summarize the posterior distributions and neither the Geweke nor the Hiedelberger and Welch statistics for these parameters exceeded critical values more frequently than expected via random chance (Figure 15). Correlations among key parameters were generally low, with the exception of natural mortality and the average unexploited equilibrium recruitment level (R_0). Recent recruitment (2008 and 2010), depletion in 2013, and predicted catch in 2013 were all positively correlated (Figure 16).

The modeled time series fit to the acoustic survey biomass index is shown in Figure 17 and is quite reasonable, given the sum of the input and estimated variance components. The 2001 data point was well below the predictions made by any model we evaluated, and no direct cause for this is known, however it was conducted about one month earlier than all other surveys between 1995 and 2009 (Table 4), which may explain some portion of the anomaly. The 2009 index is much higher than any predicted value observed during model evaluation. The uncertainty of this point is also higher than in other years, due to the presence of large numbers of Humboldt squid during the survey. Additional uncertainty has been accounted for in both the data and the models.

Selectivity at age for both the fishery and survey is relatively uncertain (better reflected when using the non-parametric selectivity option as compared to parametric forms) but generally consistent with the observation that fish are fully selected by the time they reach their full size (Figure 18). Fits to the age-composition data are also reasonably good, with close correspondence to the dominant cohorts observed in the data and also identification of small cohorts, where the data give a consistent signal (Figure 19 through Figure 21). Residual patterns to the fishery and survey age data do not show particularly evident trends that would indicate systematic bias in model predictions, but there is a reversal in trend of over-fitting between years 2011 and 2012 (Figure 22).

Posterior distributions for model parameters showed that for both steepness and natural mortality the prior distributions strongly influenced the posterior (Figure 23). The posterior for steepness was not updated much by the data The natural mortality parameter, on the other hand, is shifted to the right of the prior distribution and the prior may be constraining the posterior distribution. All other parameters showed substantial updating from noninformative priors to stationary posterior distributions.

The base-case stock assessment model indicates that the Pacific hake female spawning biomass was well below the average unfished equilibrium level at the start of the fishery and during the 1970s (Figure 24 and Table 8 and Table 9). The model predicts that the stock increased rapidly after two or more large recruitment events in the early 1980s and then declined rapidly after a peak in the mid- to-late 1980s to a low in 2000 (Figure 25, Figure 26 and Table 10). This long period of decline was followed by a brief increase to a peak in 2003 (median estimate of 1.34 million mt) as the exceptionally large 1999 year class matured. The stock is then estimated to have declined with the ageing 1999 year class to a time-series low of 0.42 million mt in 2009. Since 2009, the model predicts that biomass is increasing based on the strength of the 2008 and 2010 year classes and is at 72.3% of the average unfished equilibrium level, with a 95% probability of being between 34.7% and 159.7% (Figure 27).

Stock size estimates are quite uncertain throughout the time series, and are typically largest at the end of the time series. Figure 28 compares the three assessments performed with a similar model since 2011 in terms of estimated depletion and recruitment. The estimated depletion is similar for the 2012 and 2013 assessment models (up to 2011), but the 2011 assessment model significantly departs in 2007 due to differences in the estimated size of the 2005, 2006, and 2008 recruitments. The uncertainty intervals for the estimated 2011 spawning biomass overlap from all three models, but the median spawning biomass from the 2011 assessment model is not contained within the uncertainty intervals of the 2012 and 2013 assessment models, and vice versa. The uncertainty interval for 2011 spawning biomass is smallest in the 2013 assessment, indicating that additional data has been interpreted as informative by the model.

Estimates of historical Pacific hake recruitment indicate very large year classes in 1980 and 1999 in both assessment models, with 1970, 1984 and 2010 accounting for the other three of the five largest estimated to have occurred in the last 40 years. The strength of the 2008 cohort is estimated to be large (5.5 billion) and is the sixth largest in the time-series. The 2010 cohort is estimated as the second largest, but most uncertain, cohort at 13.6 billion individuals. In both the U.S. fishery and acoustic age compositions, the 2008 and 2010 year classes comprise a very large proportion of the recent observations. Uncertainty in estimated recruitments is substantial, especially for 2010, as indicated by the broad posterior intervals (Figure 25). The stock-recruit estimates are provided in Figure 29, showing both the extremely large variability about the expectation and the lack of relationship between spawning stock and subsequent recruitment.

The large recruitments are especially important to the Pacific hake fishery. Figure 30 shows that more than 1.2 million metric tons have been harvested from the 1999 year class, which is about 12% of the entire catch since 1966. The 1980, 1984, and 1999 year classes have been the largest contributors to catch over the entire time-series, making up 30% of the approximately 10 million tons of hake that have been harvested since 1966.

Using the estimated natural mortality and selectivity from the base Bayesian model, yield-per-recruit and spawner-per-recruit curves were calculated external to SS3 (Figure 31). Yield-per recruit curves show that it is maximized near age 3 at the exploitation rates recently observed (around 0.15–0.3). Spawner-per-recruit shows that knife-edge selectivity at age 3 would reduce the spawners-per-recruit to between 20% and 40% at these same exploitation rates. The estimated selectivity curve from the base model does not fully select fish until age 6, thus the yield-per-recruit and spawner-per-recruit curves are most similar to the age 5+ knife-edge selectivity. Although, not shown in this document, there was little change in these general results over the range of uncertainty in natural mortality. At a higher natural mortality the, yield-per-recruit was maximized at a first age of selectivity closer to 2.

3.4.4 Model uncertainty

The base case assessment model integrates over the substantial uncertainty associated with several important model parameters including: acoustic survey catchability (q), the productivity of the stock (via the steepness parameter, h, of the stock-recruitment relationship), the rate of natural mortality (M), and recruitment deviations. Although the Bayesian results presented include estimation uncertainty, this within-model uncertainty is likely an underestimate of the true uncertainty in current stock status and future projections, since it does not include structural modeling choices, data-weighting uncertainty and scientific uncertainty in selection of prior probability distributions. However, the uncertainty portrayed by the posterior distribution is a better representation of the uncertainty when compared to maximum likelihood estimates (MLE) because it allows for asymmetry (see Stewart et al 2012 for further discussion and examples). Table 11 compares the median of the posterior to the MLE, showing that median biomass, recruitment, and depletion estimates from the posterior distribution are all higher. Figure 32 shows the MLE and Bayesian estimates as well as the skewed uncertainty in the posterior distributions for spawning biomass and recruitment.

The JTC investigated a broad range of alternate models, and we present a subset of key sensitivity analyses using the Stock Synthesis (SS) modeling platform in order to provide a broad qualitative comparison of structural uncertainty with the base case. However, a major source of uncertainty in the 2013 status and target catch is in the estimate of the size of the 2010 year class, and the within model uncertainty captures the median trend of most sensitivity models.

Pacific hake displays the highest degree of recruitment variability of any west coast groundfish stock, resulting in large and rapid changes in stock biomass. This volatility, coupled with a dynamic fishery, which potentially targets strong cohorts resulting in time-varying selectivity, and little data to inform incoming recruitment until the cohort is age 2 or greater, will continue to result in highly uncertain estimates of current stock status and even less-certain projections of future stock trajectory. Currently uncertainty in this assessment is largely a function of the potentially large 2010 year class being observed once in the acoustic survey and being observed twice by the fishery, although with reduced and uncertain selectivity. The supplemental acoustic survey performed in 2012 helped reduce the uncertainty in the strength of this year class, which is a likely result when increasing the frequency of the survey. However, the survey does not quantify hake until they are 2 years old, leaving a lag in the ability to forecast even one year.

Given the uncertainty in stock status and magnitude, the JTC developed a Management Strategy Evaluation (MSE) to explore topics including testing of the basic performance of the default harvest policy and the effect of annual vs. biennial surveys. The results of these explorations showed that biomass levels and average catch was variable, mainly because of the high recruitment variability seen with Pacific hake. Even though the Pacific hake fishery is relatively data-rich, with a directed fishery-independent survey program, substantial biological sampling for both commercial fisheries and the acoustic survey, and reliable estimates of catch, the data are less informative about incoming recruitment which results in large differences between the simulated abundance and the estimated abundance.

3.4.5 Reference points

The unexploited equilibrium spawning biomass estimate was 2.08 million mt (Table 12), larger than the estimates reported in the 2011 and 2012 stock assessments (Stewart et al. 2011, JTC 2012). However, the uncertainty is broad, with the 95% posterior credibility interval ranging from 1.65 to 2.71 million mt. The equilibrium spawning biomass resulting from fishing at the $F_{40\%}$ default harvest rate target was 0.74 million mt. *MSY* is estimated occur at a smaller stock size, 0.50 million mt, with a yield of 357 thousand mt; only slightly higher than the equilibrium yield when fishing at the $F_{40\%}$ target, 337 thousand mt. The full set of reference points with uncertainty intervals for the base case and among alternate sensitivity models are reported in Table 12.

The median fishing intensity on the Pacific hake stock is estimated to have been below the $F_{40\%}$ target until 2008 (Figure 33). Uncertainty in the recent SPR estimates is large, and the estimates from the base-case model indicate that the catch has exceeded the target in three of the last five years, although the fishing intensity in 2012 was very likely to be below target. The exploitation history, in terms of both the biomass and *F* targets, is portrayed graphically via a phase-plot (Figure 34).

3.4.6 Model projections

The main source of uncertainty in the current status of Pacific hake comes from the estimate of recent year classes. Therefore, a decision table showing predicted status and fishing intensity relative to target fishing intensity is presented with uncertainty represented from within the base-case model (Table 13 and Table 14). The uncertainty in the final and projected years of the assessment are broad and expected to encompass the uncertainty due to different structural assumptions. The decision table is organized such that the projected implications for each potential management action (the rows, containing a range of potential catch levels) can be evaluated across the quantiles of the posterior distribution for the base-case model (the columns). For clarity, the implications are divided into two tables: the first table projects the depletion estimates, and the second predicts the fishing intensity relative to the target fishing intensity (based on the SPR; see table legend). Fishing intensity exceeding 100% indicates fishing in excess of the $F_{40\%}$ default harvest rate.

An additional table (Table 15) is presented containing a set of management metrics that were identified as important to the Joint Management Committee (JMC) and the Advisory Panel (AP). These metrics summarize the probability of various outcomes from the base case model given each potential management action. Although not linear, probabilities can be interpolated from this table for intermediate catch values.

The median spawning stock estimate from the base-case model is projected to remain constant with a 2013 catch of 650,000 mt, which is greater than the catch determined using the default harvest rate (626,364 mt, Table 13 and Table 14). A catch of approximately 603,000 mt results in an equal probability of the stock increasing or decreasing from 2013 to 2014, based on individual trajectories from samples of the posterior distribution (Table 15). The median values show slightly different results than the individual trajectories because increases in the projected biomass tend to be greater in magnitude than the decreases in projected biomass. Catches less than 600,000 mt result in a slight increase in the median 2014 spawning biomass, relative to 2013. However, the posterior distribution is highly uncertain, and either increasing or decreasing trends are possible over a broad range of 2012 catch levels. A catch of 696,000 mt results in the base model to predict the same catch of 696,000 mt in 2014, and a declining spawning biomass. Forecasts of depletion under fixed catch levels are graphically displayed in Figure 35.

Table 15 shows the same catch alternatives for 2013 and probabilities based on individual samples from the posterior distribution, and Figure 36 displays this graphically. As catch increases, the probability of each metric increases, and the various catch levels that produce a defined probability can be found be reading horizontally across from the y-axis. At the highest catch considered, there is an 11% probability that the spawning biomass would be less than 40% of unfished equilibrium biomass.

The median of the catch for 2013 based on the default harvest policy ($F_{40\%}$ – 40:10) is 626,364 mt, but has a wide range of uncertainty (Figure 37). The 95% posterior credibility interval ranges from 268,351 mt to 1,626,550 mt.

Given this uncertainty, the projected 2013 catch target being more than 1.5 times the highest catch in the time series as well as 1.75 times MSY, and that for many of the recent above average cohorts, the size of the year class was overestimated when it was age 2 compared to updated estimates as the cohort aged and more observations were available, additional forecast decision tables were created given three states of nature about the size of the 2010 year class. These states of nature are low 2010 recruitment, medium 2010 recruitment, and high 2010 recruitment, and each state of nature is defined to have a probability of 10%, 80%, and 10%, respectively. Table 16 shows the median depletion and fishing intensity within each state of nature, and it can be seen that in the low recruitment state of nature the fishing intensity would be at target with a 2013 catch between 300,000 and 350,000 mt. Table 17 shows the probability metrics for each state of nature. In the low recruitment state of nature there is an equal probability that the spawning biomass in 2014 will be less than or greater than the spawning biomass in 2013 with a catch between 300,000 and 350,000 mt. There is an equal probability that the spawning biomass will be below 40% of unfished equilibrium spawning biomass with a catch near 400,000 mt. The probabilities are conditional probabilities given that the state of nature occurs (i.e., there may be a 50% probability that depletion falls below 40%, but that is conditioned on there being a 10% probability that a low recruitment occurs).

3.4.7 Sensitivity analyses

Sensitivity analyses were conducted to investigate the structural uncertainty of the base model by examining the effect of changing parameter priors and assumptions. The sensitivities included the following:

1. Increasing the standard deviation on the prior for natural mortality (*M*),
2. Decreasing the mean of the prior on steepness (*h*) or increasing steepness to 1.0,
3. Increasing or decreasing the recruitment variability assumption (σ_R),
4. Increasing or decreasing the maximum age for which selectivity was estimated, and
5. Allowing fishery selectivity to change from year to year.

Using larger standard deviations for the prior on *M* increased the median posterior estimates for this parameter, from 0.224 in the base case to 0.278 with a three-fold increase in the SD of the prior distribution, from 0.1 to 0.3 (Figure 38). In all cases, the median of the prior was 0.2. Higher values of *M* in this sensitivity were associated with a larger stock sizes with greater uncertainty (Figure 39, Table 18). In combination, this changed the upper range of estimated stock status much more than the lower, with the upper limit of the 95% interval for depletion in 2013 shifting from 160% of SB_0 in the base case to 220% of SB_0 with the widest prior on *M*. The lower limit of this interval on 2013 depletion showed less sensitivity and increased from 35% to 37%.

Alternative assumptions about the mean steepness had a large effect on the posterior parameter estiamtes, but relatively little effect on model results. Decreasing the prior mean from 0.777 in the base case to 0.5, resulted in a decrease in the median of the posterior from 0.823 to 0.576 (Figure 40, Table 19). However, the time-series of depletion and recruitment was not substantially impacted by this change, and thus the stock status was also relatively unchanged (Figure 41). Over the range of depletion estimated to have occurred for hake, the very large variability in recruitment overwhelms the influence of any decline in mean recruitment implied by the spawner-recruit relationship (Figure 29).

Increasing or decreasing σ_R from 1.4 to either 1.0 or 2.0 had a small impact on the estimated recruitments or spawning biomass, but a larger impact on the equilibrium spawning biomass (Figure 42, Table 20). With an increase in σ_R from 1.4 to 2.0, the posterior median of SB_0 increases from 2,081 to 5,097 thousand mt while the estimated change in SB_{2013} only changes from 1,504 to 1,690 thousand mt. The 2013 depletion values, representing the ratio of these two quantities, changes dramatically, with a much lower stock status in the case with σ_R = 2.0. Decreasing σ_R has an opposite, though less substantial, impact on the relationship between estimated equilibrium spawning biomass and the estimated spawning biomass within the time-series. These changes are attributable to properties of the lognormal distribution that is used to model recruitment. At σ_R = 1.4, the median is 38% of the mean, while at σ_R = 1.0 and 2.0, this ratio is 61% and 14% respectively. However, the changes in σ_R do not result in equal changes in the variability of the estimated recruitments. Over the years 1971–2010 which have good information about which recruitments are high or low, changing σ_R from 1.4 to 1.0 or 2.0 results in a change in the standard deviation of the median recruitment deviations from 1.49 to 1.30 or 1.77, respectively (Figure 42, Table 20). The good match between the assumed and realized varability in recruitment for the base case, as recommended by Methot and Taylor (2012), results in a mean recruitment over the time-series that is similar to the equilibrium value. Changing the assumptions about about σ_R results in a mismatch between assumed and realized values of recruitment which leads to a time-series of recruitments that are inconstant with the equilibrium assumption and large changes in estimated stock status.

The sensitivity to changes in assumption about the maximum age for which selectivity was estimated had little influence on model results (Figure 43, Table 21). The assessment in 2012 showed much greater sensitivity at the end of the time-series due to uncertainty in the 2008 year class. This assessment was not as variable because incoming recruitment was more certain due to repeat observations from the fishery and survey.. As the maximum estimated age at selectivity increased, the selectivity at younger ages slightly decreased (Figure 44). Increasing the maximum age estimated beyond age 7 produced very uncertain estimates of selectivity at older ages (not shown).

Two sensitivity analyses were performed to investigate time-varying selectivity. Both cases were implemented by allowing all of the estimated selectivity parameters (controlling changes in selectivity from ages 1–6) to vary annually according to a random walk process over the years 1980 to 2012 (Figure 45). This required 165 additional parameters, more than tripling the number of estimated quantities in the model. The Flexible Fishery case assumed a more strict deviation penalty in the random walk (0.05) than the Very Flexible Fishery case (0.2). See Appendix C for more information on the nonparametric selectivity option. Due to the much greater computational burden of models with time-varying selectivity and potential issues with MCMC convergence, both sensitivity cases were conducted using the MLE estimates, rather than doing the full posterior integration.

Allowing time-varying fishery selectivity reduced the estimates of the 2008 and 2010 recruitment, relative to the base case model, by approximately 30% (Table 22), but otherwise had relatively little influence on the depletion time-series (Figure 46). Strong cohorts that were observed repeatedly in the fishery and the survey age-composition data were well estimated regardless of the amount of flexibility in survey selectivity, whereas the appearance of strong cohorts in the most recent years could be attributable to changes in fishing patterns instead of good recruitment. However, the consistency between the 2012 age compositions from the fishery and survey limits the extent to which the model can reduce the strength of the 2008 and 2010 year classes, even in the presence of time-varying selectivity. Although selectivity may indeed be expected to change over time, the base case model is more parsimonious, provides very similar results to models with time-varying selectivity, and is more computationally stable. An exploration of the effects of time-varying selectivity within the context of an MSE would be a valuable step toward better understanding the trade-offs related to the use of such assumptions in a stock assessment.

3.4.8 Retrospective analyses

Retrospective analyses were conducted by systematically removing the terminal year's data sequentially for ten years. For the base model, the effect of the 2012 data is dramatic, as was observed in the bridge analysis, and was a mainly a result of the estimates of the 2008 and 2010 year classes (Figure 47). A retrospective pattern is not apparent in estimates of spawning biomass over the last decade, but the large amount of variability and a pattern of low spawning biomass predicted immediately after a strong recruitment event, followed by a large biomass when the year class is finally observed suggests that the model is unable to accurately predict recruitment until has been observed a few times. Parameter estimates showed no clear patterns except that the additional variability on the acoustic survey index increased in 2011 due to the contrast in 2009 and 2011 survey biomass estimates (Table 23). However, some recruitment-deviation estimates showed retrospective patterns, especially while the corresponding cohort was young and observed only a few times (Figure 48).

In general, the model captures the direction of cohort-specific recruitment deviations (i.e. positive or negative), but it cannot determine their magnitude until several years of catch and age-composition data have been collected. Figure 48 shows the retrospective pattern in recruitment deviation estimates. As data are removed, less information is available to accurately estimate these deviations, and they move towards zero. Figure 48 shows that cohort-specific recruitment deviations do not follow a predictable retrospective pattern: some grow larger with more data (1999, 2001); some grow smaller (2002, 2004 and 2007); while still others alternate between increasing and decreasing (2000, 2001, 2005, 2006, and 2008). This is a further illustration of how multiple observations are needed to accurately determine the strength of the largest cohorts.

A comparison of the models put forward for management since 1991 (a retrospective among assessment models) shows that there has been considerable uncertainty in the Pacific hake stock biomass and status (Figure 49). Model-to-model variability (especially in the early portion of the time-series) is larger than the uncertainty reported in any single model, and this pattern does not appear to dampen as subsequent assessments are developed. An important aspect of this historical perspective is the inclusion of alternate values for survey catchability during 2004-2007, and then subsequently freely estimated values from 2008-the present. Prior to that period, catchability was ubiquitously assumed to be equal to 1.0. The 2013 base model estimates of spawning biomass appear to be consistent with many previous time-series, and the uncertainty intervals bracket a large proportion of those historical estimates.

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6 Tables

Table 1: Annual catches of Pacific hake (1000s mt) in U.S. and Canadian waters by sector, 1966-2011. Tribal catches are included in the sector totals.

	U.S.					Canada				
Year	Foreign	JV	At-sea	Shore -based	Total U.S.	Foreign	JV	Domestic	Total Canada	Total
1966	137.00	0.00	0.00	0.00	137.00	0.70	0.00	0.00	0.70	137.70
1967	168.70	0.00	0.00	8.96	177.66	36.71	0.00	0.00	36.71	214.37
1968	60.66	0.00	0.00	0.16	60.82	61.36	0.00	0.00	61.36	122.18
1969	86.19	0.00	0.00	0.09	86.28	93.85	0.00	0.00	93.85	180.13
1970	159.51	0.00	0.00	0.07	159.58	75.01	0.00	0.00	75.01	234.59
1971	126.49	0.00	0.00	1.43	127.92	26.70	0.00	0.00	26.70	154.62
1972	74.09	0.00	0.00	0.04	74.13	43.41	0.00	0.00	43.41	117.54
1973	147.44	0.00	0.00	0.07	147.51	15.13	0.00	0.00	15.13	162.64
1974	194.11	0.00	0.00	0.00	194.11	17.15	0.00	0.00	17.15	211.26
1975	205.65	0.00	0.00	0.00	205.65	15.70	0.00	0.00	15.70	221.35
1976	231.33	0.00	0.00	0.22	231.55	5.97	0.00	0.00	5.97	237.52
1977	127.01	0.00	0.00	0.49	127.50	5.19	0.00	0.00	5.19	132.69
1978	96.83	0.86	0.00	0.69	98.38	3.45	1.81	0.00	5.26	103.64
1979	114.91	8.83	0.00	0.94	124.68	7.90	4.23	0.30	12.43	137.11
1980	44.02	27.54	0.00	0.79	72.35	5.27	12.21	0.10	17.58	89.93
1981	70.36	43.56	0.00	0.88	114.80	3.92	17.16	3.28	24.36	139.16
1982	7.09	67.46	0.00	1.03	75.58	12.48	19.68	0.00	32.16	107.74
1983	0.00	72.10	0.00	1.05	73.15	13.12	27.66	0.00	40.78	113.93
1984	14.77	78.89	0.00	2.72	96.38	13.20	28.91	0.00	42.11	138.49
1985	49.85	31.69	0.00	3.89	85.44	10.53	13.24	1.19	24.96	110.40
1986	69.86	81.64	0.00	3.47	154.97	23.74	30.14	1.77	55.65	210.62
1987	49.66	106.00	0.00	4.80	160.45	21.45	48.08	4.17	73.70	234.15
1988	18.04	135.78	0.00	6.87	160.69	38.08	49.24	0.83	88.15	248.84
1989	0.00	195.64	0.00	7.41	203.05	29.75	62.72	2.56	95.03	298.08
1990	0.00	170.97	4.54	9.63	185.14	3.81	68.31	4.02	76.14	261.29
1991	0.00	0.00	205.82	23.97	229.79	5.61	68.13	16.17	89.92	319.71
1992	0.00	0.00	154.74	56.13	210.87	0.00	68.78	20.04	88.82	299.69
1993	0.00	0.00	98.04	42.11	140.15	0.00	46.42	12.35	58.77	198.92
1994	0.00	0.00	179.87	73.62	253.48	0.00	85.16	23.78	108.94	362.42
1995	0.00	0.00	102.31	74.96	177.27	0.00	26.19	46.18	72.37	249.64
1996	0.00	0.00	128.11	85.13	213.24	0.00	66.78	26.36	93.14	306.38
1997	0.00	0.00	146.05	87.42	233.47	0.00	42.57	49.23	91.79	325.26
1998	0.00	0.00	145.16	87.86	233.01	0.00	39.73	48.07	87.80	320.81
1999	0.00	0.00	141.02	83.47	224.49	0.00	17.20	70.16	87.36	311.84
2000	0.00	0.00	120.92	85.85	206.77	0.00	15.06	6.38	21.44	228.21
2001	0.00	0.00	100.53	73.41	173.94	0.00	21.65	31.94	53.59	227.53
2002	0.00	0.00	84.75	45.71	130.46	0.00	0.00	50.24	50.24	180.70
2003	0.00	0.00	86.61	55.34	141.95	0.00	0.00	63.23	63.23	205.18
2004	0.00	0.00	117.07	96.50	213.57	0.00	58.89	66.19	125.08	338.65
2005	0.00	0.00	151.07	109.05	260.12	0.00	15.69	87.34	103.04	363.16
2006	0.00	0.00	139.79	127.17	266.96	0.00	14.32	80.49	94.80	361.76
2007	0.00	0.00	126.24	91.44	217.68	0.00	6.78	66.67	73.45	291.13
2008	0.00	0.00	180.64	67.76	248.40	0.00	3.59	70.16	73.75	322.14
2009	0.00	0.00	72.35	49.22	121.57	0.00	0.00	55.88	55.88	177.46
2010	0.00	0.00	106.31	63.79	170.10	0.00	8.08	48.01	56.09	226.20
2011	0.00	0.00	128.07	102.15	230.22	0.00	9.72	45.91	55.63	285.85
2012	0.00	0.00	93.78	63.49	157.26	0.00	0.00	46.78	46.78	204.04
Mean					165.73				56.11	221.84

Table 2: Recent trend in Pacific hake landings and management.

Year	Total Landings (mt)	Coast-wide (US+Canada) catch target (mt)
2003	205,177	228,000
2004	338,654	501,073
2005	363,157	364,197
2006	361,761	364,842
2007	291,129	328,358
2008	322,145	364,842
2009	177,459	184,000
2010	226,202	262,500
2011	286,055	393,751
2012	204,040	251,809

Table 3: Annual summary of U.S. and Canadian fishery sampling included in this stock assessment. Canadian, foreign, joint-venture and at-sea sectors are in number of hauls sampled for age-composition, the shore-based sector is in number of trips.

	U.S.				Canada		
Year	Foreign	Joint-venture	At-sea	Shore-based	Foreign	Joint-venture	Domestic
1975	13	—	—	—	—	—	—
1976	142	—	—	—	—	—	—
1977	320	—	—	—	—	—	—
1978	336	5	—	—	—	—	—
1979	99	17	—	—	—	—	—
1980	191	30	—	—	—	—	—
1981	113	41	—	—	—	—	—
1982	52	118	—	—	—	—	—
1983	0	117	—	—	—	—	—
1984	49	74	—	—	—	—	—
1985	37	19	—	—	—	—	—
1986	88	32	—	—	—	—	—
1987	22	34	—	—	—	—	—
1988	39	42	—	—	—	—	—
1989	—	77	—	—	—	—	—
1990	—	143	—	15	—	5	—
1991	—	—	116	26	—	18	—
1992	—	—	164	46	—	33	—
1993	—	—	108	36	—	25	—
1994	—	—	143	50	—	41	—
1995	—	—	61	51	—	35	—
1996	—	—	123	35	—	28	—
1997	—	—	127	65	—	27	3
1998	—	—	149	64	—	21	9
1999	—	—	389	80	—	14	31
2000	—	—	413	91	—	25	—
2001	—	—	429	82	—	28	2
2002	—	—	342	71	—	—	37
2003	—	—	358	78	—	—	21
2004	—	—	381	72	—	20	28
2005	—	—	499	58	—	11	45
2006	—	—	549	83	—	21	67
2007	—	—	524	68	—	1	36
2008	—	—	680	63	—	—	51
2009	—	—	594	66	—	—	26
2010	—	—	774	75	—	—	24
2011	—	—	987	81	—		13
2012	—	—	460	65	—	—	144

Table 4: Summary of the acoustic surveys from 1995 to 2012.

Year	Start date	End date	Vessels	Biomass index (million mt)	Sampling CV[1]	Number of hauls with bio. samples
1995	1 July	1 Sept.	Miller Freeman, Ricker	1.518	0.067	69
1998	6 July	27 Aug.	Miller Freeman, Ricker	1.343	0.049	84
2001	15 June	18 Aug	Miller Freeman, Ricker	0.919	0.082	49
2003	29 June	1 Sept.	Ricker	2.521	0.071	71
2005	20 June	19 Aug.	Miller Freeman	1.755	0.085	49
2007	20 June	21 Aug.	Miller Freeman	1.123	0.075	130
2009	30 June	7 Sept.	Miller Freeman, Ricker	1.612	0.137[2]	61
2011	26 June	10 Sept	Bell Shimada, Ricker	0.521	0.1015	59
2012	23 June	7 Sept	Bell Shimada, Ricker, F/V Forum Star	1.381	0.0475	94

[1]Sampling CV includes only error associated with kriging of transect-based observations.
[2]Also includes bootstrapped estimates of uncertainty associated with delineation of Humboldt squid from hake.

Table 5: Number of Pacific hake ovaries sampled for histological analysis. The 2009 numbers reflect useable samples, while the 2012 sample are total number of samples which have not been analyzed. The 2012 trawl survey samples sizes (italics) are approximate and have yet to be finalized.

Length bin (cm)	Trawl Survey 2009	Trawl Survey 2012	Acoustic Survey 2012	Total
<20	12	*0*	0	12
20-21	6	*0*	0	6
22-23	17	*0*	0	17
24-25	16	*2*	3	21
26-27	8	*2*	7	17
28-29	4	*2*	11	17
30-31	5	*3*	22	30
32-33	13	*5*	12	30
34-35	4	*2*	24	30
36-37	9	*4*	15	28
38-39	19	*3*	8	30
40-41	17	*3*	14	34
42-43	17	*1*	9	27
44-45	13	*3*	11	27
46-47	18	*5*	8	31
48-49	19	*5*	6	30
50-51	15	*3*	9	27
52-53	4	*7*	10	21
54-55	9	*1*	9	19
56-57	5	*6*	6	17
58-59	5	*2*	7	14
60-61	7	*1*	4	12
>61	19	*6*	6	31
Total	**261**	***66***	**201**	**528**

Table 6: Summary of estimated model parameters and priors in the base-case model. The Beta prior is parameterized with a mean and standard deviation. The lognormal distribution (LN) is parameterized with the median and standard deviation in log space.

Parameter	Number estimated	Bounds (low, high)	Prior (Mean, SD) (single value = fixed)
	Stock dynamics		
Ln(R_0)	1	(13,17)	uniform
Steepness (h)	1	(0.2,1.0)	~Beta(0.777,0.113)
Recruitment variability (σ_R)	-	NA	1.40
Ln(Rec. deviations): 1946-2012	67	(-6, 6)	~LN(0, σ_r)
Natural mortality (M)	1	(0.05,0.4)	~LN(0.2,0.1)
	Catchability and selectivity (double normal)		
Acoustic survey:			
Catchability (q)	1	NA	Analytic solution
Additional value for acoustic survey log(SE)	1	(0.0, 1.2)	Uniform
Non parametric age-based selectivity: ages 3–6	4	(-5,9)	Uniform in scaled logistic space
Fishery:			
Non parametric age-based selectivity: ages 2–6	5	(-5,9)	Uniform in scaled logistic space
Total: 14 + 67 recruitment deviations = 81 estimated parameters. See Appendix A for all parameter estimates.			

Table 7: Estimates of important quantities (MLE) from the models bridging the 2012 base model to the 2013 base model.

MLE results	2012 base model	Update 2011 data and weight-at-age	Add 2012 fishery data	Add 2012 acoustic data (2013 base)
SB0 (thousand mt)	1,766	1,732	1,907	1,924
Spawning biomass 2012 (thousand mt)	483	372	949	932
Spawning biomass 2013 (thousand mt)	566	459	1,370	1,313
Depletion 2011	26.1%	18.8%	28.9%	29.7%
Depletion 2012	27.4%	21.5%	49.8%	48.4%
Depletion 2013	32.1%	26.5%	71.8%	68.2%
Age-0 recruits 2008 (billions)	4.058	2.915	4.751	4.766
Age-0 recruits 2010 (billions)	2.076	3.384	12.808	11.624

Table 8: Time-series of median posterior population estimates from the base-case model

Year	Female spawning biomass (millions mt)	Depletion	Age-0 recruits (billions)	(1-SPR) / (1-$SPR_{40\%}$)	Exploitation fraction
1966	1.068	NA	1.430	44.0%	6.2%
1967	0.992	47.9%	3.071	63.1%	10.4%
1968	0.915	44.3%	2.084	46.4%	6.4%
1969	0.983	47.6%	0.854	60.7%	9.3%
1970	1.038	50.3%	7.957	68.5%	10.4%
1971	1.033	50.3%	0.729	51.7%	6.8%
1972	1.228	60.4%	0.434	40.5%	5.5%
1973	1.406	69.0%	4.307	44.5%	4.9%
1974	1.420	69.4%	0.413	50.5%	6.8%
1975	1.422	70.0%	1.352	44.5%	6.4%
1976	1.398	68.3%	0.319	41.3%	5.4%
1977	1.323	64.6%	5.063	29.4%	3.7%
1978	1.222	59.9%	0.294	27.3%	3.4%
1979	1.258	61.4%	0.943	32.6%	4.6%
1980	1.264	61.8%	16.550	25.9%	2.8%
1981	1.231	60.1%	0.294	38.0%	5.0%
1982	1.636	80.0%	0.266	33.0%	4.7%
1983	2.044	99.5%	0.434	26.9%	2.4%
1984	2.166	105.0%	13.053	27.5%	3.0%
1985	2.070	100.2%	0.201	22.4%	2.6%
1986	2.285	110.3%	0.219	36.6%	5.8%
1987	2.416	116.7%	5.407	39.8%	4.4%
1988	2.313	111.4%	1.929	40.4%	5.2%
1989	2.225	107.4%	0.173	51.9%	8.0%
1990	2.090	101.2%	4.395	45.1%	6.3%
1991	1.900	91.9%	0.547	55.0%	8.2%
1992	1.737	84.2%	0.196	59.7%	10.0%
1993	1.567	75.8%	3.317	53.3%	7.5%
1994	1.370	66.3%	2.508	78.0%	14.9%
1995	1.149	55.5%	1.360	68.6%	12.7%
1996	1.087	52.3%	1.601	81.3%	15.2%
1997	0.990	47.7%	1.277	86.3%	15.9%
1998	0.884	42.6%	1.802	91.4%	18.8%
1999	0.768	37.0%	11.104	95.4%	21.4%
2000	0.670	32.3%	0.352	79.9%	14.7%
2001	0.962	46.2%	0.839	73.4%	13.4%
2002	1.230	58.9%	0.070	47.8%	4.6%
2003	1.340	64.1%	1.335	50.6%	6.3%
2004	1.268	60.5%	0.069	74.1%	12.8%
2005	1.064	50.8%	2.172	82.7%	18.7%
2006	0.811	39.0%	1.721	94.7%	22.7%
2007	0.617	29.7%	0.088	99.3%	27.5%
2008	0.529	25.5%	5.526	109.4%	29.2%
2009	0.424	20.4%	2.269	94.7%	18.4%
2010	0.520	25.5%	13.606	104.7%	30.7%
2011	0.642	31.5%	0.737	105.2%	21.5%
2012	1.078	51.6%	0.916	81.0%	14.5%
2013	1.504	72.3%	1.061	NA	NA

Table 9: Time-series of ~95% posterior credibility intervals for female spawning biomass, relative depletion estimates, age-0 recruits, relative spawning potential ratio[(1-SPR)/(1-SPRTarget=0.4)] and exploitation fraction from the base-case model

Year	Female spawning Biomass (millions mt)	Depletion	Age-0 recruits (billions)	(1-SPR) / (1-SPR_{target})	Exploitation fraction
1966	0.57-1.99	NA-NA	0.06-9.48	0.24-0.71	0.03-0.12
1967	0.54-1.83	0.26-0.86	0.17-11.87	0.38-0.93	0.05-0.20
1968	0.50-1.70	0.24-0.80	0.12-8.89	0.26-0.75	0.03-0.13
1969	0.58-1.79	0.28-0.81	0.06-5.02	0.35-0.88	0.05-0.18
1970	0.64-1.90	0.31-0.87	3.75-17.68	0.41-0.96	0.05-0.18
1971	0.62-1.95	0.30-0.89	0.06-3.19	0.29-0.78	0.03-0.11
1972	0.76-2.33	0.36-1.02	0.05-2.07	0.21-0.64	0.03-0.09
1973	0.88-2.63	0.43-1.16	2.14-9.93	0.24-0.68	0.03-0.08
1974	0.88-2.67	0.43-1.17	0.05-1.63	0.27-0.76	0.04-0.11
1975	0.85-2.69	0.42-1.17	0.46-3.33	0.24-0.70	0.03-0.11
1976	0.83-2.67	0.40-1.16	0.03-1.47	0.21-0.66	0.03-0.09
1977	0.77-2.50	0.38-1.09	2.57-10.54	0.15-0.50	0.02-0.06
1978	0.71-2.26	0.35-1.00	0.03-1.51	0.14-0.46	0.02-0.06
1979	0.74-2.23	0.36-1.02	0.16-3.03	0.17-0.53	0.03-0.08
1980	0.76-2.29	0.37-1.01	9.89-30.61	0.13-0.43	0.02-0.05
1981	0.76-2.19	0.36-0.97	0.04-1.44	0.21-0.60	0.03-0.08
1982	1.08-2.68	0.52-1.23	0.04-1.21	0.19-0.53	0.03-0.08
1983	1.37-3.24	0.67-1.49	0.05-1.64	0.15-0.42	0.02-0.04
1984	1.49-3.41	0.71-1.54	8.44-22.65	0.16-0.43	0.02-0.04
1985	1.43-3.17	0.69-1.45	0.03-0.97	0.13-0.35	0.02-0.04
1986	1.65-3.36	0.79-1.56	0.03-0.96	0.23-0.53	0.04-0.08
1987	1.78-3.45	0.83-1.61	3.29-9.22	0.26-0.57	0.03-0.06
1988	1.74-3.27	0.81-1.51	0.72-3.98	0.27-0.56	0.04-0.07
1989	1.69-3.08	0.79-1.45	0.02-0.72	0.36-0.70	0.06-0.10
1990	1.62-2.87	0.74-1.35	3.02-7.16	0.30-0.61	0.05-0.08
1991	1.50-2.56	0.68-1.22	0.09-1.40	0.39-0.71	0.06-0.10
1992	1.39-2.32	0.63-1.11	0.03-0.64	0.43-0.76	0.08-0.13
1993	1.26-2.06	0.57-1.00	2.30-4.95	0.38-0.69	0.06-0.09
1994	1.13-1.77	0.50-0.87	1.56-3.90	0.60-0.94	0.12-0.18
1995	0.95-1.47	0.42-0.73	0.77-2.25	0.52-0.84	0.10-0.16
1996	0.90-1.38	0.40-0.68	1.03-2.59	0.64-0.97	0.12-0.18
1997	0.83-1.24	0.37-0.62	0.70-2.12	0.69-1.01	0.13-0.19
1998	0.73-1.11	0.33-0.55	1.17-2.90	0.74-1.06	0.15-0.23
1999	0.63-0.98	0.28-0.48	8.17-15.91	0.77-1.11	0.17-0.26
2000	0.53-0.88	0.24-0.43	0.08-0.81	0.61-0.97	0.11-0.19
2001	0.78-1.25	0.35-0.61	0.52-1.30	0.55-0.90	0.10-0.17
2002	1.02-1.56	0.45-0.77	0.01-0.24	0.35-0.62	0.04-0.06
2003	1.14-1.65	0.50-0.83	0.97-1.93	0.38-0.64	0.05-0.07
2004	1.09-1.53	0.47-0.77	0.01-0.23	0.59-0.89	0.11-0.15
2005	0.93-1.28	0.40-0.64	1.56-3.38	0.67-0.96	0.16-0.21
2006	0.71-1.00	0.31-0.49	1.15-3.05	0.79-1.08	0.18-0.26
2007	0.53-0.81	0.24-0.38	0.02-0.29	0.84-1.12	0.21-0.32
2008	0.44-0.75	0.20-0.34	3.29-11.72	0.93-1.22	0.21-0.35
2009	0.33-0.67	0.15-0.30	1.09-5.52	0.72-1.10	0.12-0.24
2010	0.37-0.96	0.17-0.42	6.04-34.40	0.80-1.21	0.18-0.42
2011	0.41-1.33	0.19-0.58	0.06-9.51	0.75-1.25	0.10-0.33
2012	0.57-2.54	0.27-1.11	0.05-11.50	0.46-1.09	0.06-0.26
2013	0.71-3.68	0.35-1.60	0.05-16.93	0.98-1.00	0.13-0.20

Table 10: Estimated numbers at age at the beginning of the year from the base model (MLE; billions).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1966	1.63	1.20	0.78	0.57	0.44	0.36	0.30	0.26	0.22	0.19	0.17	0.14	0.12	0.10	0.09	0.38
1967	2.95	1.31	0.97	0.62	0.45	0.34	0.27	0.23	0.19	0.17	0.14	0.12	0.11	0.09	0.08	0.35
1968	2.15	2.38	1.06	0.77	0.48	0.33	0.25	0.19	0.16	0.14	0.12	0.10	0.09	0.07	0.06	0.30
1969	1.05	1.74	1.92	0.85	0.60	0.36	0.25	0.18	0.14	0.12	0.10	0.09	0.07	0.06	0.06	0.27
1970	6.48	0.84	1.40	1.53	0.65	0.44	0.27	0.18	0.13	0.10	0.08	0.07	0.06	0.05	0.05	0.23
1971	0.81	5.23	0.68	1.11	1.15	0.47	0.31	0.18	0.12	0.09	0.07	0.06	0.05	0.04	0.04	0.19
1972	0.48	0.66	4.22	0.54	0.86	0.87	0.35	0.23	0.13	0.09	0.06	0.05	0.04	0.04	0.03	0.16
1973	3.69	0.39	0.53	3.38	0.42	0.66	0.66	0.26	0.17	0.10	0.06	0.05	0.04	0.03	0.03	0.14
1974	0.42	2.98	0.31	0.42	2.62	0.32	0.49	0.48	0.19	0.12	0.07	0.05	0.03	0.03	0.02	0.12
1975	1.17	0.34	2.40	0.25	0.33	1.97	0.24	0.36	0.35	0.14	0.09	0.05	0.03	0.03	0.02	0.11
1976	0.34	0.95	0.27	1.92	0.19	0.25	1.48	0.18	0.26	0.26	0.10	0.07	0.04	0.03	0.02	0.09
1977	4.45	0.28	0.76	0.22	1.50	0.15	0.19	1.10	0.13	0.19	0.19	0.07	0.05	0.03	0.02	0.08
1978	0.28	3.59	0.22	0.61	0.17	1.17	0.11	0.14	0.84	0.10	0.15	0.15	0.06	0.04	0.02	0.08
1979	0.93	0.23	2.89	0.18	0.48	0.13	0.90	0.09	0.11	0.64	0.08	0.11	0.11	0.04	0.03	0.08
1980	14.56	0.75	0.19	2.32	0.14	0.37	0.10	0.69	0.07	0.08	0.49	0.06	0.09	0.08	0.03	0.08
1981	0.32	11.75	0.61	0.15	1.84	0.11	0.29	0.08	0.53	0.05	0.06	0.38	0.04	0.07	0.07	0.09
1982	0.26	0.26	9.47	0.49	0.12	1.41	0.08	0.22	0.06	0.40	0.04	0.05	0.28	0.03	0.05	0.11
1983	0.44	0.21	0.21	7.60	0.38	0.09	1.08	0.06	0.17	0.04	0.30	0.03	0.04	0.21	0.03	0.12
1984	11.81	0.36	0.17	0.17	6.01	0.30	0.07	0.83	0.05	0.13	0.03	0.23	0.02	0.03	0.16	0.11
1985	0.21	9.53	0.29	0.14	0.13	4.69	0.23	0.05	0.64	0.04	0.10	0.03	0.18	0.02	0.02	0.21
1986	0.22	0.17	7.69	0.23	0.11	0.10	3.68	0.18	0.04	0.50	0.03	0.08	0.02	0.14	0.01	0.18
1987	4.92	0.18	0.13	6.16	0.18	0.08	0.08	2.76	0.14	0.03	0.37	0.02	0.06	0.02	0.10	0.15
1988	1.90	3.97	0.15	0.11	4.81	0.14	0.06	0.06	2.06	0.10	0.02	0.28	0.02	0.04	0.01	0.19
1989	0.19	1.54	3.20	0.12	0.08	3.69	0.11	0.05	0.04	1.54	0.08	0.02	0.21	0.01	0.03	0.15
1990	4.04	0.15	1.24	2.55	0.09	0.06	2.72	0.08	0.03	0.03	1.11	0.05	0.01	0.15	0.01	0.13
1991	0.59	3.26	0.12	0.99	1.99	0.07	0.05	2.01	0.06	0.02	0.02	0.82	0.04	0.01	0.11	0.10
1992	0.20	0.47	2.63	0.10	0.76	1.48	0.05	0.03	1.43	0.04	0.02	0.02	0.58	0.03	0.01	0.15
1993	3.09	0.16	0.38	2.10	0.07	0.56	1.07	0.04	0.02	1.00	0.03	0.01	0.01	0.41	0.02	0.11
1994	2.31	2.49	0.13	0.31	1.61	0.06	0.41	0.77	0.03	0.02	0.72	0.02	0.01	0.01	0.29	0.09
1995	1.27	1.86	2.01	0.10	0.23	1.13	0.04	0.27	0.49	0.02	0.01	0.46	0.01	0.01	0.01	0.25
1996	1.49	1.02	1.50	1.60	0.08	0.16	0.79	0.03	0.18	0.33	0.01	0.01	0.31	0.01	0.00	0.17
1997	1.19	1.20	0.83	1.19	1.17	0.05	0.11	0.50	0.02	0.11	0.21	0.01	0.00	0.20	0.01	0.11
1998	1.67	0.96	0.97	0.65	0.86	0.79	0.03	0.07	0.30	0.01	0.07	0.13	0.00	0.00	0.12	0.07
1999	10.12	1.35	0.77	0.76	0.46	0.56	0.50	0.02	0.04	0.18	0.01	0.04	0.07	0.00	0.00	0.11
2000	0.37	8.16	1.09	0.60	0.53	0.30	0.34	0.27	0.01	0.02	0.10	0.00	0.02	0.04	0.00	0.06
2001	0.78	0.30	6.58	0.86	0.44	0.37	0.20	0.22	0.17	0.01	0.01	0.06	0.00	0.01	0.03	0.04
2002	0.07	0.63	0.24	5.22	0.64	0.31	0.26	0.13	0.14	0.11	0.00	0.01	0.04	0.00	0.01	0.04
2003	1.24	0.06	0.51	0.19	4.04	0.48	0.23	0.19	0.10	0.10	0.08	0.00	0.01	0.03	0.00	0.04
2004	0.07	1.00	0.05	0.40	0.15	3.04	0.36	0.17	0.14	0.07	0.08	0.06	0.00	0.00	0.02	0.03
2005	1.95	0.06	0.80	0.04	0.30	0.11	2.10	0.24	0.11	0.09	0.05	0.05	0.04	0.00	0.00	0.03
2006	1.54	1.58	0.05	0.63	0.03	0.21	0.07	1.31	0.15	0.07	0.06	0.03	0.03	0.03	0.00	0.02
2007	0.09	1.24	1.27	0.04	0.45	0.02	0.13	0.04	0.74	0.08	0.04	0.03	0.02	0.02	0.01	0.01
2008	4.77	0.08	1.00	0.99	0.02	0.28	0.01	0.07	0.02	0.39	0.04	0.02	0.02	0.01	0.01	0.01
2009	1.95	3.85	0.06	0.77	0.65	0.01	0.14	0.00	0.03	0.01	0.17	0.02	0.01	0.01	0.00	0.01
2010	11.62	1.58	3.10	0.05	0.54	0.41	0.01	0.08	0.00	0.02	0.01	0.09	0.01	0.01	0.00	0.01
2011	1.84	9.38	1.27	2.40	0.03	0.32	0.22	0.00	0.04	0.00	0.01	0.00	0.04	0.00	0.00	0.01
2012	2.21	1.49	7.55	0.98	1.58	0.02	0.17	0.10	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00

Table 11: Select parameters, derived quantities, and reference point estimates for the base case MLE and posterior medians

	MLE	Posterior median
Parameters		
R_0 (billions)	2.31	2.69
Steepness (h)	0.86	0.82
Natural mortality (M)	0.21	0.22
Acoustic catchability (Q)	1.10	1.01
Additional acoustic survey SD	0.34	0.42
Derived Quantities		
2008 recruitment (billions)	4.77	5.53
2010 recruitment (billions)	11.62	13.61
SB_0 (thousand mt)	1,924	2,081
2013 Depletion	68.2%	72.3%
2012 Fishing intensity: (1-SPR)/(1-SPR40%)	88.7%	81.0%
Reference points based on $F_{40\%}$		
Female spawning biomass ($SB_{F40\%}$ million mt)	721	744
$SPR_{MSY\text{-}proxy}$	40%	40%
Exploitation fraction corresponding to SPR	20.9%	21.8%
Yield at $SB_{F40\%}$ (million mt)	315	337
Reference points based on $SB_{40\%}$		
Female spawning biomass ($SB_{40\%}$ million mt)	770	833
$SPR_{SB40\%}$	42.4%	43.2
Exploitation fraction resulting in $SB_{40\%}$	19.2%	19.2%
Yield at $SB_{40\%}$ (million mt)	308	328
Reference points based on estimated MSY		
Female spawning biomass (SB_{MSY} million mt)	434	500
SPR_{MSY}	25.6%	28.2%
Exploitation fraction corresponding to SPR_{MSY}	37.1%	34.5%
MSY (million mt)	340	357

Table 12: Summary of Pacific hake reference points from the base-case model

Quantity	2.5th percentile	Median	97.5th percentile
Unfished female *SB* (SB_0, thousand mt)	1,653	2,081	2,709
Unfished recruitment (R_0, billions)	1.761	2.687	4.303
Reference points based on $F_{40\%}$			
Female spawning biomass ($SB_{F40\%}$ thousand mt)	556	744	942
$SPR_{MSY\text{-}proxy}$	–	40%	–
Exploitation fraction corresponding to SPR	18.4%	21.8%	25.9%
Yield at $SB_{F40\%}$ (thousand mt)	243	337	479
Reference points based on $SB_{40\%}$			
Female spawning biomass ($SB_{40\%}$ thousand mt)	661	833	1,084
$SPR_{SB40\%}$	40.6	43.2	51.4
Exploitation fraction resulting in $SB_{40\%}$	14.4%	19.2%	23.3%
Yield at $SB_{40\%}$ (thousand mt)	238	328	469
Reference points based on estimated MSY			
Female spawning biomass (SB_{MSY} thousand mt)	328	500	840
SPR_{MSY}	18.3%	28.2%	46.5%
Exploitation fraction corresponding to SPR_{MSY}	17.6%	34.5%	59.5%
MSY (thousand mt)	248	357	524

Table 13: Posterior distribution quantiles for forecasts of Pacific hake relative depletion (at the beginning of the year before fishing takes place) from the base model. Numbers for 2013 are greyed because they are the same for every catch alternative since beginning of the year quantities are given. Catch alternatives are based on: 1) arbitrary constant catch levels of 0, 300,000, and 500,000 mt (rows a–c), 2) the catch level that results in an equal probability of the population increasing or decreasing from 2013 to 2014 (row d), 3) the median values estimated via the default harvest policy ($F_{40\%}$ – 40:10) for the base case (row e), 4) the catch level that results in the median spawning biomass to remain unchanged from 2013 to 2014 (row f), and 5) the catch level that results in a 50% probability that the median predicted catch will remain the same in 2014 (row g).

Within model quantile			5%	25%	50%	75%	95%
Management Action			**Beginning of year depletion**				
	Year	Catch (mt)					
a	2013	0	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	0	47.7%	68.3%	88.1%	114.4%	169.8%
b	2013	250,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	250,000	41.8%	62.5%	82.1%	108.8%	163.2%
c	2013	300,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	300,000	40.5%	61.5%	81.1%	107.7%	162.1%
d	2013	350,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	350,000	39.3%	60.3%	79.9%	106.6%	161.0%
e	2013	400,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	400,000	38.3%	59.2%	78.6%	105.6%	159.7%
f	2013	450,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	450,000	37.0%	58.0%	77.3%	104.4%	158.7%
g	2013	500,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	500,000	35.8%	56.8%	76.0%	103.2%	157.7%
h	2013	603,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	603,000	33.9%	54.3%	73.5%	100.7%	155.7%
i	2013	626,364	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	715,041	33.4%	53.8%	72.9%	100.2%	155.3%
j	2013	650,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	650,000	32.8%	53.2%	72.4%	99.7%	154.8%
k	2013	696,000	39.2%	56.9%	72.3%	95.4%	143.2%
	2014	696,000	31.7%	52.1%	71.3%	98.7%	153.9%

Table 14: Posterior distribution quantiles for forecasts of Pacific hake fishing intensity (spawning potential ratio; (1-SPR)/(1-$SPR_{40\%}$); values greater than 100% denote fishing in excess of the $F_{40\%}$ default harvest rate) from the base model. Catch alternatives are explained in Table 13.

Within model quantile			5%	25%	50%	75%	95%
Management Action			Fishing Intensity				
	Year	Catch (mt)					
a	2013	0	0%	0%	0%	0%	0%
	2014	0	0%	0%	0%	0%	0%
b	2013	250,000	37%	50%	63%	75%	91%
	2014	250,000	29%	42%	53%	64%	82%
c	2013	300,000	42%	57%	70%	82%	98%
	2014	300,000	34%	48%	61%	72%	90%
d	2013	350,000	47%	63%	76%	88%	105%
	2014	350,000	38%	54%	67%	80%	98%
e	2013	400,000	52%	68%	82%	94%	110%
	2014	400,000	42%	59%	74%	86%	104%
f	2013	450,000	57%	73%	87%	98%	114%
	2014	450,000	47%	64%	79%	92%	110%
g	2013	500,000	61%	77%	91%	102%	117%
	2014	500,000	50%	69%	84%	97%	115%
h	2013	603,000	68%	85%	99%	109%	123%
	2014	603,000	58%	78%	93%	106%	123%
i	2013	626,364	69%	87%	100%	111%	124%
	2014	715,041	65%	85%	100%	112%	129%
j	2013	650,000	71%	88%	101%	112%	125%
	2014	650,000	61%	81%	97%	109%	127%
k	2013	696,000	74%	91%	104%	114%	127%
	2014	696,000	64%	84%	100%	113%	129%

Table 15: Probabilities of various management metrics given different catch alternatives. Catch alternatives are explained in Table 13.

Catch	Probability SB_{2014}<SB_{2013}	Probability SB_{2014}<$SB_{40\%}$	Probability SB_{2014}<$SB_{25\%}$	Probability SB_{2014}<$SB_{10\%}$	Probability Fishing intensity in 2013 > 40% Target	Probability 2014 Catch Target < 2013 Catch
0	0%	2%	0%	0%	0%	0%
250,000	2%	4%	0%	0%	2%	1%
300,000	6%	5%	1%	0%	4%	2%
350,000	11%	6%	1%	0%	9%	4%
400,000	18%	6%	1%	0%	15%	9%
450,000	25%	7%	1%	0%	22%	14%
500,000	33%	8%	1%	0%	30%	20%
603,000	50%	9%	2%	0%	45%	36%
626,364	53%	10%	2%	0%	50%	39%
650,000	57%	10%	2%	0%	55%	42%
696,000	62%	11%	3%	0%	59%	50%

Table 16: Median forecasts of Pacific hake depletion and fishing intensity (FI) for three different states of nature based on 2010 recruitment: 1) Low 2010 recruitment uses the lowest 10% of 2010 recruitment estimates, 2) Mid 2010 recruitment uses the middle 80% of 2010 recruitment estimates, and 3) High 2010 recruitment uses the highest 10% of 2010 recruitment estimates. Catch alternatives are explained in Table 13.

	State Probability	Low 2010 recruitment 10%		Mid 2010 recruitment 80%		High 2010 recruitment 10%	
Year	Catch	Depletion	FI	Depletion	FI	Depletion	FI
2013	0	41.1%	0%	72.4%	0%	141.0%	0%
2014	0	49.3%	0%	88.2%	0%	165.8%	0%
2013	250,000	41.1%	91%	72.4%	63%	141.0%	37%
2014	250,000	43.9%	82%	82.2%	53%	160.3%	29%
2013	300,000	41.1%	98%	72.4%	70%	141.0%	42%
2014	300,000	42.8%	90%	81.1%	61%	159.3%	34%
2013	350,000	41.1%	104%	72.4%	76%	141.0%	47%
2014	350,000	41.6%	98%	79.9%	67%	158.3%	38%
2013	400,000	41.1%	109%	72.4%	82%	141.0%	52%
2014	400,000	40.3%	104%	78.6%	73%	157.2%	42%
2013	450,000	41.1%	113%	72.4%	87%	141.0%	57%
2014	450,000	39.0%	110%	77.3%	79%	156.2%	47%
2013	500,000	41.1%	117%	72.4%	91%	141.0%	61%
2014	500,000	37.6%	115%	76.0%	84%	155.1%	51%
2013	603,000	41.1%	123%	72.4%	98%	141.0%	68%
2014	603,000	35.1%	123%	73.5%	93%	153.0%	58%
2013	626,364	41.1%	124%	72.4%	100%	141.0%	69%
2014	626,364	34.6%	128%	73.0%	100%	152.5%	65%
2013	650,000	41.1%	125%	72.4%	101%	141.0%	71%
2014	650,000	34.0%	126%	72.4%	97%	152.0%	61%
2013	696,000	41.1%	127%	72.4%	104%	141.0%	74%
2014	696,000	32.9%	129%	71.3%	100%	151.0%	64%

Table 17: Probabilities of various management metrics given different catch alternatives for three different states of nature based on 2010 recruitment: 1) the lower 10% of 2010 recruitment estimates, 2) the middle 80% of 2010 recruitment estimates, and 3) the highest 10% of 2010 recruitment estimates.. Catch alternatives are explained in Table 13.

Catch	Probability $SB_{2014}<SB_{2013}$	Probability $SB_{2014}<SB_{40\%}$	Probability $SB_{2014}<SB_{25\%}$	Probability $SB_{2014}<SB_{10\%}$	Probability Fishing intensity in 2013 > 40% Target	Probability 2014 Catch Target < 2013 Catch
Lower 10% of 2010 recruitment						
0	0%	21%	1%	0%	0%	0%
250,000	16%	34%	3%	0%	15%	11%
300,000	31%	39%	5%	0%	40%	23%
350,000	56%	46%	6%	0%	74%	42%
400,000	65%	49%	9%	0%	93%	74%
450,000	69%	54%	10%	0%	99%	90%
500,000	77%	59%	14%	0%	100%	97%
603,000	89%	64%	20%	0%	100%	100%
626,364	91%	68%	20%	0%	100%	100%
650,000	92%	68%	21%	0%	100%	100%
696,000	93%	71%	24%	0%	100%	100%
Middle 80% of 2010 recruitment						
0	0%	0%	0%	0%	0%	0%
250,000	1%	1%	0%	0%	0%	0%
300,000	3%	1%	0%	0%	0%	0%
350,000	7%	1%	0%	0%	2%	0%
400,000	14%	2%	0%	0%	7%	2%
450,000	23%	2%	0%	0%	15%	6%
500,000	32%	2%	0%	0%	26%	13%
603,000	51%	3%	0%	0%	44%	32%
626,364	55%	4%	0%	0%	50%	36%
650,000	59%	4%	0%	0%	56%	40%
696,000	65%	5%	0%	0%	61%	50%
Upper 10% of 2010 recruitment						
0	0%	0%	0%	0%	0%	0%
250,000	0%	0%	0%	0%	0%	0%
300,000	0%	0%	0%	0%	0%	0%
350,000	0%	0%	0%	0%	0%	0%
400,000	0%	0%	0%	0%	0%	0%
450,000	0%	0%	0%	0%	0%	0%
500,000	0%	0%	0%	0%	0%	0%
603,000	0%	0%	0%	0%	0%	0%
626,364	1%	0%	0%	0%	0%	0%
650,000	2%	0%	0%	0%	0%	0%
696,000	3%	0%	0%	0%	0%	0%

Table 18: Select parameters, derived quantities, and reference point estimates for sensitivity analyses to alternative priors natural mortality (*M*).

	Base case	Natural mortality prior SD = 0.2	Natural mortality prior SD = 0.3
Parameters			
R_0 (billions)	2.69	4.04	4.79
Steepness (*h*)	0.823	0.809	0.800
Natural mortality (*M*)	0.224	0.263	0.278
Acoustic catchability (*Q*)	NA	NA	NA
Additional acoustic survey SD	0.416	0.434	0.444
Derived Quantities			
2008 recruitment (billions)	5.53	7.82	8.79
2010 recruitment (billions)	13.61	19.92	23.17
SB_0 (thousand mt)	2,081	2,313	2,452
2013 Depletion	72.3%	83.0%	87.0%
2012 Fishing intensity (1-SPR/1-SPR40%)	81.0%	63.9%	58.1%
Reference points based on $F_{40\%}$			
Female spawning biomass ($SB_{F40\%}$ thousand mt)	744	815	857
Equilibrium exploitation fraction corresponding to SPR	21.8%	25.5%	27.0%
Yield at $SB_{F40\%}$ (thousand mt)	337	427	481

Table 19: Select parameters, derived quantities, and reference point estimates for sensitivity analyses to alternative priors on steepness (h).

	Base case	Steepness prior mean = 0.5	Steepness = 1.0
Parameters			
R_0 (billions)	2.69	3.13	2.55
Steepness (h)	0.823	0.576	1.000
Natural mortality (M)	0.224	0.230	0.223
Acoustic catchability (Q)	NA	NA	NA
Additional acoustic survey SD	0.416	0.421	0.414
Derived Quantities			
2008 recruitment (billions)	5.53	5.56	5.50
2010 recruitment (billions)	13.61	13.92	13.70
SB_0 (thousand mt)	2,081	2,298	1,999
2013 Depletion	72.3%	65.6%	76.5%
2012 Fishing intensity (1-SPR/1-SPR40%)	81.0%	79.2%	80.4%
Reference points based on $F_{40\%}$			
Female spawning biomass ($SB_{F40\%}$ thousand mt)	744	596	800
Equilibrium exploitation fraction corresponding to SPR	21.8%	22.3%	21.6%
Yield at $SB_{F40\%}$ (thousand mt)	337	270	361

Table 20: Select parameters, derived quantities, and reference point estimates for sensitivity analyses to alternative values for the standard deviation of recruitment variability (σ_r).

	Base case	Less recruitment variability (σ_r = 1.0)	More recruitment variability (σ_r = 2.0)
Parameters			
R_0 (billions)	2.69	1.83	6.83
Steepness (h)	0.823	0.823	0.843
Natural mortality (M)	0.224	0.220	0.230
Acoustic catchability (Q)	NA	NA	NA
Additional acoustic survey SD	0.416	0.408	0.438
Derived Quantities			
2008 recruitment (billions)	5.53	4.89	6.19
2010 recruitment (billions)	13.61	11.35	15.45
SB_0 (thousand mt)	2,081	1,465	5,097
2013 Depletion	72.3%	86.9%	33.7%
2012 Fishing intensity (1-SPR/1-SPR40%)	81.0%	87.2%	75.4%
Reference points based on $F_{40\%}$			
Female spawning biomass ($SB_{F40\%}$ thousand mt)	744	528	1878
Equilibrium exploitation fraction corresponding to SPR	21.8%	21.4%	22.3%
Yield at $SB_{F40\%}$ (thousand mt)	337	233	869
Recruitment variability			
Assumed SD for recruitment variability (σ_r)	1.40	1.00	2.00
SD of median estimated recruitment deviations for years with good information about cohort strength (1971-2010)	1.49	1.30	1.77

Table 21: Select parameters, derived quantities, and reference point estimates for sensitivity analyses to alternative numbers of ages for which selectivity is estimated.

	Base case	Selectivity estimated to age 5	Selectivity estimated to age 7
Parameters			
R_0 (billions)	2.69	2.70	2.69
Steepness (h)	0.823	0.822	0.823
Natural mortality (M)	0.224	0.224	0.225
Acoustic catchability (Q)	NA	NA	NA
Additional acoustic survey SD	0.416	0.431	0.436
Derived Quantities			
2008 recruitment (billions)	5.53	5.38	5.90
2010 recruitment (billions)	13.61	12.77	14.79
SB_0 (thousand mt)	2,081	2,124	2,069
2013 Depletion	72.3%	67.6%	78.6%
2012 Fishing intensity (1-SPR/1-SPR40%)	81.0%	83.0%	77.4%
Reference points based on $F_{40\%}$			
Female spawning biomass ($SB_{F40\%}$ thousand mt)	744	758	744
Equilibrium exploitation fraction corresponding to SPR	21.8%	21.6%	21.9%
Yield at $SB_{F40\%}$ (thousand mt)	337	340	338

Table 22: Select parameters, derived quantities, and reference point estimates for sensitivity analyses to two levels of time-varying fishery selectivity. Results are MLE values in all cases.

	Base case MLE	Flexible fishery selectivity	Very flexible fishery selectivity
Parameters			
R_0 (billions)	2.31	2.20	2.22
Steepness (h)	0.861	0.861	0.861
Natural mortality (M)	0.215	0.212	0.212
Acoustic catchability (Q)	1.105	1.131	1.133
Additional acoustic survey SD	0.338	0.322	0.329
Derived Quantities			
2008 recruitment (billions)	4.77	4.17	4.38
2010 recruitment (billions)	11.62	8.99	8.98
SB_0 (thousand mt)	1,924	1,882	1,894
2013 Depletion	68.2%	56.9%	57.7%
2012 Fishing intensity (1-SPR/1-SPR40%)	88.7%	92.0%	93.7%
Reference points based on $F_{40\%}$			
Female spawning biomass ($SB_{F40\%}$ thousand mt)	721	705	710
Equilibrium exploitation fraction corresponding to SPR	20.9%	20.4%	20.5%
Yield at $SB_{F40\%}$ (thousand mt)	315	301	304

Table 23: Select parameters, derived quantities, and reference point estimates for retrospective analyses using the base case. Values in italics are implied since they occur after the ending year of the respective retrospective analysis.

	Base case	-1 year	-2 years	-3 years	-4 years	-5 years
Parameters						
R_0 (billions)	2.69	2.37	3.18	2.93	2.92	2.85
Steepness (*h*)	0.823	0.808	0.812	0.806	0.804	0.797
Natural mortality (*M*)	0.224	0.217	0.226	0.223	0.226	0.222
Acoustic catchability (*Q*)	NA	NA	NA	NA	NA	NA
Additional acoustic survey SD	0.416	0.486	0.293	0.293	0.319	0.315
Derived Quantities						
2008 recruitment (billions)	5.53	3.54	14.83	1.19	*0.87*	*0.89*
2010 recruitment (billions)	13.61	1.66	*1.12*	*1.01*	*1.01*	*0.92*
SB_0 (thousand mt)	2,081	1,948	2,391	2,301	2,281	2,222
2013 Depletion	72.3%	*24.8%*	*83.3%*	*44.8%*	*36.0%*	*33.5%*
2012 Fishing intensity (1-SPR/1-SPR40%)	81.0%	*111.8%*	*41.8%*	*58.9%*	*73.5%*	*76.9%*
Reference points based on $F_{40\%}$						
Female spawning biomass ($SB_{F40\%}$ thousand mt)	744	693	851	819	800	790
Equilibrium exploitation fraction corresponding to SPR	21.8%	21.2%	22.0%	21.8%	21.9%	21.6%
Yield at $SB_{F40\%}$ (thousand mt)	337	304	389	369	363	354

7 Figures

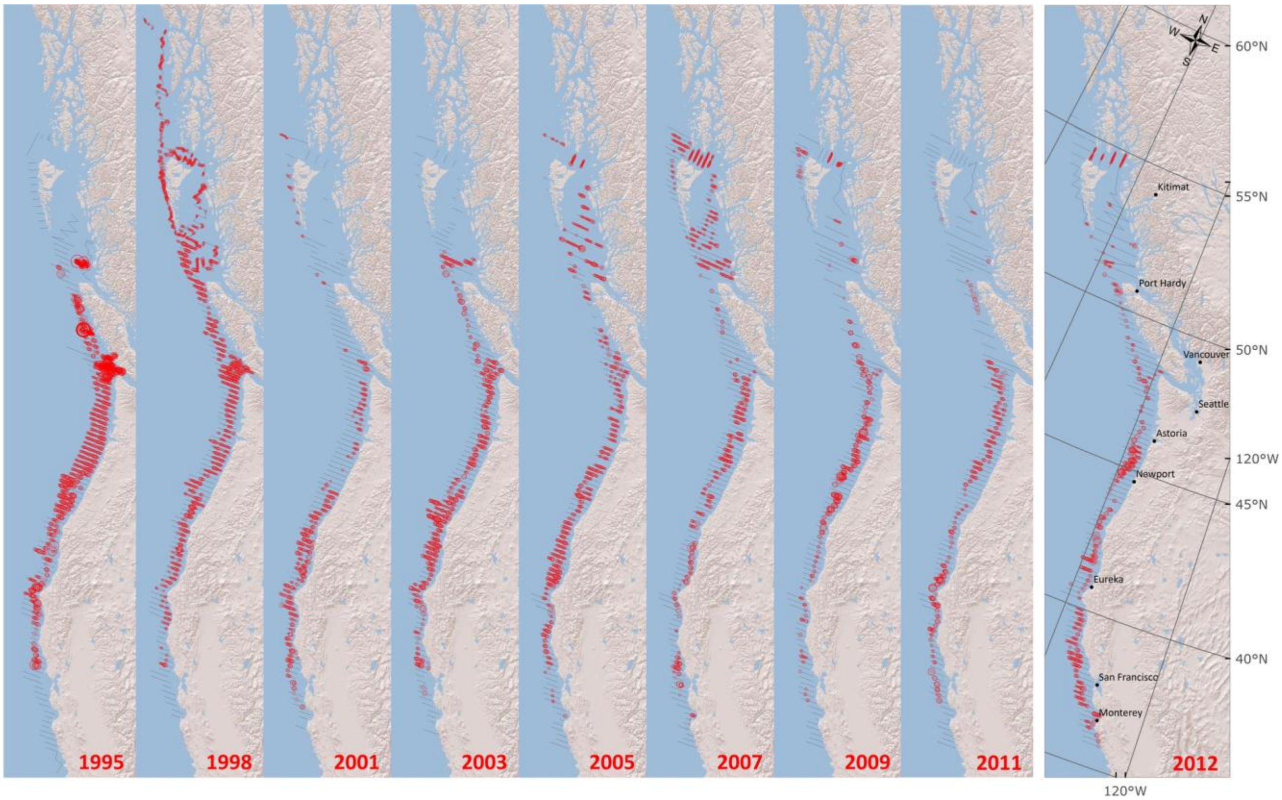


Figure 1: Spatial distribution of acoustic backscatter attributable to Pacific hake from joint US-Canada acoustic surveys 1995-2011. Area of the circles is roughly proportional to observed backscatter.

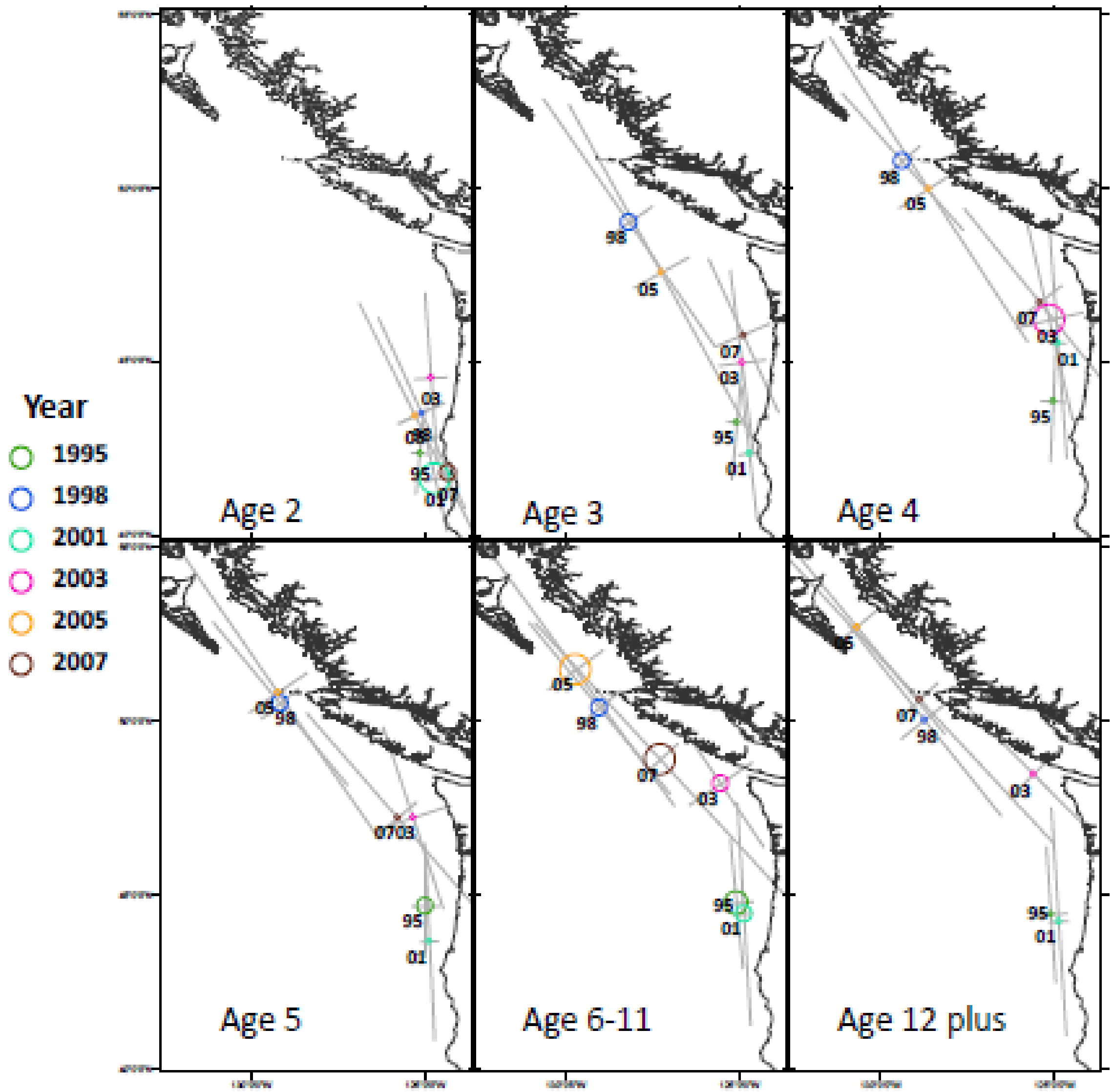


Figure 2: The mean spatial location of the hake stock (circles are proportional to biomass) and variance (grey lines) by age group and year based on acoustic survey observations 1995-2007 (Figure courtesy of O'Conner and Haltuch from preliminary results of the ongoing Fisheries And The Environment project investigating the links between ocean conditions and Pacific hake distribution).

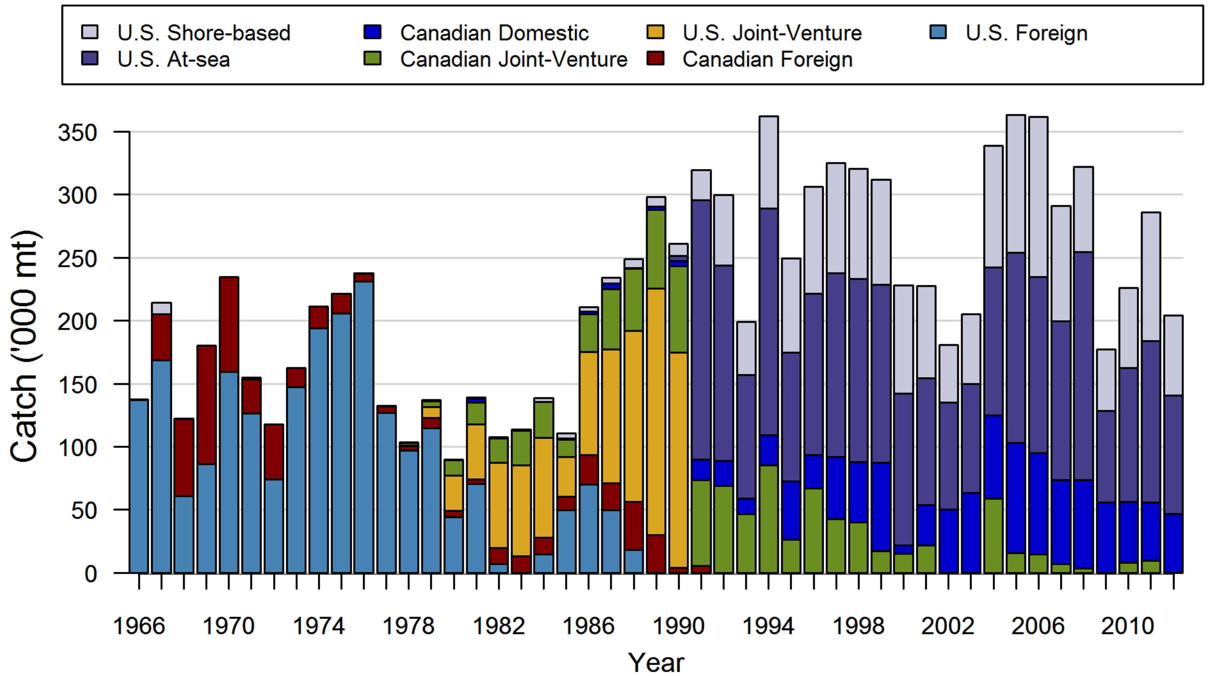


Figure 3: Total Pacific hake landings used in the assessment by sector, 1966-2011

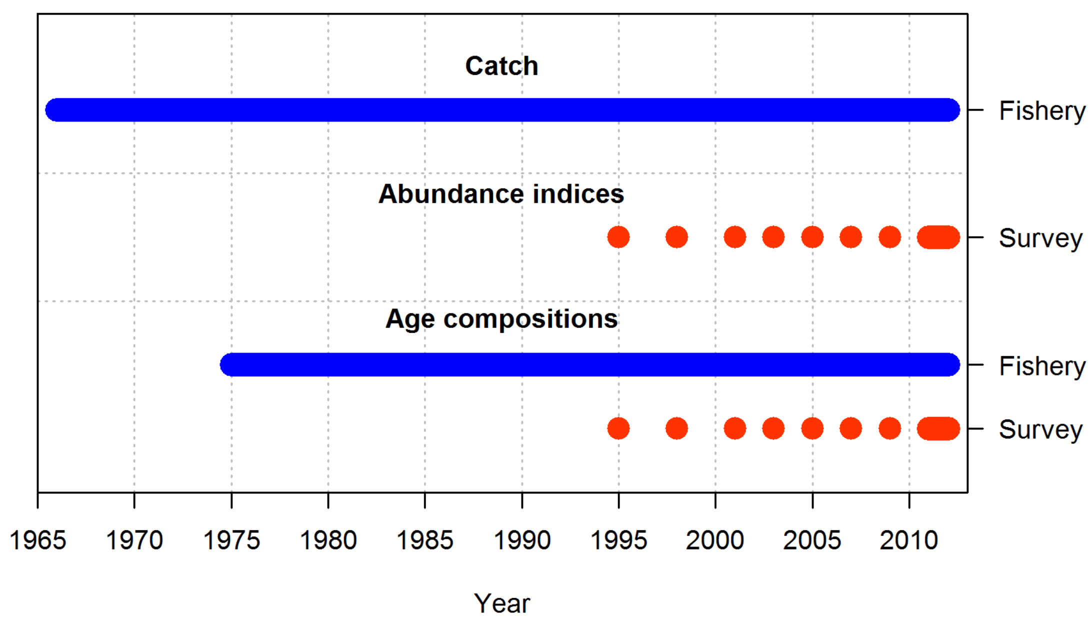


Figure 4: Overview of data used in this assessment, 1966-2012.

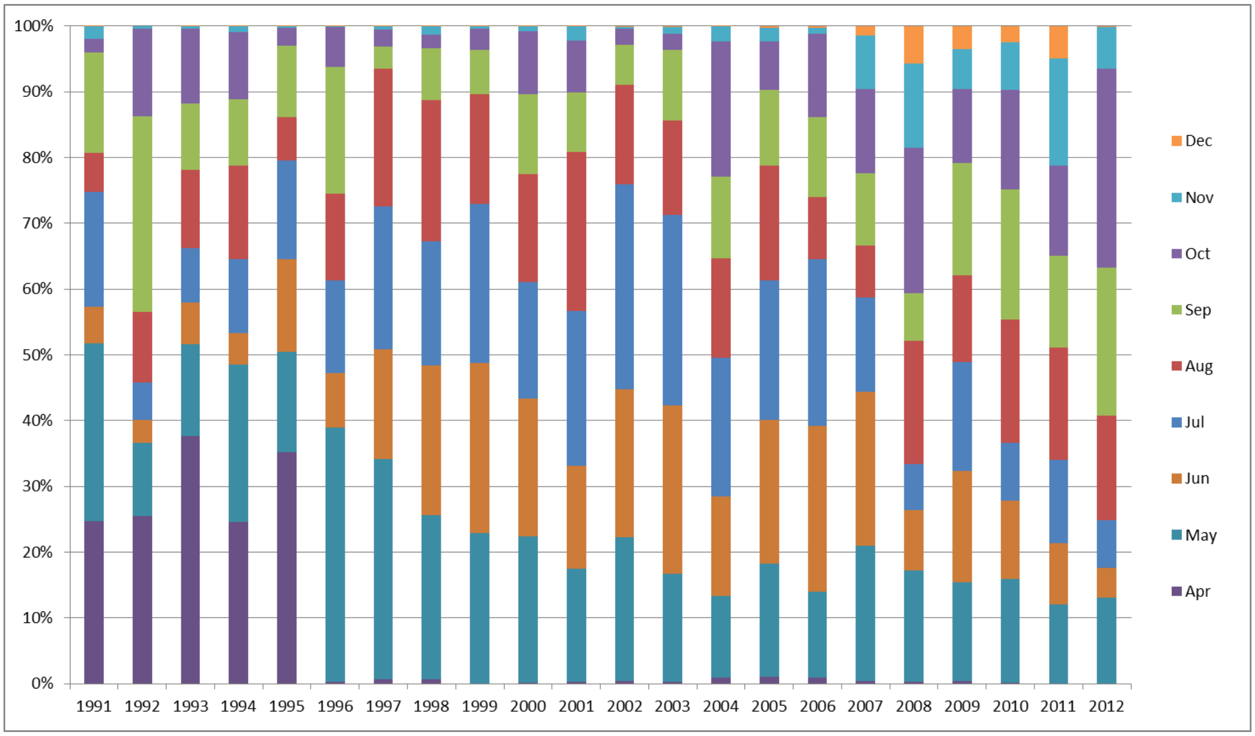


Figure 5: Proportion of catch for U.S. and Canadian combined occurring in each of the months from April through December.

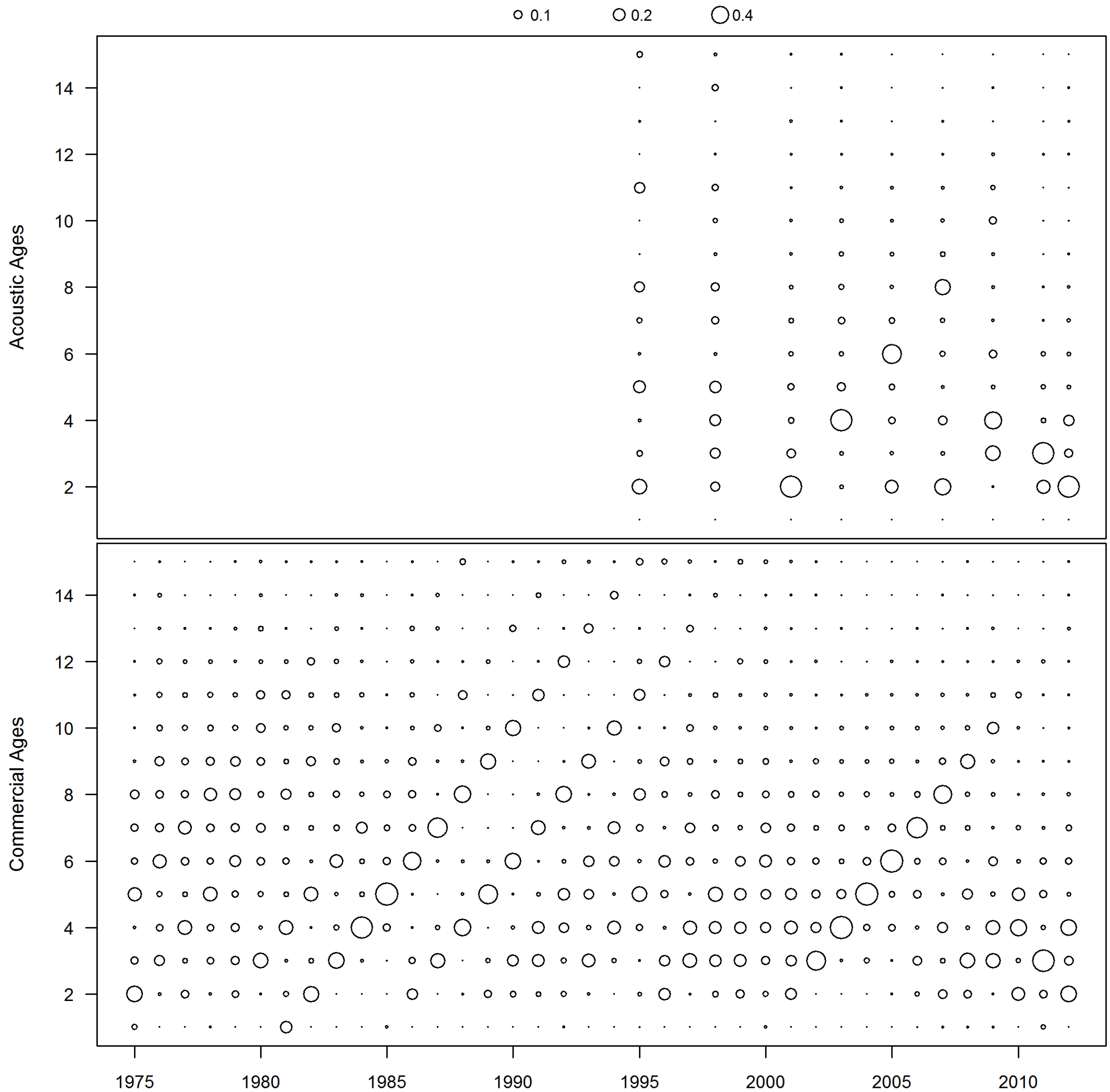


Figure 6: Age compositions for the acoustic survey (top) and the aggregate fishery (bottom, all sectors combined) for the years 1975–2011. Proportions in each year sum to 1.0 and area of the bubbles are proportional to the proportion and consistent in both panels (see key at top).

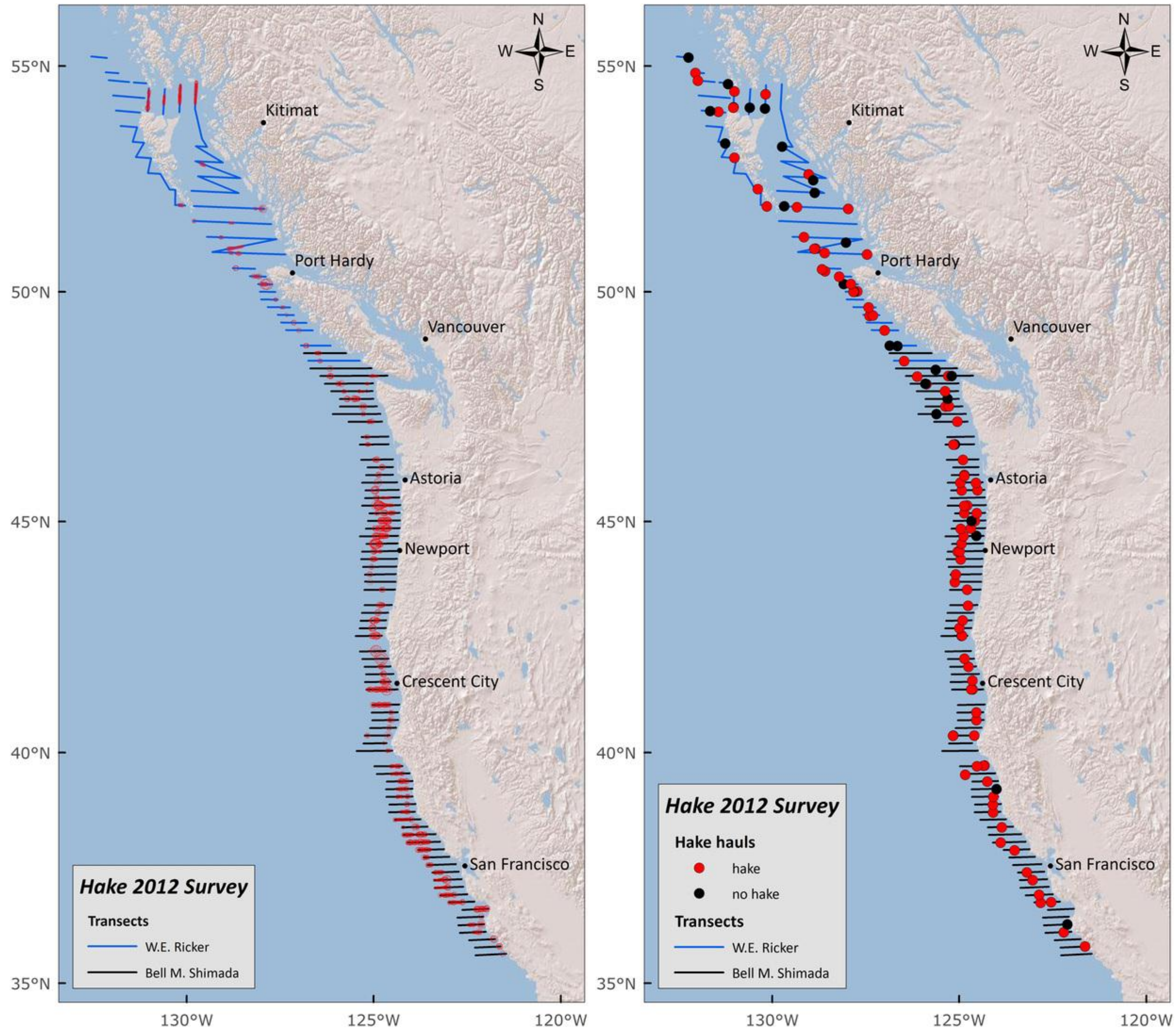


Figure 7: Acoustic survey transects surveyed in 2012 with backscatter proportional to the area of the circle (left panel) and hauls that caught or did not catch Pacific hake (right panel).

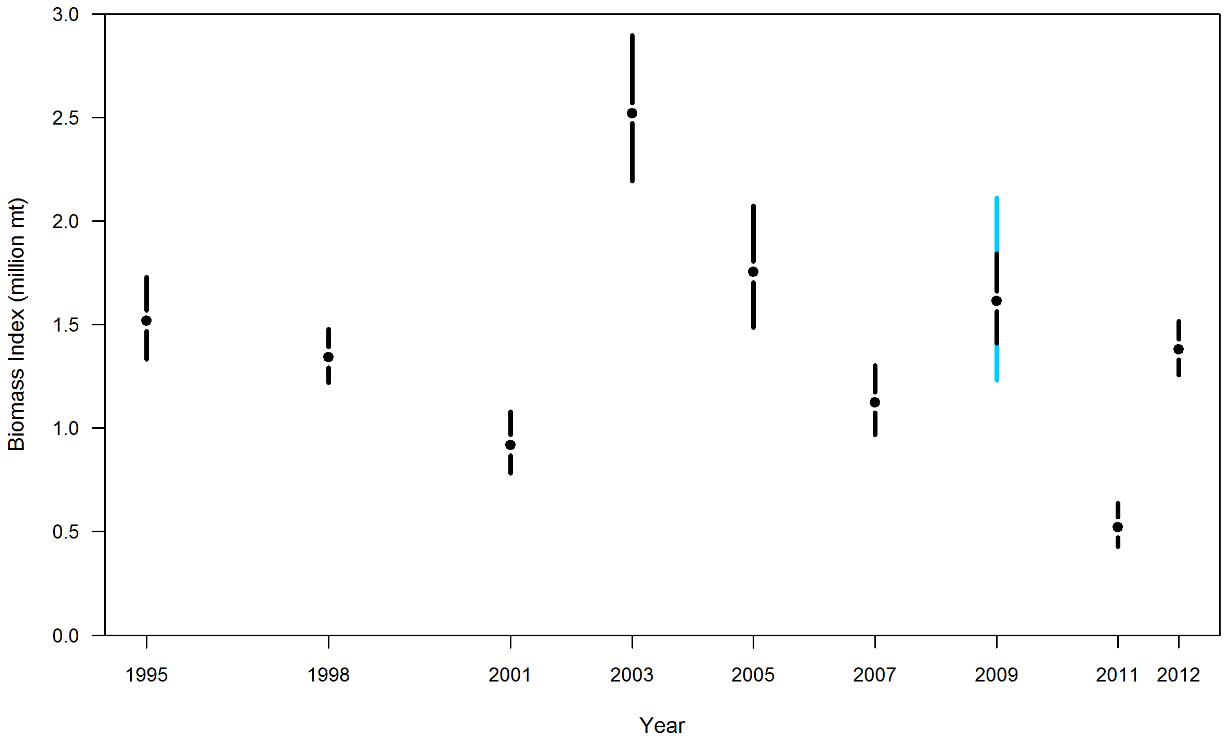


Figure 8: Acoustic survey biomass indices (millions of metric tons). Approximate 95% confidence intervals are based on only sampling variability (1995-2007, 2011, 2012) and sampling variability as well as squid/hake apportionment uncertainty (2009).

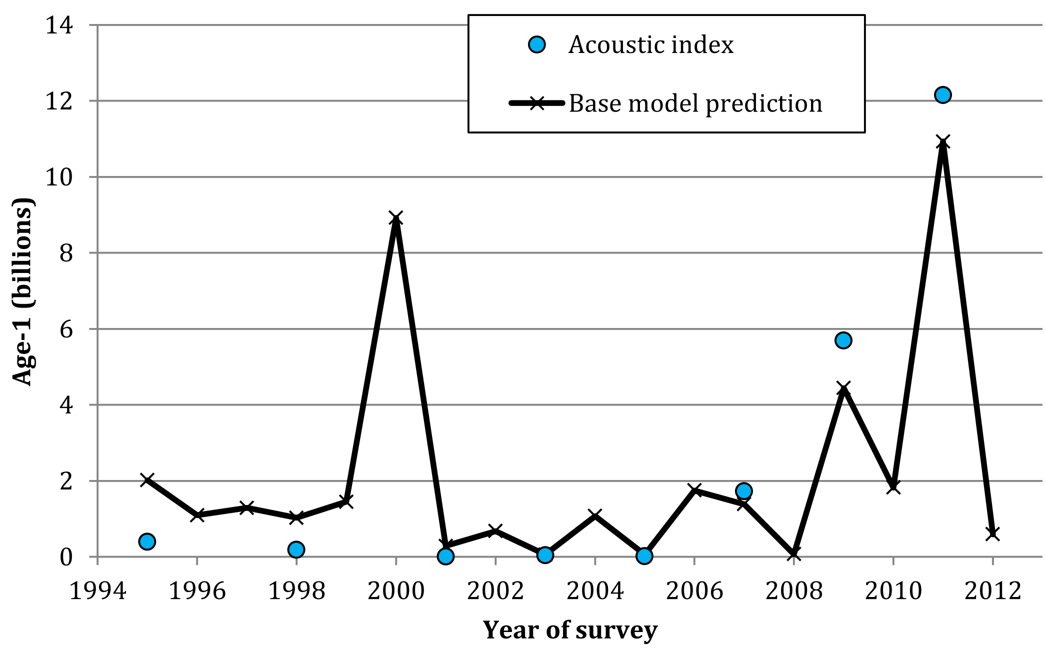


Figure 9: Preliminary acoustic survey age-1 index (scaled to have the same mean as the mean from base model recruitment for the same years) and base-case model predicted posterior median numbers at age-1. This figure represents a comparison with, not a fit to the preliminary data.

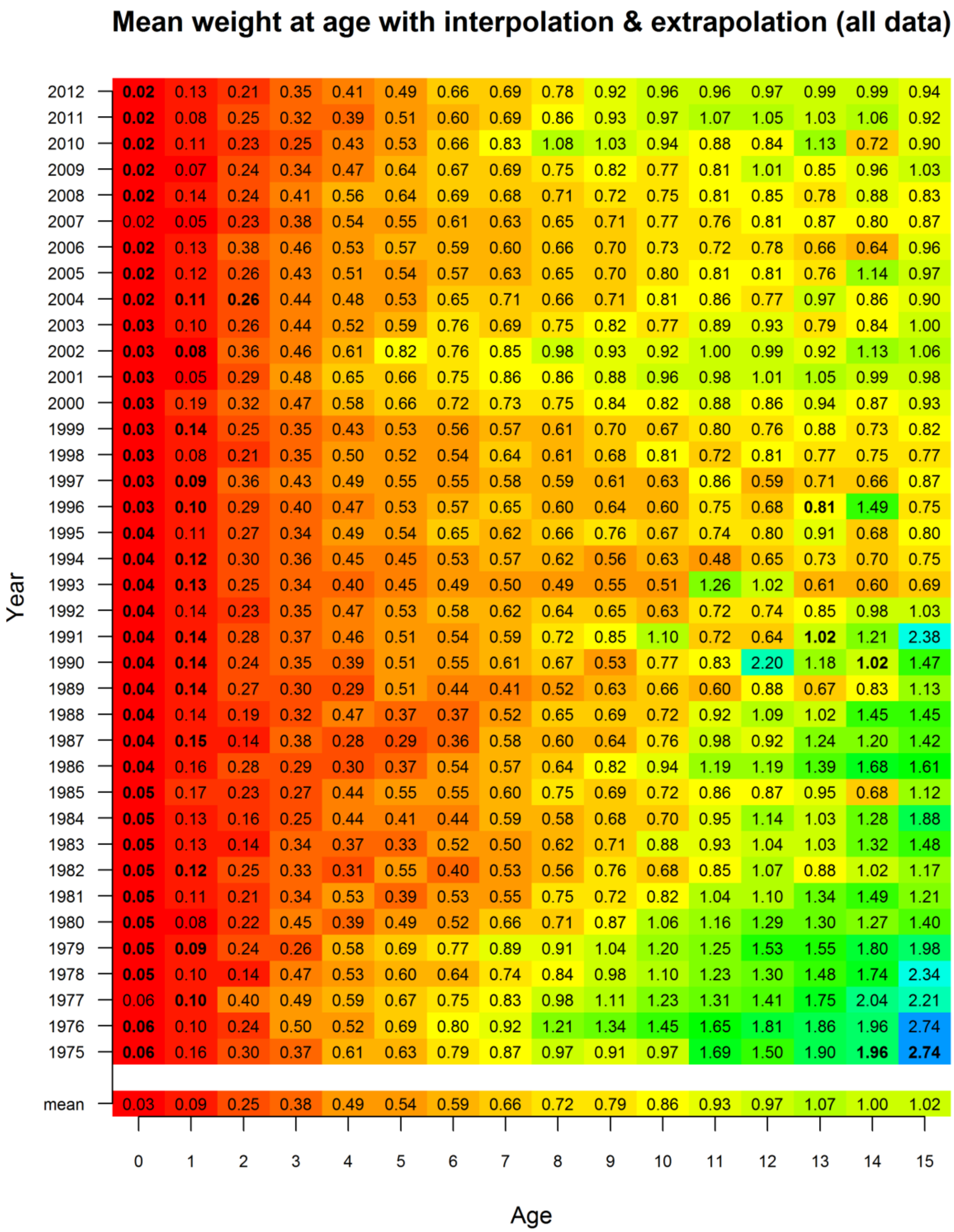


Figure 10: Empirical weight-at-age (kg) used in the assessment. Numbers shown in bold were interpolated or extrapolated from adjacent years.

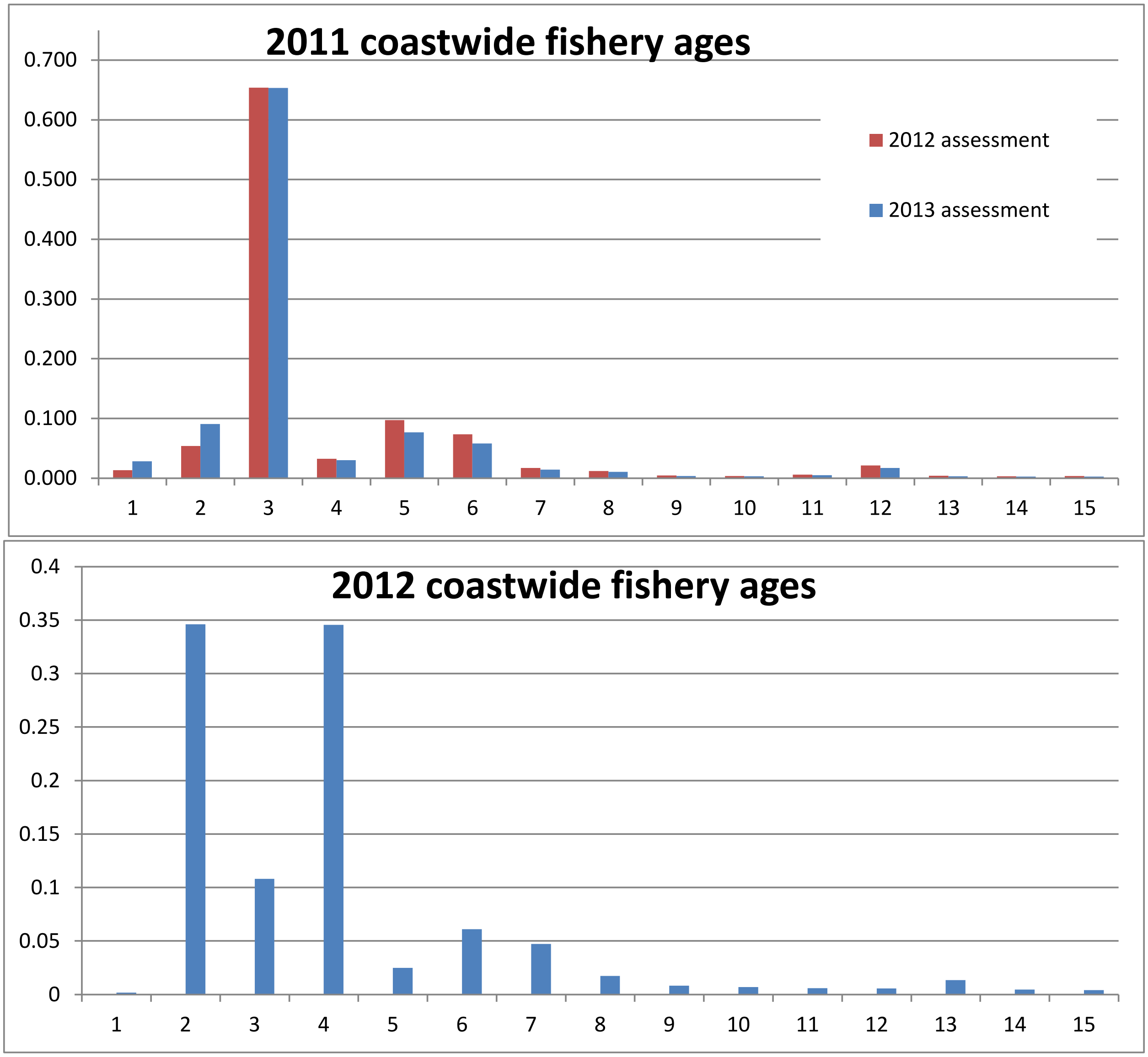


Figure 11: Fishery age compositions for 2011 (top) and 2012 (bottom). The 2011 proportions-at-age show the difference between those used in the 2012 assessment (red) and those used in the 2013 assessment (blue) containing additional ages collected late in 2011.

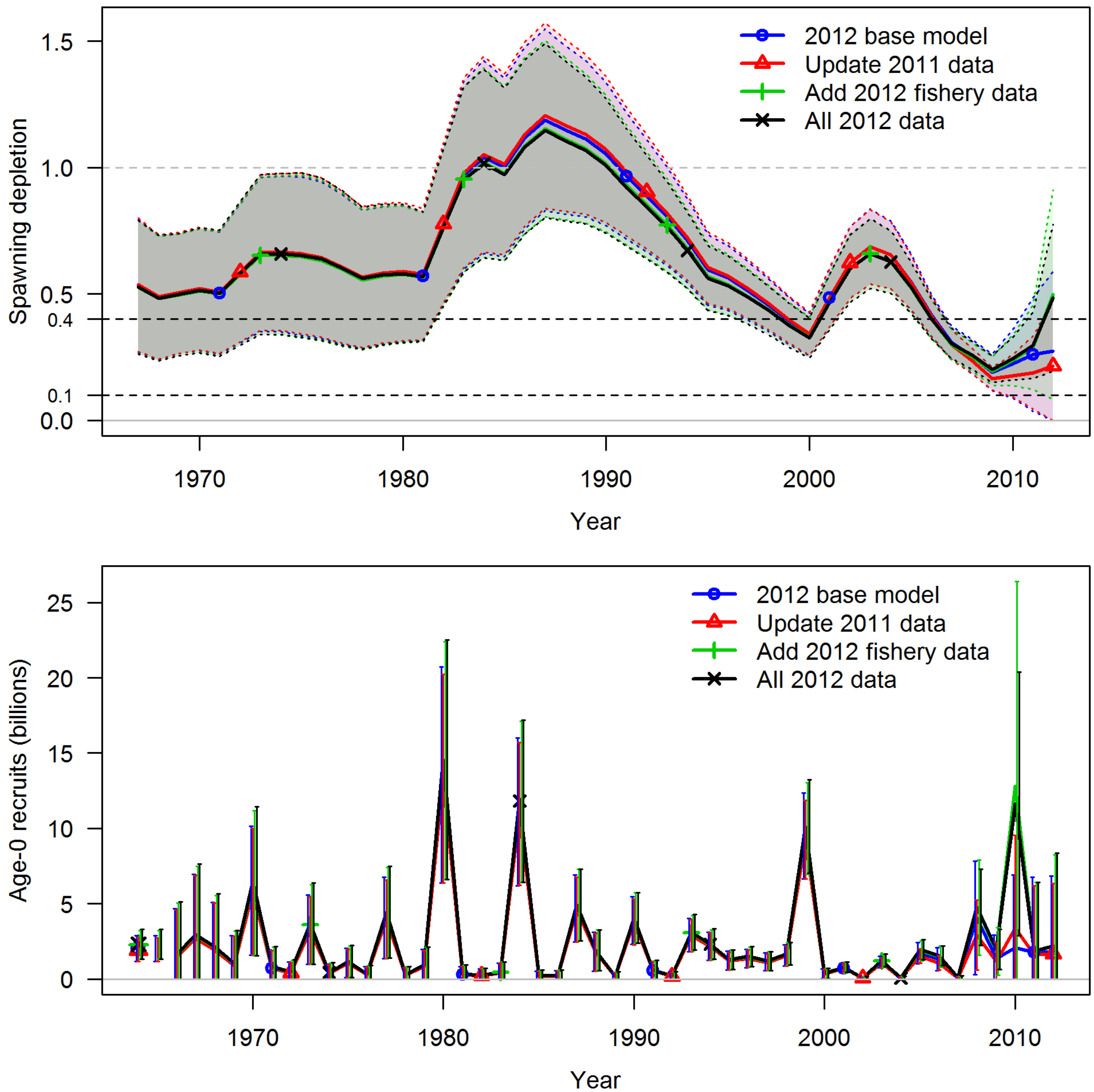


Figure 12: Bridge models from the 2012 base model to the 2013 base model (All 2012 data).

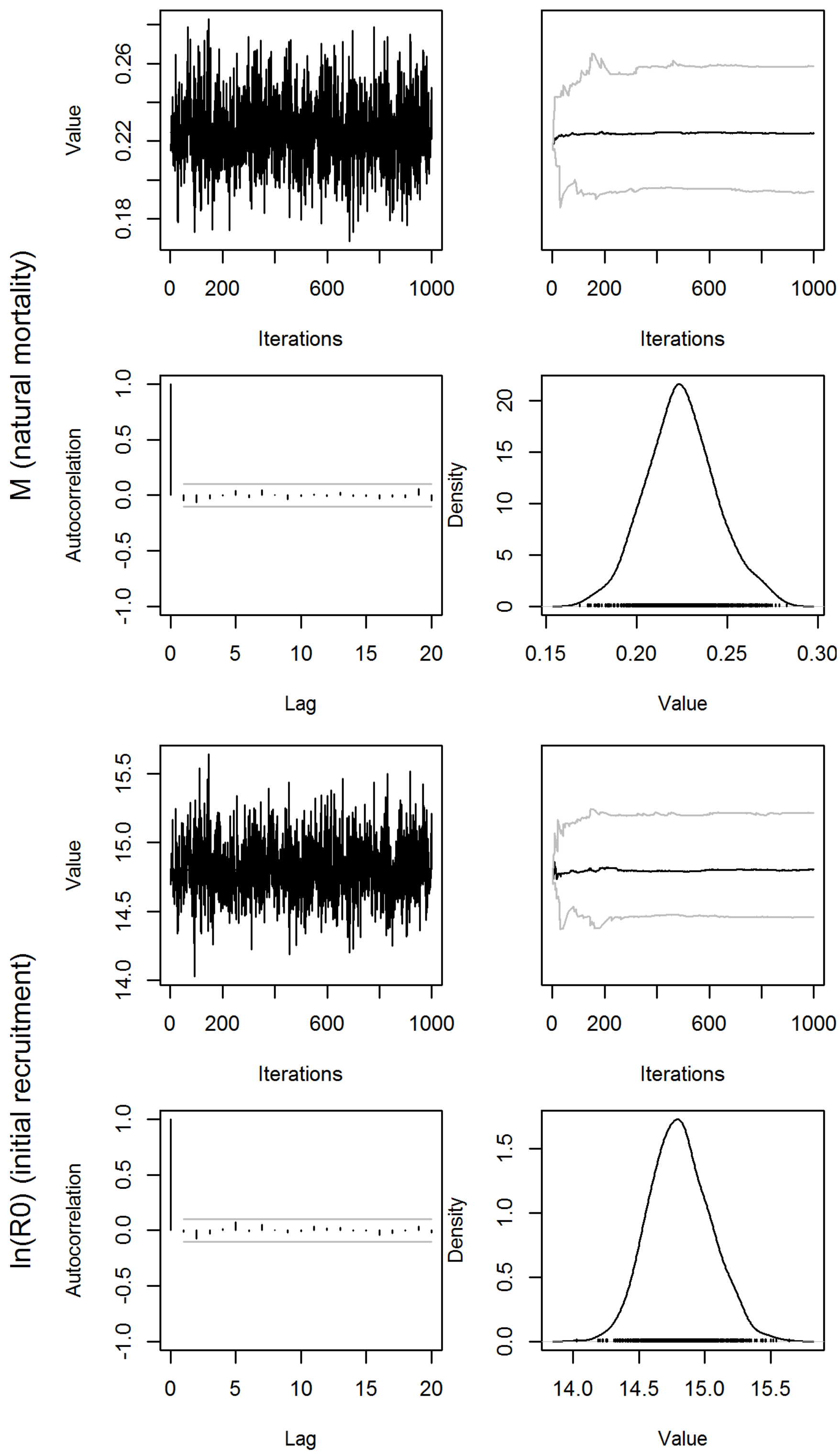


Figure 13: Summary of MCMC diagnostics for natural mortality (upper panels) and log(R0) (lower panels) in the base-case model.

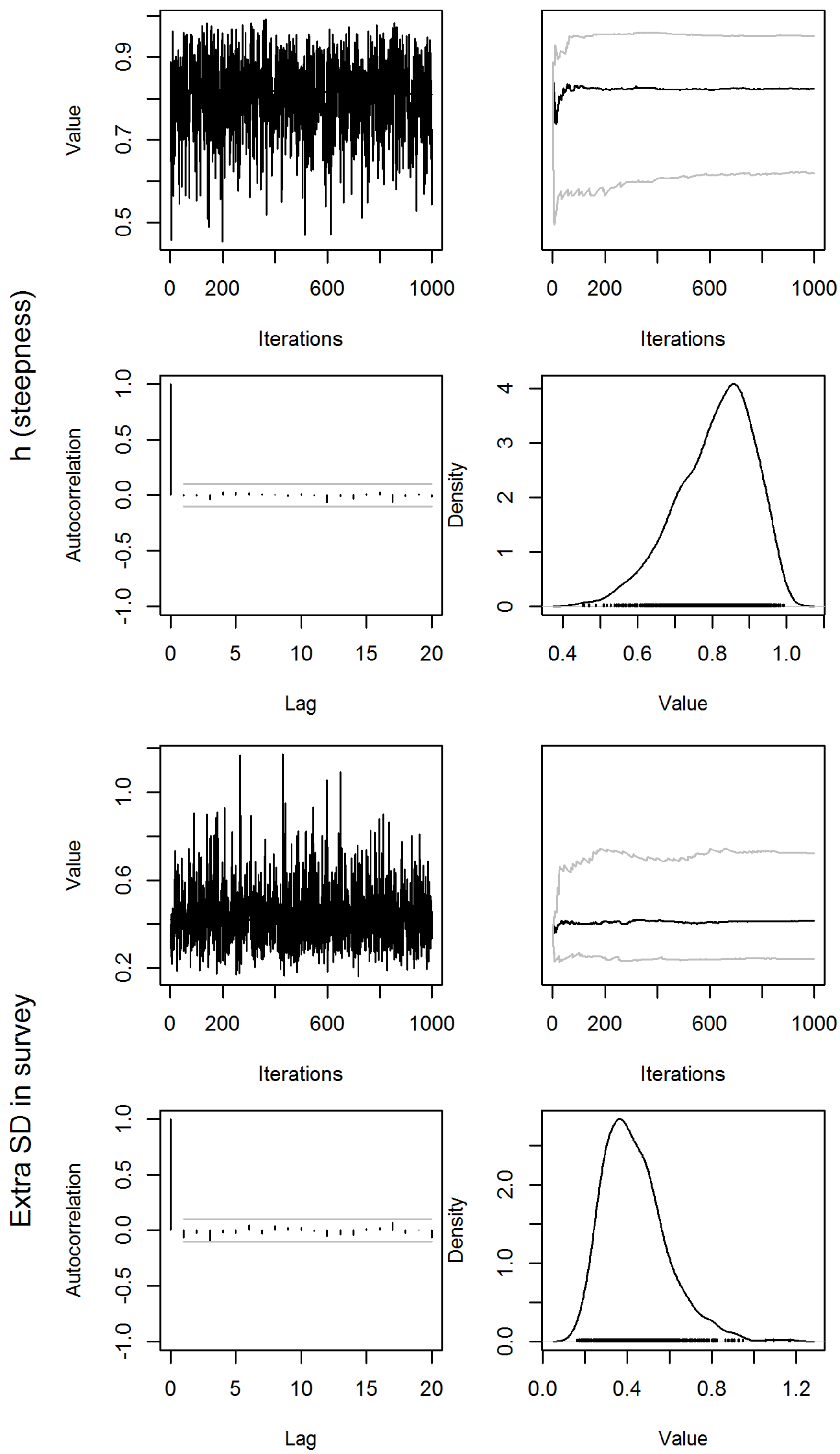


Figure 14: Summary of MCMC diagnostics for steepness (upper panels) and the additional SD for the acoustic survey index (lower panels) in the base-case model.

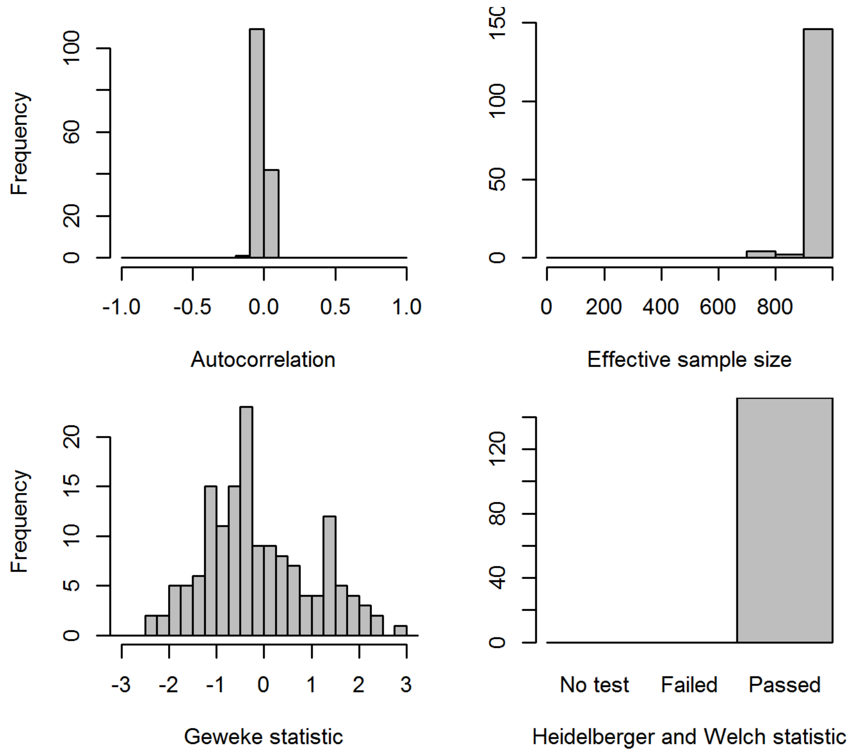


Figure 15: Summary histograms of MCMC diagnostics for all base-case model parameters and derived quantities including the recruitment, spawning biomass, and depletion time-series.

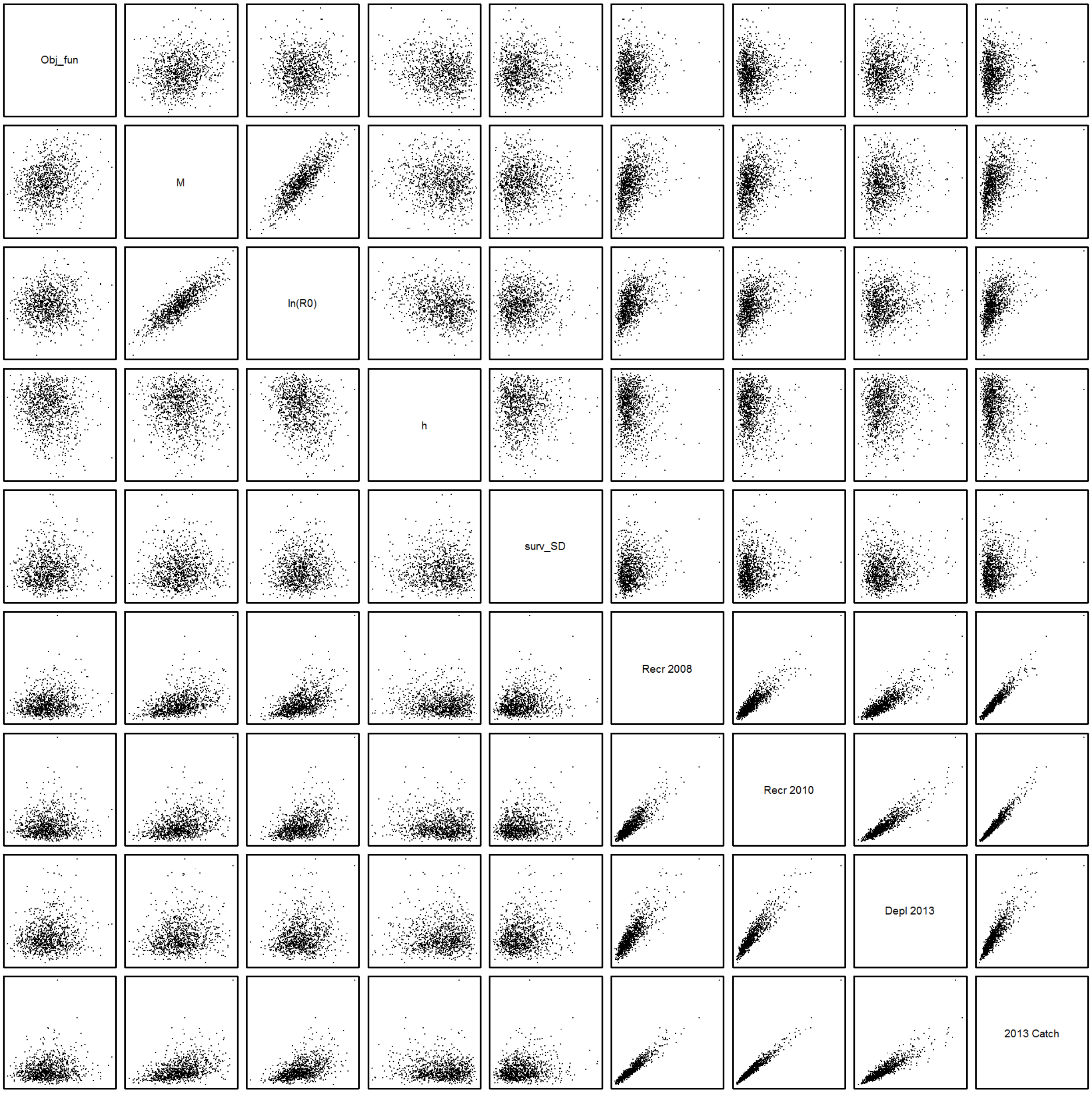


Figure 16: Posterior correlations among key base-case model parameters and derived quantities. From the top left the posteriors plotted are: objective function, natural mortality, ln(R0), steepness, the process-error SD for the acoustic survey, the 2008 recruitment deviation, the 2010 recruitment deviation, the depletion level in 2012, and the default harvest rate yield for 2013.

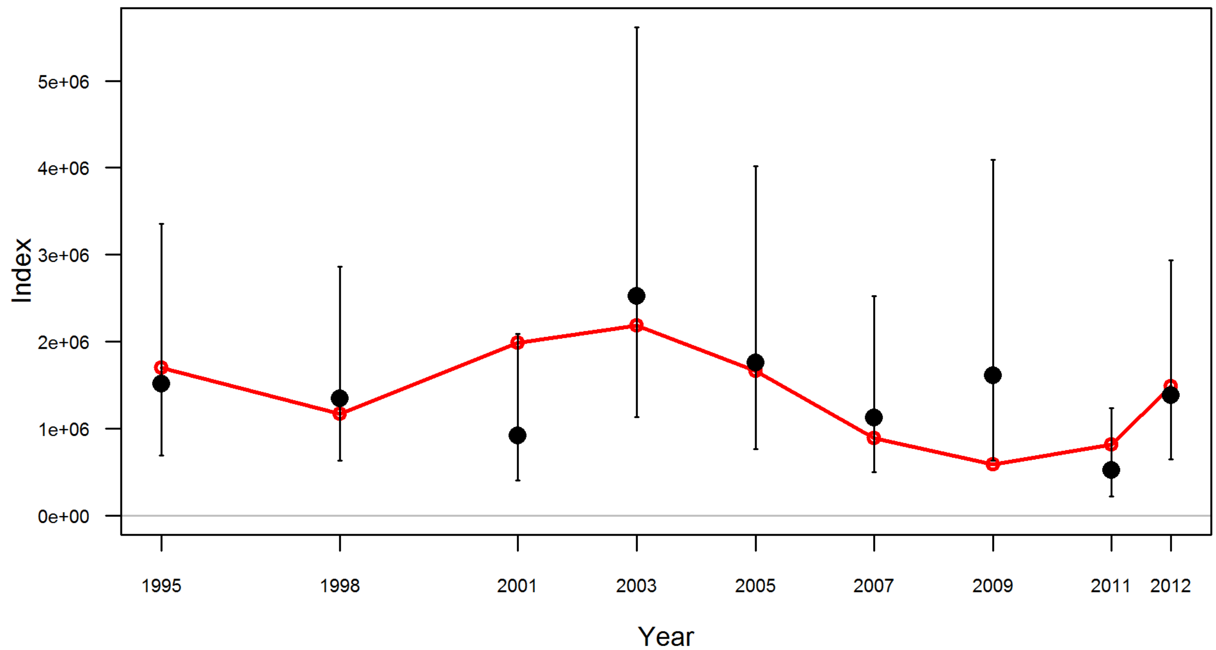


Figure 17: Predicted MLE fits to the acoustic survey with 95% confidence intervals around the index points.

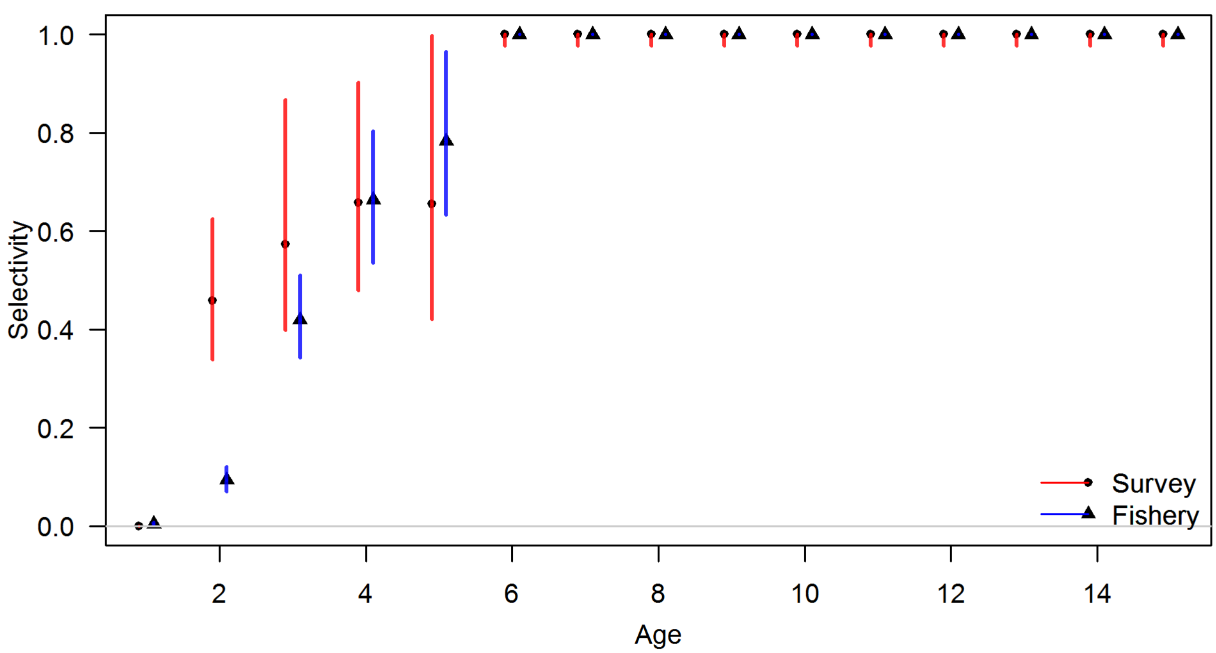


Figure 18: Estimated selectivity with 95% posterior credibility intervals for the acoustic survey and the fishery.

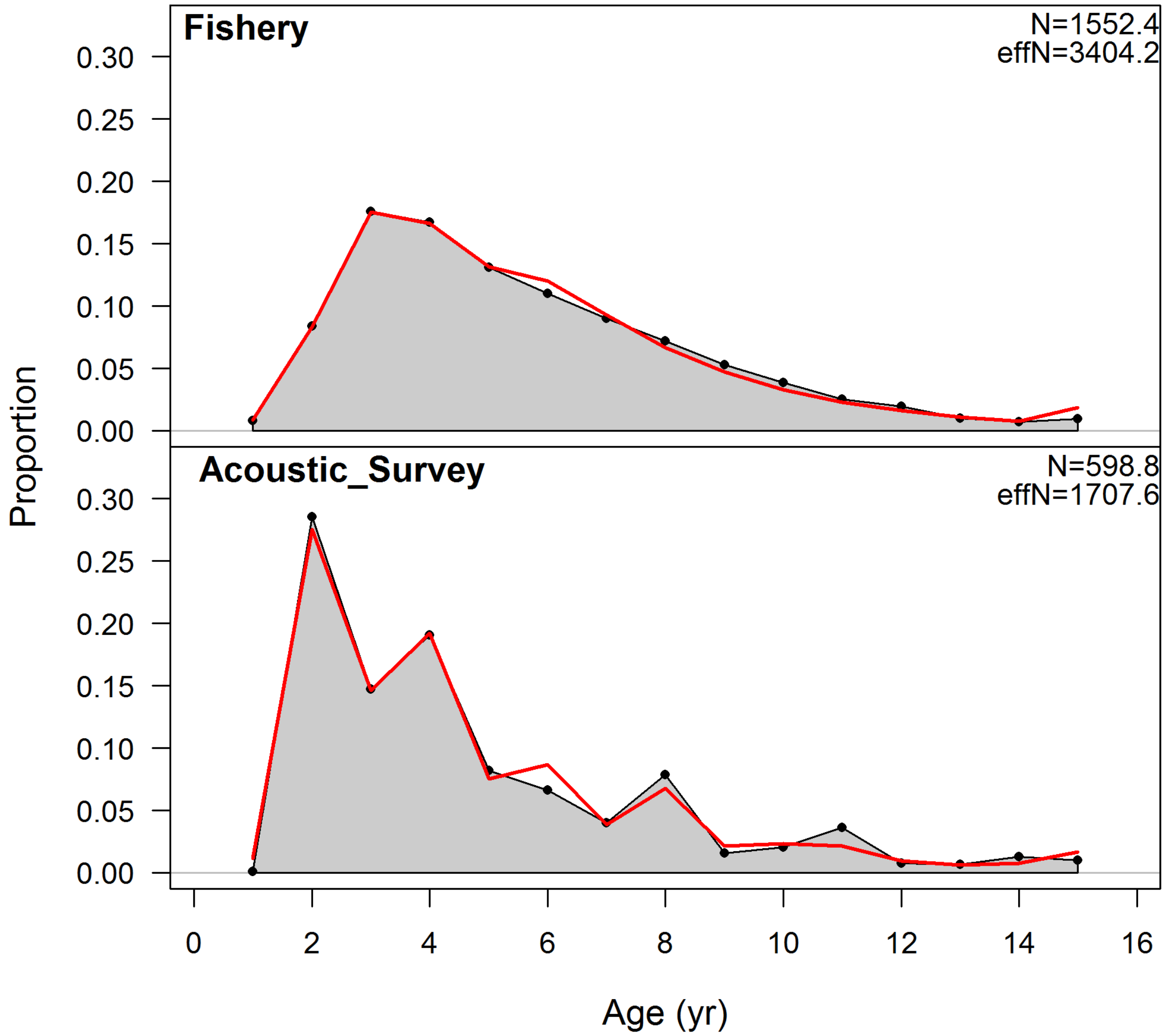


Figure 19: Base-case model fit to the aggregate fishery and acoustic age composition data.

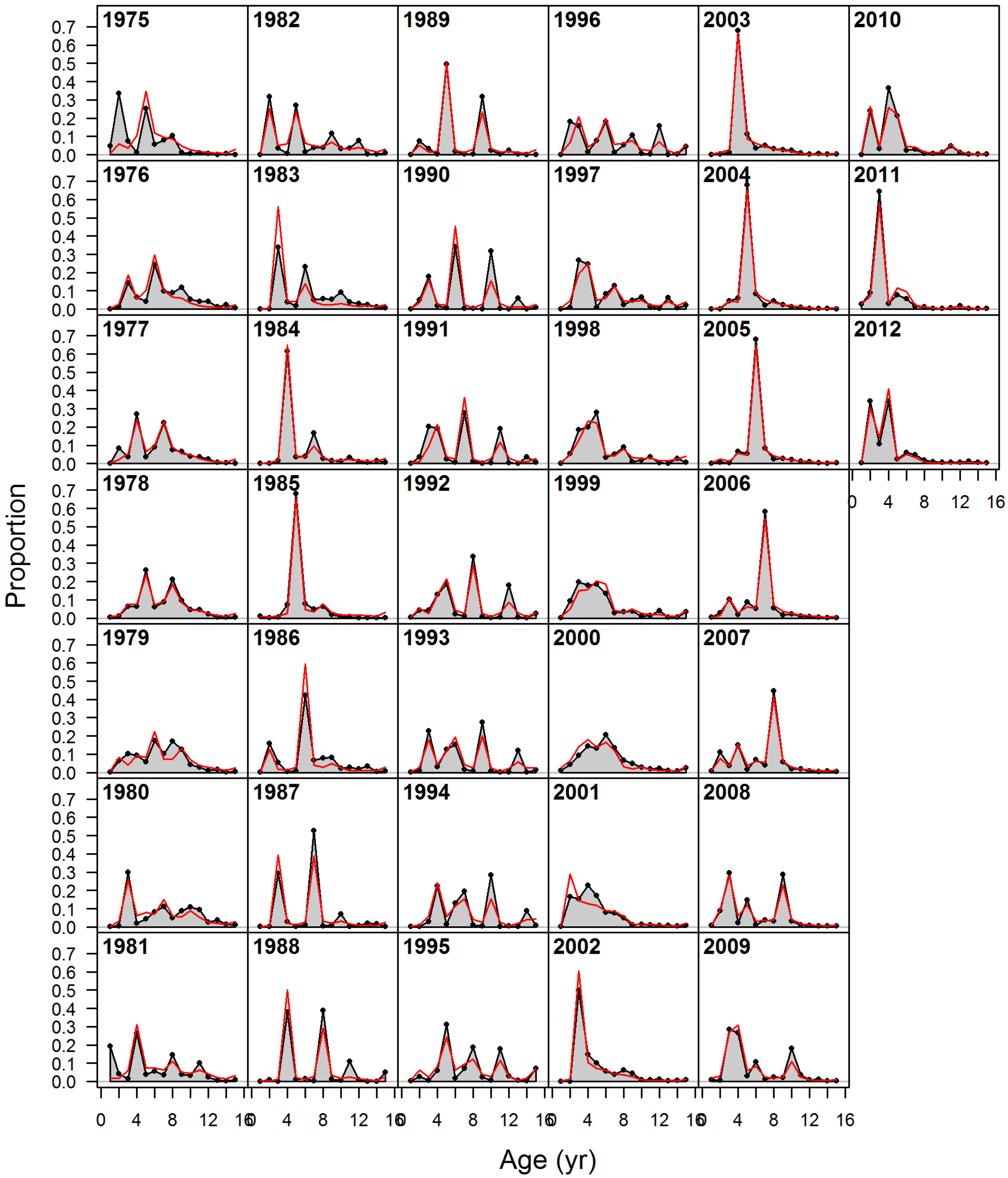


Figure 20: Base-case model fit to the observed fishery age composition data.

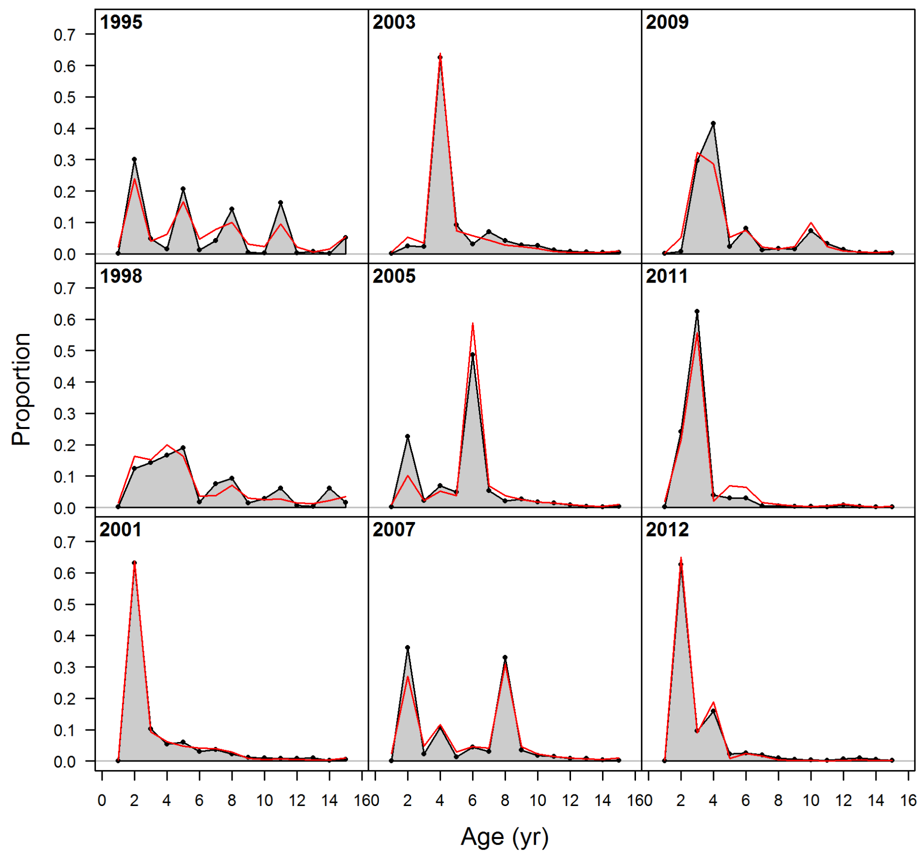


Figure 21: Base model fit to the observed acoustic survey age composition data.

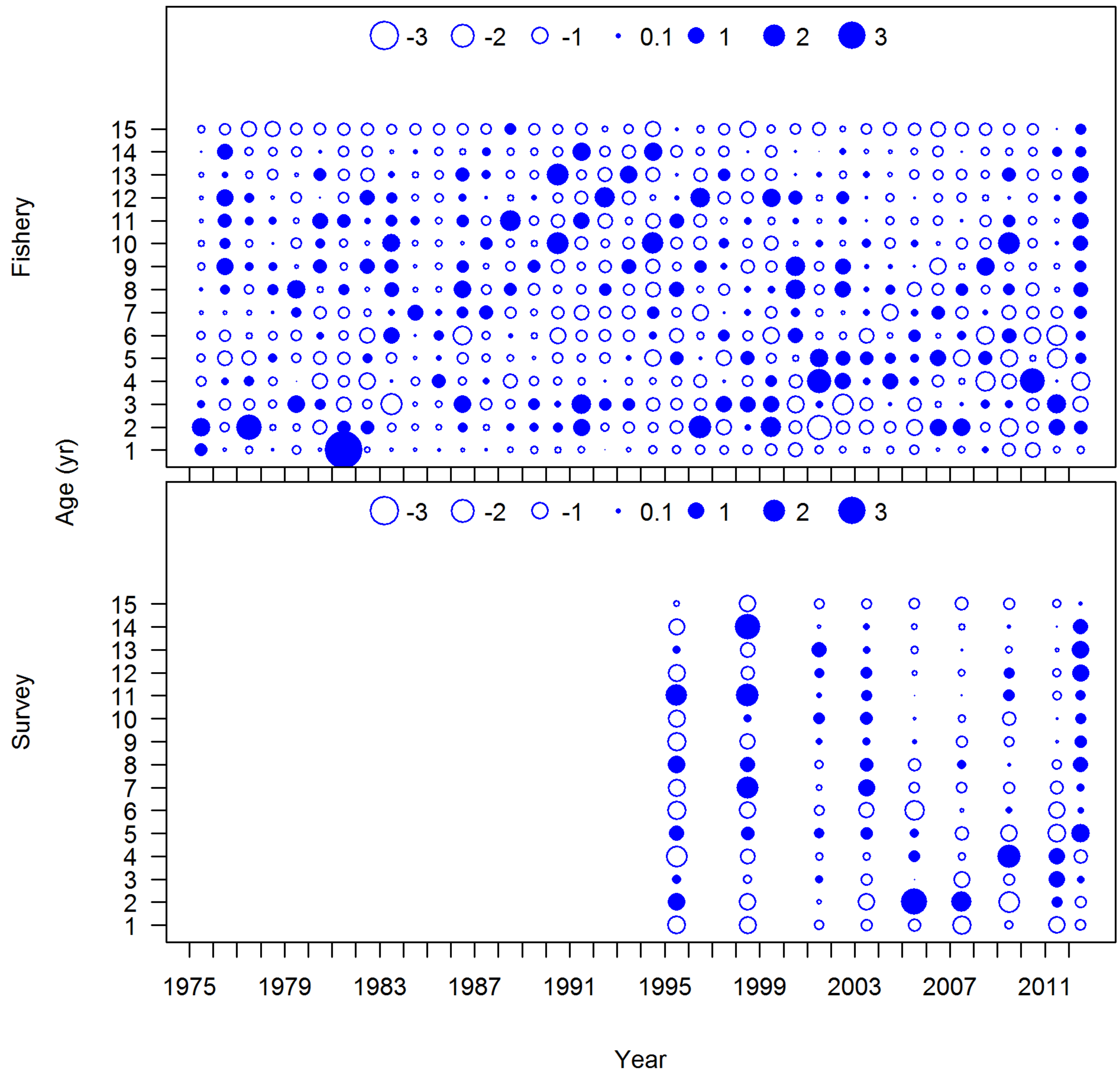


Figure 22: Pearson standardized residuals (observed - predicted) for base-case model fits to the fishery age composition data. Filled circles represent positive values.

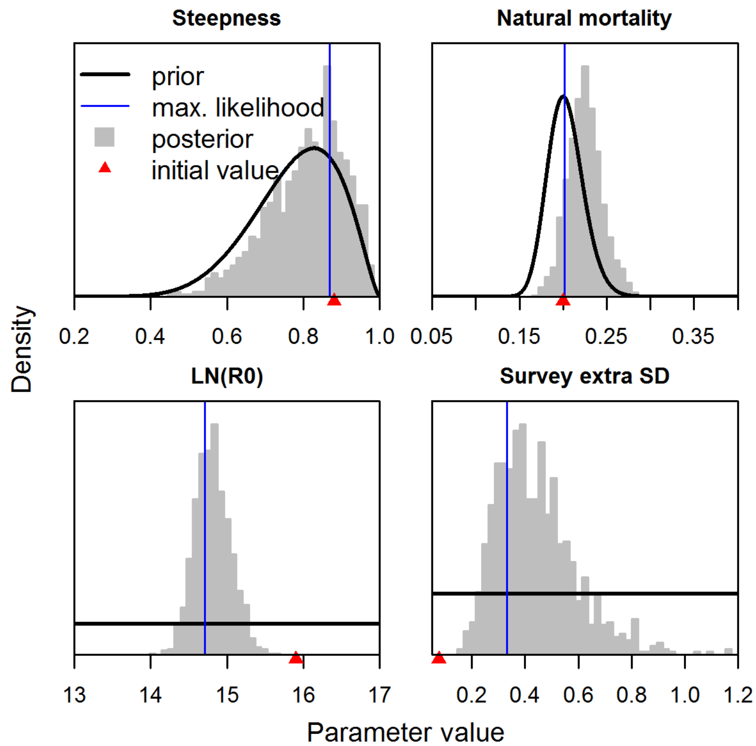


Figure 23: Prior and posterior probability distributions for key parameters in the base model. From the top left, the parameters are: steepness (h), Natural mortality (M), ln(R0), and the additional process-error SD for the acoustic survey.

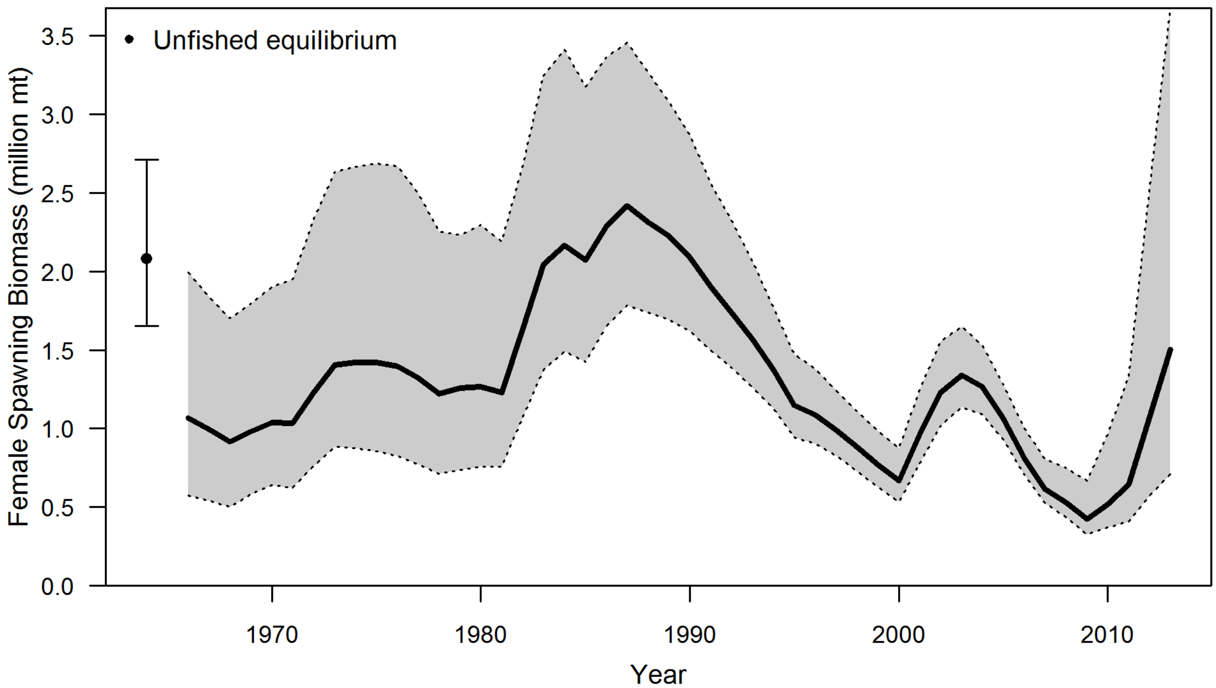


Figure 24: Posterior female spawning biomass time-series with 95% posterior credibility intervals.

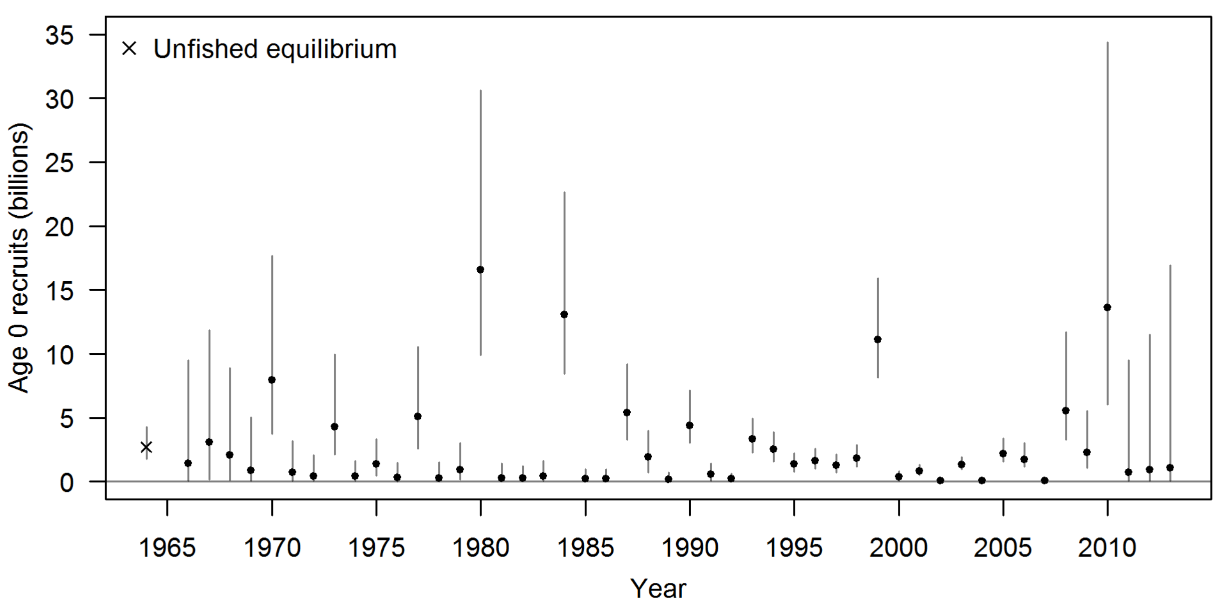


Figure 25: Posterior age-0 recruitment time-series for the base-case model with 95% posterior credibility intervals.

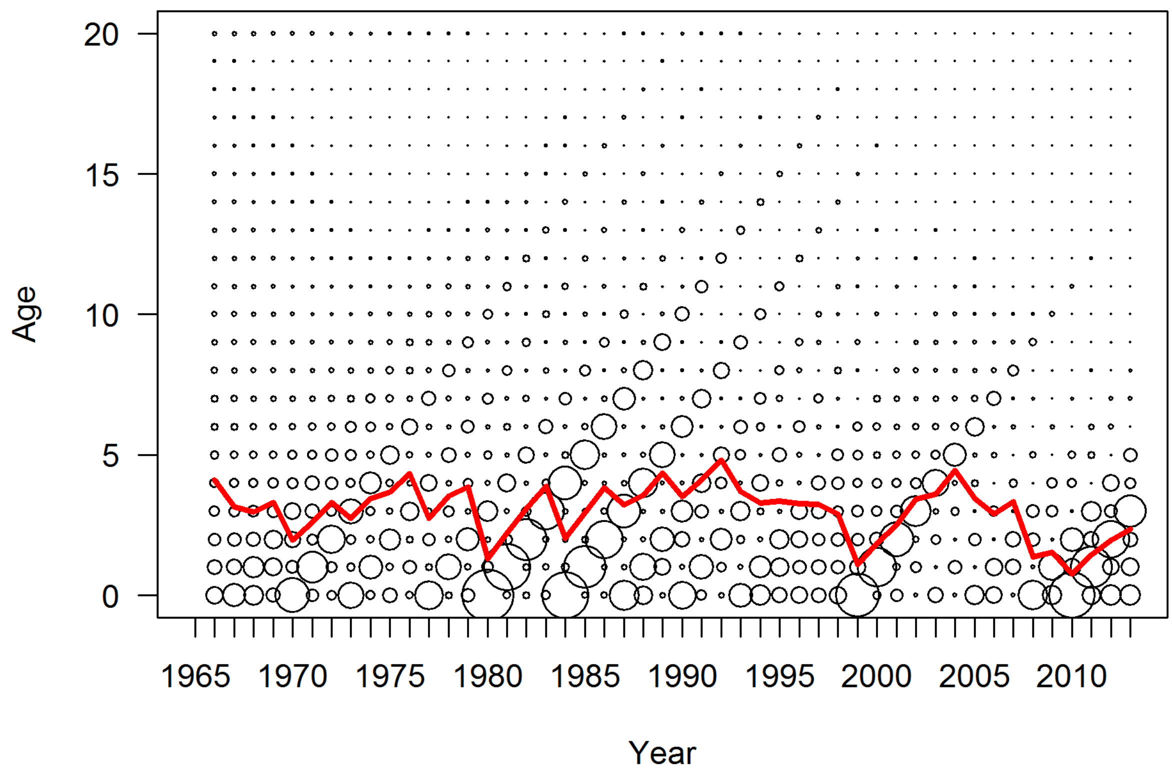


Figure 26: Estimated numbers at age (MLE) from the base-case model. Solid line indicates the average age during the time-series.

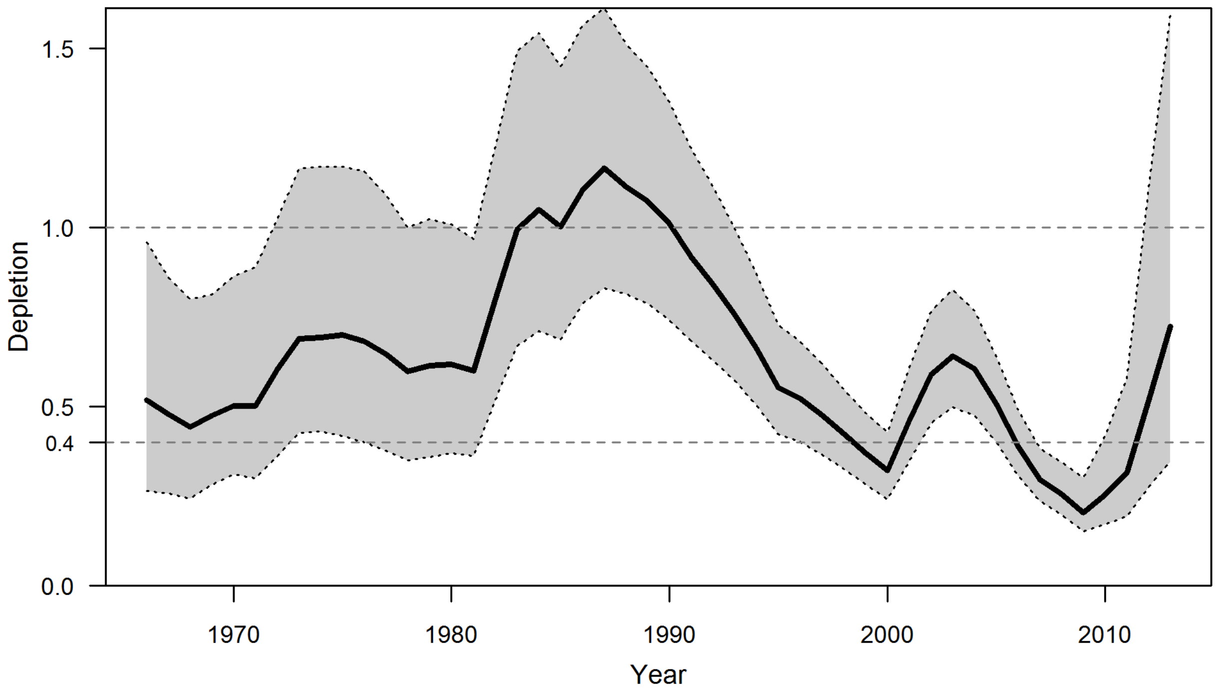
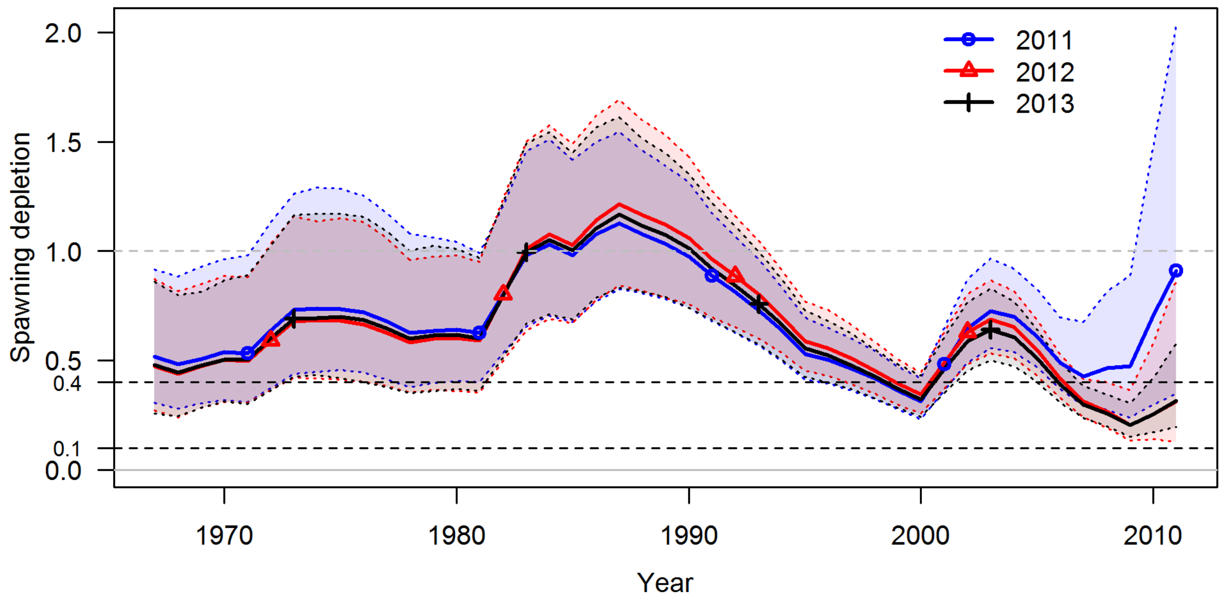


Figure 27: Time-series of posterior relative depletion with 95% posterior credibility intervals for the base model.



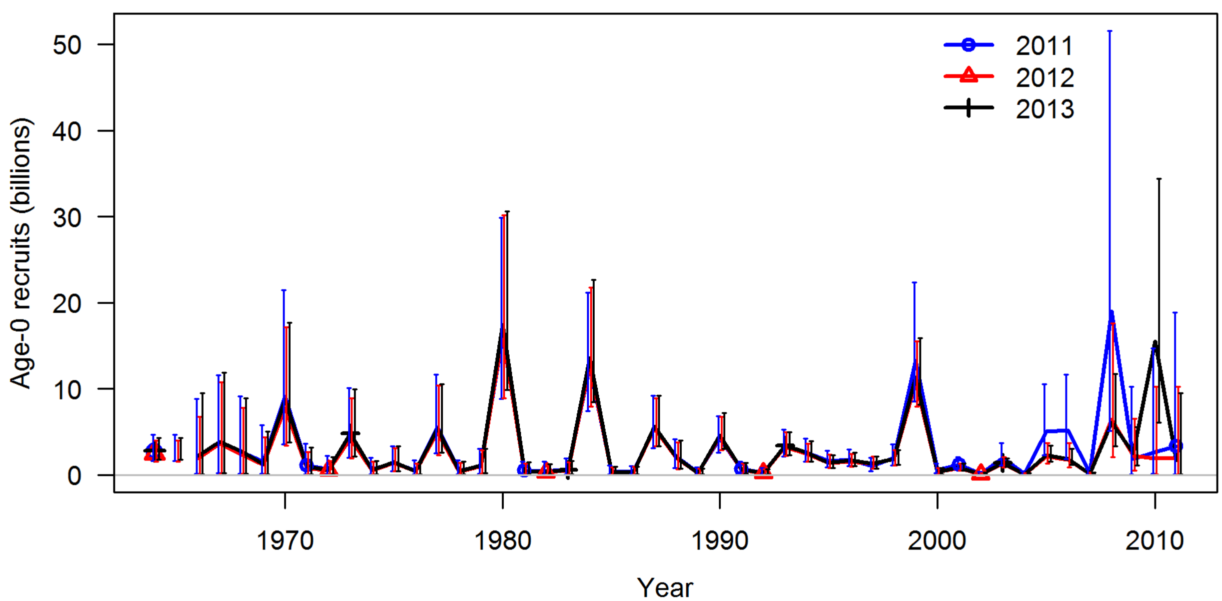


Figure 28: Estimated depletion and recruitments up to 2011, with 95% posterior credibility intervals, for the base assessment models from 2011, 2012, and 2013.

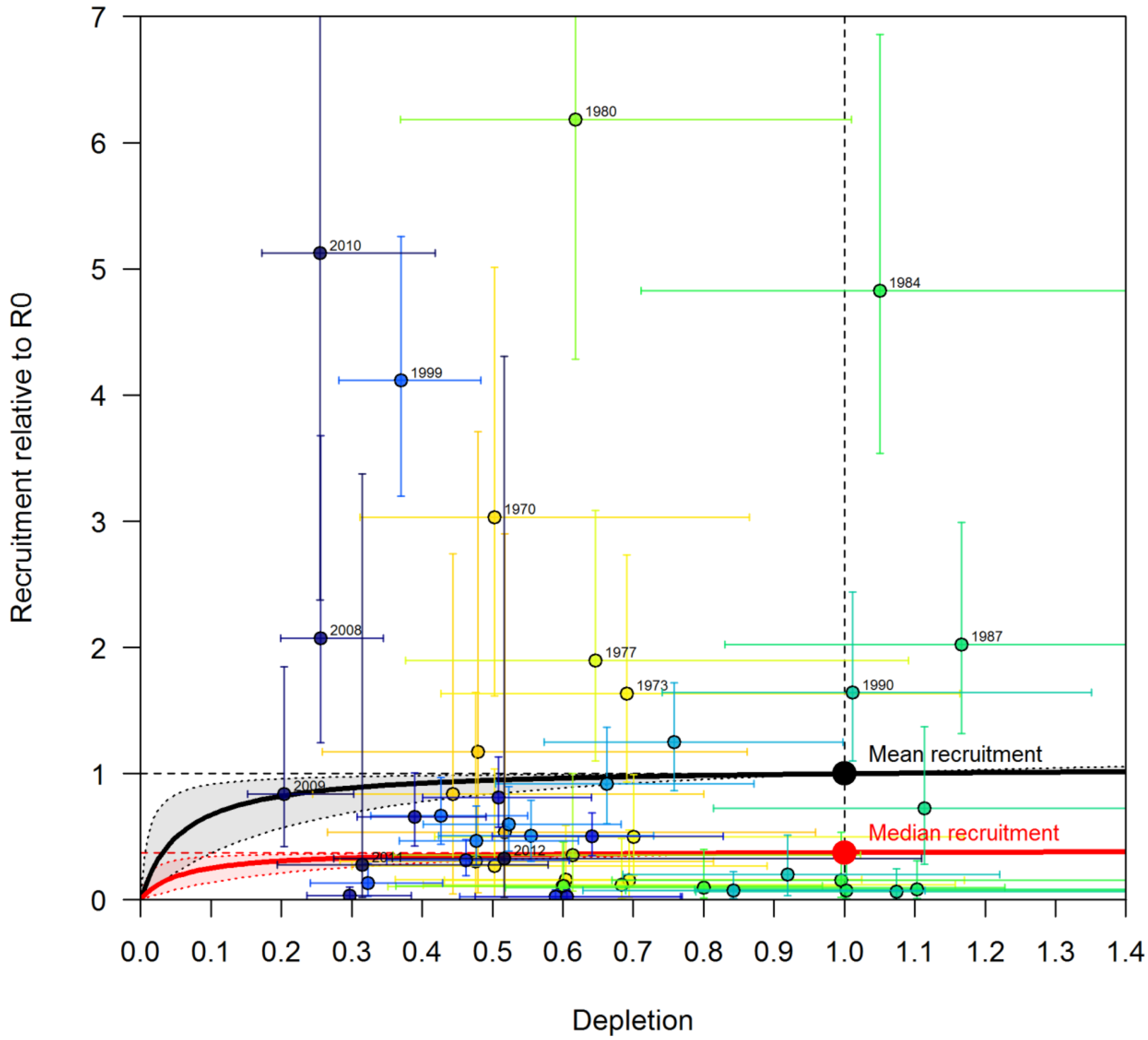


Figure 29: Estimated stock-recruit relationship for the base model with median predicted recruitments and 95% posterior credibility intervals. The thick solid black line indicates the central tendency (mean) and the red line the central tendency after bias correcting for the log-normal distribution (median).

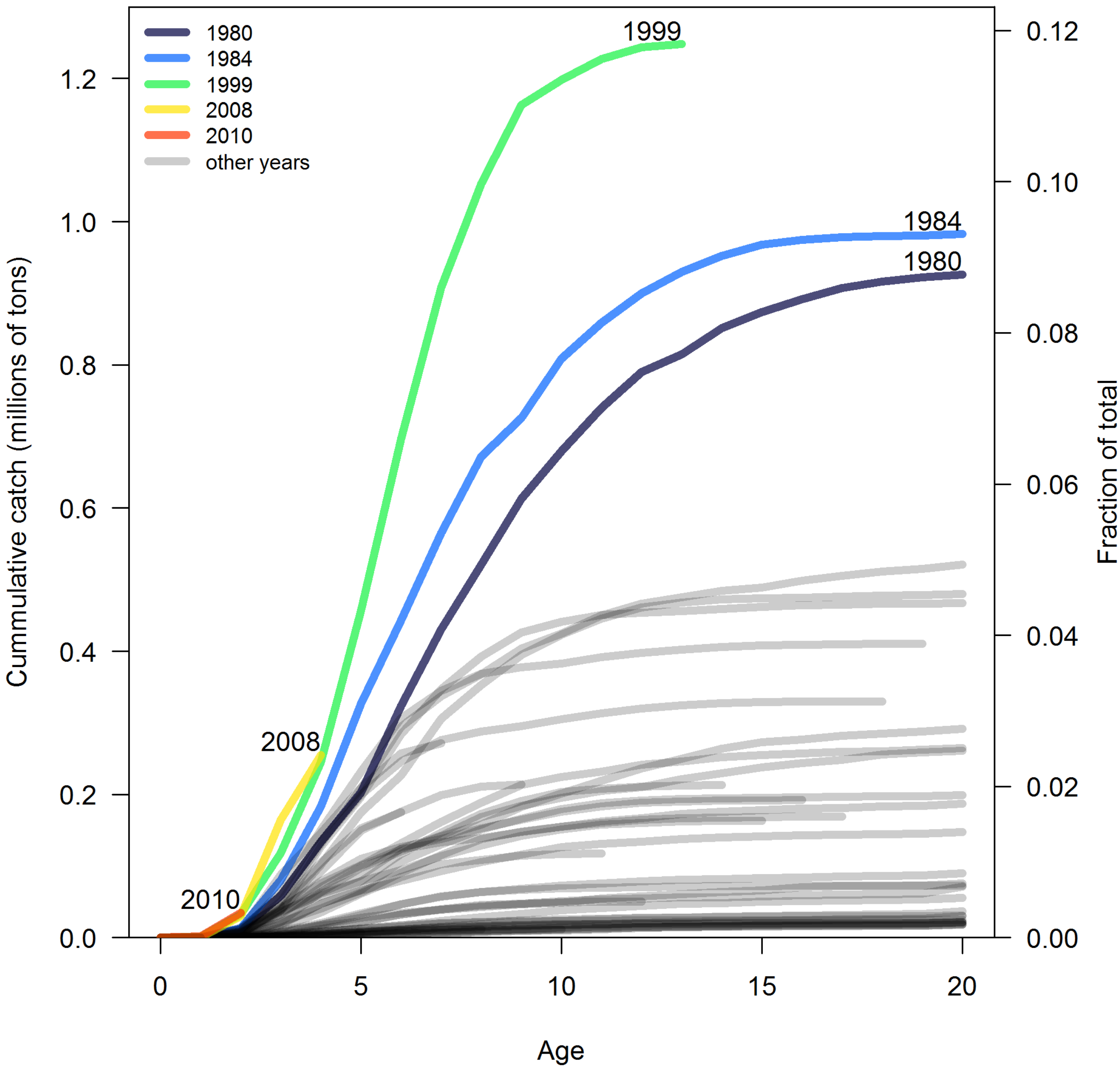


Figure 30: Model estimates of cumulative catch-at-age of each cohort. Cumulative catch in millions of metric tons is shown on the left axis and the percentage of the approximately 10 millions metric tons harvested since 1966 is shown on the right axis.

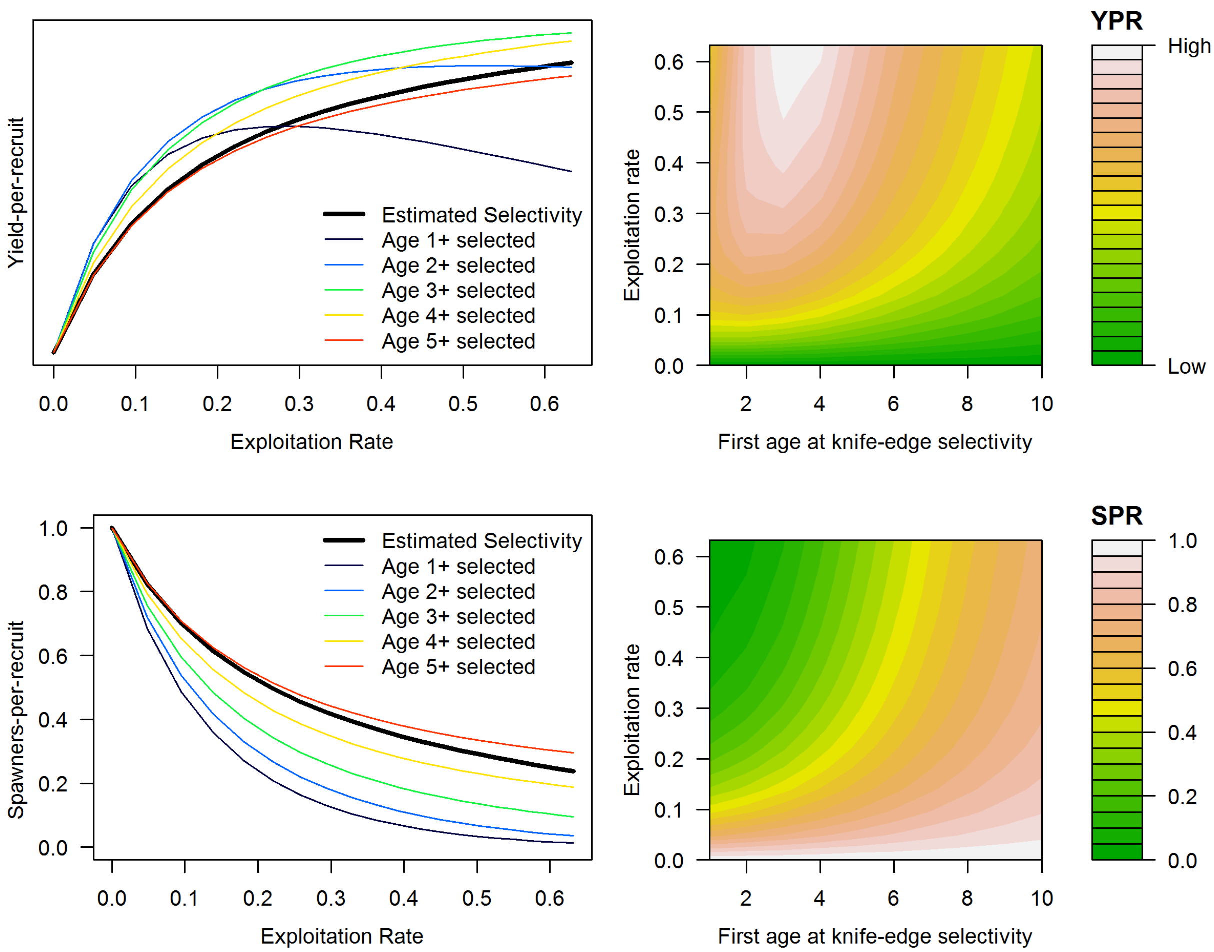


Figure 31: Equilibrium yield-per-recruit (top panels) and spawner-per-recruit (bottom panels) for Pacific hake using the estimated natural mortality from the base Bayesian model. Estimated selectivity is also from the base model, otherwise knife-edge selectivity was used.

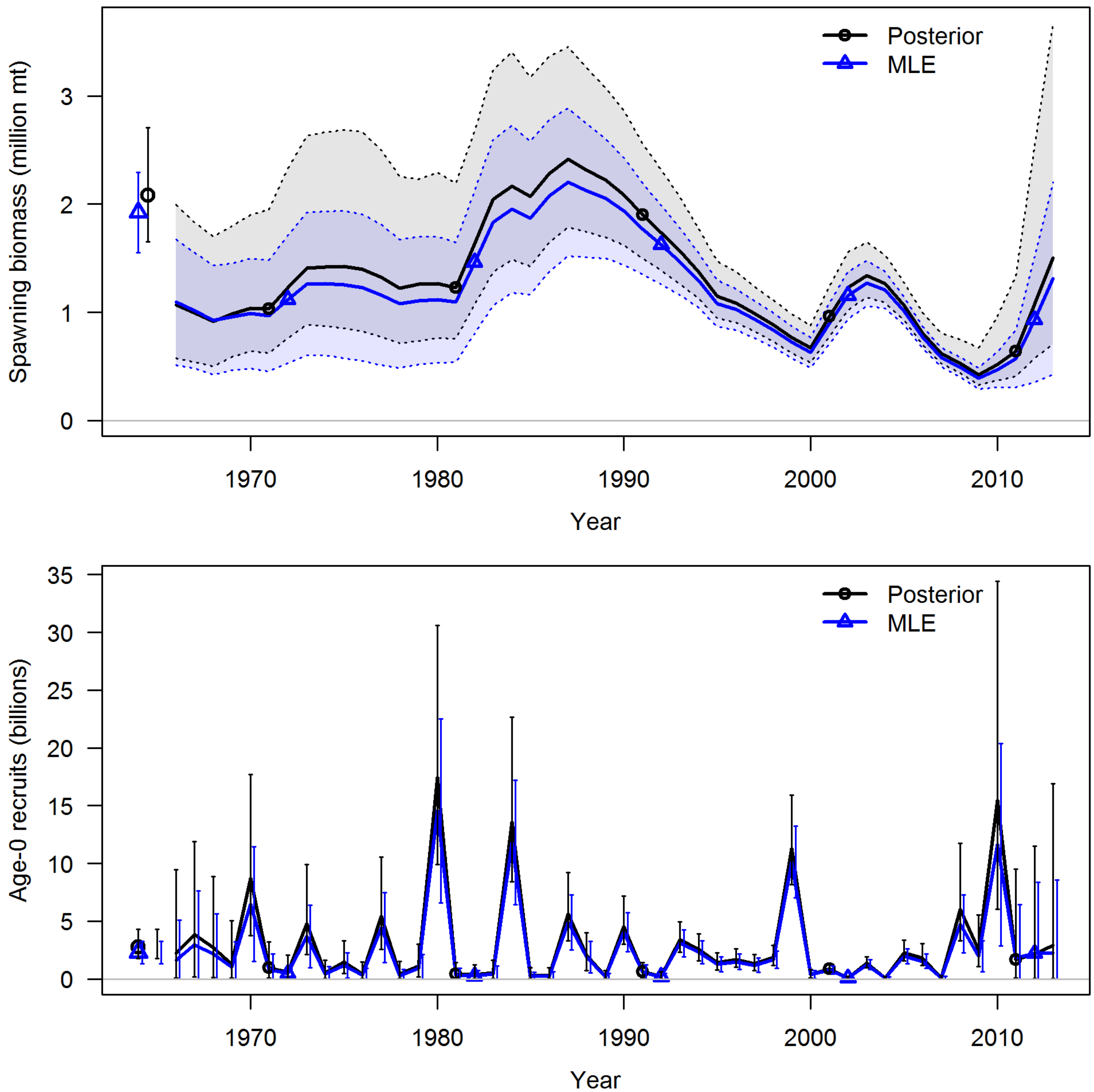


Figure 32: Comparison of MLE and Bayesian estimates (posterior) of spawning biomass and recruitment, with 95% asymptotic confidence intervals for the MLE, and 95% posterior credibility intervals for the Bayesian results.

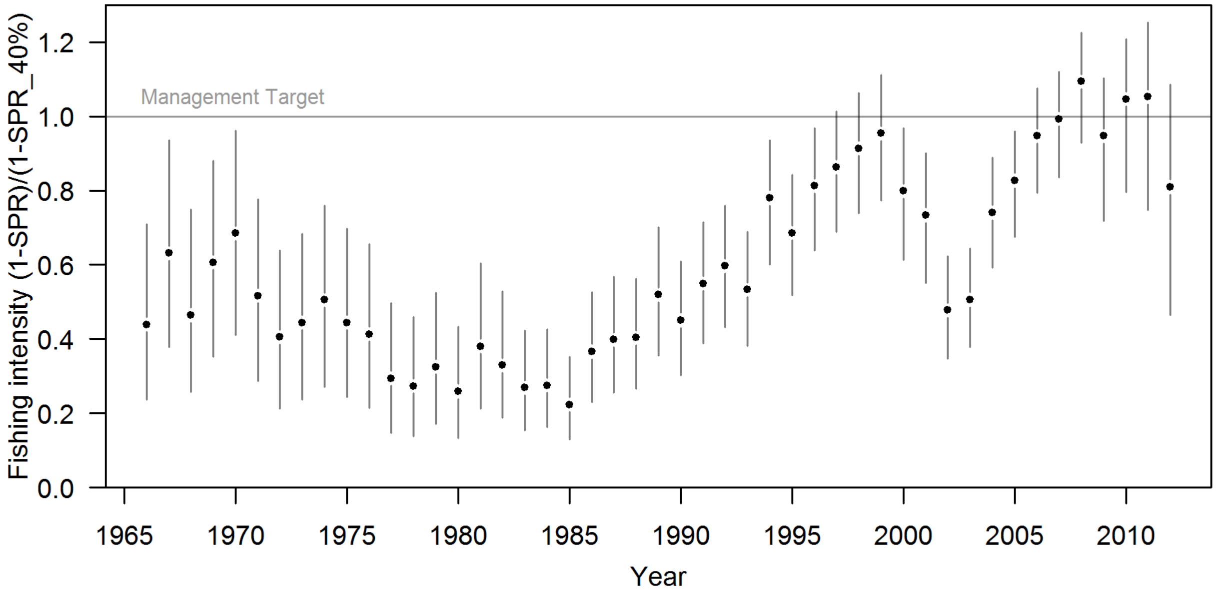


Figure 33: Trend in fishing intensity (relative SPR) through 2012.

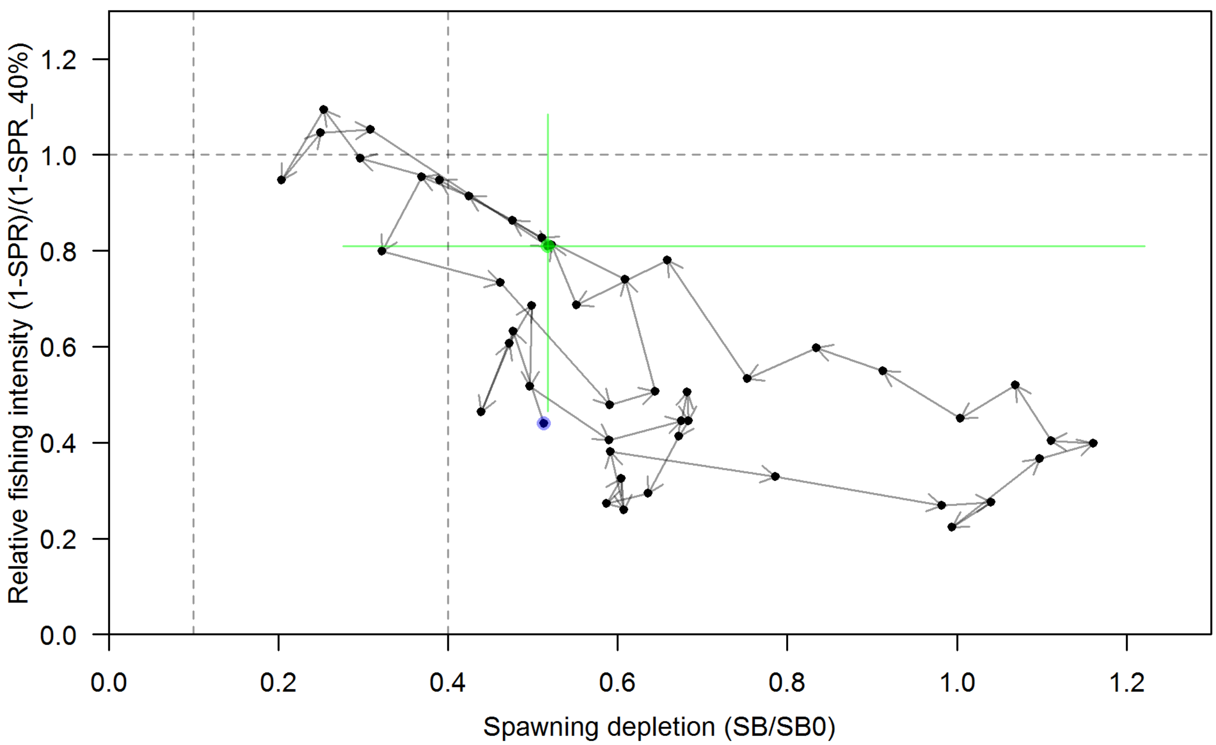


Figure 34: Temporal pattern (phase plot) of posterior median fishing intensity vs. relative posterior median spawning depletion through 2012. The blue circle indicates the start of fishing in 1966. The green circle denotes 2012 and the 95% posterior credibility intervals are shown along both axes. The arrows connects years through the time-series and the dashed lines indicate the fishing intensity target on the y-axis and the control rule limits along the x-axis (10% and 40%).

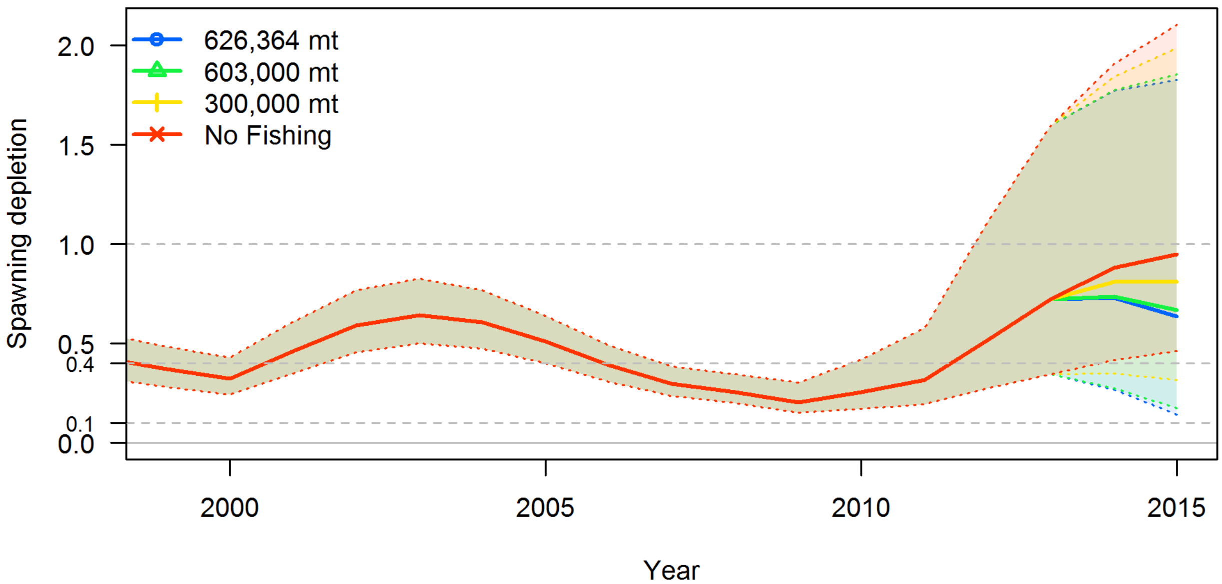


Figure 35: Time-series of estimated spawning depletion to 2013 from the base-case model, and forecast trajectories to 2015 for several several management options from the decision table, with 95% posterior credibility intervals. The 2013 catch of 626,364 mt was calculated using the default harvest policy, as defined in the Agreement, which updates future catches (see Table 13)..

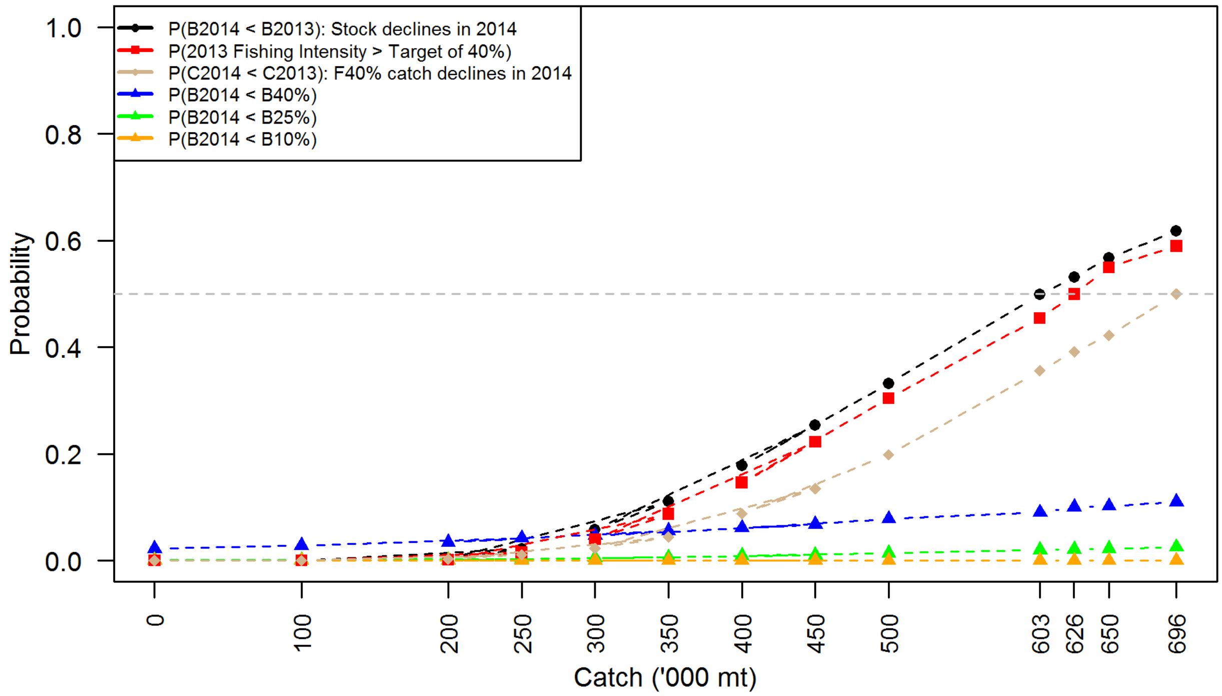


Figure 36: Probabilities of various management metrics given different catch alternatives. Catch alternatives are described in Table 13. The points show these specific catch levels and lines interpolate between the points.

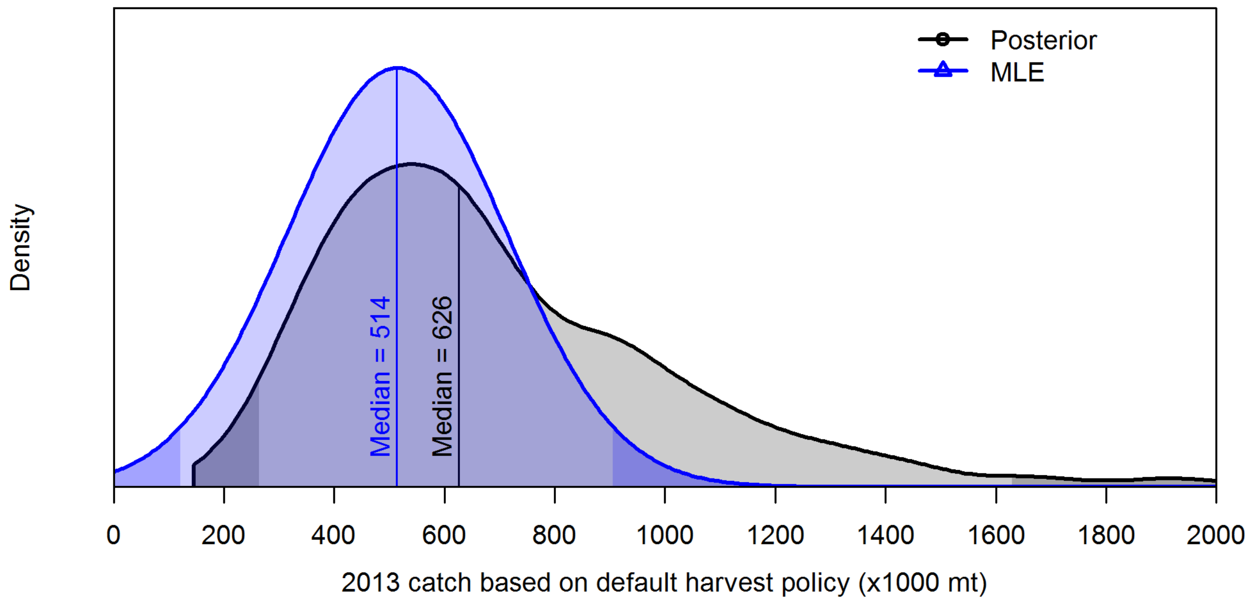


Figure 37: The MLE prediction and the posterior distribution of 2013 catch using the default harvest policy ($F_{40\%}$-40:10).

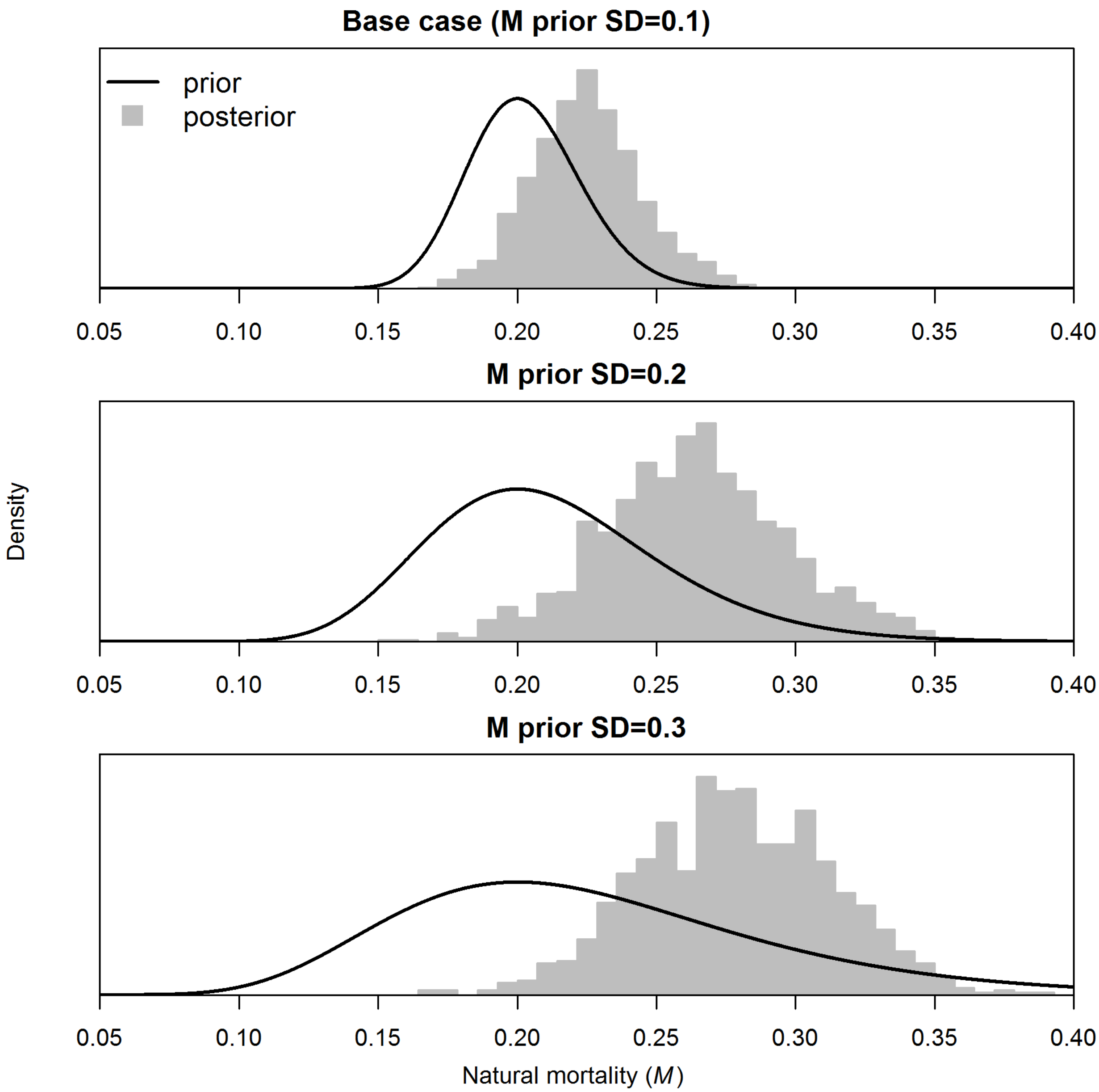


Figure 38: Alternative prior distributions for natural mortality (black lines), with resulting posterior distributions (gray histograms).

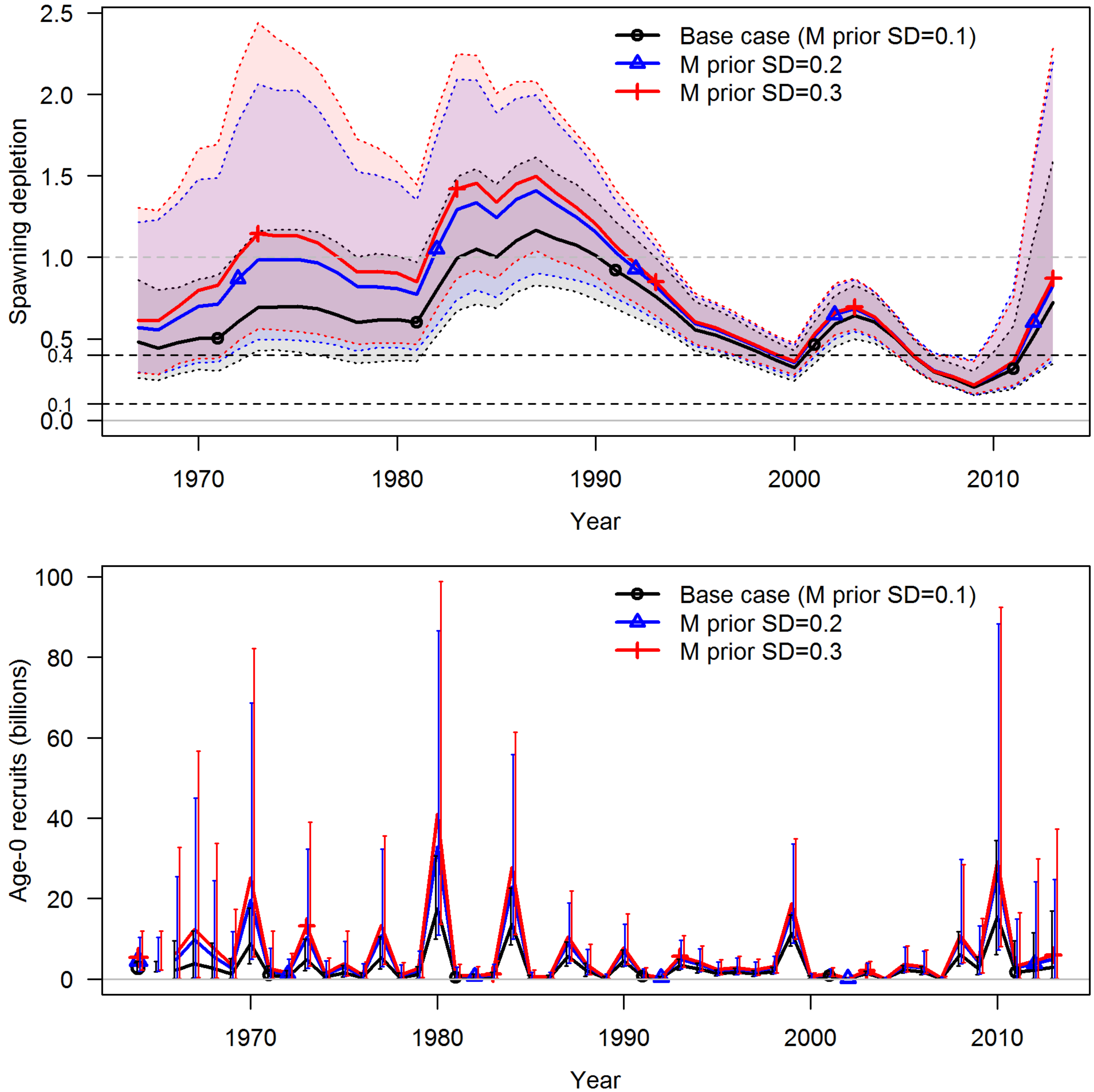


Figure 39: Sensitivity analysis to the mean of the width of the natural mortality prior.

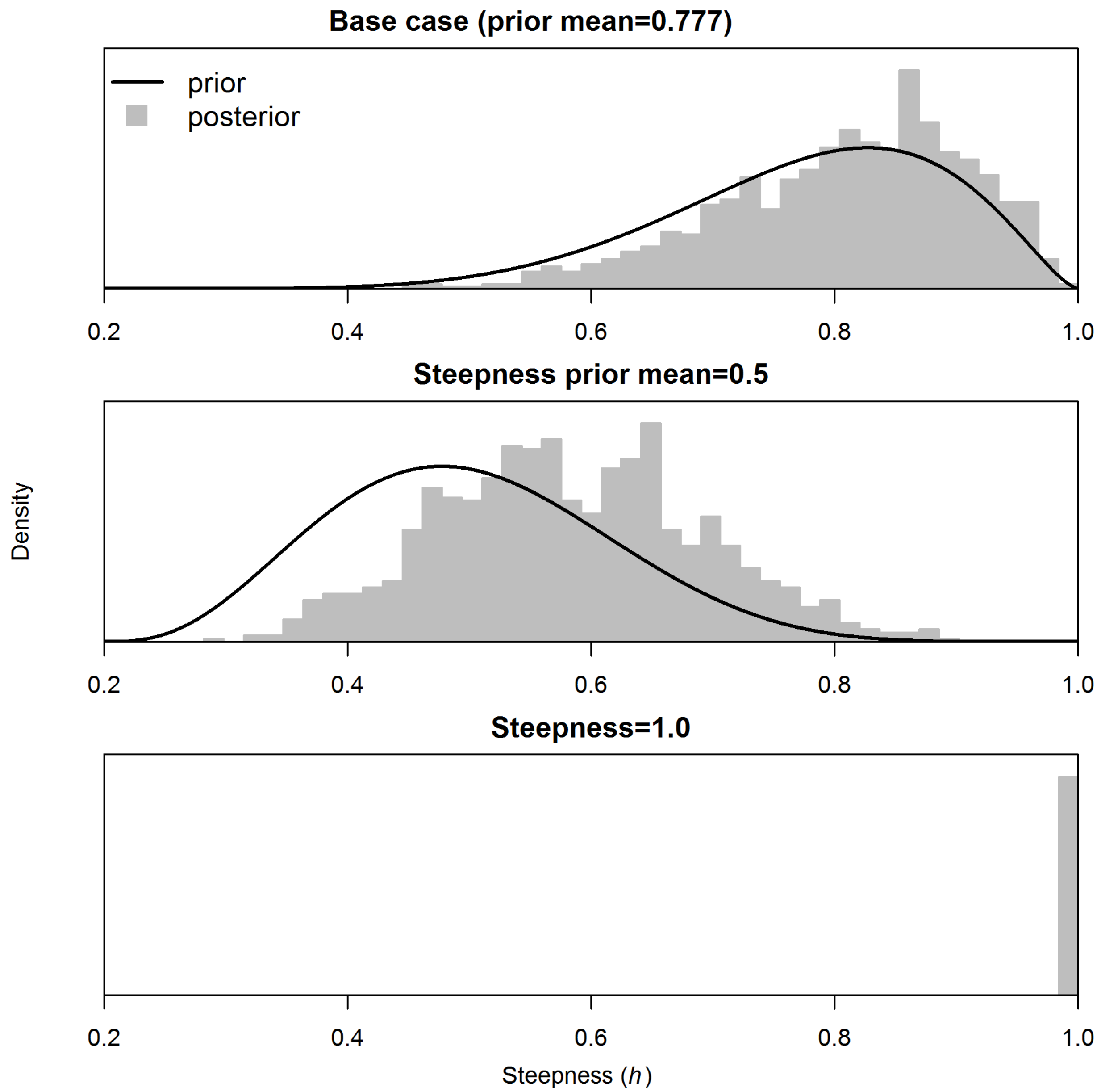


Figure 40: Alternative prior distributions for steepness (black lines), with resulting posterior distributions (gray histograms).

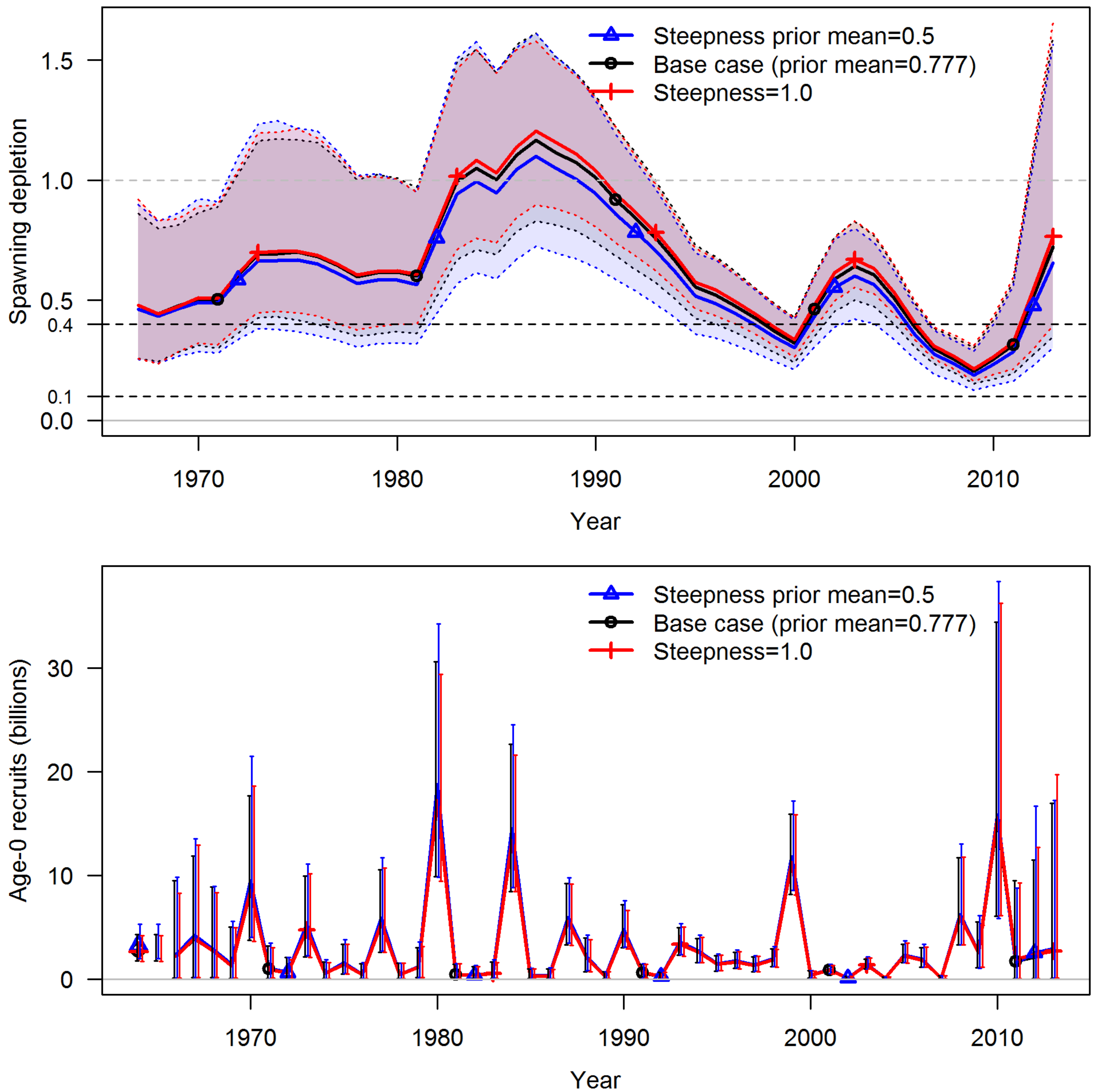


Figure 41: Sensitivity analysis to the mean of the steepness prior.

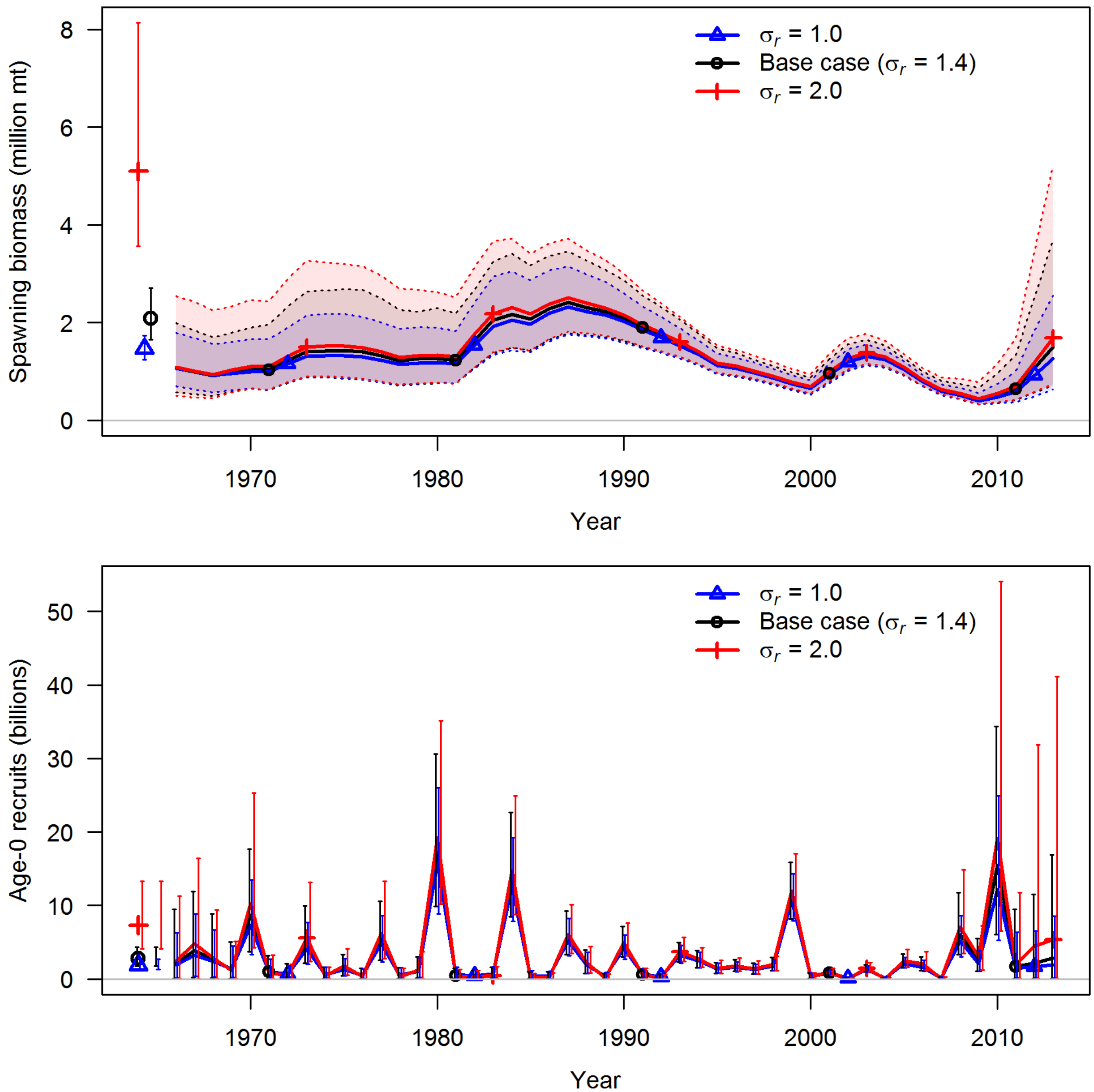


Figure 42: Sensitivity analysis to the alternative assumptions about the standard deviation of recruitment variability (σ_R). Note that upper plot shows spawning biomass rather than depletion.

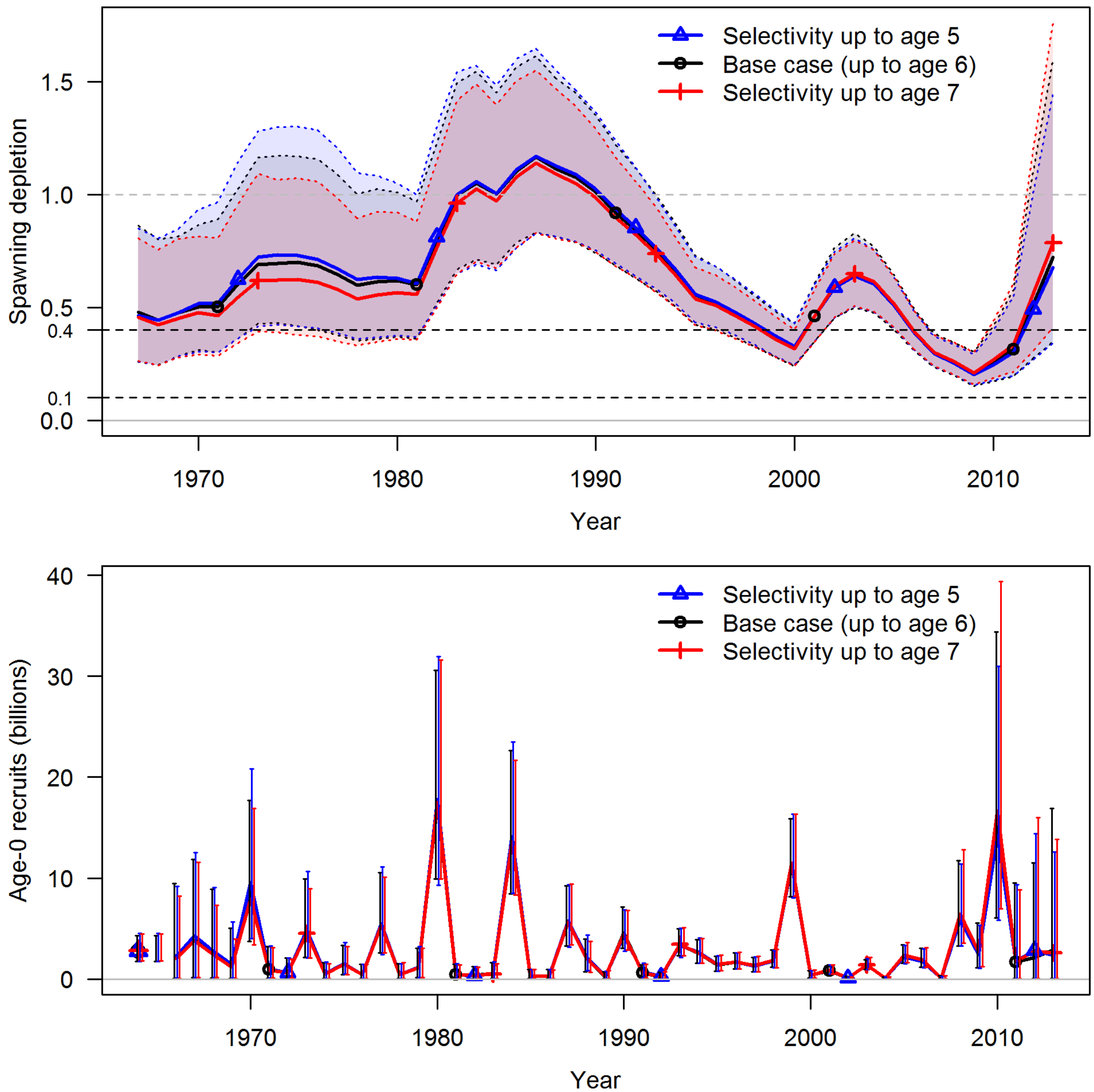


Figure 43: Sensitivity analysis to the range of ages for which selectivity is estimated.

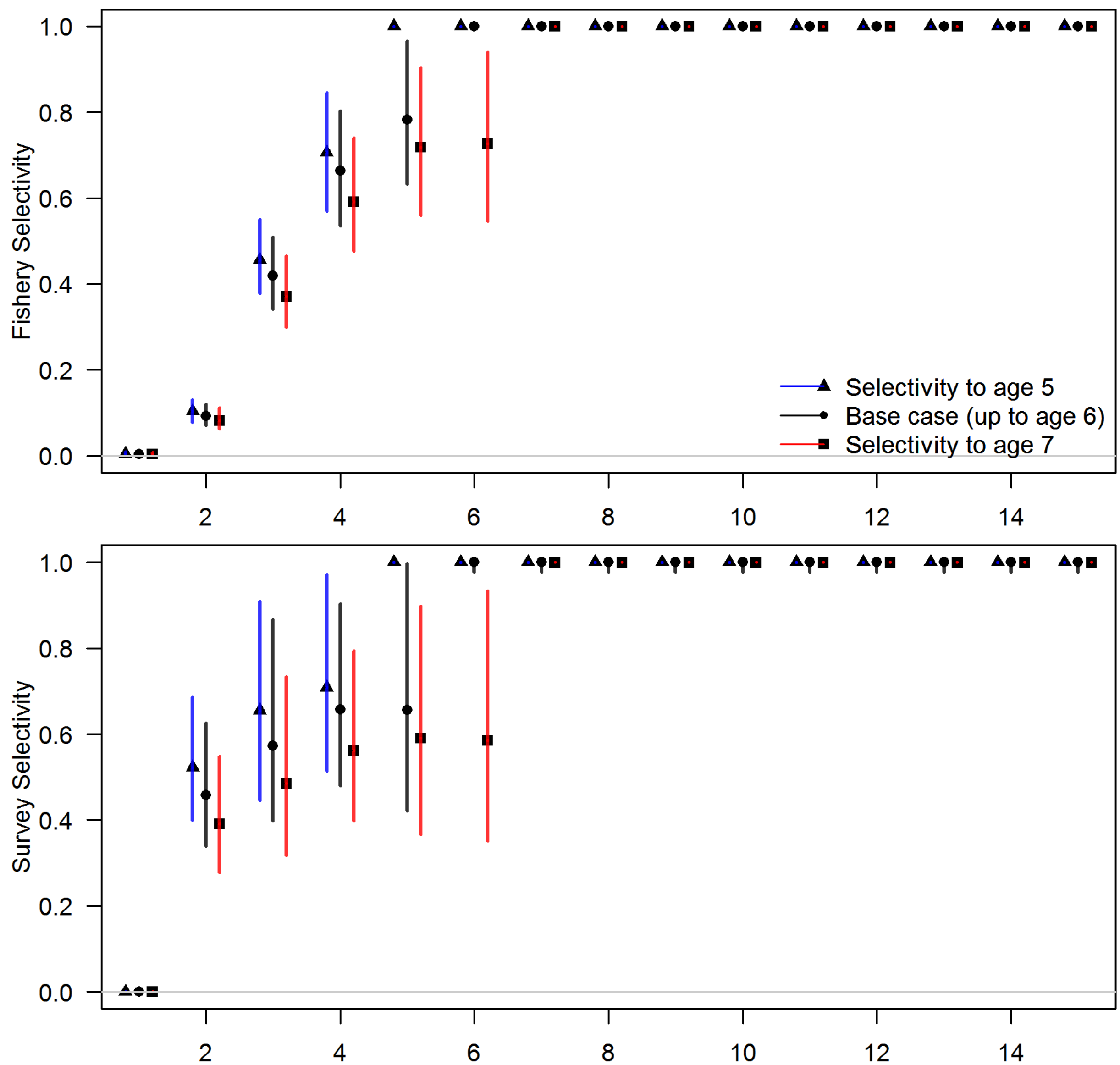


Figure 44: Estimated selectivity at age with 95% posterior credibility intervals for the base case (black) and estimating selectivity up to age 5 or age 7 (blue and red, respectively). Fishery selectivity is shown in the top panel and survey selectivity is shown in the bottom panel.

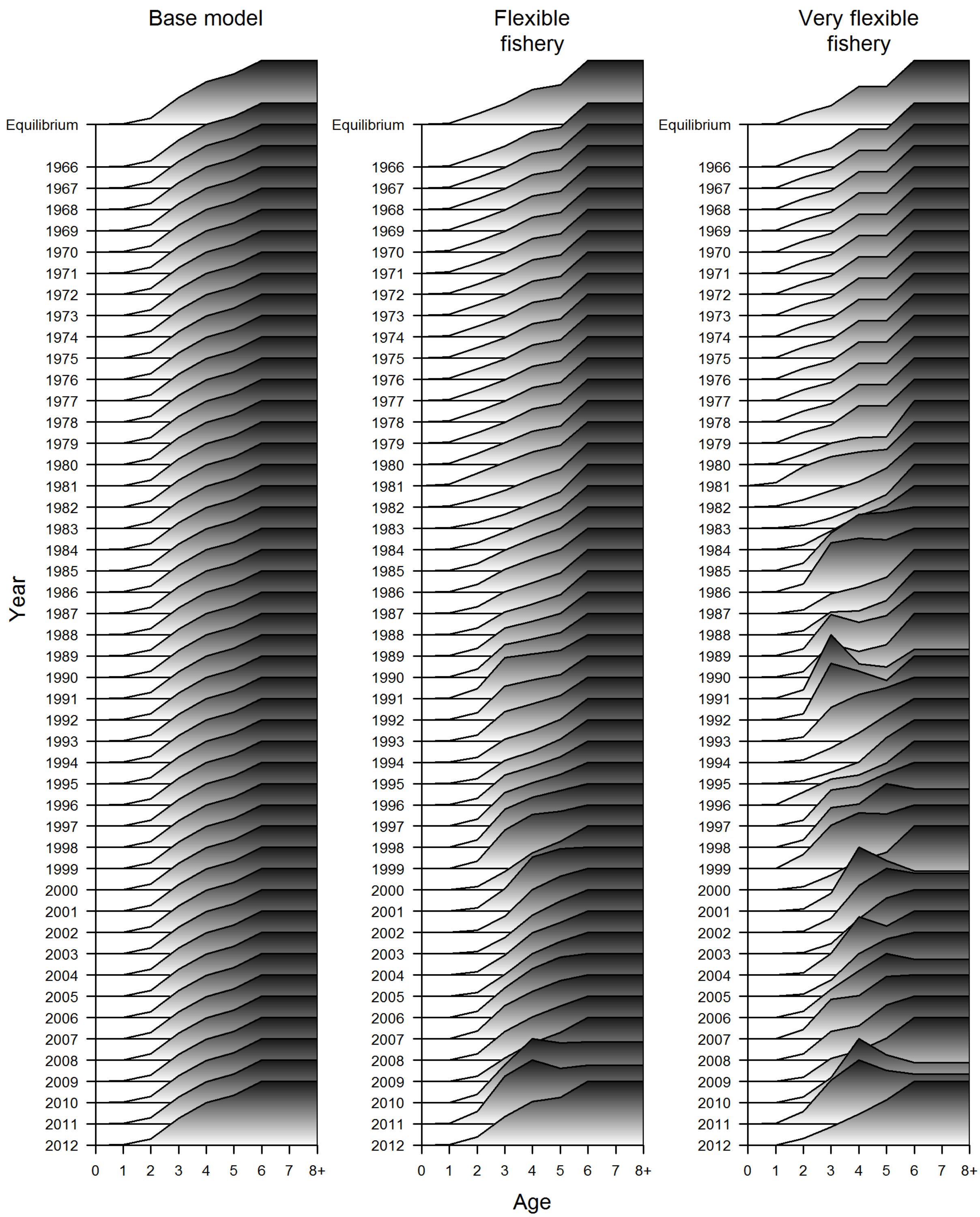
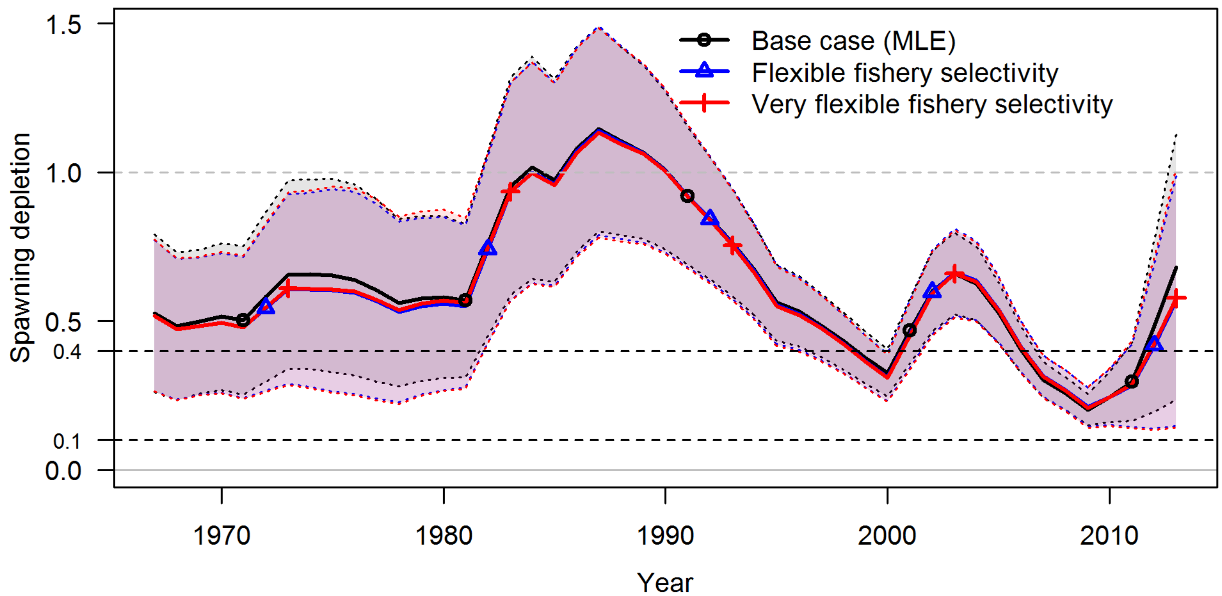


Figure 45: Estimated fishery selectivity for each year of the model under different assumptions about the flexibility of the changes.



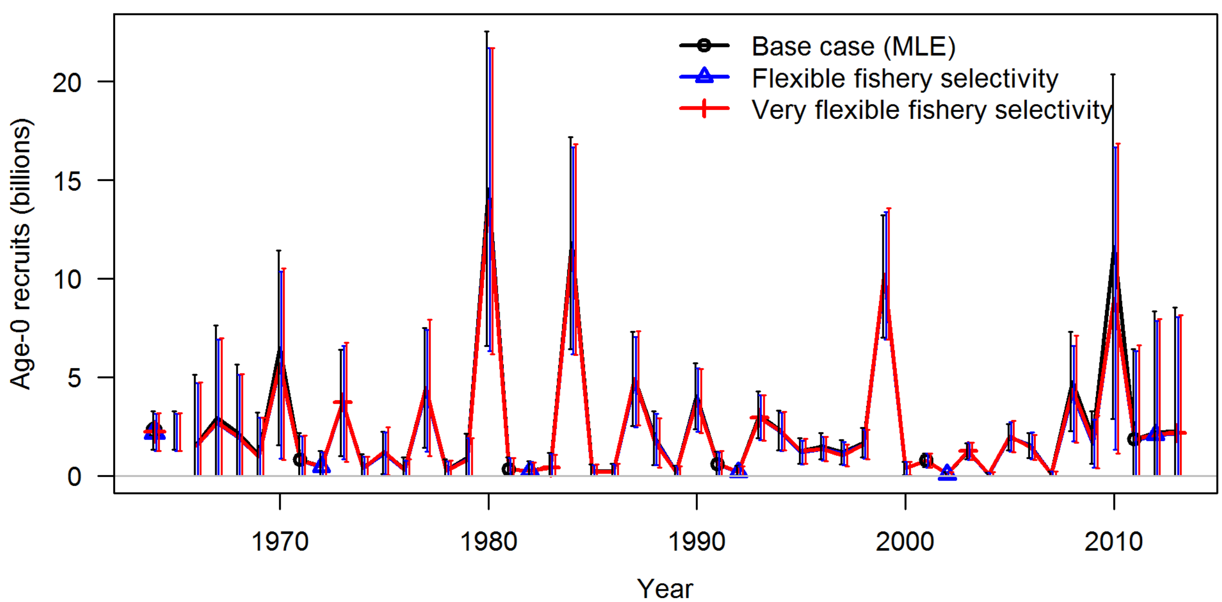
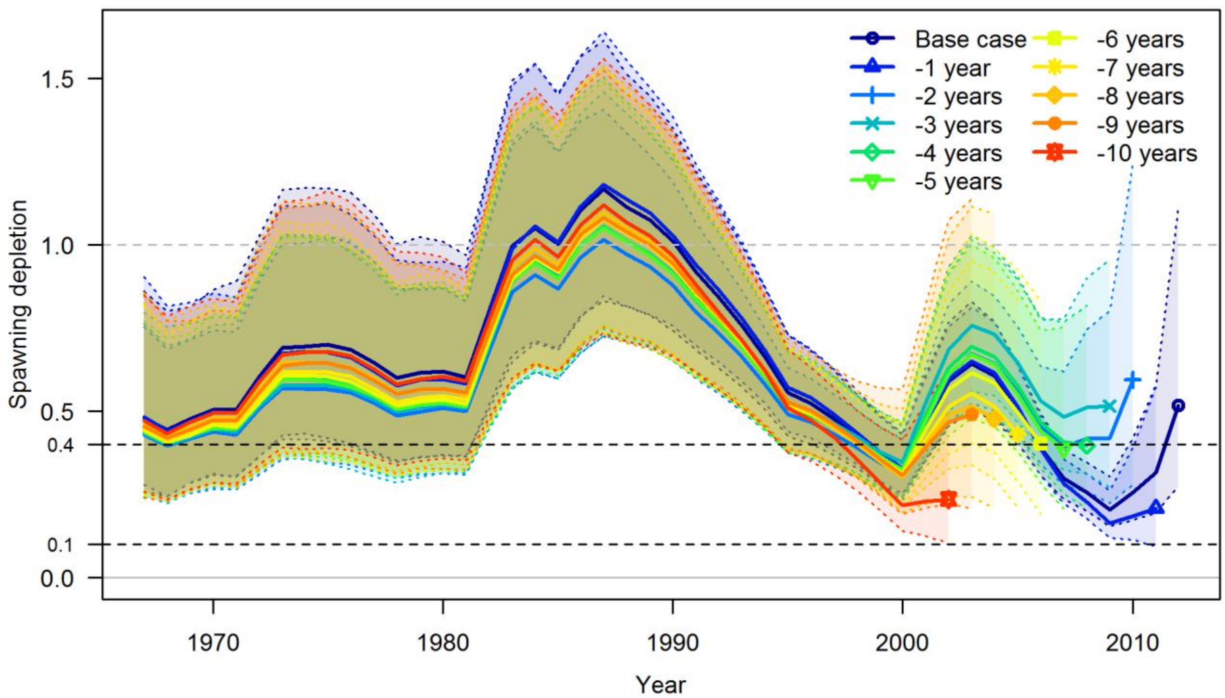


Figure 46: Sensitivity analysis to allowing fishery selectivity to change from year to year.



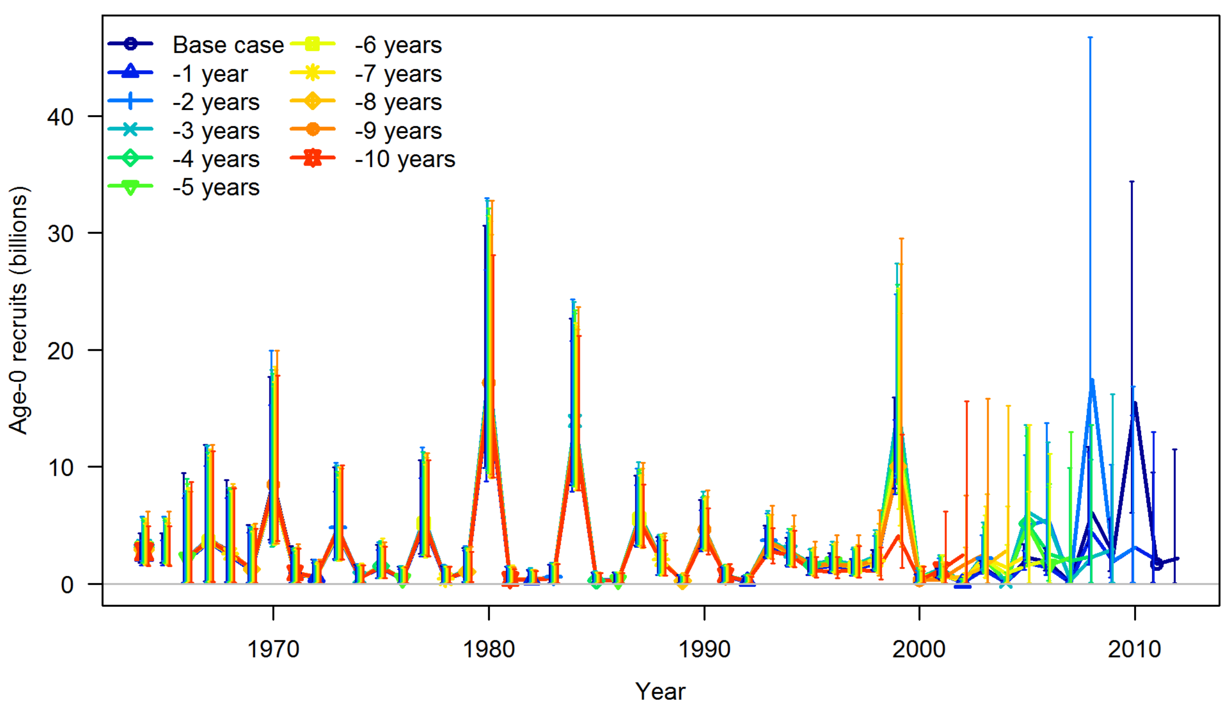


Figure 47: Retorspective analysis over the last ten years.

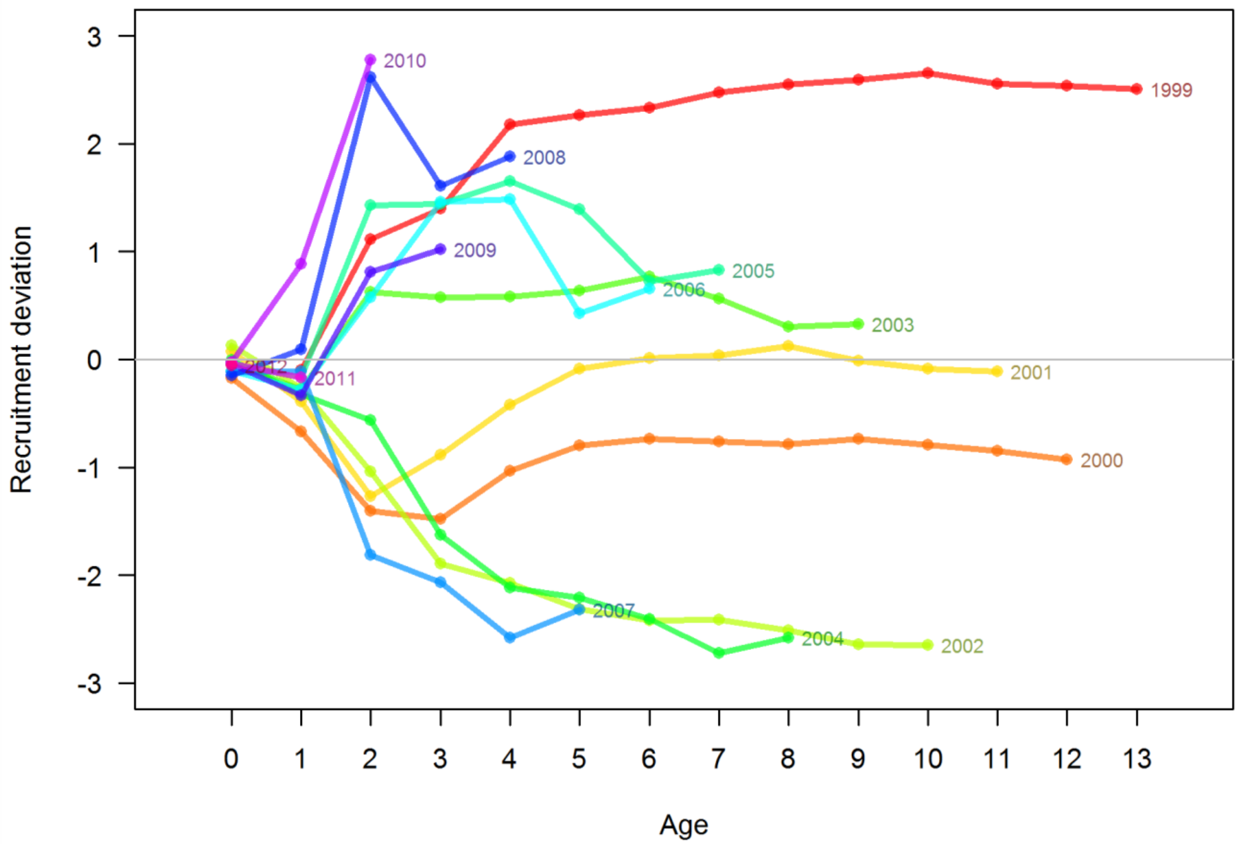


Figure 48: Retrospective analysis of recruitment estimates over the last twelve years. Lines represent estimated deviations in recruitment for cohorts starting in 1999 (with cohort birth year marked at the right of each line). Values are estimated in models with data available only up to the year in which each cohort was a given age. Recruitment deviations are log-scale difference between estimated recruitment and spawner-recruit expectation.

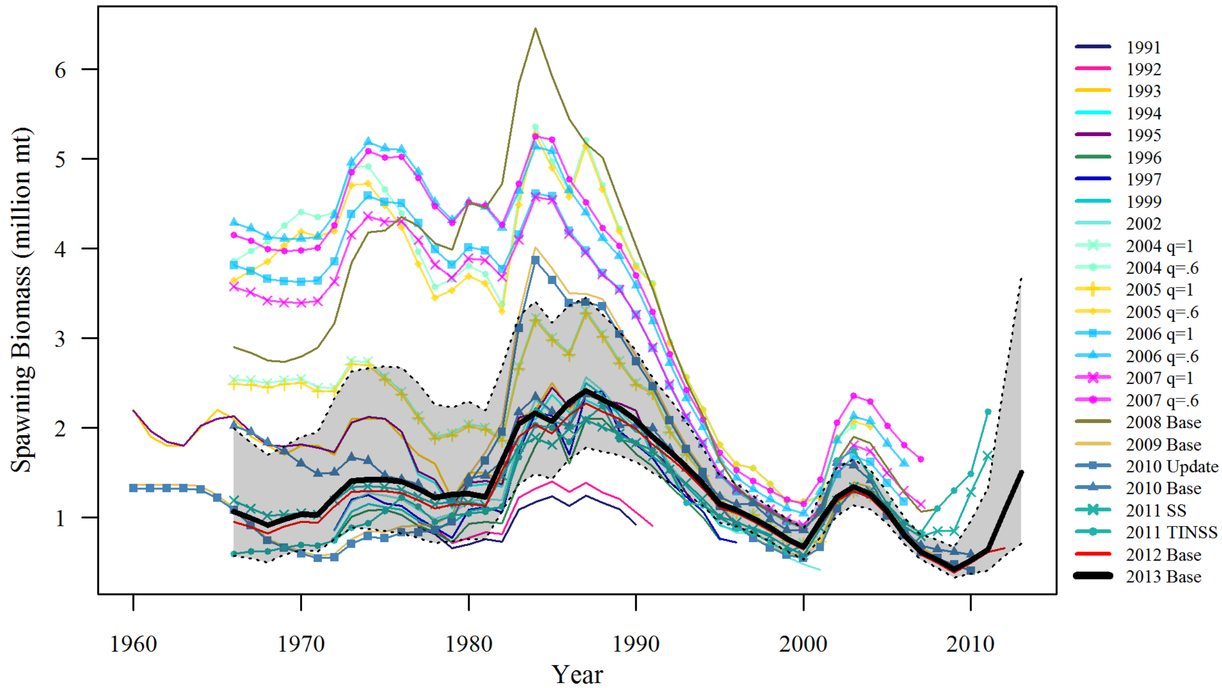


Figure 49: Posterior medians for the base 2013 assessment model (thick black line with 95% posterior credibility intervals notated with dashed lines and shading) in a retrospective comparing model results from previous stock assessments since 1991 (updates in 1998, 2000, 2001, 2003 are not included).

Appendix A. Management Strategy Evaluation (MSE)

Appendix A.1. Introduction

The Agreement between the Government of the United States of America and the Government of Canada on Pacific Hake/Whiting (The Agreement) was officially implemented in 2011. Part of this agreement defines a harvest control rule for setting Pacific Hake catches. The harvest control rule specifies an $F_{40\%}$ fishing mortality rate target combined with a 40:10 adjustment (default harvest policy). At equilibrium, the $F_{40\%}$ fishing mortality rate would reduce spawners-per-recruit (SPR) to 40% of the unfished equilibrium level. Target fishing mortality is then reduced linearly when the estimated spawning biomass depletion (i.e., SB/SB_0) is between 40% and above 10% of the estimated unfished level and then is set to zero when the estimated population falls below 10%. This harvest control rule is commonly referred to as the $F_{40\%}$-40:10 rule and it has been applied by the Pacific Fisheries Management Council since 1998 (PFMC 1998).

For Pacific Hake, estimates of depletion used for applying the 40:10 rule, and the corresponding predictions of sustainable harvest levels, have been very volatile. Harvest levels have changed as estimates have varied with data updates, but also because of several alternative assessment models that have been used since Pacific Hake assessments began (see Fig. 45 JTC (2012)). For example, the 2010 prediction of a sustainable harvest level was 455,550 mt. When forecasts were completed in 2011 using only commercial age-composition data, the model prediction increased to 973,700 mt. The high predicted 2011 biomass was followed by a 2011 acoustic survey biomass estimate that was the lowest in the survey index series; this led to a predicted sustainable harvest level from the 2012 assessment of 251,809 mt.

Large differences in the 2010 to 2012 predictions of sustainable harvest levels and the low 2011 survey biomass estimate produced at least two specific concerns for Pacific Hake management. The first concern was how well the $F_{40\%}$-40:10 rule performed at meeting conservation and yield objectives. Secondly, that the survey biomass was indicating an immediate conservation concern since it was the lowest ever observed since the survey began.

To deal with these concerns the Scientific Review Group (SRG) and the Joint Management Committee (JMC), bodies defined by The Agreement, recommended both a 2012 survey and a Management Strategy Evaluation (MSE). The 2012 survey was intended to help bolster the stock assessment's predictions, with the hope that an annual survey would provide more stock-status information than commercial age-composition data alone (the only data typically available in non-survey years). The MSE had two main objectives: i) to evaluate the expected performance of the $F_{40\%}$-40:10 rule and ii) evaluate the relative improvement that was gained by using annual instead of biennial surveys.

MSE is an iterative prospective evaluation of the full management system using computer simulation. his type of analysis is also called Harvest Strategy Evaluation (Punt and Smith 1999), Management Procedure Evaluation (Butterworth 2007), and the Management Oriented Paradigm, MOP (de la Mare 1998). MSE uses computer models to represent the underlying fish population, data gathering, stock assessment analysis, and harvest control rule application as well as measures of management strategy performance. The choice of a particular management strategy from a set of candidates is made by evaluating their ability to satisfy a hierarchy of measurable objectives, given practical and economic constraints, at a cost that is commensurate with the benefits (de la Mare 1998). The MSE approach has been used in a variety of fisheries including: Blue Eye Trevalla (Fay et al. 2011), Northeast Atlantic flatfish stocks (Kell et al. 2005), Rock Lobster (Punt and Hobday 2009) and Southern Bluefin Tuna (Kurota et al. 2010). Regionally it has been used to evaluate rebuilding revision rules for overfished rockfish stocks (Punt and Ralston 2007) and applied for several years in the B.C. Sablefish fishery (Cox and Kronlund 2008). There are typically several iterations in an MSE, with various approaches to management being simulated, modified and re-evaluated as objectives are developed and reconsidered (de la Mare 1998).

Management Strategy Evaluations have only been possible to perform in recent years due to the large amount of computer processing power, memory resources, and storage space that they require. For example, this MSE has an operating model that runs 1000 simulations, each of these has an 18 year projection, and there are 2 cases with assessments. The number of assessments run was 999x18x2 = 35,964 assessments. The output data from this MSE takes up nearly 45 GB of disk space.

For MSE, measurable management objectives typically fall into three categories: i) Conservation - to avoid deleterious changes to the stocks and the environment; ii) Socio-economic – to maximize benefits derived from fishery yield, and iii) Variability – to minimize large changes in year-to-year catch (de la Mare 1998). To make objectives measurable, performance statistics are calculated. For each statistic, time frames and probabilities are imposed, for example, the proportion of times in 2021–2030 that the depletion dropped below 10%.

In practice, one cannot maximize conservation, yield and catch stability simultaneously. Conservation and yield trade off against each other (Ricker 1958, de la Mare 1998, Kell et al. 2005, Cox and Kronlund 2008); maximizing yield may require frequent large adjustments of catch limits including complete closures in response to variability in stock assessments and recruitment (Ricker 1958, de la Mare 1998), as has been the case in Pacific Hake. In addition expected average catch is typically inversely proportional to expected final depletion (Punt and Smith 1999). In many situations, management objectives exist in a hierarchy as well. For example, there can be legal or policy constraints for avoiding small stock sizes that take precedence over other objectives, such as reducing the catch variability.

MSE is a process not a product. MSE is more than just closed-loop simulation software that is delivered to managers and stakeholders from scientists. Among other things, managers must define objectives; stakeholders must define costs/benefits associated with a range of potential outcomes; scientists must define credible hypothesis about the stock and identify assessment methods and tool available for management. All participants must communicate these elements to each other and adapt the process as need and available resources require.

Below we describe the MSE methodology as it was applied to Pacific Hake. Because, the full set of consultation activities is ongoing, the analysis we present in this paper is not yet a fully-fledged MSE. It is a first round of closed-loop simulation aimed at addressing two issues, testing the performance of the $F_{40\%}$-40:10 rule, and the relative performance of annual, vs. biennial, acoustic surveys. We also provide performance analyses of alternative rules that use different target harvest rates i.e., $F_{SPR\%}$-40:10 rules.

Appendix A.2. Materials and methods

The closed loop simulation proceeded as described in Figure A.1:

1. From the operating model, data were generated that were generally comparable to the real data collection system (for the Annual Survey Case, the survey index and age composition were generated every year, for the Biennial Survey every second year).
2. The simulated data were fit by the stock assessment model, from which
3. The control rule was applied.

4. The catch specified by the control rule was input back into the operating model to feedback into the future stock dynamics represented by the operating model.
5. Steps 1-4 were projected forward for eighteen years
6. Steps 1-5 were repeated 999 times (one for every posterior sample of the 2012 base case assessment model). The realized performance represented using performance statistics.

Operating model

We used the JTC (2012) Bayesian age-structured model stock assessment model (JTC 2012) as the operating model for Pacific hake. The model was built in Stock Synthesis version 3.23b (SS) (Methot and Wetzel 2012). The model was conditioned (i.e., fitted to) on the 1966-2012 data (Figure A.2), which resulted in approximate posterior distributions for a selected set of parameters including fishery and acoustic survey selectivity-at-age, survey catchability (q), natural mortality (M), steepness (h), unfished equilibrium biomass (B_0), and annual recruitment deviations (Table A.1). Markov Chain Monte Carlo (MCMC) was used to characterize the variability of the population by sampling every 10,000th point from a chain of 10,000,000, and discarding the first sample as a burn-in, as was done in the 2012 assessment (JTC 2012). This left 999 samples from the posterior distribution, where each sample consisted of a vector of parameters that was used to simulate the population into the future. The posterior distribution of parameters resulted in a median 2012 depletion of 33% with 2.5th-% and 97.5th-% percentiles of 9% and 102%, respectively.

Data generation

We simulated survey abundance index and age-composition data for the years 2012–2030 from the operating model to reflect the typical data available for stock assessments. The acoustic survey index of abundance was assumed to be log-normally distributed according to

$$I_{i.y} = \mathrm{LN}\left(median = q_i e^{-0.5M} B_{i,y}^{\text{survey}}, \sigma_{\ln(I)}\right) \tag{1}$$

where the median is the mid-season biomass selected by the survey, adjusted by catchability.

$$B_{i.y}^{survey} = \sum_{a=1}^{A} N_{i,y,a} s_{i,a}^{\text{survey}} \overline{w}_a \tag{2}$$

Age-based selectivity for the survey s^{survey} is taken from the posterior distribution, which means it is different for each of the 999 simulations. The beginning of year numbers-at-age, $N_{i,y,a}$, were from the operating model population, and , $\overline{w}_a$, , is the average of weight-at-age over the years from 1975 to 2011 (Table A.2). The maximum age, A was set to 15 years in the operating model.

The standard error in log-space was a combination of the intra- and inter-year standard errors.

$$\sigma_{\ln(I)} = \sqrt{\sigma^2_{\ln(\text{intra-year}),y} + \sigma^2_{\ln(\text{inter-year}),i}} \tag{3}$$

The intra-year standard error for the survey was fixed at a value of 0.085 and was the input into SS (see Table A.3 for a history of acoustic survey estimates). This standard error represents the mean of the observed standard errors determined from an analysis of the year-specific survey data. The inter-year standard error represents the additional year-to-year observation error in the survey that is not explained by the measurable sampling variability. These values are simulation specific because the assessment model estimated a value to be added to the intra-year standard error as in the 2012 assessment (JTC 2012) We chose to use a total standard error of 0.42, similar to that estimated from the 2012 assessment model. With an intra-year standard error of 0.085, the inter-year standard error, from equation 3, was approximately 0.41.

We simulated proportion-at-age data for the fishery and survey using a multinomial distribution with probabilities

$$n_{i.y,a} = N_{i,y,a} s_{i,a} \Omega \tag{4}$$

given by the product of numbers-at-age (N), selectivity (s) and ageing error Ω. Effective sample sizes for the fishery and survey were assumed to be the same as the recent estimates from the 2012 assessment (JTC 2012) and are shown in Table A.1.

The ageing error matrix (Ω) contains the probabilities of assigned ages for each true age, where the probabilities are determined from a normal distribution centered on the true age with standard deviation increasing with true age (Table A.2). Ageing error was applied before the sampling process, but in retrospect, we believe that the ageing error should be applied after the sampling process. However, in the interest of time, we were unable to rerun the simulations with this change. Initial runs suggest that the MSE results were not very sensitive to ageing error.

Assessment model

Simulated assessments were used to provide catch recommendations based on a control rule for each management strategy considered. The simulated assessments estimated spawning stock and exploitable biomass by fitting each year's simulated index and age-composition data. The stock assessment model was set up similarly to the 2012 SS base model (JTC 2012), and was therefore structurally identical to the operating model. Estimation was done by maximizing the joint posterior density. For each simulated assessment, model parameters were initialized at values estimated in the previous year and convergence was acceptable if the final maximum gradient was less than 0.1. If convergence was not acceptable, the starting parameters were jittered and the assessment was repeated. This was repeated 3 times, after which the final assessment was accepted, regardless of convergence. The majority of assessments had a maximum final gradient less than 0.001, and only one simulation in each case failed to meet the above criteria. The maximum posterior density (MPD) estimates of spawning stock biomass depletion and exploitable biomass were used for applying the $F_{40\%}$-40:10 rule to determine the year's catch.

Management strategies

For the 2013 hake MSE, we only consider a narrow range of management strategies. A management strategy is the combination of data collected (e.g., frequency and quality), the stock assessment, and the control rule which assists in determining catch. We limit the number of management strategies we consider in two key ways. First, we keep the structural form of the operating and assessment models identical. Second, out of a large universe of possible harvest control rules, we only consider one, the

40:10 rule. We do consider some alternative $F_{SPR\%}$ default harvest rates presented in the Additional Analyses section below.

We investigated four main management strategies (Table A.4). First, the management strategy of no fishing was simulated as a comparison to other cases and to determine the trajectory of the simulated (operating model) population with no catch (No Fishing). Second, perfect information from the operating model was used in the control rule to set the catch for next year (Perfect Information); data and an assessment model were not needed in this case. The third and fourth management strategies used simulated survey and fishery data, as described above, and the assessment model to estimate a population trajectory and an associated catch. Catch and fishery catch-at-age were available every year, so the only difference between these two management strategies was survey frequency. The Biennial Survey management strategy assumed that an index of abundance as well as survey and commercial catch-at-age data were available for alternate years starting in 2013 but that in non-survey years there were only catch and commercial catch-at-age data. The Annual Survey management strategy assumed that catch, commercial age-composition, the survey index, and the survey age-composition data were available every year. Surveys completed prior to 2012 are listed in Table A.3. For the hake MSE survey data were always generated for 2012 even for the Biennial Survey management strategy since the survey was underway when this analysis was being done.

The No Fishing management strategy provides a baseline measure of the stock. In this case, the operating model was run into the future with catches of zero in every year. We do not provide a full series of performance statistics for the No Fishing management strategy because there are no catch-based statistics in this instance. Accordingly, we confine our presentation of the No Fishing management strategy to plots of the depletion time series (Figure A.3) and the kernel density for depletion (Figure A.4).

The Perfect Information management strategy involved applying the catch given by the operating model's harvest control rule calculation. This case illustrates the fundamental properties of management procedures absent assessment errors. Because the Perfect Information management strategy does not have any assessment errors, it is important for disentangling the effects of assessment errors from the intrinsic properties of the default harvest policy.

Assessment errors can occur when assessment models represent the true stock dynamics improperly due to incorrect structural forms or assumptions. There are also ways such errors can be introduced even when the operating and assessment model are structurally identical, for example if there is insufficient contrast in catch and fishing mortality to generate reliable estimates of the productive potential of the stock (Ludwig and Hilborn 1983). To evaluate the effect of assessment errors, the Annual and Biennial Survey cases evaluate harvest control rule performance with more realistic data assumptions. Together with the Perfect Information management strategy, these two management strategies attempt to cover a spectrum of harvest control rule performance as a function of information quality. On one end of the spectrum the Perfect Information management strategy illustrates the theoretical limit of not needing information because the manager has perfect knowledge of what the quantities needed, and on the other; the Biennial Survey illustrates the lowest information case, with the Annual Survey case in between.

Analysis and performance measures

With MSE, performance is measured using performance statistics. We chose seven key performance metrics over (2013-2015), medium (2016-2020) and long (2021-2030) time frames (for some definitions see Table A.5). We divide performance statistics into those that measure the proportion of years within a given time period that the stock is in a particular state, and the medians of quantities that measure catch, stock-status, and variability in yield performance (Table A.6 and Table A.7, respectively). With the exception of the proportion of years that a management strategy closes the fishery all performance statistics in Table A.6 refer to the stock status given by the operating model. The second group is the medians of average depletion and average catch as well as AAV (Table A.7). For those readers wishing to consider a broader set performance measures we provide a full set of performance metrics in Table A.8.

We chose performance statistics to help illustrate if particular strategies have met conservation/legal, catch, or variability objectives. To illustrate if management procedures meet conservation objectives, we use the percentage of years that depletion is: below 10%, 10-40% and above 40% as well as the median average depletion. For yield objectives we consider the median of the average catch and for variability in yield we present use the average annual variability in catch, AAV. We also illustrate these same quantities using a range of graphics of the time series of depletion, catch as well as the long-term probability distributions of depletion, catch and AAV.

Additional Analyses

We considered an additional set of simulations in order to illustrate the general effects of varying the default harvest rate. Specifically, we applied the harvest control rule, with perfect information to a range of alternative default harvest rates. The aim of these additional simulations was to illustrate the tradeoffs between depletion, yield and catch stability.

Appendix A.3. Results

The MSE predicts that the default harvest control rule keeps the stock above 40% for a minority of years (Table A.6). The proportion of years that depletion is above 40% declines from the short to the long term in all management strategies with the highest proportion of years above 40% depletion using the Biennial Survey strategy. Within each management strategy, the proportion of years that the stock is in the 10-40% range increases as time frames extend from short to long for all management strategies (Table A.6). The proportion of years that the stock spends above 40% depletion decreases with data quality and quantity; it is lowest in the Perfect Information, Annual Survey, Biennial Survey strategies, respectively (Table A.6).

How often the operating model predicts the simulated stock to be below 10% differs between strategies, time frames, and survey frequencies. In the Perfect Information case, the MSE predicts that the stock will be below 10% depletion less than 5% of the time in the short term. In the short term, the stock has not come to equilibrium with the management strategy and is therefore sensitive to the starting conditions of the simulation period i.e. for some random simulations, the stock starts below 10% depletion. However, in the Perfect Information case, the proportion of years that the stock is predicted to be below 10% is less than 1% over the medium and long term (Table A.6 and Figure A.3). While the proportion of years that depletion is less than 10% decreases over time in the Perfect Information case, it is highest in the medium term for both Annual and Biennial Survey management strategies (Table A.6 and Figure A.3).
For all management strategies that we considered, the actual (given by the operating model) and perceived (given by the assessment model) proportion of years that the stock is below 10% depletion differed. All management strategies suffered from both false positives (i.e. they closed the fishery when the stock is above 10% depletion) and false negatives (they did not close the fishery when the stock is below 10% depletion). In the short term, the Perfect Information management strategy did not result in fishery closures even though the operating model predicts depletion to be below 10% approximately 5% of the time; this paradoxical observation is because all simulations applied the actual 2012 catch, and in some of these instances this catch was sufficiently large to deplete the simulated stock to below 10%. Similarly, over the long and medium terms, the Perfect Information management strategy essentially never closed the fishery; in these instances, the operating model predicted the frequency that the stock is

below 10% is less than 1% (Table A.6). The Annual and Biennial Survey management procedures close the fishery less frequently than the proportion of years that the simulated stock was actually below 10% in the short term (Table A.6). However, in the long term, the Annual Survey strategy closed the fishery more frequently than the proportion of years that the operating model predicted the stock to be below 10% depletion, and the Biennial Survey management strategy even more so.

The predicted distribution of long-term depletion for all management strategies considered is summarized in Figure A.4. The No Fishing case shows that in the long term, the stock is still settling to an unfished equilibrium with a mean depletion approaching unity (Figure A.3) and a long-term median depletion of approximately 75% (Figure A.4). For those instances where harvest was applied, the default harvest control rule did not produce median average depletion levels of 40% regardless of survey frequency or information quality (Table A.7). In the long term, all management strategies except No Fishing, had median depletion levels well below 40% with the means slightly higher (Figure A.4). The Perfect Information management procedure shows that the $F_{40\%}$ default harvest rate with a 40:10 control rule eventually brings the median average depletion of the stock to just below 30% and it reduces the median average depletion over the short, to the medium and long terms, settling eventually at 28% (Table A.6 and Figure A.4).

In general the median of the average catch declines from the short to the medium and long term. In the short term, the median of average catch is higher in the Annual and Biennial Survey management strategies than it is in the Perfect Information case (Table A.7). However, as the population comes to equilibrium with each of the management strategies in the long term, the median average catch in the Perfect Information case is highest and in all cases there is a very broad distribution of catch applied for every management procedure (Figure A.5).

AAV is similar between the Perfect Information, Annual Survey, and Biennial Survey only in the short term (Table A.7). In the medium and long terms, the median AAV is higher for the Annual Survey, and Biennial Survey management strategies. AAV is similar between the Annual Survey and Biennial Survey management strategies in the medium term and slightly higher in the Biennial Survey case in the long term. In all management strategies, there is a large distribution of AAV values in the long term (Figure A.6).

It bears repeating that summary statistics of central tendencies such as the median or mean, do not capture the range of possible outcomes for any given performance measure. For each summary statistics, there is considerable variability about any median (or mean) performance measure (see Figures A.4-A.6). Extreme events such as low or high catches or depletion levels are not rare. For those readers wishing to examine a more complete set of statistics, Table A.8 provides a summary table of all the statistics that we examined.

Additional Analyses

Different default harvest rates result in different median and mean depletion levels. We illustrate this by running the Perfect-Information simulations using a range of different default harvest rate ($F_{SPR\%}$) values ranging from 0.30 to 0.50. Recall that $F_{SPR\%}$ is the fishing mortality that would reduce the spawners-per-recruit to xx% of the unfished equilibrium spawners-per-recruit. Accordingly, as $F_{SPR\%}$ decreases, the actual fishing mortality increases. Figure A.14 depicts the discrete fishing mortalities associated with each of these $F_{SPR\%}$ values; note that for each $F_{SPR\%}$, there is uncertainty in the corresponding discreet exploitation rate caused by the uncertainty in selectivity and natural mortality. Note also that there is a non-linear increase in exploitation rate with linear increases in SPR% (Figure A.14). As the value of $F_{SPR\%}$ ranges from 50% to 30%, median depletions range from approximately 0.4 to 0.25. Given the asymmetry of the resultant depletion probability distributions for each $F_{SPR\%}$, the mean depletion is higher than the median.

As the default harvest rate increases ($F_{SPR\%}$ decreases), there are diminishing marginal returns in median average catches (Figure A.8) but increasing marginal AAV (Figure A.9). Increasing the default harvest rate (declining $F_{SPR\%}$) results in progressively declining mean catch increases per unit increase in target F (Figure A.8). Mean and median AAVs in catch appear to increase in a non-linear way with increases in the target harvest rate (Figure A.9).

Changes in median depletion, yield and AAV with increasing target harvest rates show that (i) depletion decreases as yield increases, as expected (Figure A.10), and (ii) relatively small increases in yield correspond to large increases in yield variability as target fishing mortality increases (Figure A.11).

Appendix A.4. Discussion

The MSE shows that the $F_{40\%}$-40:10 rule reduces the median average depletion of the stock to just below 30%. Median average depletion levels are consistent across all management strategies considered, including the Perfect Information case. While the median average depletion levels are similar between all management strategies, the probability of extreme depletion values increases with decreased information. While, for example, the biennial survey management strategy has the highest long-term proportion of years where depletion is greater than 40%, it also closes the fishery more frequently, has a higher proportion of years that depletion is less than 10%, and has the highest AAV. Summary statistics notwithstanding, a wide range of stock sizes can be expected from any management strategy, even the No Fishing case, due to high recruitment variability.

Because of the way that catches were simulated in the MSE, they may reflect different tonnages than would be taken in practice. Firstly there are statistical differences between how the MSE simulated catches and how it is done in practice. The MSE used the MPD estimate of the catch predicted by the harvest control rule. In practice, we do a full posterior integration using MCMC and there are statistical differences between this, and the multivariate normal approximation of the posterior given at the posterior mode (Stewart et al. 2012). However, the large number of assessment models run in the MSE required us to use the MPD estimates due to time constraints. Secondly, managers make decisions based on a richer set of objectives, constraints and hedging activities (Walters and Hilborn 1978); some of these constraints may include upper limits on target catches or bycatch considerations. Finally, actual catches taken in the Pacific hake fishery have recently been below the recommended TAC. The MSE does not capture these additional complexities. The actual management strategy has a potentially large unpredictable component to it.

During consultations we were asked to consider a different operating model that would be more consistent with what was anticipated to be a more optimistic 2013 assessment. For practical reasons, it was not possible to re-run the simulations. However, it is important to note that while the MSE's results may differ according to the initial state of the operating model in the short and medium terms, the long term predictions should be similar. In these simulations, 95% of the operating model initial depletion values for 2012 ranged between 9.4 and 102.2%, with a median depletion of 32.6% (see table b in JTC (2012)). Had we used a more optimistic operating model, it is likely that the short and medium term MSE performance statistics for each management strategy would be different. However, we assume that predictions for 2021-2030 will be similar. If the operating model starts simulations with a stock that is assumed have high depletion levels, then the harvest control rule will apply high catches (and vice versa if the stock size is assumed to be relatively low) so that depletion (and corresponding catches) should be similar over longer time horizons.

While there are differences between the performance statistics for annual, and biennial survey strategies, the absolute magnitude of these differences is very small. This observation holds whether the performance statistic measures average catch, depletion or AAV. We caution that the MSE we present here may paint an optimistic picture of the small improvement offered by annual, over biennial surveys. One reason is that in non-survey years, only catch and commercial age composition are available for assessment-model fitting while both operating and assessment models assume time-invariant selectivity. Previous assessments gave us reason to be suspicious of using catch and commercial age-composition data alone: using 2010 data, the 2011 assessment model predicted that a very optimistic sustainable harvest level of 973,700 mt; this prediction was followed by a 2011 survey biomass estimate was the lowest on record at 521,476 mt. There are several situations where commercial age-composition data may be inconsistent with this assumption. For example, it is possible that spatial management measures limit fishing to certain areas to produce very-rapid changes in selectivity, because the fleet is confined to fishing in areas where there are distorted proportions of younger, or older, fish. In such situations, applying an assessment model where such effects are not considered (or cannot be) may result in a poor actual biennial survey management strategy performance because the commercial age-composition data used to estimate non-survey-year stock status are inconsistent with the assessment model's time invariant selectivity assumption.

It is important to test the performance of management strategies using more realistic operating models. The example of time-varying selectivity identified above is one of large number of possible ways that the current stock assessment model structure is an over-simplification of the true state dynamics. Other parameterizations that consider spatial structure, multiple fleets, or growth type groups may provide more accurate representations of the biology as well occasional extreme survey errors like that caused by Humboldt squid. MSE is a suitable instrument to determine if alternative assessment models result in improved management performance. But the assessment model is only one management-strategy component; improvements can also be sought by considering alternative harvest control rules.

If further MSE is to be pursued for Pacific hake, then choosing between alternative management strategies will mean defining a measurable set of objectives. In this instance, only a narrow range of management strategies was considered, but if the process is expanded by new operating models then choosing between candidate management strategies becomes difficult because of the potentially large number of scenarios considered. Measurable objectives help eliminate candidate management strategies.

MSE has been applied to Pacific hake in the past. For instance, Ishimura et al (2005) examined a very comprehensive set of management strategies and showed how each performed in terms of average catch, variation in catch, the probability of closing the fishery, and a variety of other conservation-related performance measures. They considered the 40:10 rule and a comprehensive set of fixed escapement strategies in which the catch limit is the maximum of zero and a pre-specified fraction of the difference between the estimate of the current biomass and a minimum biomass for a fishery to occur. There are some important technical differences between the Ishimura et al. (2005)'s study and the JTC's MSE that make direct comparisons inappropriate. Among other things, they applied a 40:10 rule that scaled down fishing mortality, not catch, as the Agreement's harvest control rule does; and instead of simulating data collection and assessments, they used the method suggested by Punt and Hilborn (1996) and approximate the monitoring of the resource by generating the estimate of this biomass based on the true 3+ biomass, allowing for correlation in assessment errors. In spite of the methodological differences, the general tradeoff patterns between conservation, yield and catch stability they illustrate are similar to the JTC's MSE.

Conservation, yield and catch stability tradeoffs identified here are not unique to Pacific hake. The tradeoff between mean catch and variability is well known in fisheries. W.E. Ricker (1958) showed that increases in mean catch occur at the expense of increased variability in yield in part because for highly variable stocks there can be occasional cessation of fishing in order to get the long-term maximum. Before MSE existed in its current form, others identified similar tradeoffs (Walters 1975, Mendelssohn 1980). Since then, full MSE analyses have identified the same set of conservation, yield, and catch stability tradeoffs (de la Mare 1998, Punt and Smith 1999, Cox and Kronlund 2008).

Two key things have been learned from this exercise that could not have been examined using other studies like Ishimura et al (2005) and general relationships. The first is that the $F_{40\%}$-40:10 rule reduces the median average depletion of the stock to below 30%. Ishimura et al (2005) suggested that the 40:10 rule leaves the 3+ biomass on average at 52% of unfished. Unfortunately, their approach was invalid because it applied the 40:10 rule in a way that is inconsistent with the hake treaty and because they did not explicitly model stock assessments. Secondly, the marginal improvement of annual over biennial surveys is very specific to the hake case, due to the interaction of data, the assessment and the harvest control rule interacting with a stock having high recruitment variability.

The gain of pursuing MSE for hake is that it places decisions about the relative superiority of alternative management strategies (whether these be assessment model, survey frequency or harvest control rule choice), into the hands of those who bear the consequences of these choices. To continue using MSE, managers, scientists and stakeholders will have to first define measurable management objectives. The challenge will then be how to define good performance given the tradeoffs and potentially conflicting objectives among stakeholder groups.

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Appendix A.6. Tables

Table A.1: Parameters used in the operating model and for data generation. The median and 95% confidence interval (CI) are provided for the parameters estimated in the 2012 stock assessment (JTC 2012), other than recruitment deviations. These estimated parameters vary across simulations in the operating model. Fixed parameters are also given.

Parameter	Median	95% CI
Stock Dynamics		
Ln(R_0)	14.66	14.25 – 15.16
Steepness (h)	0.81	0.57 – 0.96
Recruitment variability (σ_R)	1.40	—–
Natural mortality (M)	0.22	0.18 – 0.26
Acoustic catchability (q)	1.11	0.75 – 1.49
Data generation		
Within year SE for acoustic survey in log space	0.085	—–
Total SE for acoustic survey in log space	0.420	—–
Number of age samples for fishery	96	—–
Number of age samples for acoustic survey	65	—–
Derived parameters		
B_0	3,807,210	3,001,948 – 4,800,112
Yield at 40%SPR (metric tons)	299,987	208,426 – 428,620
Depletion at 40%SPR	0.36	0.26 – 0.39
$F_{40\%SPR}$	0.21	0.18 – 0.26

Table A.2: Age-specific parameters for the true population used in the operating model. Weight-at-age varied across years and only the mean across all years is shown below. Selectivity was variable for age 6 and held constant for all older ages, thus a few simulations had selectivity less than 1 for ages 6+.

Age	Mean Weight	Maturity	Acoustic Selectivity	Fishery selectivity	Ageing Error SD
0	0.0300	0.0000	0	0	0.3292
1	0.0885	0.0000	0	0.00 (0.00–0.01)	0.3292
2	0.2562	0.1003	0.49 (0.35–0.67)	0.08 (0.06–0.11)	0.3469
3	0.3799	0.2535	0.53 (0.35–0.81)	0.40 (0.32–0.48)	0.3686
4	0.4913	0.3992	0.70 (0.51–0.98)	0.67 (0.55–0.83)	0.3953
5	0.5434	0.5180	0.64 (0.40–1.00)	0.79 (0.63–0.98)	0.4281
6	0.5906	0.6131	1*	1*	0.4684
7	0.6620	0.6895	1*	1*	0.5178
8	0.7215	0.7511	1*	1*	0.5786
9	0.7910	0.8007	1*	1*	0.6533
10	0.8629	0.8406	1*	1*	0.7451
11	0.9315	0.8724	1*	1*	0.8578
12	0.9681	0.8979	1*	1*	0.9963
13	1.0751	0.9181	1*	1*	1.1665
14	1.0016	0.9342	1*	1*	1.3756
15	1.0202	0.9469	1*	1*	1.6324
16	1.0202	0.9569	1*	1*	1.8580
17	1.0202	0.9649	1*	1*	2.1720
18	1.0202	0.9711	1*	1*	2.5300
19	1.0202	0.9761	1*	1*	2.9340
20	1.0202	0.9830	1*	1*	3.3880

*A few simulations (less than 2.5%) showed values less than 1.

Table A.3: Acoustic survey estimates for years prior to 2012. The standard error is related to the natural log of the estimate.

Year	Estimate (mt)	Standard error
1995	1517948	0.0666
1998	1342740	0.0492
2001	918622	0.0823
2003	2520641	0.0709
2005	1754722	0.0847
2007	1122809	0.0752
2009	1612027	0.1375
2011	521476	0.1015

Table A.4: Description of the four management strategies simulated.

Case	Description
No Fishing	No catch from 2013 to 2030
Perfect Information	Catch determine from true status of stock. No data or assessment.
Annual Survey	Catch determined from an annual assessment. An annual survey from 2013 to 2030 informs the assessment.
Biennial Survey	Catch determined from an annual assessment. A survey in odd numbered years from 2013 to 2030 informs the assessment.

Table A.5: Metrics used to investigate performance of the simulations.

Metric	Description	**Formula**
Depletion (D_t)	The ratio of the estimated beginning of the year female spawning biomass to estimated average unfished equilibrium female spawning biomass. Thus, lower values of relative depletion are associated with fewer mature female fish.	$D_t = \frac{B_t}{B_0}$
Median average depletion	The median of the average status of the stock over a defined period of time	$Median\left(\frac{1}{n+1}\sum_{i=t}^{t+n} D_t\right)$
P(Threshold1< D_t <Threshold2)	The probability that depletion is between two threshold values (i.e., 0.1 and 0.4) at any point of the defined period of time	$\frac{N_{within}}{N_{total}}$ where N_{within} is the total number of observations satisfying the criteria and N_{total} is the total number of observations
Median average catch	The median of the average catch over the time period defined.	$Median\left(\frac{1}{n+1}\sum_{i=t}^{t+n} C_i\right)$
Average annual variability (AAV)	The percent average change in catch divided by the average catch over the time period defined.	$AAV = \frac{1/n \sum_y \lvert C_y - C_{y-1} \rvert}{1/n \sum_y C_y}$

Table A.6: Summary of key stock status statistics in the short (2013-2015), medium (Med, 2016-2020), and long (2021-2030) time frames for the following management strategies: perfect information (Perf), the annual survey (Ann) and the biennial survey (Bien).

	Short Term			**Medium Term**			**Long Term**		
Percentage of years:	*Per*	*Ann*	*Bie*	*Per*	*Ann*	*Bie*	*Per*	*Ann*	*Bie*
Depletion above 40%	34.30%	35.90%	35.64%	28.95%	31.29%	32.67%	27.07%	29.54%	31.06%
Depletion below 10%	4.44%	6.61%	6.87%	0.94%	7.17%	8.59%	0.39%	5.39%	7.04%
Depletion between 10 and 40%	61.26%	57.49%	57.49%	70.11%	61.54%	58.74%	72.54%	65.08%	61.90%
MS closes fishery	0.00%	4.70%	3.90%	0.00%	8.51%	8.21%	0.00%	10.11%	13.61%

Table A.7: Median of key statistics for the perfect information (Per), Annual Survey (Ann) and Biennial Survey (Bie) management strategies in the short, medium and long term.

	Short Term			**Medium Term**			**Long Term**		
Medians of:	*Per*	*Ann*	*Bie*	*Per*	*Ann*	*Bie*	Per	Ann	Bie
Average catch	251	284	273	216	226	217	230	217	218
Average depletion	31.71	31.45	31.58	27.89	26.92	27.84	27.60	27.27	28.00
AAV in catch (%)	36.57	35.46	32.55	23.09	34.14	34.68	23.35	32.54	33.24

Table A.8: Complete set of performance statistics

Quantity	Short	Medium	Long	case
Start year corresponding to time period	2013	2016	2021	Perfect Information
End year corresponding to time period	2015	2020	2030	Perfect Information
Median average depletion	31.71%	27.89%	27.60%	Perfect Information
First quartile depletion	20.95%	20.14%	19.74%	Perfect Information
Third quartile depletion	47.57%	43.61%	41.60%	Perfect Information
Median final depletion	30.16%	27.94%	26.67%	Perfect Information
Median of lowest depletion	26.58%	21.59%	17.71%	Perfect Information
Median of lowest perceived depletion	NA	NA	NA	Perfect Information
First quartile of lowest depletion	17.86%	16.25%	14.54%	Perfect Information
Third quartile of lowest depletion	37.55%	29.97%	22.95%	Perfect Information
Median Average Annual Variability (AAV) in catch	36.57%	23.09%	23.35%	Perfect Information
First quartile of AAV in catch	23.34%	16.80%	18.47%	Perfect Information
Third quartile of AAV in catch	62.17%	32.20%	29.43%	Perfect Information
Median average catch	251	216	230	Perfect Information
First quartile of average catch	124	133	148	Perfect Information
Third quartile of average catch	422	392	356	Perfect Information
Median of lowest catch levels	193	139	97	Perfect Information
First quartile of lowest catch levels	91	79	57	Perfect Information
Third quartile of lowest catch levels	336	237	155	Perfect Information
Proportion with any depletion below SB10%	7.31%	2.00%	2.00%	Perfect Information
Proportion perceived to have any depletion below SB10%	NA	NA	NA	Perfect Information
Proportion of years below SB10%	4.44%	0.94%	0.39%	Perfect Information
Proportion of years between SB10% and SB40%	61.26%	70.11%	72.54%	Perfect Information
Proportion of years above SB40%	34.30%	28.95%	27.07%	Perfect Information
Start year corresponding to time period	2013	2016	2021	Annual
End year corresponding to time period	2015	2020	2030	Annual
Median average depletion	31.45%	26.92%	27.27%	Annual
First quartile depletion	19.09%	17.02%	17.69%	Annual
Third quartile depletion	50.22%	47.45%	44.19%	Annual
Median final depletion	29.65%	27.37%	27.51%	Annual
Median of lowest depletion	25.66%	19.46%	15.82%	Annual
Median of lowest perceived depletion	28.20%	20.47%	16.21%	Annual
First quartile of lowest depletion	15.30%	12.40%	10.71%	Annual
Third quartile of lowest depletion	40.69%	31.76%	22.49%	Annual
Median Average Annual Variability (AAV) in catch	35.46%	34.14%	32.54%	Annual
First quartile of AAV in catch	24.31%	25.54%	26.62%	Annual
Third quartile of AAV in catch	54.39%	50.75%	40.87%	Annual
Median average catch	284	226	217	Annual
First quartile of average catch	164	120	138	Annual

Third quartile of average catch	396	380	341	Annual
Median of lowest catch levels	192	113	66	Annual
First quartile of lowest catch levels	99	41	27	Annual
Third quartile of lowest catch levels	300	215	118	Annual
Proportion with any depletion below SB10%	11.21%	16.12%	20.42%	Annual
Proportion perceived to have any depletion below SB10%	4.70%	8.51%	10.11%	Annual
Proportion of years below SB10%	6.61%	7.17%	5.39%	Annual
Proportion of years between SB10% and SB40%	57.49%	61.54%	65.08%	Annual
Proportion of years above SB40%	35.90%	31.29%	29.54%	Annual
Start year corresponding to time period	2013	2016	2021	Biennial
End year corresponding to time period	2015	2020	2030	Biennial
Median average depletion	31.58%	27.84%	28.00%	Biennial
First quartile depletion	19.17%	17.18%	17.45%	Biennial
Third quartile depletion	50.02%	49.13%	46.02%	Biennial
Median final depletion	29.52%	28.42%	28.97%	Biennial
Median of lowest depletion	25.80%	19.73%	15.59%	Biennial
Median of lowest perceived depletion	28.94%	20.37%	16.18%	Biennial
First quartile of lowest depletion	15.59%	12.27%	10.33%	Biennial
Third quartile of lowest depletion	40.34%	32.86%	23.47%	Biennial
Median Average Annual Variability (AAV) in catch	32.55%	34.68%	33.24%	Biennial
First quartile of AAV in catch	22.80%	25.45%	27.15%	Biennial
Third quartile of AAV in catch	49.68%	51.05%	42.34%	Biennial
Median average catch	273	217	218	Biennial
First quartile of average catch	168	127	137	Biennial
Third quartile of average catch	401	357	328	Biennial
Median of lowest catch levels	206	110	60	Biennial
First quartile of lowest catch levels	110	43	20	Biennial
Third quartile of lowest catch levels	320	208	123	Biennial
Proportion with any depletion below SB10%	11.61%	16.72%	22.92%	Biennial
Proportion perceived to have any depletion below SB10%	3.90%	8.21%	13.61%	Biennial
Proportion of years below SB10%	6.87%	8.59%	7.04%	Biennial
Proportion of years between SB10% and SB40%	57.49%	58.74%	61.90%	Biennial
Proportion of years above SB40%	35.64%	32.67%	31.06%	Biennial

Appendix A.7. Figures

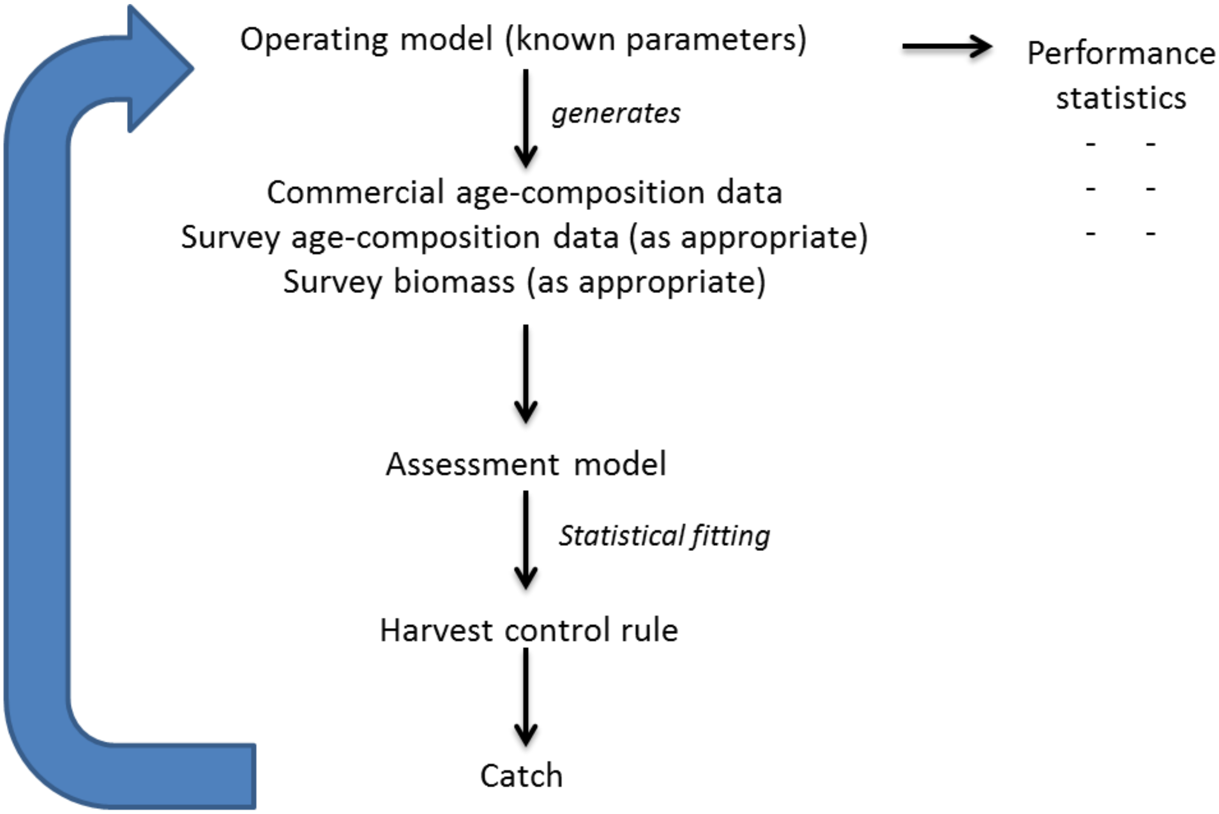


Figure A.1: Schematic of a closed-loop simulation.

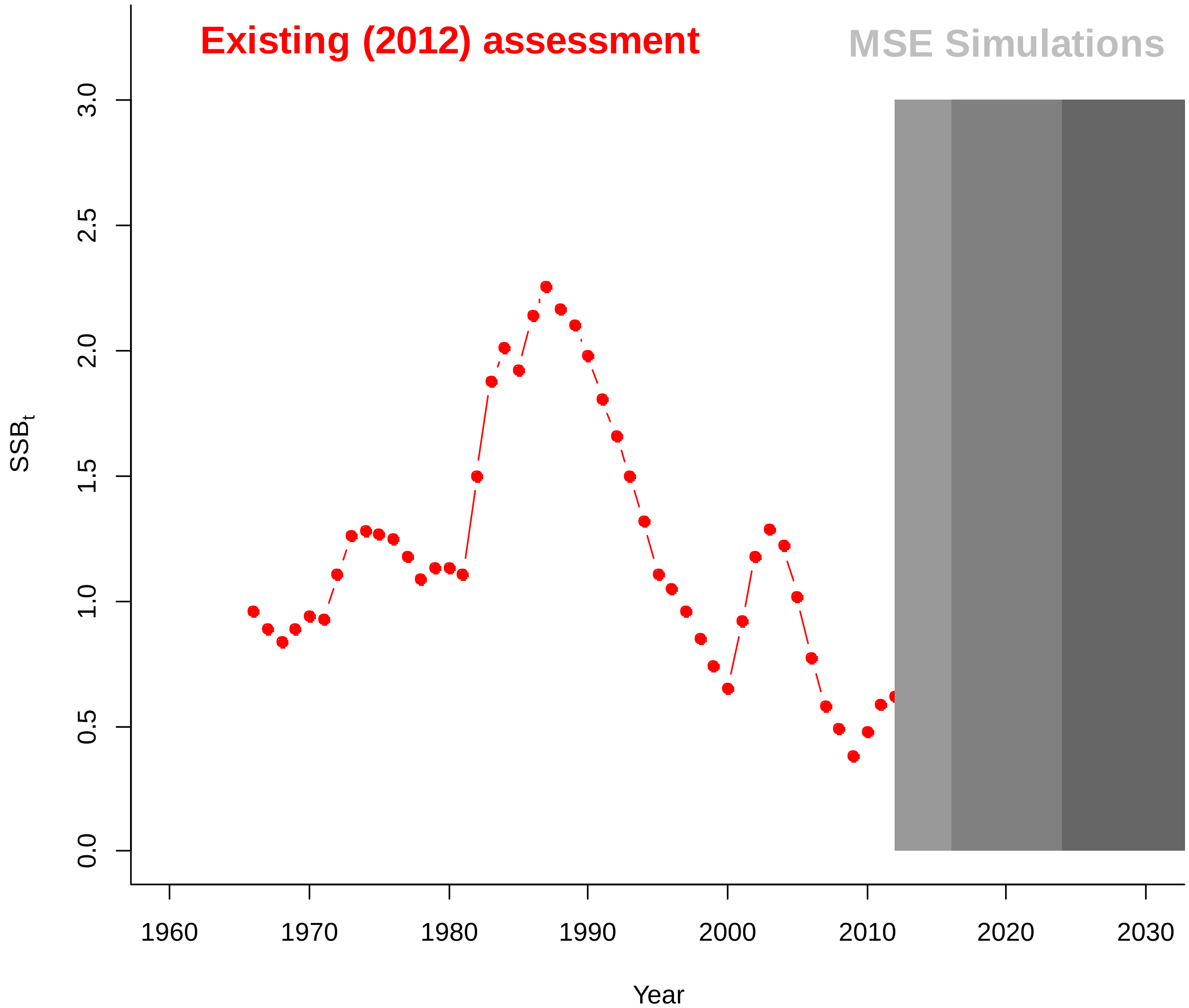


Figure A.2: Schematic of hake operating model conditioning (Existing 2012 assessment) and simulation periods (MSE Simulations)

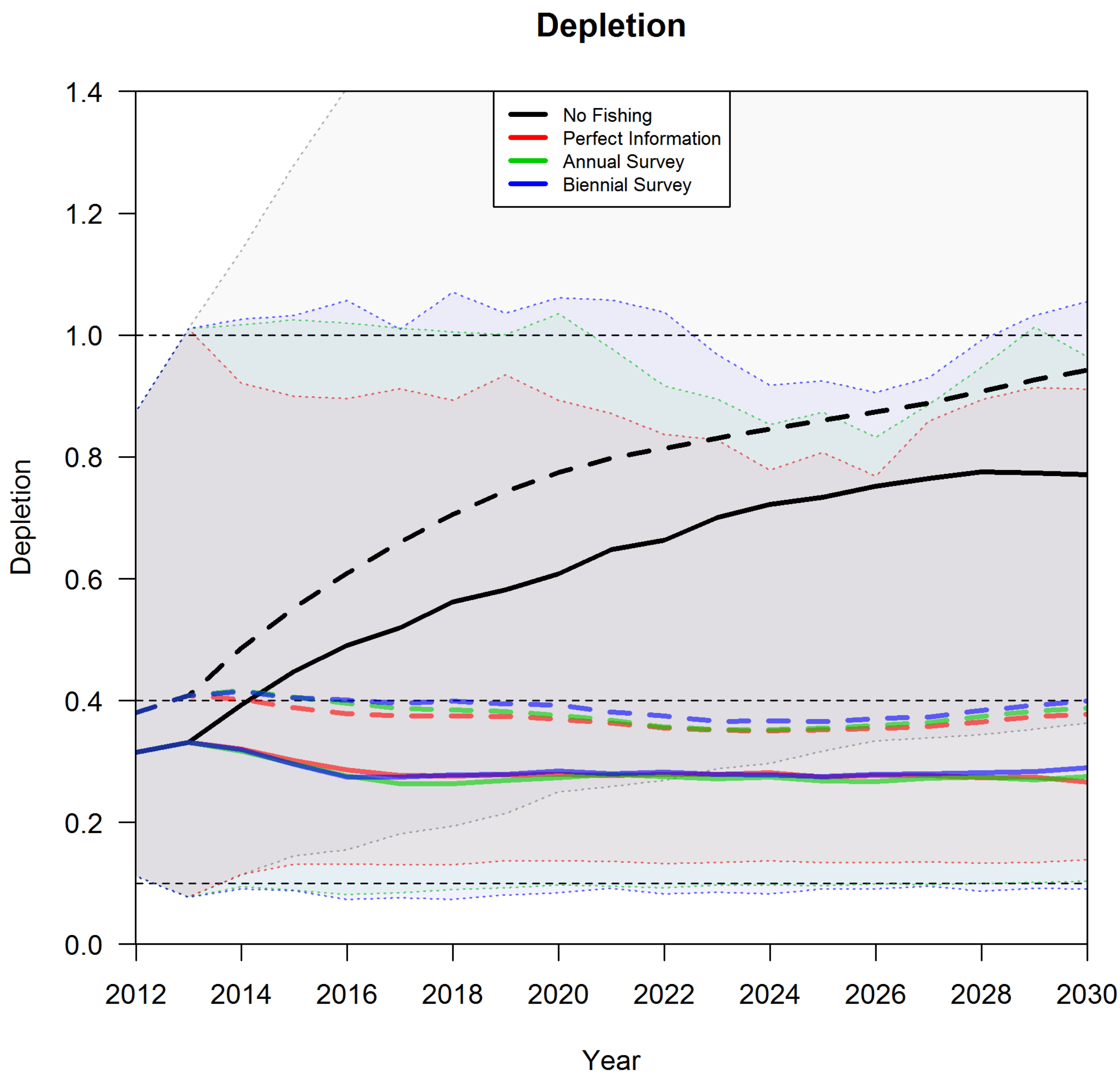


Figure A.3: Predicted depletion for each simulated management strategy. Colored shading represents the 95% credibility intervals, solid lines represent the median and dashed lines represent the means.

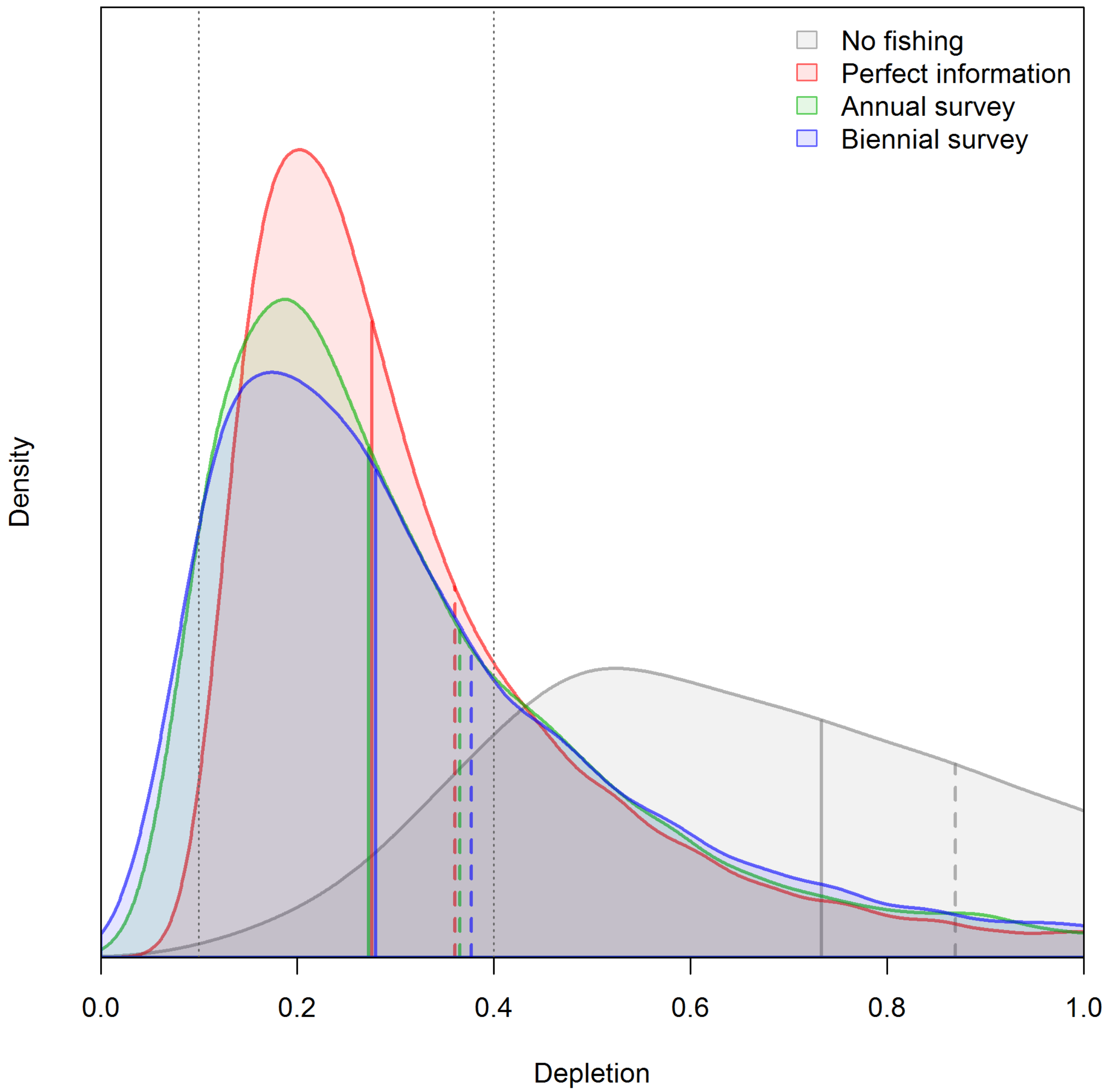


Figure A.4: Plot of kernel density estimate for depletion (B_y/B_0) for the No Fishing, Perfect Information, Annual and Biennial Survey management strategies over the long term (2021-2030). Solid vertical lines are medians. Dashed vertical lines are means.

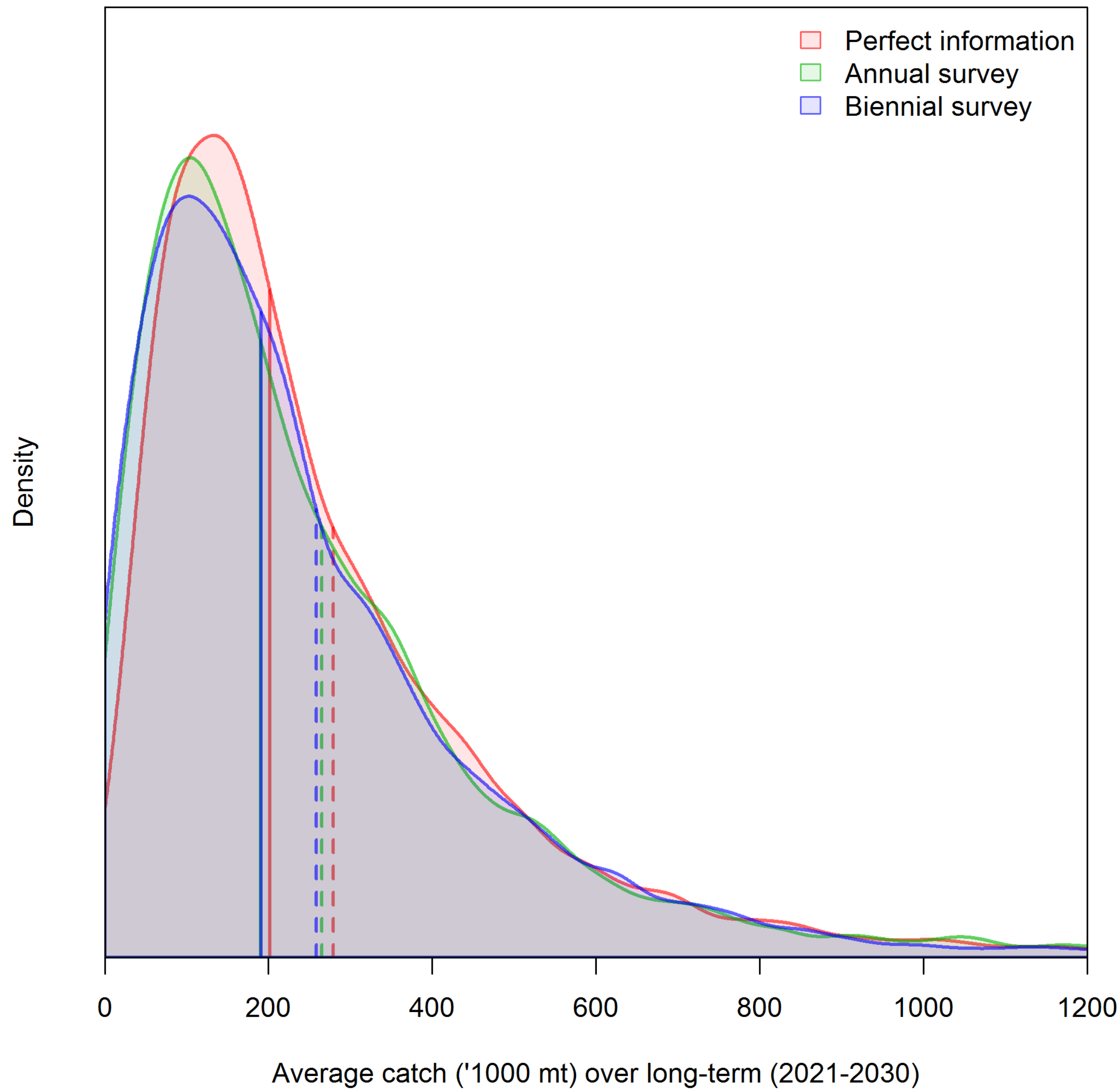


Figure A.5: Plot of kernel density estimate for catches for perfect information, annual and biennial survey management strategies in the long term (2021-2030). Solid vertical lines are medians. Dashed vertical lines are means.

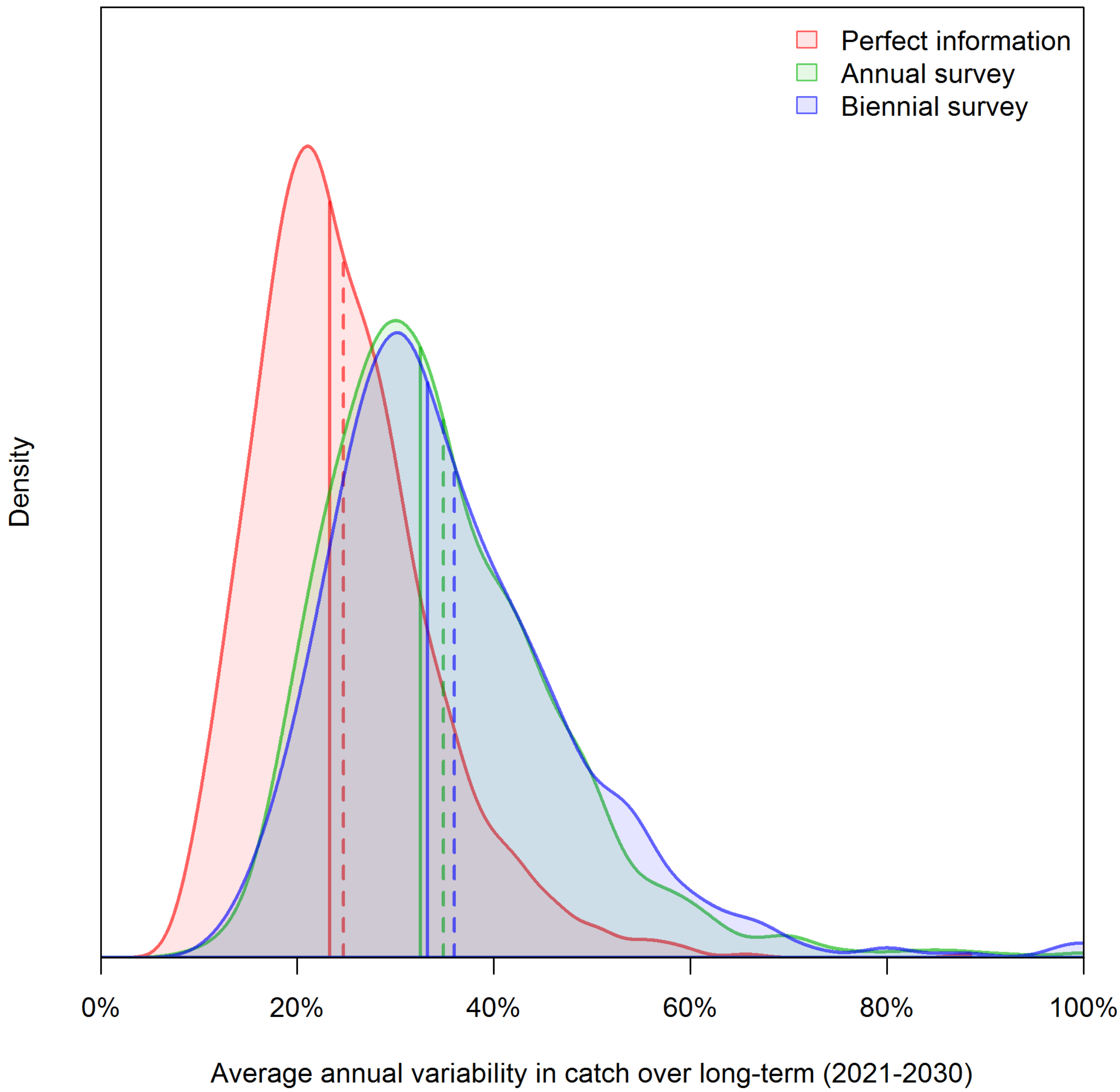


Figure A.6: Plot of kernel density estimate for average annual variability in catch (AAV) for Perfect Information, Annual and Biennial survey management strategies in the long term (2021-2030). Solid lines are medians. Dashed lines are means.

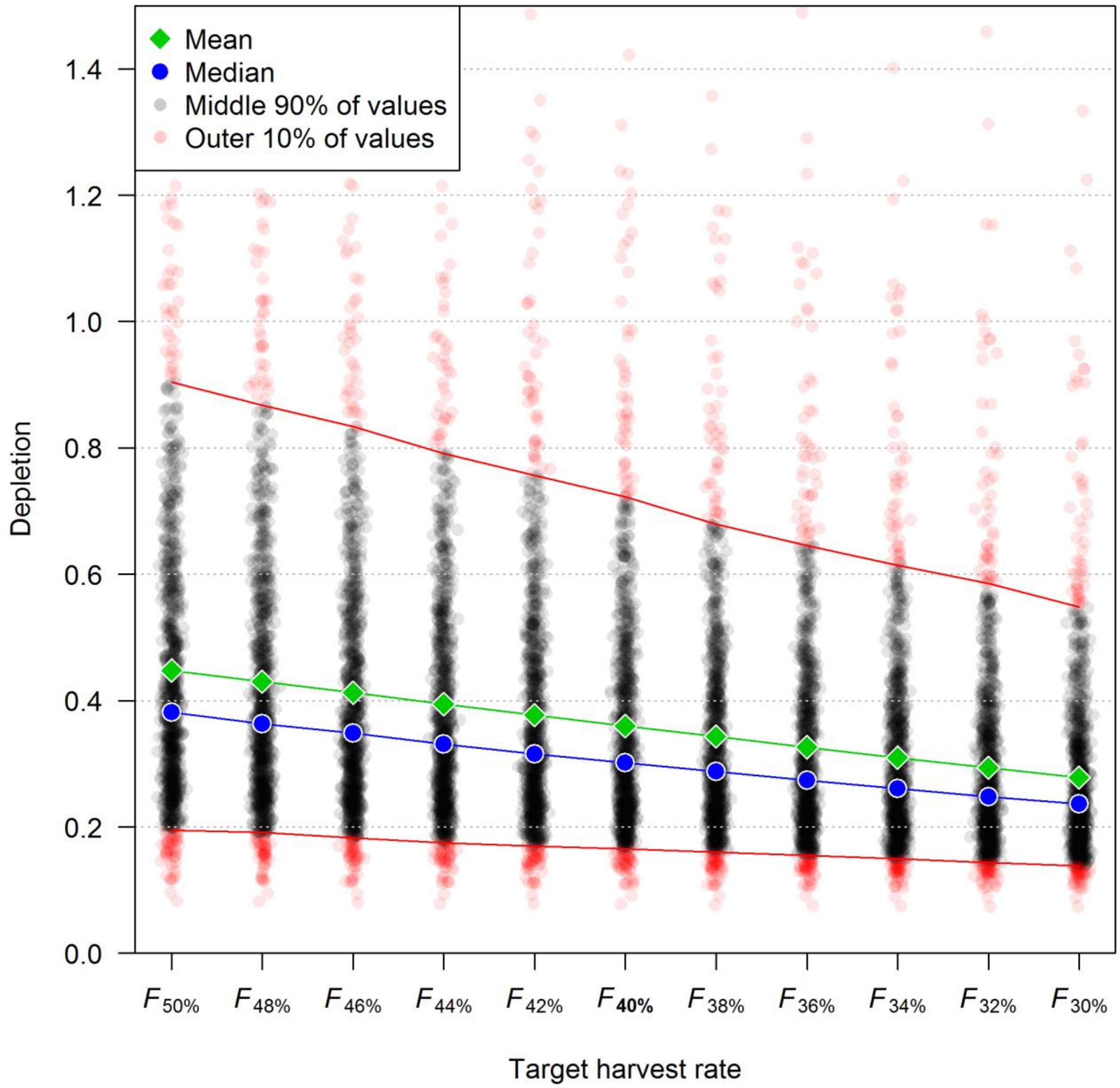


Figure A.7: Long term (2021-2030) depletion (y) as a function of the default harvest rate ($F_{SPR\%}$, x) for the perfect information case. The blue line is the median, the green line is the mean. Each dot is the MSE's simulated estimate of depletion. Horizontal positions are jittered to better illustrate distribution of individual points.

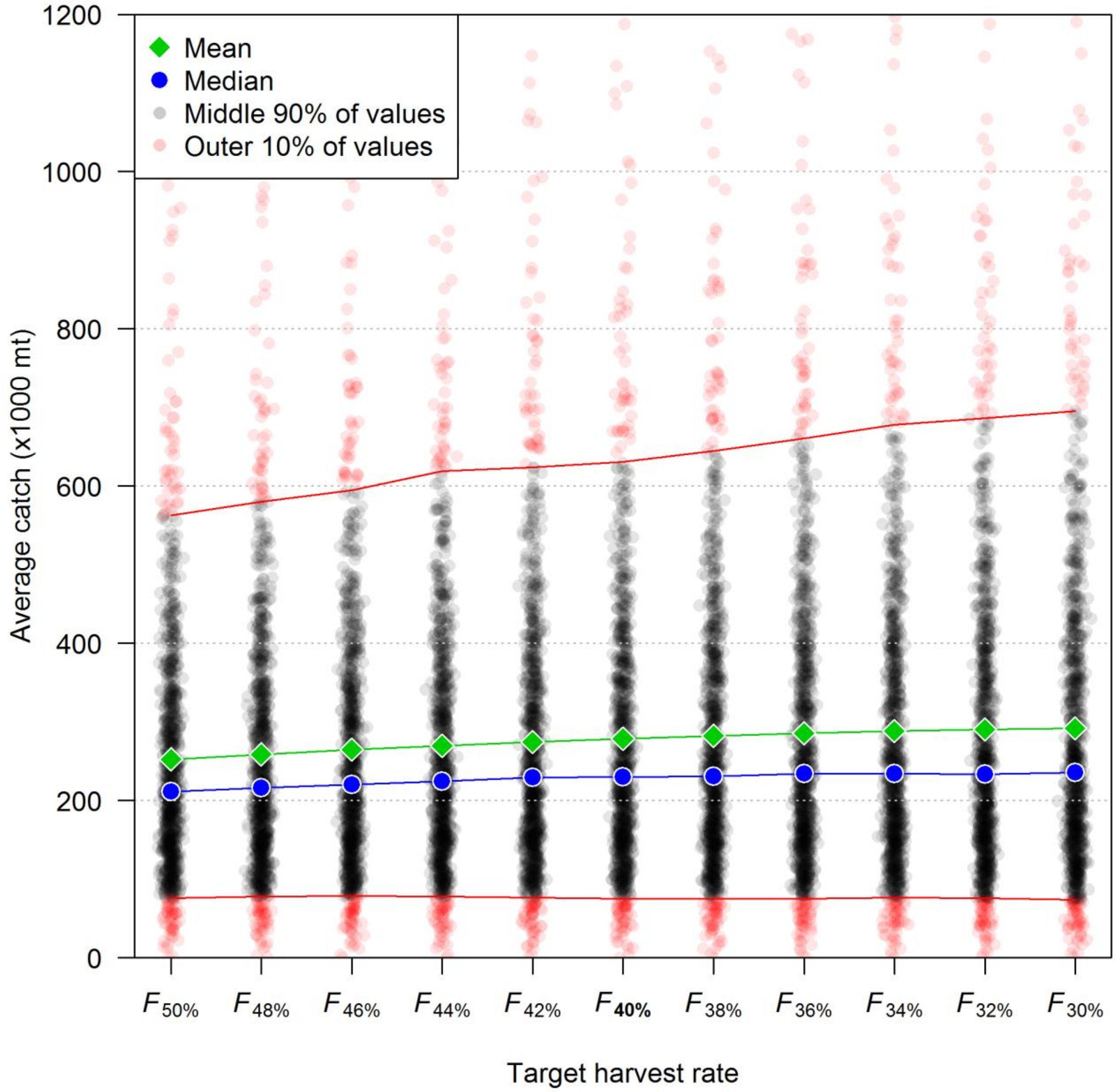


Figure A.8: Long term (2021-2030) average catch as a function of default harvest rate. Horizontal positions are jittered to better illustrate distribution of individual points

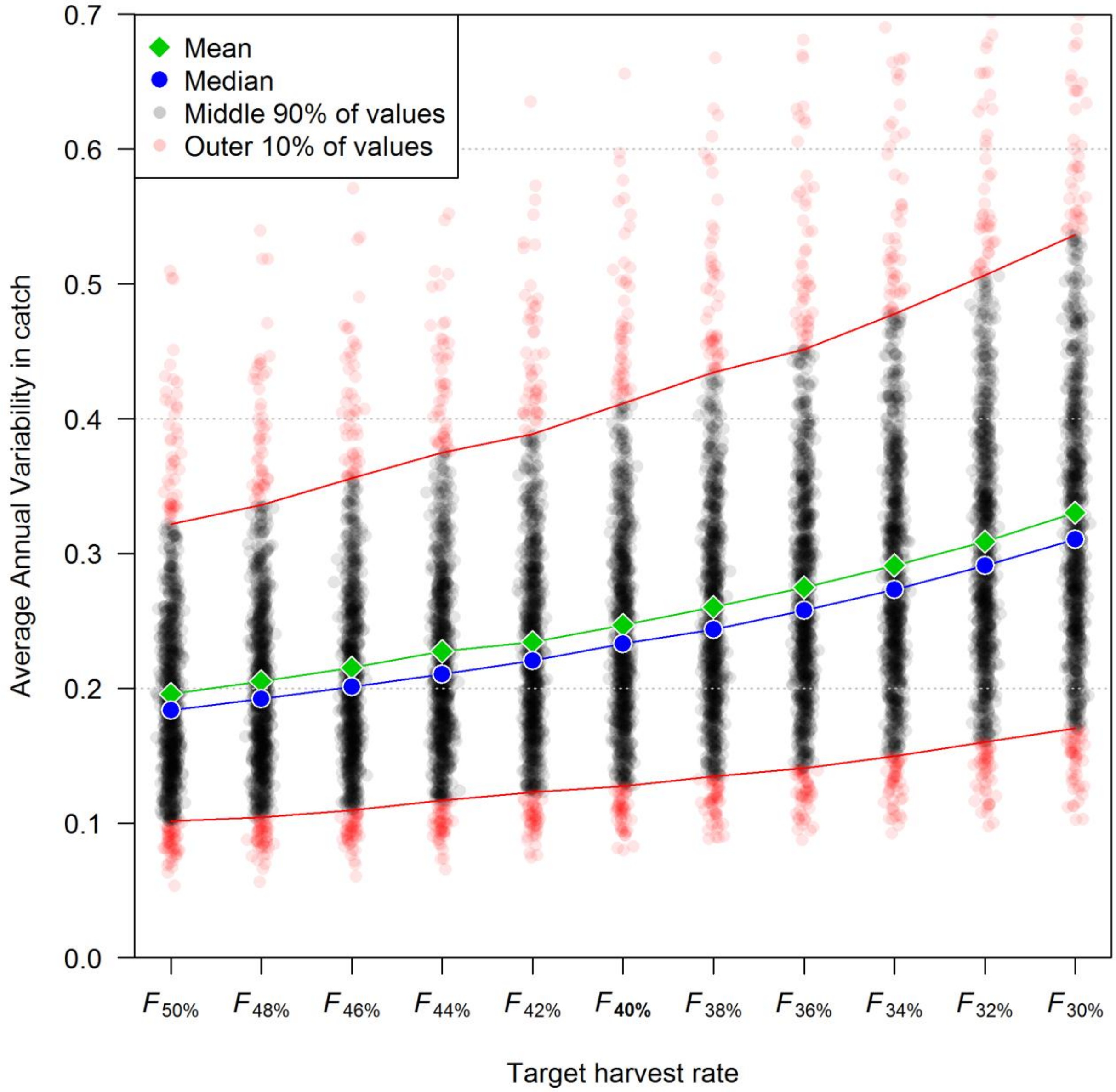


Figure A.9: Long term (2021-2030) average annual variability (AAV) as a function of the target harvest rate Fxx%. Note that F increases from left to right (see Figure A.14). Horizontal positions are jittered to better illustrate distribution of individual points.

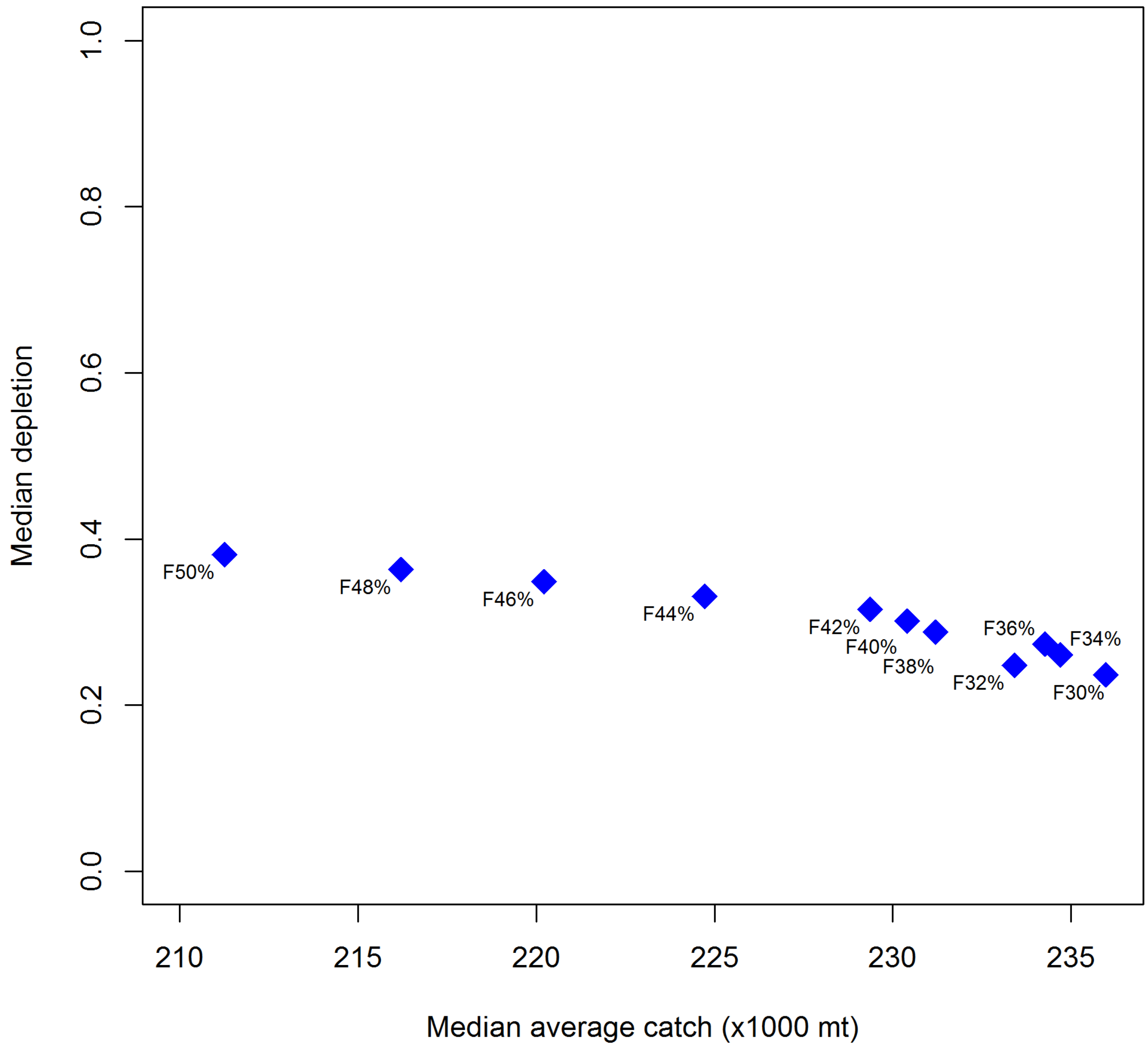


Figure A.10: Long term (2021-2030) median average depletion (y) vs. median average catch (x, mt) given by exploring alternative $F_{xx\%}$ values.

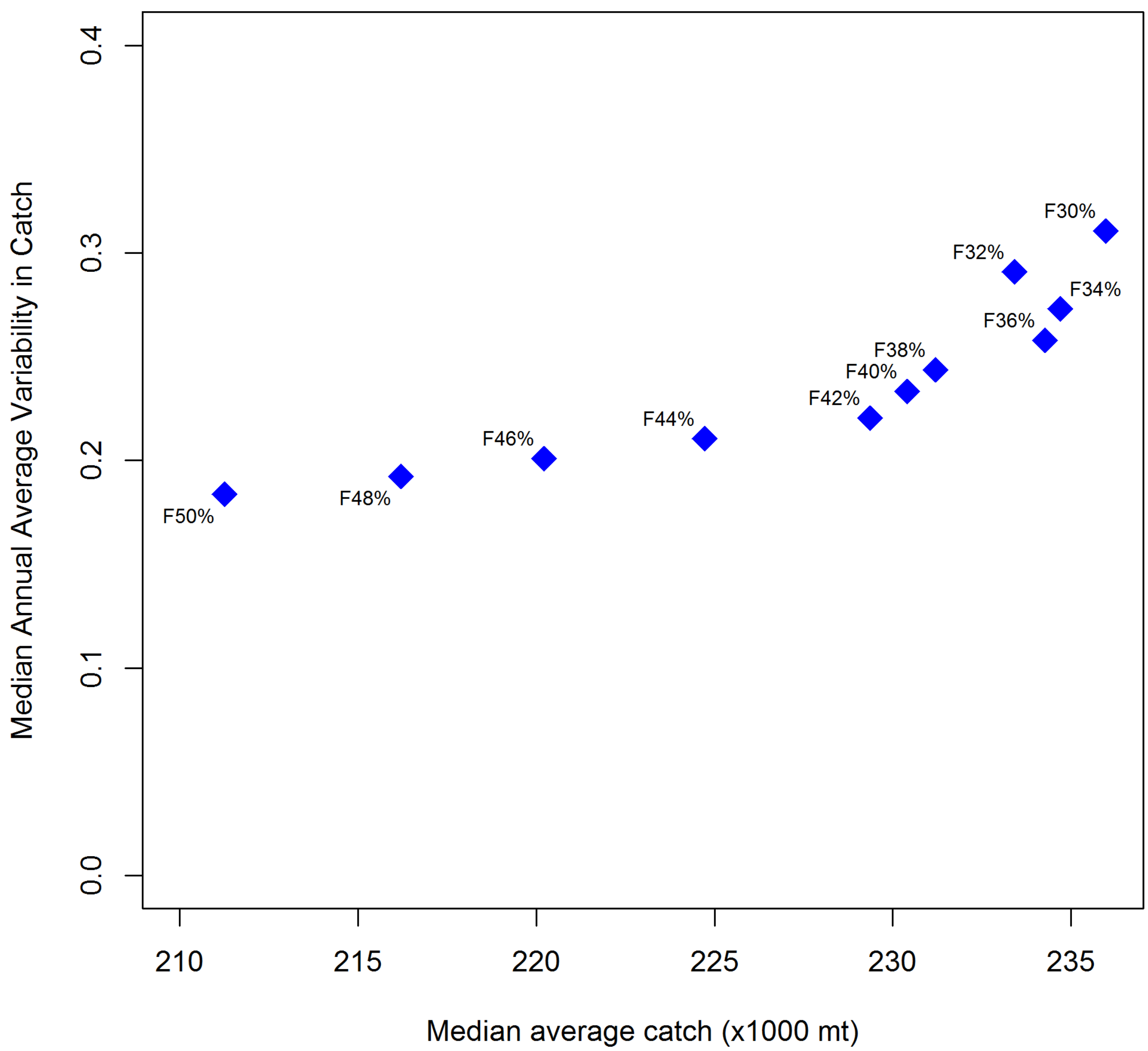


Figure A.11: Long term (2021-2030) median AAV (y) vs median average catch (x) given by alternative $F_{xx\%}$ values.

Appendix A.8. Supporting MSE Figures

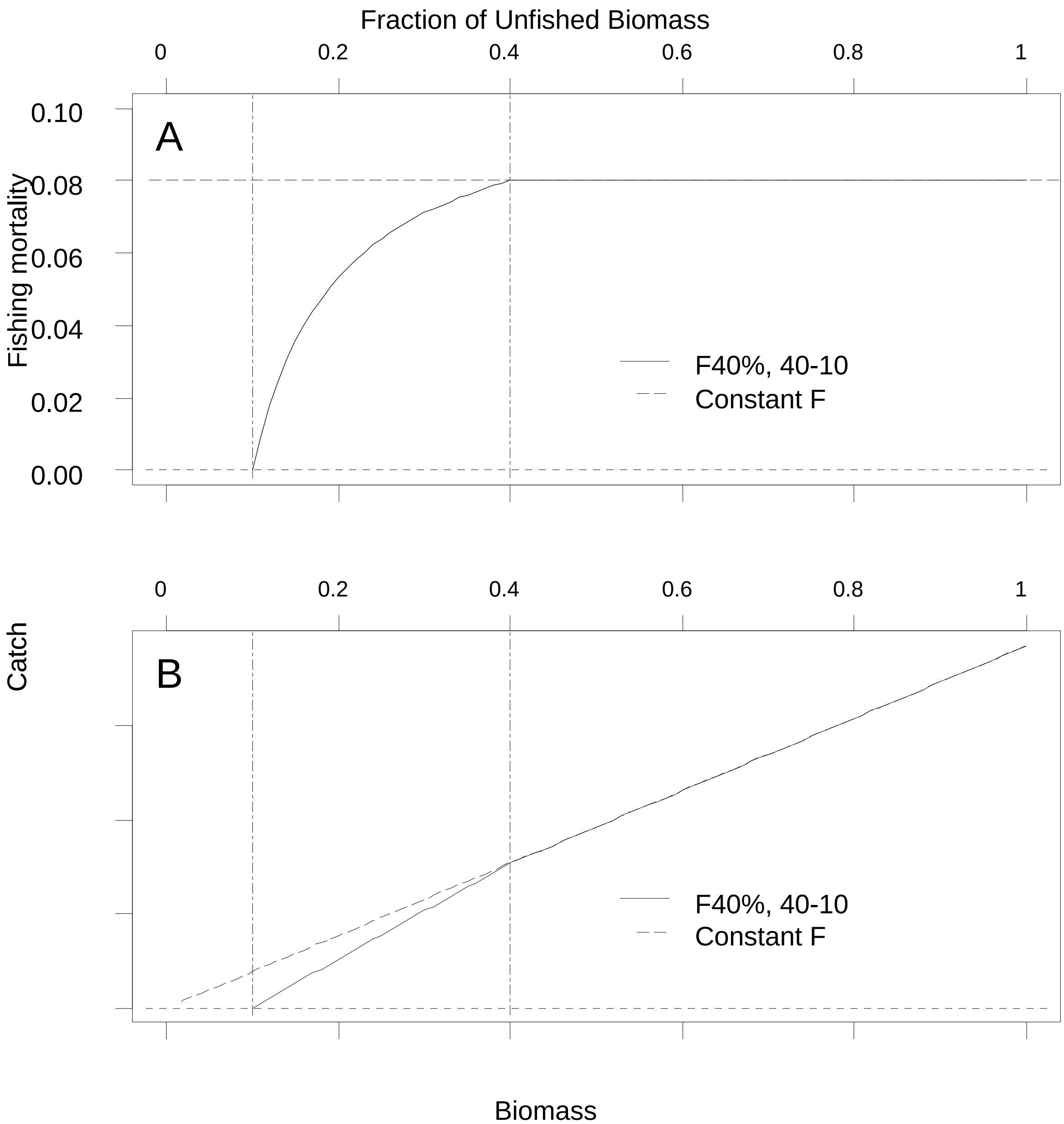


Figure A.12: The 40:10 control rule in relation to fishing mortality (top panel) and catch (bottom panel).

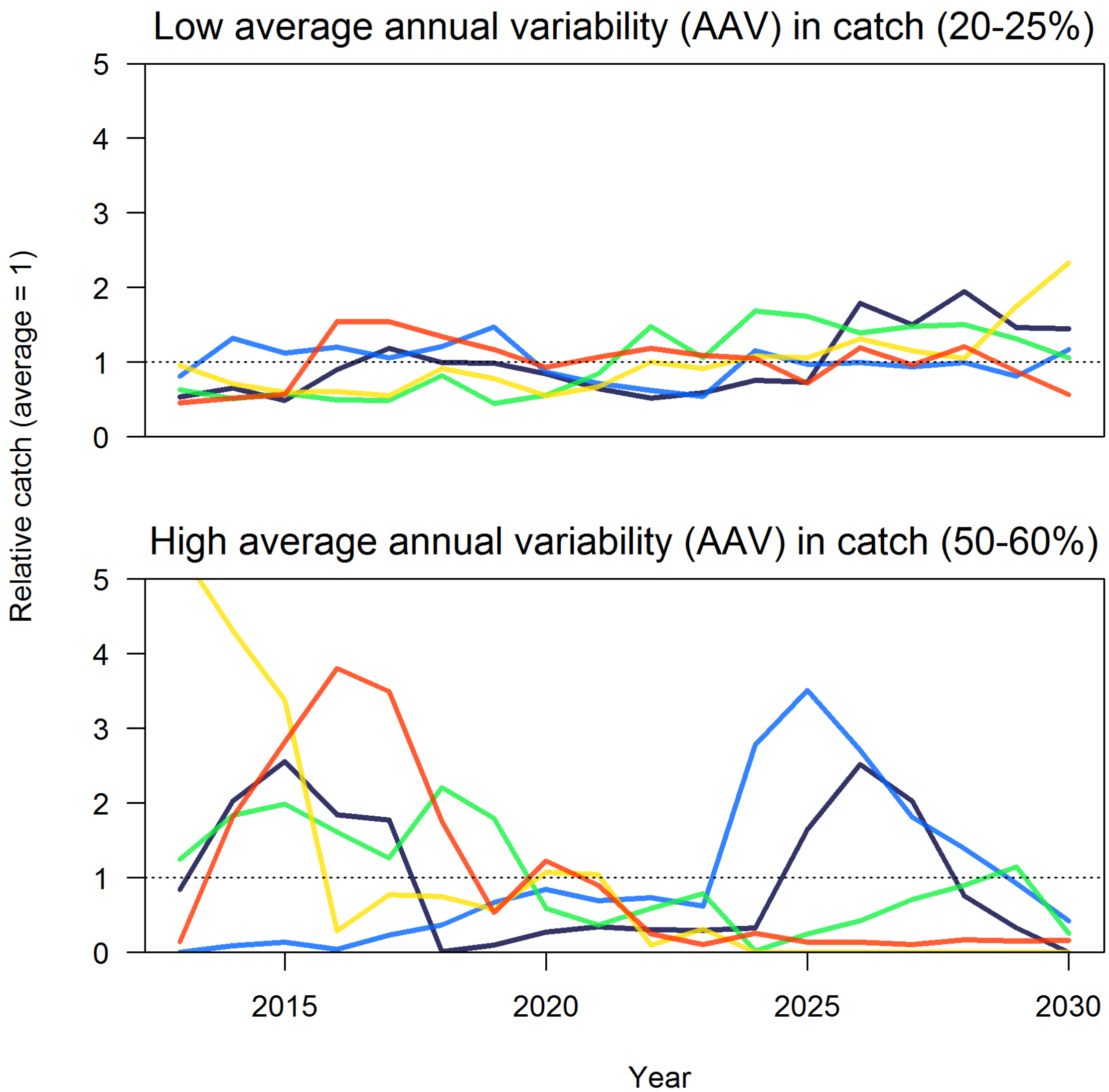


Figure A.13: Illustration of relative catch as a function of AAV in catch.

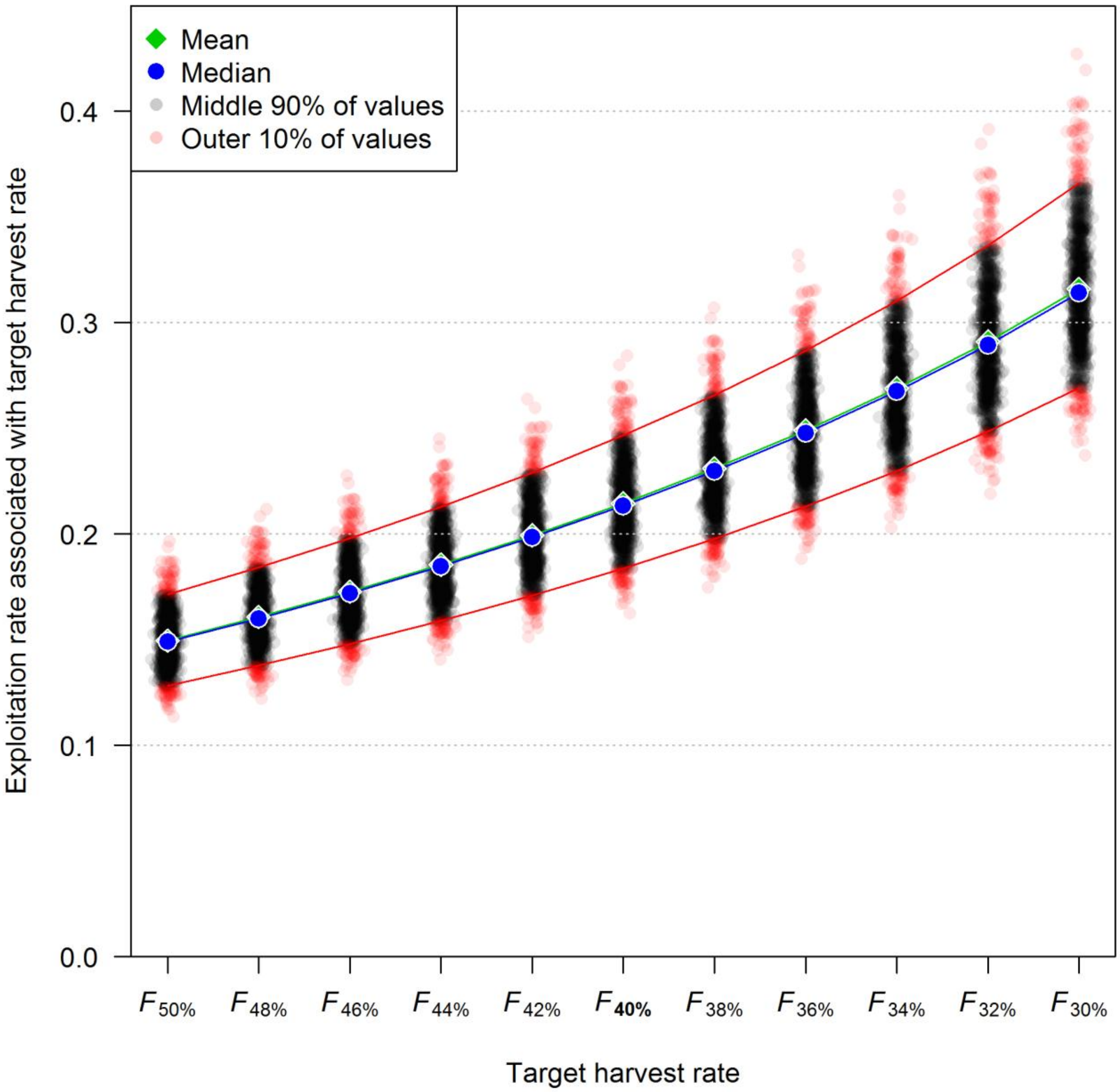


Figure A.14: Samples (dots) of discreet exploitation rates that correspond to the each random draw associated with target harvest rates expressed at Fspr%

Appendix B. List of terms and acronyms used in this document

Note: Many of these definitions are relevant to the historical management of Pacific hake and the U.S. Pacific Fishery Management Council process, and are included here only to improve interpretability of previous assessment and background documents.

40:10 Harvest control rule: The calculation leading to the ABC catch level (see below) for future years. This calculation decreases the catch linearly (given a constant age structure in the population) from the catch implied by the F_{MSY} (see below) harvest level when the stock declines below $SB_{40\%}$ (see below) to a value of 0 at $SB_{10\%}$.

40:10 adjustment: a reduction in the overall total allowable catch that is triggered when the biomass falls below 40% of its average equilibrium level in the absence of fishing. This adjustment reduces the total allowable catch on a straight-line basis from the 40% level such that the total allowable catch would equal zero when the stock is at 10% of its average equilibrium level in the absence of fishing.

ABC: Acceptable biological catch. See below.

Acceptable biological catch (ABC): The Acceptable biological catch is a scientific calculation of the sustainable harvest level of a fishery used historically to set the upper limit for fishery removals by the Pacific Fishery Management Council. It is calculated by applying the estimated (or proxy) harvest rate that produces maximum sustainable yield (MSY, see below) to the estimated exploitable stock biomass (the portion of the fish population that can be harvested). For Pacific hake, the calculation of the acceptable biological catch and application of the 40:10 adjustment is now replaced with the default harvest rate and the Total Allowable Catch.

Advisory Panel (AP): The advisory panel on Pacific Hake/Whiting established by the Agreement.

Agreement ("Treaty"): The Agreement between the government of the United States and the Government of Canada on Pacific hake/whiting, signed at Seattle, Washington, on November 21, 2003, and formally established in 2011.

AFSC: Alaska Fisheries Science Center (National Marine Fisheries Service)

Backscatter: The scattering by a target back in the direction of an acoustic source. Specifically, the Nautical Area Scattering Coefficient (a measure of scattering per area denoted by S_A) is frequently referred to as backscatter.

California Current Ecosystem: The waters of the continental shelf and slope off the west coast of North America; commonly referring to the area from central California to southern British Columbia.

Case: A combination of the harvest policy (F_{SPR} and control rule) and simulation assumptions regarding the survey. Cases considered in the MSE are "Annual", "Biennial", "Perfect information", and "No Fishing".

Catchability: The parameter defining the proportionality between a relative index of stock abundance (often a fishery independent survey) and the estimated stock abundance available to that survey (as modified by selectivity) in the assessment model.

Catch-per-unit-effort: A raw or (frequently) standardized and model-based metric of fishing success based on the catch and relative effort expended to generate that catch. Catch-per-unit-effort is often used as an index of stock abundance in the absence of fishery independent indices and/or where the two are believed to be proportional. See CPUE below.

Catch Target: A general term used to describe the catch value used for management. Depending on the context, this may be a limit rather than a target, and may be equal to a TAC, an ABC, the median result of applying the default harvest policy, or some other number. The JTC welcomes input from the JMC on the best terminology to use for these quantities.

Cohort: A group of fish born in the same year. Also see recruitment and year-class.

CPUE: Catch-per-unit-effort. See above.

CV: Coefficient of variation. A measure of uncertainty defined as the standard deviation (SD, see below) divided by the mean.

Default harvest policy (rate): The application of $F_{40\%}$ (see below) with the 40:10 adjustment (see above). Having considered any advice provided by the Joint Technical Committee, Scientific Review Group or Advisory Panel, the Joint Management Committee may recommend a different harvest rate if the scientific evidence demonstrates that a different rate is necessary to sustain the offshore hake/whiting resource.

Depletion: Abbreviated term for relative depletion (see below).

DFO: Fisheries and Oceans Canada. Federal organization which delivers programs and services that support sustainable use and development of Canada's waterways and aquatic resources.

DOC: United States Department of Commerce. Parent organization of the National Marine Fisheries Service (NMFS).

El Niño: Abnormally warm ocean climate conditions in the California Current Ecosystem (see above) as a result of broad changes in the Eastern Pacific Ocean across the eastern coast of Latin America (centered on Peru) often around the end of the calendar year.

Estimation model: A single run of Stock Synthesis within a combination of Case, Simulation and Year. The directories containing these results are named "assess2012" through "assess2030" where the year value in this case represents the last year of real or simulated data. The amount of data available to these models is therefore consistent with the stock assessments conducted in the years 2013–2031. There are 18 Estimation Models for each of 999 Simulations within each of 4 Management strategies for a total of 71,928 model results. The estimation models use maximum likelihood estimation, not MCMC.

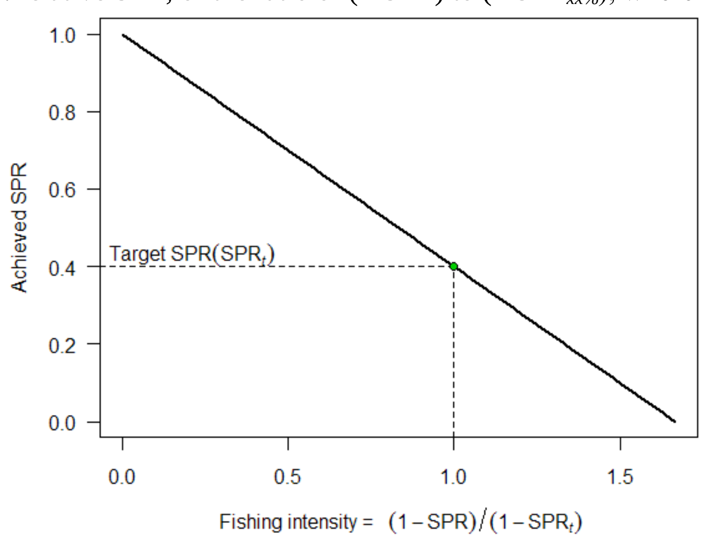
Exploitation fraction: A metric of fishing intensity that represents the total annual catch divided by the estimated population biomass over a range of ages assumed to be vulnerable to the fishery. This value is not equivalent to the instantaneous rate of fishing mortality (see below) or the Spawning Potential Ratio (*SPR*, see below).

F: Instantaneous rate of fishing mortality (or fishing mortality rate, see below).

$F_{40\%}$ (F-40 Percent): The rate of fishing mortality estimated to reduce the spawning potential ratio (SPR, see below) to 40%.

Female spawning biomass: The biomass of mature female fish at the beginning of the year. Occasionally, especially in reference points, this term is used to mean spawning output (expected egg production, see below) when this is not proportional to spawning biomass. See also spawning biomass.

Fishing intensity: A measure of the magnitude of fishing relative to a specified target. In this assessment it is defined as: relative SPR, or the ratio of (1-SPR) to (1-$SPR_{xx\%}$), where "*xx*" is the 40% proxy.



Fishing mortality rate, or instantaneous rate of fishing mortality (F): A metric of fishing intensity that is usually reported in relation to the most highly selected ages(s) or length(s), or occasionally as an average over an age range that is vulnerable to the fishery. Because it is an instantaneous rate operating simultaneously with natural mortality, it is *not* equivalent to exploitation fraction (or percent annual removal; see above) or the Spawning Potential Ratio (*SPR*, see below).

F_{MSY}: The rate of fishing mortality estimated to produce the maximum sustainable yield from the stock.

Joint Management Committee (JMC): The joint management committee established by the Agreement.

Joint Technical Committee (JTC): The joint technical committee established by the Agreement.

Kt: Knots (nautical miles per hour).

Magnuson‑Stevens Fishery Conservation and Management Act: The MSFCMA, sometimes known as the "Magnuson‑Stevens Act," established the 200‑mile fishery conservation zone, the regional fishery management council system, and other provisions of U.S. marine fishery law.

Maximum sustainable yield (*MSY*): An estimate of the largest average annual catch that can be continuously taken over a long period of time from a stock under prevailing ecological and environmental conditions.

MCMC: Markov-Chain Monte-Carlo. A numerical method used to sample from the posterior distribution (see below) of parameters and derived quantities in a Bayesian analysis. It is more computationally intensive than the maximum likelihood estimate (MLE, see below), but provides a more accurate depiction of parameter uncertainty. See Stewart et al. (2012) for a discussion of issues related to differences between MCMC and MLE.

MLE: Maximum likelihood estimate. Sometimes used interchangeably with "maximum posterior density estimate" or MPD. A numerical method used to estimate a single value of the parameters and derived quantities. It is less computationally intensive than MCMC methods (see above), but parameter uncertainty is less well characterized.

MSE: Management Strategy Evaluation. A simulation procedure that simulates a population using an operating model, generates data from that population and passes it to an estimation model, uses the estimation model and a management strategy to provide management advice, which then feeds back into the operating model to simulate an additional fixed set of time before repeating this process.

MSY: Maximum sustainable yield. See above.

mt: Metric ton(s). A unit of mass (often referred to as weight) equal to 1000 kilograms or 2,204.62 pounds.

NA: Not available.

National Marine Fisheries Service: A division of the U.S. Department of Commerce, National Ocean and Atmospheric Administration (NOAA). NMFS is responsible for conservation and management of offshore fisheries (and inland salmon).

NMFS: National Marine Fisheries Service. See above.

NOAA: National Oceanic and Atmospheric Administration. The parent agency of the National Marine Fisheries Service.

NORPAC: North Pacific Database Program. A database storing U.S. fishery observer data collected at sea.

NWFSC: Northwest Fisheries Science Center. A division of the NMFS located primarily in Seattle, Washington, but also in Newport, Oregon and other locations.

Operating Model: A model used to simulate data for use in the MSE (see above). The operating model includes components for the stock and fishery dynamics, as well as the simulation of the data sampling process, potentially including observation error. Cases in the MSE (see above) represent alternative configurations of the operating model.

Optimum yield: The amount of fish that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems. The OY is developed based on the acceptable biological catch from the fishery, taking into account relevant economic, social, and ecological factors. In the case of overfished fisheries, the OY provides for rebuilding to the target stock abundance.

OY: Optimum yield. See above.

PacFIN: Pacific Coast Fisheries Information Network. A database that provides a central repository for commercial fishery information from Washington, Oregon, and California.

PBS: Pacific Biological Station of Fisheries and Oceans Canada (DFO, see above).

Pacific Fishery Management Council (PFMC): The U.S. organization under which historical stock assessments for Pacific hake were conducted.

Pacific hake/whiting ("Pacific hake"): The stock of *Merluccius productus* located in the offshore waters of the United States and Canada (not including smaller stocks located in Puget Sound and the Strait of Georgia).

Posterior distribution: The probability distribution for parameters or derived quantities from a Bayesian model representing the prior probability distributions (see below) updated by the observed data via the likelihood equation. For stock assessments posterior distributions are approximated via numerical methods; one frequently employed method is MCMC (see above).

Prior distribution: Probability distribution for a parameter in a Bayesian analysis that represents the information available before evaluating the observed data via the likelihood equation. For some parameters noninformative priors can be constructed which allow the data to dominate the posterior distribution (see above). For others, informative priors can be constructed based on auxiliary information and/or expert knowledge or opinions.

Q: Catchability. See above.

R_0: Estimated average level of annual recruitment occurring at SB_0 (see below).

Recruits/recruitment: A group of fish born in the same year or the estimated production of new members to a fish population of the same age. Recruitment is reported at a specific life stage, often age 0 or 1, but sometimes corresponding to the age at which the fish first become vulnerable to the fishery. See also cohort and year-class.

Recruitment deviation: The offset of the recruitment in a given year relative to the stock-recruit function; values occur on a log scale and are relative to the expected recruitment at a given spawning biomass (see below).

Relative depletion: The ratio of the estimated beginning of the year female spawning biomass to estimated average unfished equilibrium female spawning biomass (SB_0, see below). Thus, lower values of relative depletion are associated with fewer mature female fish.

Relative SPR: A measure of fishing intensity transformed to have an interpretation more like F: as fishing increases the metric increases. Relative SPR is the ratio of (1-SPR) to (1-$SPR_{xx\%}$), where "*xx*" is the proxy or estimated SPR rate that produces MSY.

SB_0: The estimated average unfished equilibrium female spawning biomass or spawning output if not directly proportional to spawning biomass.

$SB_{10\%}$: The level of female spawning biomass (output) corresponding to 10% of average unfished equilibrium female spawning biomass (SB_0, size of fish stock without fishing; see above). This is the level at which the calculated catch based on the 40:10 harvest control rule (see above) is equal to 0.

$SB_{40\%}$: The level of female spawning biomass (output) corresponding to 40% of average unfished equilibrium female spawning biomass (SB_0, size of fish stock without fishing; see below).

SB_{MSY}: The estimated female spawning biomass (output) that produces the maximum sustainable yield (*MSY*). Also see $SB_{40\%}$.

Scientific Review Group (SRG): The scientific review group established by the Agreement.

Scientific and Statistical Committee (SSC): The scientific advisory committee to the PFMC. The Magnuson - Stevens Act requires that each council maintain an SSC to assist in gathering and analyzing statistical, biological, ecological, economic, social, and other scientific information that is relevant to the management of council fisheries.

SD: Standard deviation. A measure of variability within a sample.

Simulation: State of nature, including combination of parameters controlling stock productivity, 2012 status, and time-series of recruitment deviations. There are 999 simulations for each case, numbered 2–1000. These simulation models are samples from the MCMC calculations associated with the 2011 assessment model.

Spawning biomass: Abbreviated term for female spawning biomass (see above).

Spawning output: The total production of eggs (or possibly viable egg equivalents if egg quality is taken into account) given the number of females at age (and maturity and fecundity at age).

Spawning potential ratio (SPR): A metric of fishing intensity. The ratio of the spawning output per recruit under a given level of fishing to the estimated spawning output per recruit in the absence of fishing. It achieves a value of 1.0 in the absence of fishing and declines toward 0.0 as fishing intensity increases.

Spawning stock biomass (SSB): Alternative term for female spawning biomass (see above).

SPR: Spawning potential ratio. See above.

SPR_{MSY}: The estimated spawning potential ratio that produces the largest sustainable harvest (*MSY*).

$SPR_{40\%}$: The estimated spawning potential ratio that stabilizes the female spawning biomass at the MSY-proxy target of $SB_{40\%}$. Also referred to as $SPR_{MSY\text{-}proxy}$.

SS: Stock Synthesis. See below.

SSC: Scientific and Statistical Committee (see above).

STAR Panel: Stock Assessment Review Panel. A panel set up to provide independent review of all stock assessments used by the Pacific Fishery Management Council.

Steepness (*h*): A stock-recruit relationship parameter representing the proportion of R_0 expected (on average) when the female spawning biomass is reduced to 20% of SB_0 (i.e., when relative depletion is equal to 20%). This parameter can be thought of one important component to the productivity of the stock.

Stock Synthesis: The age-structured stock assessment model applied in this stock assessment. For a more detailed description of this model, see Methot and Wetzel (2013).

Target strength: The amount of backscatter from an individual acoustic target.

Total Allowable Catch (TAC): The maximum fishery removal under the terms of the Agreement.

U.S./Canadian allocation: The division of the total allowable catch of 73.88% as the United States' share and 26.12% as the Canadian share.

Vulnerable biomass: The demographic portion of the stock available for harvest by the fishery.

Year-class: A group of fish born in the same year. See also cohort and recruitment.

Appendix C. Explanation of nonparametric selectivity

For all ages in the population beginning with A_{min} = 1 for the fishery and 2 for the survey, there is a corresponding set of selectivity parameters for each fleet, p_a. The selectivity at age a is computed as,

$$S_a = \exp(S'_a - S'_{max})$$

where S'_a is the sum of parameters for ages up to a,

$$S'_a = \sum_{i=A_{min}}^{a} p_a$$

and S'_{max} is the maximum of the S'_a,

$$S'_{max} = \max(S'_a)$$

Selectivity is fixed at $S_a = 0$ for $a < A_{min}$. This formulation has the properties that the maximum selectivity is equal to 1, positive p_a values are associated with increasing selectivity between ages a-1 and a, and negative values are associated with decreasing selectivity between those ages. The parameters beyond the maximum age for which selectivity is estimated (6 in the base model, and 5 or 7 in the in a sensitivity analysis) are fixed at $p_a = 0$, resulting in constant selectivity beyond the last estimated value. The condition that maximum selectivity is equal to 1 results in one fewer degree of freedom than the number of estimated selectivity values. Therefore, the parameter corresponding to the first age of estimated selectivity (1 for the fishery and 2 for the survey), is fixed at 1.0.

In addition to a sensitivity considering changes in the maximum age of estimated selectivity, a sensitivity was conducted to examine the effect of two alternatives for time-varying selectivity. In these cases, the estimated parameters for the fishery selectivity, p_a for a in the range (2, 6) were assumed to follow a random walk over the years 1980-2012. This is formulated as

$$p_{a,y} = p_{a,y-1} + \varepsilon_{a,y}$$

where the $\varepsilon_{a,y}$ are additional parameters estimated in the model. The values of $\varepsilon_{a,y}$ are included in an additional likelihood component with negative log likelihood proportional to

$$-\log(L) \propto \frac{1}{2} \sum_{a=2}^{6} \sum_{y=1980}^{2012} \frac{{\varepsilon_{a,y}}^2}{{\sigma_a}^2}$$

The "flexible fishery" sensitivity analysis set all $\sigma_a = 0.05$ while the "very flexible fishery" case set all $\sigma_a = 0.2$. This sensitivity is intended to explore the effect of two degrees of time-varying selectivity on quantities of interest, but by no means does it represent the full range of possibilities. The statistical properties of this time-varying selectivity formulation have not been adequately explored, and many other parameterizations for time-varying selectivity are available. These options would benefit from further testing in a simulation or MSE context before being applied in an assessment model for application to management.

Appendix D. Estimated parameters in the base assessment model

Parameter	Posterior median
NatM_p_1_Fem_GP_1	0.2241
SR_LN.R0.	14.8037
SR_BH_steep	0.8226
Early_InitAge_20	-0.0757
Early_InitAge_19	-0.0905
Early_InitAge_18	0.0209
Early_InitAge_17	-0.0526
Early_InitAge_16	-0.0862
Early_InitAge_15	-0.1652
Early_InitAge_14	-0.1605
Early_InitAge_13	-0.0377
Early_InitAge_12	-0.1694
Early_InitAge_11	-0.1689
Early_InitAge_10	-0.2427
Early_InitAge_9	-0.2728
Early_InitAge_8	-0.2677
Early_InitAge_7	-0.4053
Early_InitAge_6	-0.3155
Early_InitAge_5	-0.4272
Early_InitAge_4	-0.3362
Early_InitAge_3	-0.2177
Early_InitAge_2	-0.1348
Early_InitAge_1	-0.0005
Early_RecrDev_1966	0.4151
Early_RecrDev_1967	1.1946
Early_RecrDev_1968	0.8858
Early_RecrDev_1969	-0.1398
Main_RecrDev_1970	2.1488
Main_RecrDev_1971	-0.2683
Main_RecrDev_1972	-0.7791
Main_RecrDev_1973	1.5022
Main_RecrDev_1974	-0.8386
Main_RecrDev_1975	0.3090
Main_RecrDev_1976	-1.0886
Main_RecrDev_1977	1.6587
Main_RecrDev_1978	-1.1963
Main_RecrDev_1979	-0.0167
Main_RecrDev_1980	2.8446
Main_RecrDev_1981	-1.1399
Main_RecrDev_1982	-1.3179
Main_RecrDev_1983	-0.8634

Parameter	Posterior median
Main_RecrDev_1984	2.5546
Main_RecrDev_1985	-1.5977
Main_RecrDev_1986	-1.5325
Main_RecrDev_1987	1.6785
Main_RecrDev_1988	0.6563
Main_RecrDev_1989	-1.7773
Main_RecrDev_1990	1.4786
Main_RecrDev_1991	-0.6191
Main_RecrDev_1992	-1.6213
Main_RecrDev_1993	1.2251
Main_RecrDev_1994	0.9293
Main_RecrDev_1995	0.3562
Main_RecrDev_1996	0.5235
Main_RecrDev_1997	0.2963
Main_RecrDev_1998	0.6651
Main_RecrDev_1999	2.5040
Main_RecrDev_2000	-0.9257
Main_RecrDev_2001	-0.1107
Main_RecrDev_2002	-2.6462
Main_RecrDev_2003	0.3274
Main_RecrDev_2004	-2.5835
Main_RecrDev_2005	0.8272
Main_RecrDev_2006	0.6522
Main_RecrDev_2007	-2.3190
Main_RecrDev_2008	1.8795
Late_RecrDev_2009	1.0208
Late_RecrDev_2010	2.7750
Late_RecrDev_2011	-0.1653
Late_RecrDev_2012	-0.0548
ForeRecr_2013	0.0416
ForeRecr_2014	-0.0121
ForeRecr_2015	0.0760
Q_extraSD_2_Acoustic_Survey	0.4162
AgeSel_1P_3_Fishery	3.1936
AgeSel_1P_4_Fishery	1.5091
AgeSel_1P_5_Fishery	0.4566
AgeSel_1P_6_Fishery	0.1701
AgeSel_1P_7_Fishery	0.2452
AgeSel_2P_4_Acoustic_Survey	0.2330
AgeSel_2P_5_Acoustic_Survey	0.1322
AgeSel_2P_6_Acoustic_Survey	-0.0039
AgeSel_2P_7_Acoustic_Survey	0.4220

Appendix E. SS data file

```
#C 2013 Hake data file

### Global model specifications ###
1966    # Start year
2012    # End year
1       # Number of seasons/year
12      # Number of months/season
1       # Spawning occurs at beginning of season
1       # Number of fishing fleets
1       # Number of surveys
1       # Number of areas
Fishery%Acoustic_Survey
0.5 0.5 # fleet timing_in_season
1 1     # Area of each fleet
1       # Units for catch by fishing fleet: 1=Biomass(mt),2=Numbers(1000s)
0.01    # SE of log(catch) by fleet for equilibrium and continuous options
1       # Number of genders
20      # Number of ages in population dynamics

### Catch section ###
0  # Initial equilibrium catch (landings + discard) by fishing fleet

47 # Number of lines of catch
# Catch Year Season
137700  1966    1
214370  1967    1
122180  1968    1
180130  1969    1
234590  1970    1
154620  1971    1
117540  1972    1
162640  1973    1
211260  1974    1
221350  1975    1
237520  1976    1
132690  1977    1
103640  1978    1
137110  1979    1
89930   1980    1
139120  1981    1
107741  1982    1
113931  1983    1
138492  1984    1
110399  1985    1
210616  1986    1
234148  1987    1
248840  1988    1
```

```
298079  1989    1
261286  1990    1
319710  1991    1
299687  1992    1
198924  1993    1
362422  1994    1
249644  1995    1
306383  1996    1
325257  1997    1
320815  1998    1
311844  1999    1
228214  2000    1
227531  2001    1
180698  2002    1
205177  2003    1
338654  2004    1
363157  2005    1
361761  2006    1
291129  2007    1
322145  2008    1
177459  2009    1
226202  2010    1
285850  2011    1
204040  2012    1

9 # Number of index observations
# Units: 0=numbers,1=biomass,2=F; Errortype: -1=normal,0=lognormal,>0=T
# Fleet Units Errortype
1 1 0 # Fishery
2 1 0 # Acoustic Survey

# Year seas index obs se(log)
# Acoustic survey
1995    1       2       1517948 0.0666
1998    1       2       1342740 0.0492
2001    1       2       918622  0.0823
2003    1       2       2520641 0.0709
2005    1       2       1754722 0.0847
2007    1       2       1122809 0.0752
2009    1       2       1612027 0.1375
2011    1       2       521476  0.1015
2012    1       2       1380724 0.0475

0 #_N_fleets_with_discard
0 #_N_discard_obs
0 #_N_meanbodywt_obs
30 #_DF_for_meanbodywt_T-distribution_like

## Population size structure
2 # Length bin method: 1=use databins; 2=generate from binwidth,min,max below;
```

```
2 # Population length bin width
10 # Minimum size bin
70 # Maximum size bin

-1      # Minimum proportion for compressing tails of observed compositional data
0.001   # Constant added to expected frequencies
0       # Combine males and females at and below this bin number

26 # Number of Data Length Bins
# Lower edge of bins
20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70
0 #_N_Length_obs

15 #_N_age_bins
# Age bins
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

40 # N_ageerror_definitions
# Annual keys with cohort effect
#age0      age1       age2       age3       age4       age5       age6       age7       age8       age9       age10      age11
age12      age13      age14      age15      age16      age17      age18      age19      age20      yr         def        comment
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1973     def1       expected
ages
0.329242   0.329242   0.346917   0.368632   0.395312   0.42809    0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1973     def1       SD of age
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1974     def2       expected
ages
0.329242   0.329242   0.346917   0.368632   0.395312   0.42809    0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1974     def2       SD of age
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1975     def3       expected
ages
0.329242   0.329242   0.346917   0.368632   0.395312   0.42809    0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1975     def3       SD of age
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1976     def4       expected
ages
0.329242   0.329242   0.346917   0.368632   0.395312   0.42809    0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1976     def4       SD of age
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1977     def5       expected
ages
0.329242   0.329242   0.346917   0.368632   0.395312   0.42809    0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1977     def5       SD of age
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1978     def6       expected
ages
```

```
0.329242   0.329242   0.346917   0.368632   0.395312   0.42809    0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1978     def6       SD of age
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1979     def7       expected
ages
0.329242   0.329242   0.346917   0.368632   0.395312   0.42809    0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1979     def7       SD of age
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1980     def8       expected
ages
0.329242   0.329242   0.346917   0.368632   0.395312   0.42809    0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1980     def8       SD of age
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1981     def9       expected
ages
0.329242   0.1810831  0.346917   0.368632   0.395312   0.42809    0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1981     def9       SD of age
with adjustments for age 1
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1982     def10      expected
ages
0.329242   0.329242   0.19080435 0.368632   0.395312   0.42809    0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1982     def10      SD of age
with adjustments for age 2
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1983     def11      expected
ages
0.329242   0.329242   0.346917   0.2027476  0.395312   0.42809    0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1983     def11      SD of age
with adjustments for age 3
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1984     def12      expected
ages
0.329242   0.329242   0.346917   0.368632   0.2174216  0.42809    0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1984     def12      SD of age
with adjustments for age 4
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1985     def13      expected
ages
0.329242   0.1810831  0.346917   0.368632   0.395312   0.2354495  0.468362   0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1985     def13      SD of age
with adjustments for ages 1,5
0.5        1.5        2.5        3.5        4.5        5.5        6.5        7.5        8.5        9.5        10.5       11.5
12.5       13.5       14.5       15.5       16.5       17.5       18.5       19.5       20.5       # 1986     def14      expected
ages
0.329242   0.329242   0.19080435 0.368632   0.395312   0.42809    0.2575991  0.517841   0.57863    0.653316   0.745076   0.857813
0.996322   1.1665     1.37557    1.63244    1.858      2.172      2.53       2.934      3.388      # 1986     def14      SD of age
with adjustments for ages 2,6
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0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 1987    def15     expected
ages
0.329242  0.329242  0.346917  0.2027476 0.395312  0.42809   0.468362  0.28481255 0.57863  0.653316  0.745076  0.857813
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 1987    def15     SD of age
with adjustments for ages 3,7
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 1988    def16     expected
ages
0.329242  0.329242  0.346917  0.368632  0.2174216 0.42809   0.468362  0.517841  0.3182465 0.653316  0.745076  0.857813
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 1988    def16     SD of age
with adjustments for ages 4,8
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 1989    def17     expected
ages
0.329242  0.329242  0.346917  0.368632  0.395312  0.2354495 0.468362  0.517841  0.57863   0.3593238 0.745076  0.857813
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 1989    def17     SD of age
with adjustments for ages 5,9
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 1990    def18     expected
ages
0.329242  0.329242  0.346917  0.368632  0.395312  0.42809   0.2575991 0.517841  0.57863   0.653316  0.4097918 0.857813
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 1990    def18     SD of age
with adjustments for ages 6,10
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 1991    def19     expected
ages
0.329242  0.329242  0.346917  0.368632  0.395312  0.42809   0.468362  0.28481255 0.57863  0.653316  0.745076  0.47179715
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 1991    def19     SD of age
with adjustments for ages 7,11
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 1992    def20     expected
ages
0.329242  0.329242  0.346917  0.368632  0.395312  0.42809   0.468362  0.517841  0.3182465 0.653316  0.745076  0.857813
0.5479771 1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 1992    def20     SD of age
with adjustments for ages 8,12
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 1993    def21     expected
ages
0.329242  0.329242  0.346917  0.368632  0.395312  0.42809   0.468362  0.517841  0.57863   0.3593238 0.745076  0.857813
0.996322  0.641575  1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 1993    def21     SD of age
with adjustments for ages 9,13
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 1994    def22     expected
ages
0.329242  0.329242  0.346917  0.368632  0.395312  0.42809   0.468362  0.517841  0.57863   0.653316  0.4097918 0.857813
0.996322  1.1665    0.7565635 1.63244   1.858     2.172     2.53      2.934     3.388     # 1994    def22     SD of age
with adjustments for ages 10,14
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0.5         1.5         2.5         3.5         4.5         5.5         6.5         7.5         8.5         9.5         10.5        11.5
12.5        13.5        14.5        15.5        16.5        17.5        18.5        19.5        20.5        # 1995      def23       expected
ages
0.329242    0.329242    0.346917    0.368632    0.395312    0.42809     0.468362    0.517841    0.57863     0.653316    0.745076    0.47179715
0.996322    1.1665      1.37557     0.897842    1.858       2.172       2.53        2.934       3.388       # 1995      def23       SD of age
with adjustments for ages 11,15
0.5         1.5         2.5         3.5         4.5         5.5         6.5         7.5         8.5         9.5         10.5        11.5
12.5        13.5        14.5        15.5        16.5        17.5        18.5        19.5        20.5        # 1996      def24       expected
ages
0.329242    0.329242    0.346917    0.368632    0.395312    0.42809     0.468362    0.517841    0.57863     0.653316    0.745076    0.857813
0.5479771   1.1665      1.37557     1.63244     1.0219      2.172       2.53        2.934       3.388       # 1996      def24       SD of age
with adjustments for ages 12,16
0.5         1.5         2.5         3.5         4.5         5.5         6.5         7.5         8.5         9.5         10.5        11.5
12.5        13.5        14.5        15.5        16.5        17.5        18.5        19.5        20.5        # 1997      def25       expected
ages
0.329242    0.329242    0.346917    0.368632    0.395312    0.42809     0.468362    0.517841    0.57863     0.653316    0.745076    0.857813
0.996322    0.641575    1.37557     1.63244     1.858       1.1946      2.53        2.934       3.388       # 1997      def25       SD of age
with adjustments for ages 13,17
0.5         1.5         2.5         3.5         4.5         5.5         6.5         7.5         8.5         9.5         10.5        11.5
12.5        13.5        14.5        15.5        16.5        17.5        18.5        19.5        20.5        # 1998      def26       expected
ages
0.329242    0.329242    0.346917    0.368632    0.395312    0.42809     0.468362    0.517841    0.57863     0.653316    0.745076    0.857813
0.996322    1.1665      0.7565635   1.63244     1.858       2.172       1.3915      2.934       3.388       # 1998      def26       SD of age
with adjustments for ages 14,18
0.5         1.5         2.5         3.5         4.5         5.5         6.5         7.5         8.5         9.5         10.5        11.5
12.5        13.5        14.5        15.5        16.5        17.5        18.5        19.5        20.5        # 1999      def27       expected
ages
0.329242    0.329242    0.346917    0.368632    0.395312    0.42809     0.468362    0.517841    0.57863     0.653316    0.745076    0.857813
0.996322    1.1665      1.37557     0.897842    1.858       2.172       2.53        1.6137      3.388       # 1999      def27       SD of age
with adjustments for ages 15,19
0.5         1.5         2.5         3.5         4.5         5.5         6.5         7.5         8.5         9.5         10.5        11.5
12.5        13.5        14.5        15.5        16.5        17.5        18.5        19.5        20.5        # 2000      def28       expected
ages
0.329242    0.1810831   0.346917    0.368632    0.395312    0.42809     0.468362    0.517841    0.57863     0.653316    0.745076    0.857813
0.996322    1.1665      1.37557     1.63244     1.0219      2.172       2.53        2.934       1.8634      # 2000      def28       SD of age
with adjustments for ages 1,16,20
0.5         1.5         2.5         3.5         4.5         5.5         6.5         7.5         8.5         9.5         10.5        11.5
12.5        13.5        14.5        15.5        16.5        17.5        18.5        19.5        20.5        # 2001      def29       expected
ages
0.329242    0.329242    0.19080435  0.368632    0.395312    0.42809     0.468362    0.517841    0.57863     0.653316    0.745076    0.857813
0.996322    1.1665      1.37557     1.63244     1.858       1.1946      2.53        2.934       3.388       # 2001      def29       SD of age
with adjustments for ages 2,17
0.5         1.5         2.5         3.5         4.5         5.5         6.5         7.5         8.5         9.5         10.5        11.5
12.5        13.5        14.5        15.5        16.5        17.5        18.5        19.5        20.5        # 2002      def30       expected
ages
0.329242    0.329242    0.346917    0.2027476   0.395312    0.42809     0.468362    0.517841    0.57863     0.653316    0.745076    0.857813
0.996322    1.1665      1.37557     1.63244     1.858       2.172       1.3915      2.934       3.388       # 2002      def30       SD of age
with adjustments for ages 3,18
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0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 2003    def31     expected
ages
0.329242  0.329242  0.346917  0.368632  0.2174216 0.42809   0.468362  0.517841  0.57863   0.653316  0.745076  0.857813
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      1.6137    3.388     # 2003    def31     SD of age
with adjustments for ages 4,19
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 2004    def32     expected
ages
0.329242  0.329242  0.346917  0.368632  0.395312  0.2354495 0.468362  0.517841  0.57863   0.653316  0.745076  0.857813
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     1.8634    # 2004    def32     SD of age
with adjustments for ages 5,20
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 2005    def33     expected
ages
0.329242  0.329242  0.346917  0.368632  0.395312  0.42809   0.2575991 0.517841  0.57863   0.653316  0.745076  0.857813
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 2005    def33     SD of age
with adjustments for age 6
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 2006    def34     expected
ages
0.329242  0.329242  0.346917  0.368632  0.395312  0.42809   0.468362  0.28481255 0.57863  0.653316  0.745076  0.857813
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 2006    def34     SD of age
with adjustments for age 7
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 2007    def35     expected
ages
0.329242  0.329242  0.346917  0.368632  0.395312  0.42809   0.468362  0.517841  0.3182465 0.653316  0.745076  0.857813
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 2007    def35     SD of age
with adjustments for age 8
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 2008    def36     expected
ages
0.329242  0.329242  0.346917  0.368632  0.395312  0.42809   0.468362  0.517841  0.57863   0.3593238 0.745076  0.857813
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 2008    def36     SD of age
with adjustments for age 9
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 2009    def37     expected
ages
0.329242  0.1810831 0.346917  0.368632  0.395312  0.42809   0.468362  0.517841  0.57863   0.653316  0.4097918 0.857813
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 2009    def37     SD of age
with adjustments for ages 1,10
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 2010    def38     expected
ages
0.329242  0.329242  0.19080435 0.368632 0.395312  0.42809   0.468362  0.517841  0.57863   0.653316  0.745076  0.47179715
0.996322  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 2010    def38     SD of age
with adjustments for ages 2,11
```

```
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 2011    def39     expected
ages
0.329242  0.1810831 0.346917  0.202748  0.395312  0.42809   0.468362  0.517841  0.57863   0.653316  0.745076  0.857813
0.547977  1.1665    1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 2011    def39     SD of age
with adjustments for ages 1,3,12
0.5       1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5       9.5       10.5      11.5
12.5      13.5      14.5      15.5      16.5      17.5      18.5      19.5      20.5      # 2012    def40     expected
ages
0.329242  0.329242  0.19080435 0.368632 0.2174216 0.42809   0.468362  0.517841  0.57863   0.653316  0.745076  0.857813
0.996322  0.641575  1.37557   1.63244   1.858     2.172     2.53      2.934     3.388     # 2012    def40     SD of age
with adjustments for ages 2,4,13

47      # Number of age comp observations
1       # Length bin refers to: 1=population length bin indices; 2=data length bin indices
0       #_combine males into females at or below this bin number
# Acoustic survey ages (N=8)
1995    1       2       0       0       23      -1      -1      68      0.000   0.304   0.048   0.014   0.209   0.012   0.042   0.144
0.003   0.001   0.165   0.001   0.007   0.000   0.051
1998    1       2       0       0       26      -1      -1      103     0.000   0.125   0.144   0.168   0.191   0.016   0.076   0.093
0.014   0.028   0.061   0.005   0.003   0.061   0.015
2001    1       2       0       0       29      -1      -1      57      0.000   0.641   0.104   0.054   0.060   0.030   0.037   0.022
0.011   0.010   0.008   0.008   0.010   0.002   0.004
2003    1       2       0       0       31      -1      -1      71      0.000   0.024   0.023   0.635   0.092   0.031   0.070   0.042
0.028   0.026   0.011   0.007   0.005   0.004   0.004
2005    1       2       0       0       33      -1      -1      47      0.000   0.229   0.021   0.069   0.048   0.492   0.053   0.020
0.027   0.016   0.013   0.007   0.002   0.001   0.002
2007    1       2       0       0       35      -1      -1      70      0.000   0.366   0.022   0.108   0.013   0.044   0.030   0.334
0.034   0.017   0.014   0.007   0.007   0.003   0.001
2009    1       2       0       0       37      -1      -1      66      0.000   0.006   0.299   0.421   0.023   0.082   0.012   0.016
0.015   0.073   0.032   0.013   0.003   0.004   0.002
2011    1       2       0       0       39      -1      -1      59      0.000   0.244   0.631   0.039   0.029   0.030   0.004   0.004
0.003   0.002   0.001   0.007   0.003   0.001   0.000
2012    1       2       0       0       40      -1      -1      96      0.000   0.637   0.097   0.161   0.022   0.026   0.019   0.01
0.005   0.003   0.002   0.006   0.009   0.005   0.001

#Aggregate marginal fishery age comps (n=38)                                    nTrips  a1      a2      a3      a4      a5
a6      a7      a8      a9      a10     a11     a12     a13     a14     a15
1975    1       1       0       0       3       -1      -1      13      0.046   0.338   0.074   0.012   0.254   0.055   0.080   0.105
0.010   0.006   0.009   0.005   0.000   0.005   0.000
1976    1       1       0       0       4       -1      -1      142     0.001   0.013   0.145   0.067   0.041   0.246   0.098   0.089
0.121   0.054   0.043   0.041   0.011   0.024   0.007
1977    1       1       0       0       5       -1      -1      320     0.000   0.084   0.037   0.275   0.036   0.091   0.227   0.076
0.065   0.040   0.036   0.023   0.006   0.003   0.001
1978    1       1       0       0       6       -1      -1      341     0.005   0.011   0.065   0.063   0.264   0.061   0.089   0.215
0.098   0.047   0.047   0.023   0.005   0.004   0.003
1979    1       1       0       0       7       -1      -1      116     0.000   0.065   0.102   0.094   0.057   0.177   0.103   0.174
0.128   0.042   0.029   0.010   0.016   0.000   0.004
1980    1       1       0       0       8       -1      -1      221     0.001   0.005   0.301   0.019   0.045   0.082   0.112   0.050
0.089   0.111   0.095   0.026   0.038   0.015   0.011
```

1981	1	1	0	0	9	-1	-1	154	0.195	0.040	0.014	0.267	0.039	0.055	0.034	0.147
0.038	0.032	0.102	0.023	0.005	0.002	0.007										
1982	1	1	0	0	10	-1	-1	170	0.000	0.321	0.035	0.005	0.273	0.015	0.037	0.039
0.118	0.033	0.036	0.076	0.002	0.003	0.007										
1983	1	1	0	0	11	-1	-1	117	0.000	0.000	0.341	0.040	0.018	0.235	0.051	0.056
0.053	0.094	0.039	0.031	0.023	0.011	0.007										
1984	1	1	0	0	12	-1	-1	123	0.000	0.000	0.014	0.621	0.036	0.038	0.168	0.028
0.015	0.012	0.033	0.009	0.006	0.014	0.005										
1985	1	1	0	0	13	-1	-1	56	0.010	0.001	0.003	0.073	0.688	0.080	0.049	0.063
0.018	0.006	0.006	0.002	0.000	0.000	0.000										
1986	1	1	0	0	14	-1	-1	120	0.000	0.160	0.056	0.005	0.008	0.428	0.067	0.080
0.083	0.022	0.028	0.018	0.033	0.005	0.007										
1987	1	1	0	0	15	-1	-1	56	0.000	0.000	0.296	0.029	0.001	0.010	0.533	0.004
0.012	0.071	0.000	0.007	0.019	0.018	0.000										
1988	1	1	0	0	16	-1	-1	81	0.000	0.008	0.000	0.384	0.011	0.015	0.002	0.394
0.011	0.005	0.111	0.008	0.000	0.000	0.051										
1989	1	1	0	0	17	-1	-1	77	0.000	0.073	0.032	0.003	0.501	0.016	0.003	0.001
0.321	0.023	0.001	0.023	0.001	0.000	0.000										
1990	1	1	0	0	18	-1	-1	163	0.000	0.052	0.179	0.017	0.006	0.347	0.003	0.002
0.000	0.321	0.003	0.001	0.060	0.000	0.009										
1991	1	1	0	0	19	-1	-1	160	0.000	0.035	0.204	0.196	0.025	0.007	0.278	0.011
0.001	0.002	0.192	0.004	0.000	0.036	0.007										
1992	1	1	0	0	20	-1	-1	243	0.005	0.042	0.042	0.130	0.187	0.022	0.010	0.340
0.008	0.001	0.003	0.181	0.004	0.000	0.024										
1993	1	1	0	0	21	-1	-1	175	0.000	0.010	0.230	0.032	0.127	0.156	0.015	0.008
0.278	0.007	0.001	0.000	0.121	0.001	0.014										
1994	1	1	0	0	22	-1	-1	234	0.000	0.000	0.029	0.228	0.012	0.131	0.197	0.010
0.003	0.286	0.001	0.003	0.000	0.089	0.008										
1995	1	1	0	0	23	-1	-1	147	0.002	0.025	0.005	0.058	0.315	0.018	0.072	0.190
0.024	0.006	0.180	0.030	0.005	0.001	0.071										
1996	1	1	0	0	24	-1	-1	186	0.000	0.182	0.158	0.014	0.078	0.183	0.010	0.054
0.109	0.004	0.003	0.159	0.000	0.001	0.045										
1997	1	1	0	0	25	-1	-1	222	0.000	0.008	0.272	0.250	0.010	0.084	0.130	0.024
0.049	0.065	0.015	0.002	0.064	0.006	0.022										
1998	1	1	0	0	26	-1	-1	243	0.000	0.053	0.188	0.203	0.283	0.032	0.050	0.091
0.010	0.017	0.037	0.003	0.001	0.026	0.005										
1999	1	1	0	0	27	-1	-1	514	0.000	0.095	0.198	0.181	0.187	0.136	0.028	0.034
0.036	0.009	0.014	0.040	0.004	0.003	0.035										
2000	1	1	0	0	28	-1	-1	529	0.010	0.044	0.094	0.147	0.134	0.210	0.137	0.067
0.048	0.027	0.020	0.022	0.011	0.008	0.024										
2001	1	1	0	0	29	-1	-1	541	0.000	0.168	0.154	0.231	0.174	0.081	0.078	0.049
0.012	0.013	0.012	0.007	0.007	0.005	0.009										
2002	1	1	0	0	30	-1	-1	450	0.000	0.000	0.505	0.149	0.102	0.056	0.039	0.063
0.045	0.007	0.007	0.012	0.002	0.004	0.009										
2003	1	1	0	0	31	-1	-1	457	0.000	0.001	0.012	0.690	0.115	0.035	0.049	0.031
0.026	0.022	0.007	0.003	0.005	0.002	0.003										
2004	1	1	0	0	32	-1	-1	501	0.000	0.000	0.046	0.061	0.690	0.084	0.022	0.044
0.025	0.011	0.009	0.003	0.002	0.002	0.001										
2005	1	1	0	0	33	-1	-1	613	0.000	0.006	0.004	0.066	0.053	0.690	0.083	0.023
0.028	0.022	0.011	0.010	0.002	0.001	0.002										

```
2006    1       1       0       0       34      -1      -1      720     0.003   0.028   0.103   0.018   0.089   0.052   0.589   0.055
0.015   0.022   0.011   0.008   0.004   0.001   0.001
2007    1       1       0       0       35      -1      -1      629     0.008   0.113   0.037   0.151   0.015   0.071   0.039   0.451
0.057   0.019   0.018   0.008   0.004   0.006   0.003
2008    1       1       0       0       36      -1      -1      794     0.008   0.089   0.299   0.023   0.149   0.011   0.037   0.033
0.290   0.031   0.010   0.009   0.005   0.003   0.004
2009    1       1       0       0       37      -1      -1      686     0.007   0.005   0.287   0.270   0.030   0.109   0.010   0.024
0.019   0.182   0.034   0.008   0.012   0.002   0.003
2010    1       1       0       0       38      -1      -1      873     0.000   0.243   0.033   0.369   0.214   0.024   0.029   0.006
0.006   0.011   0.047   0.011   0.001   0.001   0.002
2011    1       1       0       0       39      -1      -1      1081    0.028   0.091   0.653   0.030   0.077   0.058   0.014   0.011
0.004   0.003   0.005   0.017   0.003   0.003   0.003
2012    1       1       0       0       40      -1      -1      669     0.002   0.346   0.108   0.345   0.025   0.061   0.047   0.017
0.008   0.007   0.006   0.006   0.013   0.005   0.004

0 # No Mean size-at-age data
0       # Total number of environmental variables
0       # Total number of environmental observations
0 # No Weight frequency data
0 # No tagging data
0 # No morph composition data

999 # End data file
```

Appendix F. SS control file

```
#C 2013 Hake control file

1       # N growth patterns
1       # N sub morphs within patterns
1       # Number of block designs for time varying parameters
0 # number of blocks per design

# Mortality and growth specifications
0.5     # Fraction female (birth)
0       # M setup: 0=single parameter,1=breakpoints,2=Lorenzen,3=age-specific;4=age-
specific,seasonal interpolation
1       # Growth model: 1=VB with L1 and L2, 2=VB with A0 and Linf, 3=Richards, 4=Read vector of
L@A
1       # Age for growth Lmin
20      # Age for growth Lmax
0.0     # Constant added to SD of LAA (0.1 mimics SS2v1 for compatibility only)
0       # Variability of growth: 0=CV~f(LAA), 1=CV~f(A), 2=SD~f(LAA), 3=SD~f(A)
5       #_maturity_option:  1=length logistic; 2=age logistic; 3=read age-maturity matrix by
growth_pattern; 4=read age-fecundity; 5=read fec and wt from wtatage.ss
2       # First age allowed to mature
1       # Fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b
0       # Hermaphroditism option:  0=none; 1=age-specific fxn
1       # MG parm offset option: 1=none, 2= M,G,CV_G as offset from GP1, 3=like SS2v1
1       # MG parm env/block/dev_adjust_method: 1=standard; 2=logistic transform keeps in base parm
bounds; 3=standard w/ no bound check

# Lo   Hi    Init  Prior  Prior  Prior  Param  Env    Use    Dev    Dev    Dev   Block  block
# bnd  bnd   value  mean  type   SD     phase  var    dev    minyr  maxyr  SD    design switch
0.05   0.4   0.2    -1.609438 3  0.1    4      0      0      0      0      0     0      0       # M

### Growth parameters ignored in empirical input approach
2      15    5      32    -1     99     -5     0      0      0      0      0     0       0 # A0
45     60    53.2   50    -1     99     -3     0      0      0      0      0     0       0 # Linf
0.2    0.4   0.30   0.3   -1     99     -3     0      0      0      0      0     0     0 # VBK
0.03   0.16  0.066  0.1   -1     99     -5     0      0      0   0 0 0 0 # CV of length at age 0
0.03   0.16  0.062  0.1   -1     99     -5     0      0      0   0 0 0 0 # CV of length at age inf
# W-L, maturity and fecundity parameters
# Female placeholders
-3     3     7.0E-06 7.0E-06 -1  99     -50    0      0      0   0 0 0       0   # F W-L slope
-3     3     2.9624 2.9624  -1   99     -50    0      0      0   0 0 0       0   # F W-L exponent
# Maturity ok from 2010 assessment
-3     43    36.89  36.89   -1   99     -50    0      0      0   0 0 0       0   # L at 50%
maturity
-3     3     -0.48  -0.48   -1   99     -50    0      0      0   0 0 0       0   # F Logistic
maturity slope
# No fecundity relationship
-3     3     1.0    1.0     -1   99     -50    0      0      0   0 0 0       0   # F Eggs/gm
intercept
-3     3     0.0    0.0     -1   99     -50    0      0      0   0 0 0       0   # F Eggs/gm slope
# Unused recruitment interactions
0      2     1      1       -1   99     -50    0      0      0   0 0 0       0   # placeholder only
0      2     1      1       -1   99     -50    0      0      0   0 0 0       0   # placeholder only
0      2     1      1       -1   99     -50    0      0      0   0 0 0       0   # placeholder only
0      2     1      1       -1   99     -50    0      0      0   0 0 0       0   # placeholder only
0 0 0 0 0 0 0 0 0 0 # Unused MGparm_seas_effects

# Spawner-recruit parameters
3 # S-R function: 1=B-H w/flat top, 2=Ricker, 3=standard B-H, 4=no steepness or bias adjustment
# Lo    Hi      Init    Prior   Prior   Prior   Param
# bnd   bnd     value   mean    type    SD      phase
13      17      15.9    15      -1      99      1        # Ln(R0)
0.2     1       0.88    0.777   2       0.113   4        # Steepness with Myers' prior
1.0     1.6     1.4     1.1     -1      99      -6       # Sigma-R
-5      5       0       0       -1      99      -50      # Env link coefficient
-5      5       0       0       -1      99      -50      # Initial equilibrium recruitment offset
```

```
 0      2       0       1       -1      99      -50     # Autocorrelation in rec devs
0 # index of environmental variable to be used
0 # SR environmental target: 0=none;1=devs;_2=R0;_3=steepness
1 # Recruitment deviation type: 0=none; 1=devvector; 2=simple deviations

# Recruitment deviations
1970    # Start year standard recruitment devs
2008    # End year standard recruitment devs
1       # Rec Dev phase

1 # Read 11 advanced recruitment options: 0=no, 1=yes
1946    # Start year for early rec devs
3       # Phase for early rec devs
5       # Phase for forecast recruit deviations
1       # Lambda for forecast recr devs before endyr+1
# the following 5 bias adjustment settings are not used in the MCMC
1965    # Last recruit dev with no bias_adjustment
1971    # First year of full bias correction (linear ramp from year above)
2009    # Last year for full bias correction in_MPD
2010    # First_recent_yr_nobias_adj_in_MPD
0.86    # Maximum bias adjustment in MPD
0       # Period of cycles in recruitment (N parms read below)
-6      # Lower bound rec devs
6       # Upper bound rec devs
0       # Read init values for rec devs

# Fishing mortality setup
0.1     # F ballpark for tuning early phases
-1999   # F ballpark year
1       # F method:  1=Pope's; 2=Instan. F; 3=Hybrid
0.95    # Max F or harvest rate (depends on F_Method)

# Init F parameters by fleet
#LO     HI      INIT    PRIOR   PR_type SD      PHASE
0       1       0.0     0.01    -1      99       -50

# Catchability setup
# A=do power: 0=skip, survey is prop. to abundance, 1= add par for non-linearity
# B=env. link: 0=skip, 1= add par for env. effect on Q
# C=extra SD: 0=skip, 1= add par. for additive constant to input SE (in ln space)
# D=type: <0=mirror lower abs(#) fleet, 0=no par Q is median unbiased, 1=no par Q is mean unbiased,
2=estimate par for ln(Q)
#    3=ln(Q) + set of devs about ln(Q) for all years. 4=ln(Q) + set of devs about Q for indexyr-1
# A B C D
# Create one par for each entry > 0 by row in cols A-D
0       0       0       0        # US_Foreign
0       0       1       0        # Acoustic_Survey

#LO      HI     INIT    PRIOR   PR_type SD      PHASE
0.05 1.2        0.0755  0.0755  -1      0.1      4 # additive value for acoustic survey

#_SELEX_&_RETENTION_PARAMETERS
# Size-based setup
# A=Selex option: 1-24
# B=Do_retention: 0=no, 1=yes
# C=Male offset to female: 0=no, 1=yes
# D=Extra input (#)
# A B C D
# Size selectivity
0       0       0       0  # Fishery
0       0       0       0  # Acoustic_Survey
# Age selectivity
17      0       0       20  # Fishery
17      0       0       20  # Acoustic_Survey

# Selectivity parameters
# Lo    Hi     Init    Prior   Prior  Prior  Param  Env  Use  Dev     Dev     Dev   Block   block
```

```
# bnd   bnd    value   mean    type   SD     phase  var  dev  minyr   maxyr   SD    design  switch
# Fishery age-based
  -1002 3       -1000   -1      -1     0.01   -2     0 0 0 0 0 0 0 # 0.0 at age 0
  -1    1        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Age 1 is Reference
  -5    9        2.8    -1      -1     0.01   2      0 0 0 0 0 0 0 # Change to age 2
  -5    9        0.1    -1      -1     0.01   2      0 0 0 0 0 0 0 # Change to age 3
  -5    9        0.1    -1      -1     0.01   2      0 0 0 0 0 0 0 # Change to age 4
  -5    9        0.1    -1      -1     0.01   2      0 0 0 0 0 0 0 # Change to age 5
  -5    9        0.0    -1      -1     0.01   2      0 0 0 0 0 0 0 # Change to age 6
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 7
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 8
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 9
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 10
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 11
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 12
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 13
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 14
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 15
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 16
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 17
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 18
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 19
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 20

# Acoustic survey - nonparametric age-based selectivity
# Acoustic Survey double non-parametric age-based selectivity
  -1002 3       -1000   -1      -1     0.01   -2     0 0 0 0 0 0 0 # 0.0 at age 0
  -1002 3       -1000   -1      -1     0.01   -2     0 0 0 0 0 0 0 # 0.0 at age 1
  -1    1        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Age 2 is reference
  -5    9        0.1    -1      -1     0.01   2      0 0 0 0 0 0 0 # Change to age 3
  -5    9        0.1    -1      -1     0.01   2      0 0 0 0 0 0 0 # Change to age 4
  -5    9        0.0    -1      -1     0.01   2      0 0 0 0 0 0 0 # Change to age 5
  -5    9        0.0    -1      -1     0.01   2      0 0 0 0 0 0 0 # Change to age 6
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 7
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 8
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 9
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 10
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 11
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 12
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 13
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 14
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 15
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 16
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 17
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 18
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 19
  -5    9        0.0    -1      -1     0.01   -2     0 0 0 0 0 0 0 # Change to age 20

0 # Tagging flag: 0=no tagging parameters,1=read tagging parameters

### Likelihood related quantities ###
1 # Do variance/sample size adjustments by fleet (1)
# # Component
 0    0   # Constant added to index CV
 0    0   # Constant added to discard SD
 0    0   # Constant added to body weight SD
 1    1   # multiplicative scalar for length comps
 0.12 0.94 # multiplicative scalar for agecomps
 1    1   # multiplicative scalar for length at age obs


1       # Lambda phasing: 1=none, 2+=change beginning in phase 1
1       # Growth offset likelihood constant for Log(s): 1=include, 2=not
0 # N changes to default Lambdas = 1.0
# Component codes:
#  1=Survey, 2=discard, 3=mean body weight
#  4=length frequency, 5=age frequency, 6=Weight frequency
```

```
#  7=size at age, 8=catch, 9=initial equilibrium catch
#  10=rec devs, 11=parameter priors, 12=parameter devs
#  13=Crash penalty
# Component fleet/survey  phase  value  wtfreq_method

1       # Extra SD reporting switch
2  2 -1 15 # selex type (fleet), len=1/age=2, year, N selex bins (4 values)
1  1    # Growth pattern, N growth ages (2 values)
1 -1  1 # NatAge_area(-1 for all), NatAge_yr, N Natages (3 values)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 # placeholder for vector of selex bins to be reported
-1 # growth ages
-1 # NatAges

999 # End control file
```

Appendix G. SS starter file (starter.ss

```
#C 2013 Hake starter file

2013hake_data.SS     # Data file
2013hake_control.SS  # Control file

0       # 0=use init values in control file; 1=use ss3.par
1       # run display detail (0,1,2)
2       # detailed age-structured reports in REPORT.SSO (0,1)
0       # write detailed checkup.sso file (0,1)
0  # write parm values to ParmTrace.sso (0=no,1=good,active; 2=good,all; 3=every_iter,all_parms;
4=every,active)
0       # write to cumreport.sso (0=no,1=like&timeseries; 2=add survey fits)
0       # Include prior_like for non-estimated parameters (0,1)
0       # Use Soft Boundaries to aid convergence (0,1) (recommended)
1     # Number of datafiles to produce: 1st is input, 2nd is estimates, 3rd and higher are
bootstrap
25      # Turn off estimation for parameters entering after this phase
1       # MCeval burn interval
1       # MCeval thin interval
0       # jitter initial parm value by this fraction
-1      # min yr for sdreport outputs (-1 for styr)
-2      # max yr for sdreport outputs (-1 for endyr; -2 for endyr+Nforecastyrs
0       # N individual STD years
0.00001 # final convergence criteria (e.g. 1.0e-04)
0       # retrospective year relative to end year (e.g. -4)
3       # min age for calc of summary biomass
1       # Depletion basis:  denom is: 0=skip; 1=rel X*B0; 2=rel X*Bmsy; 3=rel X*B_styr
1.0     # Fraction (X) for Depletion denominator (e.g. 0.4)
1       # SPR_report_basis:  0=skip; 1=(1-SPR)/(1-SPR_tgt); 2=(1-SPR)/(1-SPR_MSY); 3=(1-SPR)/(1-
SPR_Btarget); 4=rawSPR
1       # F_report_units: 0=skip; 1=exploitation(Bio); 2=exploitation(Num); 3=sum(Frates); 4=true F
for range of ages
0       # F_report_basis: 0=raw; 1=F/Fspr; 2=F/Fmsy ; 3=F/Fbtgt
999     # check value for end of file
```

Appendix H. SS forecast file (forecast.ss)

```
#C 2013 Hake forecast file

# for all year entries except rebuilder; enter either: actual year, -999 for styr, 0 for endyr, neg
number for rel. endyr
1      # Benchmarks: 0=skip; 1=calc F_spr,F_btgt,F_msy
2      # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt); 4=set to F(endyr)
0.4    # SPR target (e.g. 0.40)
0.4    # Biomass target (e.g. 0.40)
#_Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF (enter actual year, or
values of 0 or -integer to be rel. endyr)
 -999 -999 -999 -999 -999 -999
2      #Bmark_relF_Basis: 1 = use year range; 2 = set relF same as forecast below
#
1      # Forecast: 0=none; 1=F(SPR); 2=F(MSY) 3=F(Btgt); 4=Ave F (uses first-last relF yrs);
5=input annual F scalar
3      # N forecast years
1      # F scalar (only used for Do_Forecast==5)
#_Fcast_years:  beg_selex, end_selex, beg_relF, end_relF  (enter actual year, or values of 0 or -
integer to be rel. endyr)
-5 0 -5 0
1      # Control rule method (1=catch=f(SSB) west coast; 2=F=f(SSB) )
0.4    # Control rule Biomass level for constant F (as frac of Bzero, e.g. 0.40); (Must be > the no
F level below)
0.1    # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)
1      # Control rule target as fraction of Flimit (e.g. 0.75)
3      #_N forecast loops (1=OFL only; 2=ABC; 3=get F from forecast ABC catch with allocations
applied)
3      #_First forecast loop with stochastic recruitment
-1     #_Forecast loop control #3 (reserved for future bells&whistles)
0      #_Forecast loop control #4 (reserved for future bells&whistles)
0      #_Forecast loop control #5 (reserved for future bells&whistles)
2011   #FirstYear for caps and allocations (should be after years with fixed inputs)
0      # stddev of log(realized catch/target catch) in forecast (set value>0.0 to cause active
impl_error)
0      # Do West Coast gfish rebuilder output (0/1)
1999   # Rebuilder:  first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
2002   # Rebuilder:  year for current age structure (Yinit) (-1 to set to endyear+1)
1      # fleet relative F:  1=use first-last alloc year; 2=read seas(row) x fleet(col) below
# Note that fleet allocation is used directly as average F if Do_Forecast=4
2      # basis for fcast catch tuning and for fcast catch caps and allocation  (2=deadbio;
3=retainbio; 5=deadnum; 6=retainnum)
# Conditional input if relative F choice = 2
# Fleet relative F:  rows are seasons, columns are fleets
#_Fleet:  Fishery
#  1
# max totalcatch by fleet (-1 to have no max) must enter value for each fleet
 -1
# max totalcatch by area (-1 to have no max); must enter value for each fleet
 -1
# fleet assignment to allocation group (enter group ID# for each fleet, 0 for not included in an
alloc group)
 1
# allocation fraction for each of: 1 allocation groups
1
0      # Number of forecast catch levels to input (else calc catch from forecast F)
2      # basis for input Fcast catch:  2=dead catch; 3=retained catch; 99=input Hrate(F) (units are
from fleetunits; note new codes in SSV3.20)
999    # verify end of input
```

Appendix I. Weight-at-age file (wtatage.ss)

```
# empirical weight-at-age Stock Synthesis input file for hake
# created by code in the R script: wtatage_calculations.R
# creation date: 2013-01-08 18:04:48
###################################################
157 # Number of lines of weight-at-age input to be read
20 # Maximum age

#Maturity x Fecundity: Fleet = -2 (Values unchanged from 2012 Stock Assessment)

 #_#Yr seas gender GP bseas fleet a0 a1     a2     a3     a4    a5     a6     a7     a8     a9    a10    a11    a12    a13    a14
a15    a16    a17    a18    a19    a20
 -1940    1      1  1     1    -2  0  0 0.1003 0.2535 0.3992 0.518 0.6131 0.6895 0.7511 0.8007 0.8406 0.8724 0.8979 0.9181 0.9342
0.9469 0.9569 0.9649 0.9711 0.9761 0.983
#All matrices below use the same values, pooled across all data sources

#Weight at age for population in middle of the year: Fleet = -1
 #_#Yr seas gender GP bseas fleet     a0     a1     a2     a3     a4     a5     a6     a7     a8     a9    a10    a11    a12    a13
a14    a15    a16    a17    a18    a19    a20
 -1940    1      1  1     1    -1 0.0300 0.0900 0.2481 0.3798 0.4859 0.5433 0.5919 0.6625 0.7220 0.7918 0.8636 0.9318 0.9707 1.0708
1.0023 1.0191 1.0191 1.0191 1.0191 1.0191 1.0191
  1975    1      1  1     1    -1 0.0550 0.1575 0.2987 0.3658 0.6143 0.6306 0.7873 0.8738 0.9678 0.9075 0.9700 1.6933 1.5000 1.9000
1.9555 2.7445 2.7445 2.7445 2.7445 2.7445 2.7445
  1976    1      1  1     1    -1 0.0550 0.0986 0.2359 0.4973 0.5188 0.6936 0.8041 0.9166 1.2097 1.3375 1.4498 1.6532 1.8066 1.8588
1.9555 2.7445 2.7445 2.7445 2.7445 2.7445 2.7445
  1977    1      1  1     1    -1 0.0550 0.1006 0.4021 0.4870 0.5902 0.6650 0.7493 0.8267 0.9781 1.1052 1.2349 1.3148 1.4058 1.7511
2.0367 2.2094 2.2094 2.2094 2.2094 2.2094 2.2094
  1978    1      1  1     1    -1 0.0539 0.1026 0.1360 0.4699 0.5300 0.6027 0.6392 0.7395 0.8391 0.9775 1.0971 1.2349 1.3028 1.4814
1.7419 2.3379 2.3379 2.3379 2.3379 2.3379 2.3379
  1979    1      1  1     1    -1 0.0528 0.0913 0.2410 0.2587 0.5821 0.6868 0.7677 0.8909 0.9128 1.0369 1.1987 1.2482 1.5326 1.5520
1.7950 1.9817 1.9817 1.9817 1.9817 1.9817 1.9817
  1980    1      1  1     1    -1 0.0517 0.0800 0.2236 0.4529 0.3922 0.4904 0.5166 0.6554 0.7125 0.8740 1.0616 1.1623 1.2898 1.3001
1.2699 1.3961 1.3961 1.3961 1.3961 1.3961 1.3961
  1981    1      1  1     1    -1 0.0506 0.1079 0.2137 0.3422 0.5264 0.3933 0.5254 0.5462 0.7464 0.7204 0.8231 1.0413 1.0989 1.3449
1.4926 1.2128 1.2128 1.2128 1.2128 1.2128 1.2128
  1982    1      1  1     1    -1 0.0494 0.1183 0.2465 0.3336 0.3097 0.5496 0.3956 0.5275 0.5629 0.7606 0.6837 0.8539 1.0670 0.8793
1.0186 1.1693 1.1693 1.1693 1.1693 1.1693 1.1693
  1983    1      1  1     1    -1 0.0483 0.1287 0.1357 0.3410 0.3694 0.3277 0.5200 0.5028 0.6179 0.7060 0.8800 0.9299 1.0356 1.0310
1.3217 1.4823 1.4823 1.4823 1.4823 1.4823 1.4823
  1984    1      1  1     1    -1 0.0472 0.1315 0.1642 0.2493 0.4385 0.4113 0.4352 0.5872 0.5802 0.6758 0.7010 0.9513 1.1364 1.0258
1.2807 1.8800 1.8800 1.8800 1.8800 1.8800 1.8800
  1985    1      1  1     1    -1 0.0461 0.1740 0.2297 0.2679 0.4414 0.5497 0.5474 0.6014 0.7452 0.6933 0.7231 0.8584 0.8698 0.9458
0.6759 1.1217 1.1217 1.1217 1.1217 1.1217 1.1217
  1986    1      1  1     1    -1 0.0450 0.1555 0.2771 0.2909 0.3024 0.3735 0.5425 0.5717 0.6421 0.8209 0.9403 1.1860 1.1900 1.3864
1.6800 1.6142 1.6142 1.6142 1.6142 1.6142 1.6142
  1987    1      1  1     1    -1 0.0439 0.1478 0.1388 0.3790 0.2786 0.2870 0.3621 0.5775 0.5975 0.6369 0.7638 0.9820 0.9250 1.2407
1.2031 1.4157 1.4157 1.4157 1.4157 1.4157 1.4157
  1988    1      1  1     1    -1 0.0428 0.1400 0.1870 0.3189 0.4711 0.3689 0.3731 0.5163 0.6474 0.6851 0.7183 0.9167 1.0924 1.0225
1.4500 1.4537 1.4537 1.4537 1.4537 1.4537 1.4537
```

```
  1989    1      1  1     1    -1 0.0417 0.1389 0.2737 0.3047 0.2931 0.5134 0.4386 0.4064 0.5167 0.6263 0.6611 0.6027 0.8758 0.6686
0.8282 1.1264 1.1264 1.1264 1.1264 1.1264 1.1264
  1990    1      1  1     1    -1 0.0406 0.1378 0.2435 0.3506 0.3906 0.5111 0.5462 0.6076 0.6678 0.5300 0.7691 0.8312 2.2000 1.1847
1.0166 1.4668 1.4668 1.4668 1.4668 1.4668 1.4668
  1991    1      1  1     1    -1 0.0394 0.1367 0.2754 0.3697 0.4598 0.5138 0.5437 0.5907 0.7210 0.8497 1.0997 0.7185 0.6403 1.0174
1.2051 2.3828 2.3828 2.3828 2.3828 2.3828 2.3828
  1992    1      1  1     1    -1 0.0383 0.1356 0.2316 0.3473 0.4743 0.5334 0.5817 0.6210 0.6406 0.6530 0.6330 0.7217 0.7354 0.8501
0.9750 1.0272 1.0272 1.0272 1.0272 1.0272 1.0272
  1993    1      1  1     1    -1 0.0372 0.1274 0.2486 0.3384 0.3960 0.4539 0.4935 0.5017 0.4880 0.5491 0.5100 1.2630 1.0250 0.6135
0.5995 0.6850 0.6850 0.6850 0.6850 0.6850 0.6850
  1994    1      1  1     1    -1 0.0361 0.1191 0.3000 0.3626 0.4469 0.4473 0.5262 0.5700 0.6218 0.5598 0.6341 0.4850 0.6491 0.7300
0.7013 0.7455 0.7455 0.7455 0.7455 0.7455 0.7455
  1995    1      1  1     1    -1 0.0350 0.1108 0.2682 0.3418 0.4876 0.5367 0.6506 0.6249 0.6597 0.7560 0.6670 0.7442 0.7998 0.9101
0.6804 0.8008 0.8008 0.8008 0.8008 0.8008 0.8008
  1996    1      1  1     1    -1 0.0339 0.1007 0.2876 0.3982 0.4674 0.5317 0.5651 0.6509 0.5957 0.6362 0.6049 0.7500 0.6756 0.8109
1.4853 0.7509 0.7509 0.7509 0.7509 0.7509 0.7509
  1997    1      1  1     1    -1 0.0328 0.0906 0.3555 0.4322 0.4931 0.5476 0.5453 0.5833 0.5855 0.6071 0.6315 0.8633 0.5946 0.7118
0.6618 0.8693 0.8693 0.8693 0.8693 0.8693 0.8693
  1998    1      1  1     1    -1 0.0317 0.0805 0.2091 0.3539 0.5041 0.5172 0.5420 0.6412 0.6099 0.6769 0.8078 0.7174 0.8100 0.7733
0.7510 0.7714 0.7714 0.7714 0.7714 0.7714 0.7714
  1999    1      1  1     1    -1 0.0306 0.1352 0.2502 0.3455 0.4251 0.5265 0.5569 0.5727 0.6117 0.7030 0.6650 0.7989 0.7554 0.8787
0.7348 0.8187 0.8187 0.8187 0.8187 0.8187 0.8187
  2000    1      1  1     1    -1 0.0294 0.1899 0.3216 0.4729 0.5766 0.6598 0.7176 0.7279 0.7539 0.8378 0.8159 0.8814 0.8554 0.9391
0.8744 0.9336 0.9336 0.9336 0.9336 0.9336 0.9336
  2001    1      1  1     1    -1 0.0283 0.0512 0.2867 0.4843 0.6527 0.6645 0.7469 0.8629 0.8555 0.8802 0.9630 0.9790 1.0054 1.0494
0.9927 0.9768 0.9768 0.9768 0.9768 0.9768 0.9768
  2002    1      1  1     1    -1 0.0272 0.0756 0.3583 0.4575 0.6058 0.8160 0.7581 0.8488 0.9771 0.9322 0.9176 0.9974 0.9890 0.9236
1.1250 1.0573 1.0573 1.0573 1.0573 1.0573 1.0573
  2003    1      1  1     1    -1 0.0261 0.1000 0.2551 0.4355 0.5225 0.5879 0.7569 0.6915 0.7469 0.8246 0.7692 0.8887 0.9266 0.7894
0.8414 0.9965 0.9965 0.9965 0.9965 0.9965 0.9965
  2004    1      1  1     1    -1 0.0250 0.1081 0.2577 0.4360 0.4807 0.5319 0.6478 0.7068 0.6579 0.7094 0.8050 0.8581 0.7715 0.9704
0.8631 0.8959 0.8959 0.8959 0.8959 0.8959 0.8959
  2005    1      1  1     1    -1 0.0239 0.1162 0.2603 0.4311 0.5086 0.5393 0.5682 0.6336 0.6550 0.7027 0.7962 0.8104 0.8109 0.7602
1.1449 0.9678 0.9678 0.9678 0.9678 0.9678 0.9678
  2006    1      1  1     1    -1 0.0228 0.1324 0.3831 0.4575 0.5341 0.5740 0.5910 0.5979 0.6560 0.6997 0.7259 0.7220 0.7753 0.6580
0.6399 0.9550 0.9550 0.9550 0.9550 0.9550 0.9550
  2007    1      1  1     1    -1 0.0217 0.0461 0.2272 0.3776 0.5352 0.5530 0.6073 0.6328 0.6475 0.7055 0.7723 0.7627 0.8137 0.8702
0.8008 0.8698 0.8698 0.8698 0.8698 0.8698 0.8698
  2008    1      1  1     1    -1 0.0217 0.1403 0.2445 0.4081 0.5630 0.6371 0.6865 0.6818 0.7084 0.7210 0.7488 0.8073 0.8483 0.7755
0.8834 0.8332 0.8332 0.8332 0.8332 0.8332 0.8332
  2009    1      1  1     1    -1 0.0217 0.0667 0.2448 0.3431 0.4712 0.6371 0.6702 0.6942 0.7463 0.8226 0.7672 0.8115 1.0147 0.8503
0.9582 1.0334 1.0334 1.0334 1.0334 1.0334 1.0334
  2010    1      1  1     1    -1 0.0217 0.1089 0.2325 0.2535 0.4335 0.5293 0.6577 0.8349 1.0828 1.0276 0.9409 0.8763 0.8373 1.1253
0.7200 0.9021 0.9021 0.9021 0.9021 0.9021 0.9021
  2011    1      1  1     1    -1 0.0217 0.0844 0.2457 0.3219 0.3864 0.5142 0.5967 0.6914 0.8620 0.9294 0.9742 1.0691 1.0451 1.0268
1.0578 0.9212 0.9212 0.9212 0.9212 0.9212 0.9212
  2012    1      1  1     1    -1 0.0217 0.1270 0.2073 0.3516 0.4085 0.4934 0.6574 0.6930 0.7802 0.9151 0.9633 0.9639 0.9713 0.9935
0.9924 0.9425 0.9425 0.9425 0.9425 0.9425 0.9425

#Weight at age for population at beginning of the year: Fleet = 0
```

```
 #_#Yr seas gender GP bseas fleet     a0     a1     a2     a3     a4     a5     a6     a7     a8     a9    a10    a11    a12    a13
a14    a15    a16    a17    a18    a19    a20
 -1940    1      1  1     1     0 0.0300 0.0900 0.2481 0.3798 0.4859 0.5433 0.5919 0.6625 0.7220 0.7918 0.8636 0.9318 0.9707 1.0708
1.0023 1.0191 1.0191 1.0191 1.0191 1.0191 1.0191
  1975    1      1  1     1     0 0.0550 0.1575 0.2987 0.3658 0.6143 0.6306 0.7873 0.8738 0.9678 0.9075 0.9700 1.6933 1.5000 1.9000
1.9555 2.7445 2.7445 2.7445 2.7445 2.7445 2.7445
  1976    1      1  1     1     0 0.0550 0.0986 0.2359 0.4973 0.5188 0.6936 0.8041 0.9166 1.2097 1.3375 1.4498 1.6532 1.8066 1.8588
1.9555 2.7445 2.7445 2.7445 2.7445 2.7445 2.7445
  1977    1      1  1     1     0 0.0550 0.1006 0.4021 0.4870 0.5902 0.6650 0.7493 0.8267 0.9781 1.1052 1.2349 1.3148 1.4058 1.7511
2.0367 2.2094 2.2094 2.2094 2.2094 2.2094 2.2094
  1978    1      1  1     1     0 0.0539 0.1026 0.1360 0.4699 0.5300 0.6027 0.6392 0.7395 0.8391 0.9775 1.0971 1.2349 1.3028 1.4814
1.7419 2.3379 2.3379 2.3379 2.3379 2.3379 2.3379
  1979    1      1  1     1     0 0.0528 0.0913 0.2410 0.2587 0.5821 0.6868 0.7677 0.8909 0.9128 1.0369 1.1987 1.2482 1.5326 1.5520
1.7950 1.9817 1.9817 1.9817 1.9817 1.9817 1.9817
  1980    1      1  1     1     0 0.0517 0.0800 0.2236 0.4529 0.3922 0.4904 0.5166 0.6554 0.7125 0.8740 1.0616 1.1623 1.2898 1.3001
1.2699 1.3961 1.3961 1.3961 1.3961 1.3961 1.3961
  1981    1      1  1     1     0 0.0506 0.1079 0.2137 0.3422 0.5264 0.3933 0.5254 0.5462 0.7464 0.7204 0.8231 1.0413 1.0989 1.3449
1.4926 1.2128 1.2128 1.2128 1.2128 1.2128 1.2128
  1982    1      1  1     1     0 0.0494 0.1183 0.2465 0.3336 0.3097 0.5496 0.3956 0.5275 0.5629 0.7606 0.6837 0.8539 1.0670 0.8793
1.0186 1.1693 1.1693 1.1693 1.1693 1.1693 1.1693
  1983    1      1  1     1     0 0.0483 0.1287 0.1357 0.3410 0.3694 0.3277 0.5200 0.5028 0.6179 0.7060 0.8800 0.9299 1.0356 1.0310
1.3217 1.4823 1.4823 1.4823 1.4823 1.4823 1.4823
  1984    1      1  1     1     0 0.0472 0.1315 0.1642 0.2493 0.4385 0.4113 0.4352 0.5872 0.5802 0.6758 0.7010 0.9513 1.1364 1.0258
1.2807 1.8800 1.8800 1.8800 1.8800 1.8800 1.8800
  1985    1      1  1     1     0 0.0461 0.1740 0.2297 0.2679 0.4414 0.5497 0.5474 0.6014 0.7452 0.6933 0.7231 0.8584 0.8698 0.9458
0.6759 1.1217 1.1217 1.1217 1.1217 1.1217 1.1217
  1986    1      1  1     1     0 0.0450 0.1555 0.2771 0.2909 0.3024 0.3735 0.5425 0.5717 0.6421 0.8209 0.9403 1.1860 1.1900 1.3864
1.6800 1.6142 1.6142 1.6142 1.6142 1.6142 1.6142
  1987    1      1  1     1     0 0.0439 0.1478 0.1388 0.3790 0.2786 0.2870 0.3621 0.5775 0.5975 0.6369 0.7638 0.9820 0.9250 1.2407
1.2031 1.4157 1.4157 1.4157 1.4157 1.4157 1.4157
  1988    1      1  1     1     0 0.0428 0.1400 0.1870 0.3189 0.4711 0.3689 0.3731 0.5163 0.6474 0.6851 0.7183 0.9167 1.0924 1.0225
1.4500 1.4537 1.4537 1.4537 1.4537 1.4537 1.4537
  1989    1      1  1     1     0 0.0417 0.1389 0.2737 0.3047 0.2931 0.5134 0.4386 0.4064 0.5167 0.6263 0.6611 0.6027 0.8758 0.6686
0.8282 1.1264 1.1264 1.1264 1.1264 1.1264 1.1264
  1990    1      1  1     1     0 0.0406 0.1378 0.2435 0.3506 0.3906 0.5111 0.5462 0.6076 0.6678 0.5300 0.7691 0.8312 2.2000 1.1847
1.0166 1.4668 1.4668 1.4668 1.4668 1.4668 1.4668
  1991    1      1  1     1     0 0.0394 0.1367 0.2754 0.3697 0.4598 0.5138 0.5437 0.5907 0.7210 0.8497 1.0997 0.7185 0.6403 1.0174
1.2051 2.3828 2.3828 2.3828 2.3828 2.3828 2.3828
  1992    1      1  1     1     0 0.0383 0.1356 0.2316 0.3473 0.4743 0.5334 0.5817 0.6210 0.6406 0.6530 0.6330 0.7217 0.7354 0.8501
0.9750 1.0272 1.0272 1.0272 1.0272 1.0272 1.0272
  1993    1      1  1     1     0 0.0372 0.1274 0.2486 0.3384 0.3960 0.4539 0.4935 0.5017 0.4880 0.5491 0.5100 1.2630 1.0250 0.6135
0.5995 0.6850 0.6850 0.6850 0.6850 0.6850 0.6850
  1994    1      1  1     1     0 0.0361 0.1191 0.3000 0.3626 0.4469 0.4473 0.5262 0.5700 0.6218 0.5598 0.6341 0.4850 0.6491 0.7300
0.7013 0.7455 0.7455 0.7455 0.7455 0.7455 0.7455
  1995    1      1  1     1     0 0.0350 0.1108 0.2682 0.3418 0.4876 0.5367 0.6506 0.6249 0.6597 0.7560 0.6670 0.7442 0.7998 0.9101
0.6804 0.8008 0.8008 0.8008 0.8008 0.8008 0.8008
  1996    1      1  1     1     0 0.0339 0.1007 0.2876 0.3982 0.4674 0.5317 0.5651 0.6509 0.5957 0.6362 0.6049 0.7500 0.6756 0.8109
1.4853 0.7509 0.7509 0.7509 0.7509 0.7509 0.7509
  1997    1      1  1     1     0 0.0328 0.0906 0.3555 0.4322 0.4931 0.5476 0.5453 0.5833 0.5855 0.6071 0.6315 0.8633 0.5946 0.7118
0.6618 0.8693 0.8693 0.8693 0.8693 0.8693 0.8693
```

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  1998    1      1  1     1     0 0.0317 0.0805 0.2091 0.3539 0.5041 0.5172 0.5420 0.6412 0.6099 0.6769 0.8078 0.7174 0.8100 0.7733
0.7510 0.7714 0.7714 0.7714 0.7714 0.7714 0.7714
  1999    1      1  1     1     0 0.0306 0.1352 0.2502 0.3455 0.4251 0.5265 0.5569 0.5727 0.6117 0.7030 0.6650 0.7989 0.7554 0.8787
0.7348 0.8187 0.8187 0.8187 0.8187 0.8187 0.8187
  2000    1      1  1     1     0 0.0294 0.1899 0.3216 0.4729 0.5766 0.6598 0.7176 0.7279 0.7539 0.8378 0.8159 0.8814 0.8554 0.9391
0.8744 0.9336 0.9336 0.9336 0.9336 0.9336 0.9336
  2001    1      1  1     1     0 0.0283 0.0512 0.2867 0.4843 0.6527 0.6645 0.7469 0.8629 0.8555 0.8802 0.9630 0.9790 1.0054 1.0494
0.9927 0.9768 0.9768 0.9768 0.9768 0.9768 0.9768
  2002    1      1  1     1     0 0.0272 0.0756 0.3583 0.4575 0.6058 0.8160 0.7581 0.8488 0.9771 0.9322 0.9176 0.9974 0.9890 0.9236
1.1250 1.0573 1.0573 1.0573 1.0573 1.0573 1.0573
  2003    1      1  1     1     0 0.0261 0.1000 0.2551 0.4355 0.5225 0.5879 0.7569 0.6915 0.7469 0.8246 0.7692 0.8887 0.9266 0.7894
0.8414 0.9965 0.9965 0.9965 0.9965 0.9965 0.9965
  2004    1      1  1     1     0 0.0250 0.1081 0.2577 0.4360 0.4807 0.5319 0.6478 0.7068 0.6579 0.7094 0.8050 0.8581 0.7715 0.9704
0.8631 0.8959 0.8959 0.8959 0.8959 0.8959 0.8959
  2005    1      1  1     1     0 0.0239 0.1162 0.2603 0.4311 0.5086 0.5393 0.5682 0.6336 0.6550 0.7027 0.7962 0.8104 0.8109 0.7602
1.1449 0.9678 0.9678 0.9678 0.9678 0.9678 0.9678
  2006    1      1  1     1     0 0.0228 0.1324 0.3831 0.4575 0.5341 0.5740 0.5910 0.5979 0.6560 0.6997 0.7259 0.7220 0.7753 0.6580
0.6399 0.9550 0.9550 0.9550 0.9550 0.9550 0.9550
  2007    1      1  1     1     0 0.0217 0.0461 0.2272 0.3776 0.5352 0.5530 0.6073 0.6328 0.6475 0.7055 0.7723 0.7627 0.8137 0.8702
0.8008 0.8698 0.8698 0.8698 0.8698 0.8698 0.8698
  2008    1      1  1     1     0 0.0217 0.1403 0.2445 0.4081 0.5630 0.6371 0.6865 0.6818 0.7084 0.7210 0.7488 0.8073 0.8483 0.7755
0.8834 0.8332 0.8332 0.8332 0.8332 0.8332 0.8332
  2009    1      1  1     1     0 0.0217 0.0667 0.2448 0.3431 0.4712 0.6371 0.6702 0.6942 0.7463 0.8226 0.7672 0.8115 1.0147 0.8503
0.9582 1.0334 1.0334 1.0334 1.0334 1.0334 1.0334
  2010    1      1  1     1     0 0.0217 0.1089 0.2325 0.2535 0.4335 0.5293 0.6577 0.8349 1.0828 1.0276 0.9409 0.8763 0.8373 1.1253
0.7200 0.9021 0.9021 0.9021 0.9021 0.9021 0.9021
  2011    1      1  1     1     0 0.0217 0.0844 0.2457 0.3219 0.3864 0.5142 0.5967 0.6914 0.8620 0.9294 0.9742 1.0691 1.0451 1.0268
1.0578 0.9212 0.9212 0.9212 0.9212 0.9212 0.9212
  2012    1      1  1     1     0 0.0217 0.1270 0.2073 0.3516 0.4085 0.4934 0.6574 0.6930 0.7802 0.9151 0.9633 0.9639 0.9713 0.9935
0.9924 0.9425 0.9425 0.9425 0.9425 0.9425 0.9425

#Weight at age for Fishery: Fleet = 1
 #_#Yr seas gender GP bseas fleet     a0     a1     a2     a3     a4     a5     a6     a7     a8     a9    a10    a11    a12    a13
a14    a15    a16    a17    a18    a19    a20
 -1940    1      1  1     1     1 0.0300 0.0900 0.2481 0.3798 0.4859 0.5433 0.5919 0.6625 0.7220 0.7918 0.8636 0.9318 0.9707 1.0708
1.0023 1.0191 1.0191 1.0191 1.0191 1.0191 1.0191
  1975    1      1  1     1     1 0.0550 0.1575 0.2987 0.3658 0.6143 0.6306 0.7873 0.8738 0.9678 0.9075 0.9700 1.6933 1.5000 1.9000
1.9555 2.7445 2.7445 2.7445 2.7445 2.7445 2.7445
  1976    1      1  1     1     1 0.0550 0.0986 0.2359 0.4973 0.5188 0.6936 0.8041 0.9166 1.2097 1.3375 1.4498 1.6532 1.8066 1.8588
1.9555 2.7445 2.7445 2.7445 2.7445 2.7445 2.7445
  1977    1      1  1     1     1 0.0550 0.1006 0.4021 0.4870 0.5902 0.6650 0.7493 0.8267 0.9781 1.1052 1.2349 1.3148 1.4058 1.7511
2.0367 2.2094 2.2094 2.2094 2.2094 2.2094 2.2094
  1978    1      1  1     1     1 0.0539 0.1026 0.1360 0.4699 0.5300 0.6027 0.6392 0.7395 0.8391 0.9775 1.0971 1.2349 1.3028 1.4814
1.7419 2.3379 2.3379 2.3379 2.3379 2.3379 2.3379
  1979    1      1  1     1     1 0.0528 0.0913 0.2410 0.2587 0.5821 0.6868 0.7677 0.8909 0.9128 1.0369 1.1987 1.2482 1.5326 1.5520
1.7950 1.9817 1.9817 1.9817 1.9817 1.9817 1.9817
  1980    1      1  1     1     1 0.0517 0.0800 0.2236 0.4529 0.3922 0.4904 0.5166 0.6554 0.7125 0.8740 1.0616 1.1623 1.2898 1.3001
1.2699 1.3961 1.3961 1.3961 1.3961 1.3961 1.3961
  1981    1      1  1     1     1 0.0506 0.1079 0.2137 0.3422 0.5264 0.3933 0.5254 0.5462 0.7464 0.7204 0.8231 1.0413 1.0989 1.3449
1.4926 1.2128 1.2128 1.2128 1.2128 1.2128 1.2128
```

```
  1982    1       1  1     1     1 0.0494 0.1183 0.2465 0.3336 0.3097 0.5496 0.3956 0.5275 0.5629 0.7606 0.6837 0.8539 1.0670 0.8793
1.0186 1.1693 1.1693 1.1693 1.1693 1.1693 1.1693
  1983    1       1  1     1     1 0.0483 0.1287 0.1357 0.3410 0.3694 0.3277 0.5200 0.5028 0.6179 0.7060 0.8800 0.9299 1.0356 1.0310
1.3217 1.4823 1.4823 1.4823 1.4823 1.4823 1.4823
  1984    1       1  1     1     1 0.0472 0.1315 0.1642 0.2493 0.4385 0.4113 0.4352 0.5872 0.5802 0.6758 0.7010 0.9513 1.1364 1.0258
1.2807 1.8800 1.8800 1.8800 1.8800 1.8800 1.8800
  1985    1       1  1     1     1 0.0461 0.1740 0.2297 0.2679 0.4414 0.5497 0.5474 0.6014 0.7452 0.6933 0.7231 0.8584 0.8698 0.9458
0.6759 1.1217 1.1217 1.1217 1.1217 1.1217 1.1217
  1986    1       1  1     1     1 0.0450 0.1555 0.2771 0.2909 0.3024 0.3735 0.5425 0.5717 0.6421 0.8209 0.9403 1.1860 1.1900 1.3864
1.6800 1.6142 1.6142 1.6142 1.6142 1.6142 1.6142
  1987    1       1  1     1     1 0.0439 0.1478 0.1388 0.3790 0.2786 0.2870 0.3621 0.5775 0.5975 0.6369 0.7638 0.9820 0.9250 1.2407
1.2031 1.4157 1.4157 1.4157 1.4157 1.4157 1.4157
  1988    1       1  1     1     1 0.0428 0.1400 0.1870 0.3189 0.4711 0.3689 0.3731 0.5163 0.6474 0.6851 0.7183 0.9167 1.0924 1.0225
1.4500 1.4537 1.4537 1.4537 1.4537 1.4537 1.4537
  1989    1       1  1     1     1 0.0417 0.1389 0.2737 0.3047 0.2931 0.5134 0.4386 0.4064 0.5167 0.6263 0.6611 0.6027 0.8758 0.6686
0.8282 1.1264 1.1264 1.1264 1.1264 1.1264 1.1264
  1990    1       1  1     1     1 0.0406 0.1378 0.2435 0.3506 0.3906 0.5111 0.5462 0.6076 0.6678 0.5300 0.7691 0.8312 2.2000 1.1847
1.0166 1.4668 1.4668 1.4668 1.4668 1.4668 1.4668
  1991    1       1  1     1     1 0.0394 0.1367 0.2754 0.3697 0.4598 0.5138 0.5437 0.5907 0.7210 0.8497 1.0997 0.7185 0.6403 1.0174
1.2051 2.3828 2.3828 2.3828 2.3828 2.3828 2.3828
  1992    1       1  1     1     1 0.0383 0.1356 0.2316 0.3473 0.4743 0.5334 0.5817 0.6210 0.6406 0.6530 0.6330 0.7217 0.7354 0.8501
0.9750 1.0272 1.0272 1.0272 1.0272 1.0272 1.0272
  1993    1       1  1     1     1 0.0372 0.1274 0.2486 0.3384 0.3960 0.4539 0.4935 0.5017 0.4880 0.5491 0.5100 1.2630 1.0250 0.6135
0.5995 0.6850 0.6850 0.6850 0.6850 0.6850 0.6850
  1994    1       1  1     1     1 0.0361 0.1191 0.3000 0.3626 0.4469 0.4473 0.5262 0.5700 0.6218 0.5598 0.6341 0.4850 0.6491 0.7300
0.7013 0.7455 0.7455 0.7455 0.7455 0.7455 0.7455
  1995    1       1  1     1     1 0.0350 0.1108 0.2682 0.3418 0.4876 0.5367 0.6506 0.6249 0.6597 0.7560 0.6670 0.7442 0.7998 0.9101
0.6804 0.8008 0.8008 0.8008 0.8008 0.8008 0.8008
  1996    1       1  1     1     1 0.0339 0.1007 0.2876 0.3982 0.4674 0.5317 0.5651 0.6509 0.5957 0.6362 0.6049 0.7500 0.6756 0.8109
1.4853 0.7509 0.7509 0.7509 0.7509 0.7509 0.7509
  1997    1       1  1     1     1 0.0328 0.0906 0.3555 0.4322 0.4931 0.5476 0.5453 0.5833 0.5855 0.6071 0.6315 0.8633 0.5946 0.7118
0.6618 0.8693 0.8693 0.8693 0.8693 0.8693 0.8693
  1998    1       1  1     1     1 0.0317 0.0805 0.2091 0.3539 0.5041 0.5172 0.5420 0.6412 0.6099 0.6769 0.8078 0.7174 0.8100 0.7733
0.7510 0.7714 0.7714 0.7714 0.7714 0.7714 0.7714
  1999    1       1  1     1     1 0.0306 0.1352 0.2502 0.3455 0.4251 0.5265 0.5569 0.5727 0.6117 0.7030 0.6650 0.7989 0.7554 0.8787
0.7348 0.8187 0.8187 0.8187 0.8187 0.8187 0.8187
  2000    1       1  1     1     1 0.0294 0.1899 0.3216 0.4729 0.5766 0.6598 0.7176 0.7279 0.7539 0.8378 0.8159 0.8814 0.8554 0.9391
0.8744 0.9336 0.9336 0.9336 0.9336 0.9336 0.9336
  2001    1       1  1     1     1 0.0283 0.0512 0.2867 0.4843 0.6527 0.6645 0.7469 0.8629 0.8555 0.8802 0.9630 0.9790 1.0054 1.0494
0.9927 0.9768 0.9768 0.9768 0.9768 0.9768 0.9768
  2002    1       1  1     1     1 0.0272 0.0756 0.3583 0.4575 0.6058 0.8160 0.7581 0.8488 0.9771 0.9322 0.9176 0.9974 0.9890 0.9236
1.1250 1.0573 1.0573 1.0573 1.0573 1.0573 1.0573
  2003    1       1  1     1     1 0.0261 0.1000 0.2551 0.4355 0.5225 0.5879 0.7569 0.6915 0.7469 0.8246 0.7692 0.8887 0.9266 0.7894
0.8414 0.9965 0.9965 0.9965 0.9965 0.9965 0.9965
  2004    1       1  1     1     1 0.0250 0.1081 0.2577 0.4360 0.4807 0.5319 0.6478 0.7068 0.6579 0.7094 0.8050 0.8581 0.7715 0.9704
0.8631 0.8959 0.8959 0.8959 0.8959 0.8959 0.8959
  2005    1       1  1     1     1 0.0239 0.1162 0.2603 0.4311 0.5086 0.5393 0.5682 0.6336 0.6550 0.7027 0.7962 0.8104 0.8109 0.7602
1.1449 0.9678 0.9678 0.9678 0.9678 0.9678 0.9678
  2006    1       1  1     1     1 0.0228 0.1324 0.3831 0.4575 0.5341 0.5740 0.5910 0.5979 0.6560 0.6997 0.7259 0.7220 0.7753 0.6580
0.6399 0.9550 0.9550 0.9550 0.9550 0.9550 0.9550
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  2007    1      1  1     1     1 0.0217 0.0461 0.2272 0.3776 0.5352 0.5530 0.6073 0.6328 0.6475 0.7055 0.7723 0.7627 0.8137 0.8702
0.8008 0.8698 0.8698 0.8698 0.8698 0.8698 0.8698
  2008    1      1  1     1     1 0.0217 0.1403 0.2445 0.4081 0.5630 0.6371 0.6865 0.6818 0.7084 0.7210 0.7488 0.8073 0.8483 0.7755
0.8834 0.8332 0.8332 0.8332 0.8332 0.8332 0.8332
  2009    1      1  1     1     1 0.0217 0.0667 0.2448 0.3431 0.4712 0.6371 0.6702 0.6942 0.7463 0.8226 0.7672 0.8115 1.0147 0.8503
0.9582 1.0334 1.0334 1.0334 1.0334 1.0334 1.0334
  2010    1      1  1     1     1 0.0217 0.1089 0.2325 0.2535 0.4335 0.5293 0.6577 0.8349 1.0828 1.0276 0.9409 0.8763 0.8373 1.1253
0.7200 0.9021 0.9021 0.9021 0.9021 0.9021 0.9021
  2011    1      1  1     1     1 0.0217 0.0844 0.2457 0.3219 0.3864 0.5142 0.5967 0.6914 0.8620 0.9294 0.9742 1.0691 1.0451 1.0268
1.0578 0.9212 0.9212 0.9212 0.9212 0.9212 0.9212
  2012    1      1  1     1     1 0.0217 0.1270 0.2073 0.3516 0.4085 0.4934 0.6574 0.6930 0.7802 0.9151 0.9633 0.9639 0.9713 0.9935
0.9924 0.9425 0.9425 0.9425 0.9425 0.9425 0.9425

#Weight at age for Survey: Fleet = 2
 #_#Yr seas gender GP bseas fleet     a0     a1     a2     a3     a4     a5     a6     a7     a8     a9    a10    a11    a12    a13
a14    a15    a16    a17    a18    a19    a20
 -1940    1      1  1     1     2 0.0300 0.0900 0.2481 0.3798 0.4859 0.5433 0.5919 0.6625 0.7220 0.7918 0.8636 0.9318 0.9707 1.0708
1.0023 1.0191 1.0191 1.0191 1.0191 1.0191 1.0191
  1975    1      1  1     1     2 0.0550 0.1575 0.2987 0.3658 0.6143 0.6306 0.7873 0.8738 0.9678 0.9075 0.9700 1.6933 1.5000 1.9000
1.9555 2.7445 2.7445 2.7445 2.7445 2.7445 2.7445
  1976    1      1  1     1     2 0.0550 0.0986 0.2359 0.4973 0.5188 0.6936 0.8041 0.9166 1.2097 1.3375 1.4498 1.6532 1.8066 1.8588
1.9555 2.7445 2.7445 2.7445 2.7445 2.7445 2.7445
  1977    1      1  1     1     2 0.0550 0.1006 0.4021 0.4870 0.5902 0.6650 0.7493 0.8267 0.9781 1.1052 1.2349 1.3148 1.4058 1.7511
2.0367 2.2094 2.2094 2.2094 2.2094 2.2094 2.2094
  1978    1      1  1     1     2 0.0539 0.1026 0.1360 0.4699 0.5300 0.6027 0.6392 0.7395 0.8391 0.9775 1.0971 1.2349 1.3028 1.4814
1.7419 2.3379 2.3379 2.3379 2.3379 2.3379 2.3379
  1979    1      1  1     1     2 0.0528 0.0913 0.2410 0.2587 0.5821 0.6868 0.7677 0.8909 0.9128 1.0369 1.1987 1.2482 1.5326 1.5520
1.7950 1.9817 1.9817 1.9817 1.9817 1.9817 1.9817
  1980    1      1  1     1     2 0.0517 0.0800 0.2236 0.4529 0.3922 0.4904 0.5166 0.6554 0.7125 0.8740 1.0616 1.1623 1.2898 1.3001
1.2699 1.3961 1.3961 1.3961 1.3961 1.3961 1.3961
  1981    1      1  1     1     2 0.0506 0.1079 0.2137 0.3422 0.5264 0.3933 0.5254 0.5462 0.7464 0.7204 0.8231 1.0413 1.0989 1.3449
1.4926 1.2128 1.2128 1.2128 1.2128 1.2128 1.2128
  1982    1      1  1     1     2 0.0494 0.1183 0.2465 0.3336 0.3097 0.5496 0.3956 0.5275 0.5629 0.7606 0.6837 0.8539 1.0670 0.8793
1.0186 1.1693 1.1693 1.1693 1.1693 1.1693 1.1693
  1983    1      1  1     1     2 0.0483 0.1287 0.1357 0.3410 0.3694 0.3277 0.5200 0.5028 0.6179 0.7060 0.8800 0.9299 1.0356 1.0310
1.3217 1.4823 1.4823 1.4823 1.4823 1.4823 1.4823
  1984    1      1  1     1     2 0.0472 0.1315 0.1642 0.2493 0.4385 0.4113 0.4352 0.5872 0.5802 0.6758 0.7010 0.9513 1.1364 1.0258
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  1985    1      1  1     1     2 0.0461 0.1740 0.2297 0.2679 0.4414 0.5497 0.5474 0.6014 0.7452 0.6933 0.7231 0.8584 0.8698 0.9458
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  1986    1      1  1     1     2 0.0450 0.1555 0.2771 0.2909 0.3024 0.3735 0.5425 0.5717 0.6421 0.8209 0.9403 1.1860 1.1900 1.3864
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  1987    1      1  1     1     2 0.0439 0.1478 0.1388 0.3790 0.2786 0.2870 0.3621 0.5775 0.5975 0.6369 0.7638 0.9820 0.9250 1.2407
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  1988    1      1  1     1     2 0.0428 0.1400 0.1870 0.3189 0.4711 0.3689 0.3731 0.5163 0.6474 0.6851 0.7183 0.9167 1.0924 1.0225
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  1989    1      1  1     1     2 0.0417 0.1389 0.2737 0.3047 0.2931 0.5134 0.4386 0.4064 0.5167 0.6263 0.6611 0.6027 0.8758 0.6686
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  1990    1      1  1     1     2 0.0406 0.1378 0.2435 0.3506 0.3906 0.5111 0.5462 0.6076 0.6678 0.5300 0.7691 0.8312 2.2000 1.1847
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  1992    1      1  1     1     2 0.0383 0.1356 0.2316 0.3473 0.4743 0.5334 0.5817 0.6210 0.6406 0.6530 0.6330 0.7217 0.7354 0.8501
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JOINT MANAGEMENT COMMITTEE

Agreement Between The Government Of The United States Of America And The Government Of Canada On Pacific Hake/Whiting

March 19, 2013

Ms. Susan Farlinger
Regional Director General – Pacific Region
Fisheries and Oceans Canada
Suite 200 – 401 Burrard Street
Vancouver, B.C. Canada V6C 2S4

William W. Stelle, Jr.
Regional Administrator
National Marine Fisheries Service
7600 Sand Point Way, NE, Bldg. 1
Seattle, WA 98115

Dear Ms. Farlinger and Mr. Stelle:

The Joint Management Committee (JMC) established under the *Agreement Between the Government of the United States of America and the Government of Canada on Pacific Hake/Whiting* (the Agreement) met in Lynwood, Washington on Monday and Tuesday, March 18-19, 2013. The primary purpose of the meeting was to develop recommendations to the Parties on: 1) the coastwide hake/whiting total allowable catch (TAC) for 2013; 2) each Party's national hake/whiting TAC, including any adjustments (uncaught TAC from the 2012 year to be carried forward to the 2013 year) allowed by the Agreement; and 3) operational and research measures for the proper care and management of the hake/whiting resource.

<u>Recommendation on Coastwide Hake/Whiting TAC and each Party's National TAC</u>

Consistent with Article II 3.(e) of the Agreement, and after reviewing the advice of the Joint Technical Committee (JTC), the Scientific Review Group (SRG), and the Advisory Panel (AP), the JMC recommends a coastwide TAC of 336,200 metric tons (mt). Based on Article III 2. of the Agreement, the Canadian share of the coastwide TAC is 26.12 percent, or 87,815 mt, and the U.S. share is 73.88 percent, or 248,385 mt. Consistent with Article II 5.(b) of the Agreement, an adjustment (carryover from 2012) of 7,552 mt is added to the Canadian share, for an adjusted Canadian TAC of 95,367. In the same manner, an adjustment of 21,360 mt is added to the United States share, for an adjusted United States TAC of 269,745 mt. This results in a coastwide adjusted TAC of 365,112 mt for 2013.

JOINT MANAGEMENT COMMITTEE

Agreement Between The Government Of The United States Of America And The Government Of Canada On Pacific Hake/Whiting

Additional Recommendations

The JMC recommends establishment of an interim working group made up of scientists, fishery managers, and stakeholders to consider the JTC and SRG recommendations in developing a draft workplan for further consideration by the JMC in May, 2013. This workplan will include further consideration and development of the Management Strategy Evaluation (MSE) process for consideration at the next meeting of the JMC, scheduled for May 22, 2013.

Thank you for your consideration of these recommendations. Additional information, including a summary of the meeting, will be forthcoming.

Paul Ryall
Co-Chair
Joint Management Committee

Frank Lockhart
Co-Chair
Joint Management Committee

GROUNDFISH ADVISORY SUBPANEL REPORT ON IMPLEMENTATION OF THE 2013 PACIFIC WHITING FISHERY UNDER THE U.S.-CANADA PACIFIC WHITING AGREEMENT

The Groundfish Advisory Subpanel (GAP) was briefed about the 2013 Total Allowable Catch (TAC) determination by the Whiting Agreement Joint Management Committee (JMC). The JMC process addressed issues relevant to setting the 2013 TAC and reached a consensus recommendation, which was forwarded to the Parties for implementation. Given that the JMC provided a consensus recommendation, the GAP has identified two issues for the Council.

The first is to establish a set-aside amount for incidental catches of whiting in non-whiting fisheries and catches in research surveys. The GAP recommends 2,000 mt be established as the 2013 set-aside to accommodate research and incidental catch. This is the same amount as in 2012. Presumably, it is adequate to cover research and incidental catches, which were about 1,565 mt in 2011 (that is, 220 mt non-whiting IFQ; 1.6 mt fixed gear; 282 mt pink shrimp trawl; and 1062 mt research – based on Bellman et al. 2012. *Estimated discard and catch of groundfish species in the 2011 U.S. west coast fisheries*).

Secondly, the GAP reviewed the National Marine Fisheries Service (NMFS) letter about the tribal whiting fishery included under Agenda Item D.4. Specific to determination of the 2013 tribal whiting set-aside, the GAP strongly believes that NMFS is obligated to make a good faith determination of the actual amount the tribes could realistically harvest. This should include past performance in catching requested amounts and tangible tribal fishery management plans that describe how each tribe will manage their respective fisheries. Information should also be provided about how bycatch and impacts on protected species will be minimized. For example, the Makah tribe has a long history in the fishery, including documented fishery management plans, monitoring and enforcement programs, and dedicated vessels and crew. In stark contrast, NMFS provides no evidence that the Quileute tribe, which has no experience in the tribal whiting fishery, will have viable fishing operations in 2013 or demonstrable fishery management plans.

Related to the amount provided to the tribal fishery is the issue of NMFS authority to reapportion tribal whiting to the non-tribal whiting sectors. The GAP recommends that the Council request NMFS be prepared to exercise the reapportionment authority in a timely and effective manner. In 2012, reapportionment to the shoreside quota share fishery was delayed because NMFS, apparently, was not prepared to provide reapportioned whiting to the quota share program. Moreover, almost 20,000 mt of tribal fish was stranded in 2012. Noting that the tribal set-aside for 2013 could be as high as 63,000 mt; NMFS should anticipate that the tribes would likely not catch their entire set-aside. Therefore, the GAP recommends the Council request NMFS act swiftly and effectively to reapportion tribal whiting on (or soon after) September 15.

PFMC
04/06/13

Agenda Item D.4.c
Supplemental GMT Report
April 2013

GROUNDFISH MANAGEMENT TEAM REPORT ON IMPLEMENTATION OF THE 2013 PACIFIC WHITING FISHERY UNDER THE U.S.-CANADA PACIFIC WHITING AGREEMENT

The Groundfish Management Team (GMT) reviewed the 2013 Total Allowable Catch (TAC) recommendation of the Pacific whiting Joint Management Committee (JMC). Council action under this agenda item is to review the JMC recommendation and plan for the 2013 fishery, including deductions from the TAC to account for Pacific whiting mortality in research and non-groundfish fisheries (primarily pink shrimp).

Table 1 includes the final estimates of Pacific whiting mortality from 2007 to 2011 for research and the pink shrimp fishery from the West Coast Groundfish Mortality Reports. The 2012 data are not yet final; therefore, the GMT provided an estimate based on data from the 2013 stock assessment and expected research activities. Increasing abundance, due in part to high recruitment in the 2010 year class could cause the 2013 catch to exceed the 2011 catch of 1,344 mt (Table 1). Further, estimated research mortality in 2012 and 2013 is expected to be higher than in 2011 (2,000 mt, compared to 1,062 mt). **Given this information, the GMT recommends a set-aside of 2,500 mt be adopted to accommodate for Pacific whiting mortality in research and pink shrimp.**

Table 1. Estimates of Pacific whiting mortality from 2005-2011.

	2013 estimate	2012 estimate	2011	2010	2009	2008	2007
Research [1/]	2,000	2,000	1061.9	133	35	12	49
Pink shrimp[1/]	500	500	282.1	398.9	1,937	684	2,808
Total	2,500	2,500	1,344	532	1,972	696	2,857

1/ Estimates for 2013 are based on correspondence with the Science Centers and on planned research projects. Catch from 2011-2007 are those reported in the West Coast Groundfish Mortality Reports (2012 is not yet available).

PFMC
04/07/13

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Sustainable Fisheries Division F/NWR2
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115-0070

FEB 20 2013

MEMORANDUM FOR: The Record

FROM: Frank Lockhart
Assistant Regional Administrator

SUBJECT: Categorical Exclusion Determination under National Environmental Policy Act (NEPA) for Rule to establish an interim 2013 Tribal Whiting Allocation

This memorandum provides the National Marine Fisheries Service's (NMFS) rationale for determining that a categorical exclusion (CE) is the appropriate level of NEPA review for a proposed and final rule establishing an interim allocation of Pacific whiting to the Washington coastal treaty Indian tribes in 2013. This rule meets the requirements of CEQ regulations at 40 CFR Part 1500-1508 and NOAA Administrative Order NAO 2166 for a categorical exclusion from detailed environmental review.

Background Information and Description of the Action

The 1996 regulations at 50 CFR 660.324(d) establish the process by which the tribes with treaty fishing rights in the area covered by the Pacific Coast Groundfish Fishery Management Plan (FMP) request new allocations. The regulations state that "the Secretary will develop tribal allocations and regulations under this paragraph in consultation with the affected tribe(s) and, insofar as possible, with tribal consensus.'' Procedures set forth in the above-described regulations were developed to coordinate the tribes' exercise of their treaty right in ocean fisheries within the Council and NOAA's decision-making processes for the groundfish fishery.

NMFS is in the process of developing, in coordination with the tribes and states of Washington and Oregon, scientific information needed to negotiate a long term tribal allocation, but this process is not yet complete. Therefore, NMFS is moving forward with this proposed rule as an interim measure to address the allocation for the 2013 tribal Pacific whiting fishery. As with the 2012 allocation, this rule is not intended to establish any precedent for future whiting seasons or for the long-term tribal allocation of whiting. In the proposed rule NMFS states its' belief that the proposed tribal allocation formula will result in a tribal allocation that lies within the range of the long term tribal treaty right to Pacific whiting. This belief is based on the best available scientific information gathered to date.

NMFS' proposed Pacific whiting allocation for the 2013 tribal fishery [17.5% of the U.S. TAC] plus 16,000 mt is based on discussions over the last six months with the Makah and Quileute Tribes and Quinault Indian Nation regarding their intent for the 2013 fishing season. The Makah tribe indicated their intent to continue to fish as in previous years. The Quileute tribe indicated that they will participate in 2013 and requested 16,000 mt. The Quinault Indian Nation indicated that they did not plan to participate in the fishery, but reserved the right to harvest, should they change their mind. NMFS will again contact the tribes during the proposed rule comment period to refine, if necessary, the 2013 allocation before a final decision is made. A specific amount for the tribal allocation for 2013 cannot be provided until late March, 2013 when the bilateral Joint Management Committee for the Pacific Whiting Treaty with Canada makes the decision on a coastwide TAC for 2013 following review, evaluation, and comment by the Scientific Review Group, Joint Technical Committee, and Advisory Panels established through the Treaty.

During the public comment period, NMFS will continue to consult with the tribes. After the comment period concludes, NMFS will consider these discussions as well as any public comments received, before making a final decision on the specific tribal allocation of Pacific whiting for 2013.

Effects of the Action

This action does not affect the overall amount of whiting that may be harvested. That amount is decided under the whiting treaty process, as described above. This action allocates a portion of the U.S. TAC to the treaty tribes. The potential effects of this allocation, and the resulting harvest and bycatch considerations, were analyzed and accounted for in the Environmental Impact Statement supporting the 2013-2014 groundfish harvest specifications and management measures.

The allocation of Pacific whiting to the treaty tribes provides additional economic opportunities in their respective coastal communities. Socioeconomic effects of the tribal whiting fishery are further evaluated in the RIR/IRFA as a component of the proposed rule.

Categorical Exclusion Determination Based on CEQ Regulations and NOAA Administrative order -NAO 216-6

In analyzing the appropriateness of a categorical exclusion (CE) determination for the Tribal whiting fishery in 2013, factors at section 5.05b NAO 216-6 and the specific guidance on significance at sections 6.01 and 6.02 were considered. Further, the allocation of whiting to the tribes in 2013 was evaluated on whether the action could be categorically excluded from the requirement to prepare an Environmental Assessment (EA) or Environmental Impact Statement (EIS) in accordance with NAO 216-6 Section 6.03a.3(b), 6.03c.3, and 6.03d regarding fishery management actions under the Magnuson-Stevens Act. Specifically, 6.03d.4(a) states that fishery management actions that are ongoing or recurring fisheries actions of a routine administrative nature may qualify for a CE if the actions do not have an impact beyond what was already considered. This action does not affect the overall amount of Pacific whiting harvested on an annual basis. The potential effects of this allocation, and the resulting harvest and bycatch considerations, including potential impacts on overfished species, were analyzed and accounted for in the Environmental Impact Statement supporting the 2013-2014 groundfish harvest specifications and management measures. This action provides the Washington coastal treaty Indian tribes with whiting harvest opportunities as a portion of the overall whiting TAC, which is considered a routine matter.

NAO 216-6 Sections 6.01 and 6.02 state that when adverse impacts are possible, the responsible program manager (RPM) should determine the appropriate course of action. If none of these situations may be reasonably expected to occur, NAO 216-6 states that the RPM should prepare an EA or determine, in accordance with Section 5.05, the applicability of a CE. This project does not trigger the six exceptions for categorical exclusions listed in NAO 216-6, Section 5.05c: (1) A geographic area with unique characteristics; (2) public controversy based on potential environmental consequences; (3) uncertain environmental impacts or unique or unknown risks; (4) establishment of a precedent or decision in principle about future proposals; (5) cumulatively significant impacts; or (6) adverse effects upon endangered or threatened species or their habitats. Accordingly, NMFS finds that the 2013 allocation of Pacific whiting to the Washington coastal treaty Indian tribes, as listed herein, is appropriate for a CE, and will not result in any potential significant impact under these factors.

In summary, NMFS finds that the 2013 proposed allocation of Pacific whiting to the Washington coastal treaty Indian tribes does not have the potential to individually or cumulatively pose significant effects to the quality of the human environment, either under the tests of NAO 216-6 Sections 6.01 and 6.02 or under 40 CFR 1508.27. Based on the above determination, the 2013 proposed allocation of Pacific whiting to the Washington coastal treaty Indian tribes is categorically excluded under NAO 216-6 and NEPA from both further analysis and requirements to prepare detailed environmental documents.

cc: GCNW (McNulty)
NWR (Lockhart)
NWR (Biegel)
PFMC (Dahl)

Agenda Item D.5
Situation Summary
April 2013

CONSIDER BAROTRAUMA DEVICE MORTALITY RATES

Rockfish that are brought up quickly from deeper depths suffer barotrauma caused by expansion of gasses, which causes tissue damage and a high rate of mortality. In June 2012, the Council discussed methods that can be employed to increase survival of rockfish released in recreational fisheries. The Council was briefed on improved survival of released rockfish by the use of descending devices that enable fish to be released at deeper depths. This allows recompression of expanded gasses that cause barotrauma in fish species that cannot quickly acclimate to the change in depth. Studies have shown there is both short and long-term survival of some of these fish when they are released at deeper depths using descending devices.

In June 2012, the Council tasked the Groundfish Management Team (GMT) with examining information and proposals on the use of descending devices when releasing cowcod and yelloweye rockfish to mitigate barotrauma. The GMT's progress report was provided in November 2012. The Council and its advisors agreed that the use of descending devices was a "best practices" release method. The Council further tasked the GMT to develop depth-dependent mortality rates for canary rockfish released using descending devices and to work with the Scientific and Statistical Committee (SSC) on the analysis of mortality rates for canary, cowcod, and yelloweye rockfish released using these devices. The GMT and members of the SSC Groundfish Subcommittee met on January 17 to discuss the analysis. The refined GMT report with the requested analysis is provided in Agenda Item D.5.b, GMT Report. The GMT recommends the Council approve a change in the current mortality rate used for rockfish released in recreational fisheries.

The Council task at this meeting is to provide guidance on the application of bycatch mortality rates associated with barotrauma reduction devices in recreational groundfish fisheries. The Council should consider the advice of the SSC on the science that informs this issue and GMT, Groundfish Advisory Subpanel, and public advice on issues associated with refining recreational fishery discard mortality rates for these three species.

<u>Council Action</u>:

1. **Provide guidance on application of bycatch mortality rates associated with barotrauma reduction devices in recreational groundfish fisheries.**

<u>Reference Materials:</u>

1. Agenda Item D.5.b, GMT Report: Groundfish Management Team Report on Proposed Discard Mortality for Cowcod, Canary Rockfish, and Yelloweye Rockfish Released Using Descending Devices in the Recreational Fishery.

Agenda Order:

a. Agenda Item Overview — John DeVore
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action:** Discussion and Guidance on Application of Bycatch Mortality Rates Associated with Barotrauma Reduction Devices in Groundfish Fisheries

PFMC
03/22/13

GROUNDFISH MANAGEMENT TEAM REPORT ON
PROPOSED DISCARD MORTALITY FOR COWCOD, CANARY ROCKFISH, AND YELLOWEYE ROCKFISH RELEASED USING DESCENDING DEVICES IN THE RECREATIONAL FISHERY

Contents

GMT Recommendations:

1. **Approve the use of mortality rates reflecting the use of descending devices for canary rockfish, yelloweye rockfish and cowcod in recreational catch accounting.**
2. **Consider the selection of mortality estimates that incorporate confidence intervals according to the level of perceived risk and uncertainty in the estimates to provide a precautionary buffer.**

Introduction

At the November 2012 Pacific Fisheries Management Council (PFMC or Council) meeting, the Groundfish Management Team (GMT) submitted a progress report on developing mortality estimates for rockfish caught by hook-and-line gear, and released using descending devices (PFMC, November 2012, I.3b, GMT Report). Comments on the content of that report were provided by the Scientific and Statistical Committee (SSC; PFMC, November 2012, I.3b, Supplemental SSC Report). At that meeting, the Council directed the GMT to work with the SSC to further refine the mortality estimates for yelloweye rockfish and cowcod, and to develop estimates for canary rockfish. Additional guidance was provided by the Council to develop buffers against uncertainties as suggested by the SCC. A joint meeting between members of the SSC groundfish sub-group and the GMT was held in January to provide an opportunity for discussion and refinement of the methods, the results of which are provided in this report. This document describes the GMT preferred method of estimating mortality for cowcod, canary rockfish, and yelloweye rockfish released with a descending device. These estimates account for short- and long-term mortality based on current research, mortality from sources unaccounted for in the studies used to generate mortality estimates, and additional buffer alternatives that the Council may wish to consider.

Short-Term Mortality

Species-specific estimates

Data to inform short-term mortality of canary and yelloweye rockfishes when descending devices are used is available from cage studies conducted by Hannah et al. (2012) off the Oregon coast, and unpublished data subsequently collected by the Oregon Department of Fish and Wildlife (ODFW). Mortality of discarded fish varied with capture depth, ranging from 0 - 17 percent for 41 canary rockfish caught between 10 and 45 fathoms (Table 1) and 0 – 5 percent for 99 yelloweye rockfish caught between 10 and 50 fathoms (Table 2). Sample size within some of the 10 fathom depth bins was small (Table 1 and Table 2). To help address this issue, the GMT recommends stratifying the data based on 10-30 fathoms, 30-50 fathoms, and greater than 50 fathoms. This does not alleviate the issue of low sample size in some cases; however, the SSC recommended, and the GMT supports, the use of additional data from other species to supplement estimates made with limited sample sizes. The use of data from other species as a proxy for species with limited data but with similar life history and anatomy is discussed below.

Table 1. Canary rockfish mortality (1-day survival; %) for 2-4 day barrel studies by Hannah et al. (2012) and subsequent ODFW research (unpublished data).

Capture depth (fm)	Alive	Dead	Total	Mortality (%)
0-10	NA	NA	NA	NA
10-20	15	0	15	0%
20-30	30	0	30	0%
30-40	5	1	6	17%
40-50	4	1	5	20%
Grand Total	54	2	56	4%

Table 2. Yelloweye rockfish mortality (1-day survival; %) for 2-4 day barrel studies by Hannah et al. (2012) and subsequent ODFW research (unpublished data).

Capture depth (fm)	Alive	Dead	Total	Mortality (%)
0-10	NA	NA	NA	NA
10-20	5	0	5	0%
20-30	31	0	31	0%
30-40	43	1	44	2%
40-50	18	1	19	5%
Grand Total	97	2	99	2%

The number of sampled cowcod from studies informing species specific mortality was low or non-existent in each depth bin, and varied between studies (Table 3). Data from the Smiley and Drawbridge (2007) hyperbaric chamber study conducted in 50-70 fathoms reflects cowcod survival assessed by whether or not the fish was actively feeding after seven days, potentially overestimating true mortality. Five out of the 16 cowcod were deemed "dead" based on that assessment. Results from a recent acoustic tagging study informing mortality when using descending devices conducted by the National Marine Fisheries Service (NMFS) Southwest Fishery Science Center by Wegner et al. (in prep) was presented to the Council in June 2012 (http://www.pcouncil.org/wp-content/uploads/D2c_SUP_SWFSC_PPT_VETTER_JUN202BB.pdf). Though this constitutes unpublished data not yet subject to a peer review, a presentation summarizing the results is provided for reference in the briefing book and members of the GMT have been in direct correspondence with the author regarding interpretation of the results provided. While estimates of mortality from other species and from studies conducted at shallower depths were considered as a proxy for cowcod, data from the acoustic tagging study by Wegner et al. (in prep) was conducted in deeper depths (70-100 fathoms) and had the only direct mortality estimates for cowcod. The study showed that all nine tagged cowcod were still alive two days after release. Five fish left the array prior to 10 days, their survivability was unknown. For the purpose of our analysis, we only used the data from fish remaining within the array to provide an estimate of mortality from this study. This is discussed further under the section regarding uncertainties reflected in the choice of the unaccounted for mortality added to the estimates of mortality from this study to address the additional uncertainty resulting from this assumption.

Table 3. Cowcod mortality (1-day survival; %) from acoustic tagging by conducted by Wegner et al. (in prep).

Capture Depth (fm)	Alive	Dead	Total	Mortality (%)
0-50	NA	NA	NA	NA
51-70	NA	NA	NA	NA
70-100	4	0	4	0%
Grand Total	4	0	4	0%

Indirect estimates of discard mortality from other species

Species-specific mortality estimates are not available for cowcod, canary, and yelloweye rockfish caught at some depths; data do not currently exist for canary and yelloweye rockfish caught at depths greater than 50 fathoms, or for cowcod caught at depths less than 50 fathoms (see Table 1,
Table 2 and Table 3). As such, mortality estimated for species other than cowcod, canary, and yelloweye rockfish returned to the depth using descending devices may be considered as proxy-estimates for application to these three species. In addition, a combination of data for species having similar life history and anatomy serves to supplement the sample size to provide acceptable estimates of mortality at a given depth. Proxy data was selected for each species and depth bin to make the best use of the available data for representative species given sample sizes. Descriptions of supplemental or proxy data used to estimate mortality rates, and justifications for their use are provided in Table 4 for each species and depth bin.

The GMT considered a variety of mortality estimates that could be used as proxies of short-term mortality for cowcod, yelloweye, and canary rockfish where direct estimates do not exist, or where supplementation may improve estimates (GMT Report I.3.b, PFMC, November 2012). Data from 119 quillback, yelloweye, canary and copper rockfish are available from 10-30 fathoms to inform mortality estimates for canary and yelloweye rockfish for which no mortality was observed in the 2-day cage study by Hannah et al (2012). There are sufficient data for 63 yelloweye rockfish for 2-4 days from Hannah et al (2012) to make species specific estimates for 30-50 fathoms; however, there were insufficient species-specific data available for canary rockfish at this depth range. Only 11 samples of canary rockfish were available in this depth bin. To alleviate the data gaps, the 11 samples from canary rockfish were combined with the 63 yelloweye from Hannah et al (2012) and the 182 sunset, bocaccio and flag rockfish from Jarvis and Lowe (2008) for a total of 256 samples resulting in a short-term mortality estimate of 17 percent for canary rockfish in the 30-50 fathoms depth bin.

The GMT recommends discard mortalities provided by Wegner et al. (in prep) as the proxy estimates for canary and yelloweye rockfish for depths greater than 50 fathoms. Wegner et al. (in prep) provided mortality estimates for a variety of rockfishes caught at depths greater than 50 fathoms, tagged with acoustic transmitters, and released using descending devices. Wegner et al.

(in prep) found that 23 percent of these fish (n = 30) that were within the array after 10 days no longer exhibited depth movement or acceleration indicative of survival and were deemed dead. No additional mortality was observed for fish remaining within the array from the sixth day until the end of the four month study, thus the 10-day mortality estimate may be representative of mortality for the extent of the study. Data from 30 cowcod, bocaccio, sunset, starry and bank rockfish that remained in array at day 10, seven of which died, were used to provide a 10+ day mortality estimate of 23 percent. This value was applied as the total mortality estimate for canary and yelloweye rockfish in deeper than 50 fathoms (Table 4).

Direct mortality estimates of 25 percent for cowcod in 50-100 fm were available from combining data from Wegner et al (in prep) and Smiley and Drawbridge (2007). The SSC expressed concern regarding the use of data from the barometric chamber study to estimate mortality in cowcod, since treatment of these fish differs greatly from that expected when anglers release fish with a descending device. In addition, the definition of mortality in the barometric chamber study was based on ability to feed after seven days rather than actual mortality. Therefore, data from Smiley and Drawbridge (2007) was not included in developing mortality estimates for cowcod.

The sample size for cowcod in 50 – 100 fathoms from the acoustic tagging study (Wegner at al., in prep) provided only 4 fish, though data for an additional 26 shelf rockfish are available from Wegner et al (in prep). Proxy data from the cage study by Jarvis and Lowe (2008) provides data from 182 shelf rockfish to inform mortality in shallower depths. Thus data from the four cowcod combined with other shelf rockfish (Wegner et al., in prep) were employed to provide a suitable proxy for cowcod. Estimates of 10+ day mortality for the four cowcod and 26 additional shelf rockfish sampled from 70 to 100 fathoms by Wegner et al (in prep) provide a mortality estimate of 23 percent to apply in the 50-100 fathom depth bin. Two-day mortality estimates of 22 percent from Jarvis and Lowe (2008) for shelf rockfish species returned to depths of 30 - 50 fathoms in cages in the Southern California Bight are used to inform mortality in 10-30 fathom and 30-50 fathom depth bins assuming mortality rates in shallower depths would be equal or less than observed in 30-50 fathoms.

No data were available from studies to inform mortality estimates when using descending devices from 0-10 fathom for any of the three species. For these cases, we used the lesser value between surface release mortality and mortality when using descending devices for the bin in question. The rationale was that mortality is expected to be lower in the 0-10 fathom depth bin than in the 10-30 fm depth bin. Either should provide a suitable proxy since the majority of the fish are able to escape the surface and return to depth under their own power, as reflected by relatively low cumulative mortality rates (<25 percent) for surface release in this shallowest depth bin (PFMC 2009). Proxy mortality rates applied in each depth bin for each species are provided in Table 4.

Table 4. **Species and sources of data used in proxy estimates of mortality for canary, cowcod and yelloweye rockfish and associated sample sizes and rates in each depth bin.**

Species	**Depth (fm)**	**Source of Short Term Mortality Data**	**Reason for Use of Proxy Data**	**Sample Size**	**Lived**	**Died**	**Mortality**
Canary Rockfish	0-10	Surface Release Mortality (PFMC 2009) or 10-30 fm	No data at this depth. Devices likely not needed	NA	NA	NA	NA
	10-30	Canary, yelloweye, copper and quillback rockfish (Hannah et al 2012)	Similar life history and anatomy	119	119	0	0%
	30-50	Bocaccio, flag and vermilion rockfish (Jarvis and Lowe 2008) / yelloweye and canary rockfish (ODFW unpublished data)	Only 11 samples for canary rockfish. Similar life history and anatomy.	256	212	44	17%
	>50	Cowcod, bocaccio, bank, sunset (Wegner et al. in prep)	No observations for subject species. Similar life history and anatomy.	30	23	7	23%
Yelloweye Rockfish	0-10	Surface Release Mortality (PFMC 2009) or 10-30 fm	No data at this depth. Devices likely not needed	NA	NA	NA	NA
	10-30	Canary, yelloweye, copper and quillback rockfish (Hannah et al 2012)	Similar life history and anatomy	119	119	0	0%
	30-50	Yelloweye (Hannah et al. 2012, ODFW, unpublished data)	NA-Sample size sufficient.	63	61	2	3%
	>50	Cowcod, bocaccio, bank, sunset rockfish (Wegner et al. in prep)	No observations for subject species. Similar life history and anatomy.	30	23	7	23%

Cowcod	0-10	Surface Release Mortality (PFMC 2009) or 10-30 fm	No data at this depth. Devices likely not needed	NA	NA	NA	NA
	10-30	Bocaccio, flag and vermilion rockfish 30-50 fm (Jarvis and Lowe 2008)	No observations for subject species. Similar life history and anatomy.	NA	NA	NA	22%
	30-50	Flag, vermilion and bocaccio (Jarvis and Lowe 2008)	No observations for subject species. Similar life history and anatomy.	182	142	40	22%
	>50	Cowcod, bocaccio, bank, sunset rockfish (Wegner et al. in prep)	NA-Limited data available for subject species. Similar life history and anatomy.	30	23	7	23%

Long-Term Mortality

Short-term mortality estimates for cowcod canary and yelloweye rockfish in less than 50 fm shown in Table 4 were based on studies that observed mortality within 2 - 4 days and are considered short-term mortality. Although many researchers have demonstrated that most discard mortality occurs during the initial 2 – 5 days post release, literature also shows additional mortality occurring beyond 2 – 5 days (Davis 2005; Parker et al 2006, Suuronen and Erickson 2010). To account for this expected additional mortality beyond 2 - 4 days for canary and yelloweye in 10 to 50 fathoms, the GMT applied the 3 – 10+ day mortality of 15 percent (4 dead out of 27 present after 2 days and remaining in array at day 10; Table 5) from the acoustic-tagging study by Wegner et al. (in prep) that was estimated for shelf rockfish species caught between 70-100 fathoms. Even though this estimate was derived using rockfishes other than canary and yelloweye rockfish, it may provide a reasonable proxy of long-term mortality because this rate was based on fish that were at large for up to 4 months (i.e., not caged) and unprotected from predators. The 15 percent long-term mortality estimate was also applied to cowcod in less than 50 fathoms based on cage studies conducted by Jarvis and Lowe (2008).

Table 5. Short-term, long-term, unaccounted and cumulative discard mortality estimates reflecting the use of descending devices in the release of cowcod, canary and yelloweye rockfish.

Species	Depth (fm)	Short-Term Mortality	Long-Term Mortality	Additional Unaccounted for Mortality	Cumulative Mortality
Canary	0-10	NA	NA	NA	NA
	10-30	1%	15%	5%	20%[1]
	30-50	17%	15%	5%	33%[1]
	>50	23%	NA	10%	31%[2]
Yelloweye	0-10	NA	NA	NA	NA
	10-30	1%	15%	5%	20%[1]
	30-50	3%	15%	5%	22%[1]
	>50	23%	NA	10%	31%[2]
Cowcod	0-10	NA	NA	NA	NA
	10-30	22%	15%	5%	37%[1]
	30-50	22%	15%	5%	37%[1]
	>50	23%	NA	10%	31%[2]

1. M =1 – (1–Short-Term Mortality) * (1–Long-Term Mortality)* (1-Unaccounted for Mortality)
2. M =1 – (1- 0.23 Wegner All RF 10+ Days) * (1-Unaccouted for Mortality))

The other option considered was to use the precautionary five percent per 10 fathoms long-term mortality estimate that is currently applied to fish released at the surface (PFMC 2012, November, Agenda Item I.3.b, GMT Report). This option may be less representative than using data from Wegner et al. (in prep) because it is a precautionary value intended to provide a buffer for the higher mortality observed in surface release, especially in deeper depths. The 15 percent mortality estimate provided by the acoustic tagging study is applied in a multiplicative fashion to provide an estimate of total mortality, which includes short- and long-term mortality estimates (equations are provided in the section reviewing cumulative mortality rate estimates).

The GMT points out that the additional long-term mortality estimate of 15 percent includes data from bank rockfish, which appear to be more sensitive to barotrauma than the other species in the Wegner et al. (in prep) study. Including discard-mortality of bank rockfish in this proxy may add an additional layer of precaution for canary and yelloweye rockfish, because the latter species appear to be more resistant to deleterious effects of barotrauma (Wegner et al., in prep and Hannah et al. 2012). In addition, the acoustic tagging was carried out in southern California where the thermocline typically is stronger than to the north of Point Conception where yelloweye and canary rockfish are found, adding a potential additional layer of precaution when applied to these more northerly distributed species where temperature differences are typically less extreme (Jarvis and Lowe, 2008). Note that the Wegner et al study was conducted during March when the thermocline is weakest. It should also be pointed out that during El Nino years, the thermocline may also be strong north of Point Conception.

No additional mortality was observed from six days to four months post-release in the acoustic tagging study. The additional “3 - 10+ day” mortality estimate is therefore considered representative of expected additional long-term mortality over the duration of the four month study. Other studies suggest that including an additional 15 percent to account for long-term mortality for rockfish may be higher than might be expected. For example, barometric chamber studies conducted on 90 black rockfish indicated only 3.3 percent mortality for fish held for at least 21 days after rapid decompression from 4 atmospheres of pressure equivalent to 20 fathoms then subsequent recompression (Parker et al. 2006). In this study, two fish died within the first nine days and only one fish died thereafter, indicating the potential for much lower long-term mortality; though these fish were protected from predation and reflect the response of black rockfish to barotrauma rather than species included in Wegner et al. (in prep). Finally, the GMT notes that even though mortality estimates from Wegner et al. (in prep) were derived using other rockfish species, the majority of fish in that acoustic tagging study were caught in depths between 70 and 100 fathoms, whereas the rates were applied to depths less than 70 fathoms for canary and yelloweye rockfish. Since many assume that discard mortality may increase with increasing depth, application of discard-mortality estimates obtained from rockfish caught at deeper depths to those caught at shallower depths may also be considered precautionary.

Mortality estimates shown for cowcod, canary and yelloweye rockfish in greater than 50 fm (Table 5) were provided by an acoustic tagging study (Wegner et al., in prep), where mortality was estimated at 10 days (with no additional mortality observed up to four months). As such, the GMT assumes that the mortality shown in Table 3 (7 of 30 sampled fish died = 23 percent) includes long-term mortality for fish caught and returned to the seabed using descending devices. Short- and long-term mortality are therefore included in the 10+ day estimates of 23 percent applied in waters deeper than 50 fathoms.

Buffers for Unaccounted Mortality, Confidence Intervals to Account for Management Uncertainty and Cumulative Mortality Estimates

The GMT addresses uncertainty in two ways. The first is the evaluation of potential bias and uncertainty from studies informing mortality estimates and incorporation of estimates of additional unaccounted for mortality to be combined with long and short-term mortality estimates to reflect these biases. The second is an additional precautionary buffer based on upper confidence intervals surrounding point estimates of discard mortality for the Council to select in addressing risk, based on their comfort level with the uncertainty in the estimates to account for management uncertainty.

Buffers for Unaccounted Mortality

Key uncertainties in mortality estimates for fish released with descending devices include: the effect of depth of capture; limited species-specific research on cowcod and canary rockfish; the effect of time on deck; the effect of thermal shock (e.g., temperate gradient across the thermocline); long-term mortality; potential negative effects on reproduction and productivity; and others. To provide a suitable buffer for missing aspects of mortality that might result from biases that cause underestimation of mortality rates, we examined potential biases between the mortality of fish in the research studies compared to that expected with use of descending devices by anglers on a typical fishing trip (Appendix A). These include both negative biases that would cause the rates from the studies to underestimate mortality expected when anglers use a descending device and positive biases that reflect aspects of the study that may cause the estimate to exceed mortality likely to result from use of a device on a fishing trip. Descriptions of the potential causes of differences between estimates from each study and mortality of fish released by anglers are provided in Appendix A.

The wide range of potential biases affecting mortality either positively or negatively makes a net balance hard to determine. To avoid over complicating the issue while still attempting to acknowledge some level of unaccounted for mortality, the GMT recommends additional buffers on the order of five to ten percent depending on the depth of capture be applied to point estimates of total mortality (Table 5). To be consistent with guidance provided by the Council, the same buffer was applied over all depth bins that used mortality rate from sources with similar biases.

To address the potential for unaccounted mortality in studies used to estimate discard mortality when a descending device is used, we added an additional five percent mortality to estimates from the results of cage studies, and an additional 10 percent to estimates from acoustic tagging results. As discussed above, the fate of fish that left the array in the acoustic tagging studies (Wegner et al. in prep) is uncertain. The actual fate of the fish that left the array is unknown and it could also be argued that these fish died after leaving the array. To address this uncertainty, a higher additional mortality was applied to estimates derived from tagging studies. A five percent buffer was applied multiplicatively to mortality estimates from cage studies for cowcod, canary and yelloweye rockfish in depths less than 50 fathoms. A 10 percent buffer was applied for mortality estimates that were derived from acoustic tagging studies (Table 5). Equations used to combine mortality components and values used in the calculation are provided below Table 5 and are referenced therein.

No additional mortality was added to estimates of long-term mortality since the estimates were obtained from fish sampled in depths greater than 70 fathoms and applied to depths shallower than 50 fathoms, which already add a layer of precaution, assuming mortality is higher at deeper depths. Previous research suggests that this estimate may be higher than expected over the period in question given supporting data from mark recapture study (Hochhalter 2012) and barometric chamber studies (Parker et al. 2006) indicating that estimates are unlikely to underestimate mortality.

To address positive bias from inclusion of overlapping time periods of four day barrel trials in recent Hannah data with the 3-10 day long-term mortality, the GMT considered the SSC suggestion to extrapolate two day mortality to longer periods or adjust four day mortality. Extrapolating daily mortality from two day trials out to four days was not possible because of low mortality sample sizes (i.e. number of dead fish) each day. Thus the GMT decided not to adjust the estimates and include two and four day estimates (combined) as two day estimates.

Buffers for Management Uncertainty Selected by the Council

The point estimates of total mortality result from methods suggested by the SSC that incorporates short-term, long-term and unaccounted for mortality. Additional mortality reflecting levels of precaution using the 60, 75, 90 or 95 percent confidence interval (CI) of the short-term mortality estimates in less than 50 fathoms and the 10+ day mortality estimates in greater than 50 fathoms can be selected by the Council to further address uncertainty. Short-term mortality estimates along with confidence intervals are provided in Table 6 for each species in 10-30 fathom, 30-50 fathom and greater than 50 fathoms depth bins. These upper confidence intervals were included as a measure of risk that the Council may wish to apply when selecting mortality values that account for the use of descending devices (Table 6).

Table 6. Estimates of total mortality reflecting point estimates of short-term mortality associated with the use of descending devices in the release of cowcod, canary and yelloweye rockfish and precautionary estimates using the 60, 75, 90 and 95 percent confidence interval for short-term mortality in less than 50 fathoms and 10+ day mortality in greater than 50 fathoms.

Species	Depth (fm)	Mortality Estimate	Upper 60% CI	Upper 75% CI	Upper 90% CI	Upper 95% CI
Canary Rockfish	0-10	NA	NA	NA	NA	NA
	10-30	1%	1%	2%	2%	2%
	30-50	17%	19%	20%	22%	22%
	>50	23%	32%	35%	39%	42%
Yelloweye Rockfish	0-10	NA	NA	NA	NA	NA
	10-30	1%	1%	2%	2%	2%
	30-50	3%	7%	8%	10%	11%
	>50	23%	32%	35%	39%	42%
Cowcod	0-10	NA	NA	NA	NA	NA
	10-30	22%	25%	26%	28%	29%
	30-50	22%	25%	26%	28%	29%
	>50	23%	32%	35%	39%	42%

The estimates resulting from application of the upper 95 percent CI of mortality are very close to the point estimate when sample sizes are high (e.g., in less than 50 fathom), but low sample size in greater than 50 fathoms increases the 95 percent CI. The 60 percent CI provides a moderate buffer for uncertainty. The 75 percent upper confidence interval estimate provides an estimate for which half of the expected binomial upper confidence interval distribution of mortality rates are higher and half are lower than the estimated value. The 90 and 95 percent CI provide more precautionary mortality, though they reflect values of mortality near the upper tail of the confidence interval distribution resulting in greater potential for overestimation relative to the unknown true mortality.

It is important to recognize that the confidence interval reflects the precision of the estimate expected, given the sample size used to generate the mortality estimate. The point estimate could be either above or below the true mortality rate (i.e. is bi-directional). Although we acknowledge that confidence intervals are bi-directional of the point estimate, we only consider the upper confidence interval to provide a measure of the highest mortality that can be expected with the precision of the estimate given the sample size.

Total Discard Mortality Estimate for Descending Device Use

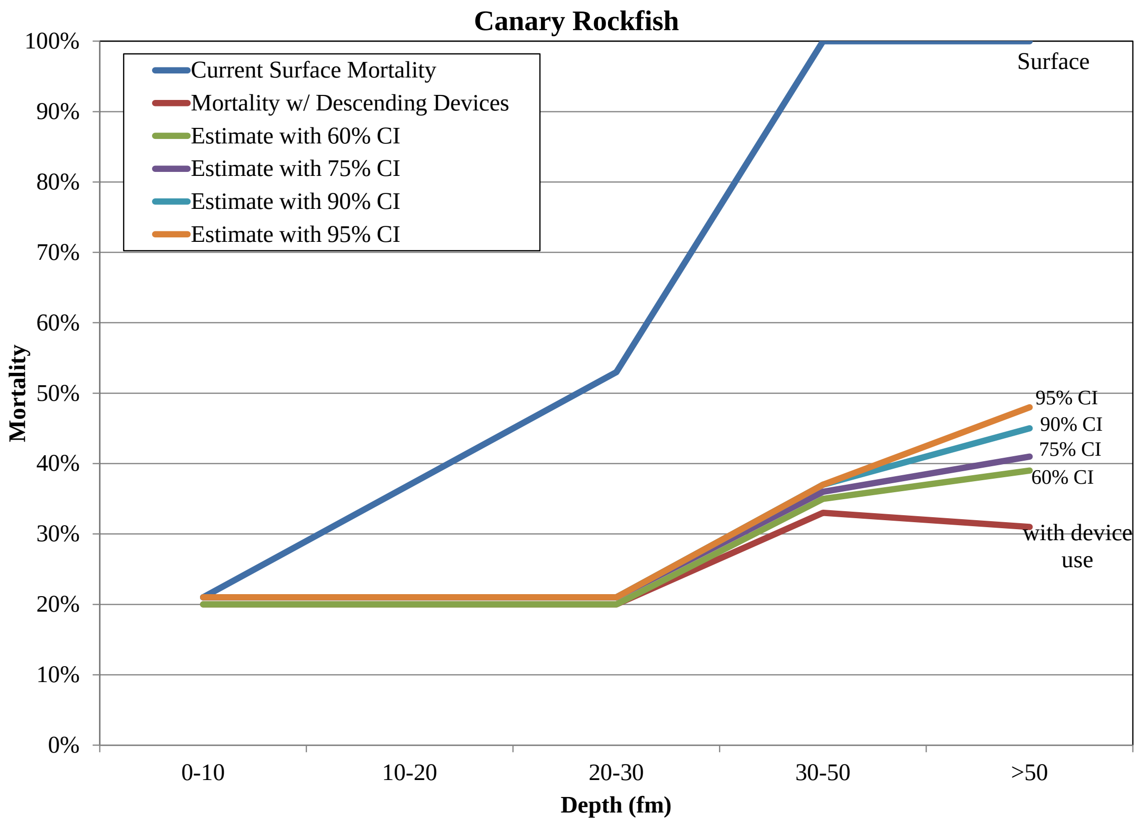
In November of 2012, the Council asked the GMT to consider buffers and combine depth bins with similar results. One alternative provided in Council guidance to illustrate their intent was to have depth bins of 0-30 fathoms, 31-59 fathoms, and greater than 59 fathoms, with a 15 percent buffer added for each depth bin. The 15 percent buffer added to each depth bin was intended to be analogous to the 5 percent added to each 10 fathom depth bin in the surface mortality calculations. During Council discussion, it was clarified that the motion was intended to be general guidance and not prescriptive. A subgroup of the GMT discussed the bins and buffers specifically mentioned in the Council motion, however for some depth bins the additional 15 percent buffer created a higher mortality using descending devices than mortality currently in place for fish released at the surface. Therefore, those specific buffers were not examined further. However the GMT believes that the mortality estimates and buffers that were subsequently examined and presented here fit within the intent, and clarification, of the motion, by combining depth bins with similar results and including buffers for uncertainty.

Surface mortality (currently applied to recreational discards), proposed cumulative mortality when using descending devices, and associated upper confidence intervals are provided in Table 7 and Figure 1. These estimates allow easy comparison between surface-release mortality estimates and cumulative mortality estimates with and without upper confidence intervals when using descending devices. When mortality reflecting the use of descending devices was higher than that for surface release, or surface mortality was higher than the mortality shown for the next deeper depth bin, the lower of the estimates was used. Mortality when using descending devices is not expected to be higher than surface release. Similarly, mortality is expected to be lowest in shallower depths. Substitution of values with estimates from surface mortality or estimates of discard mortality from deeper depth bins are noted in the table. Equations used in calculating the estimates of total mortality reflecting precautionary estimates from upper confidence intervals are analogous to those provided below Table 5 with the exception that the upper confidence interval of short-term mortality estimates from Table 6 were used instead of the point estimates.

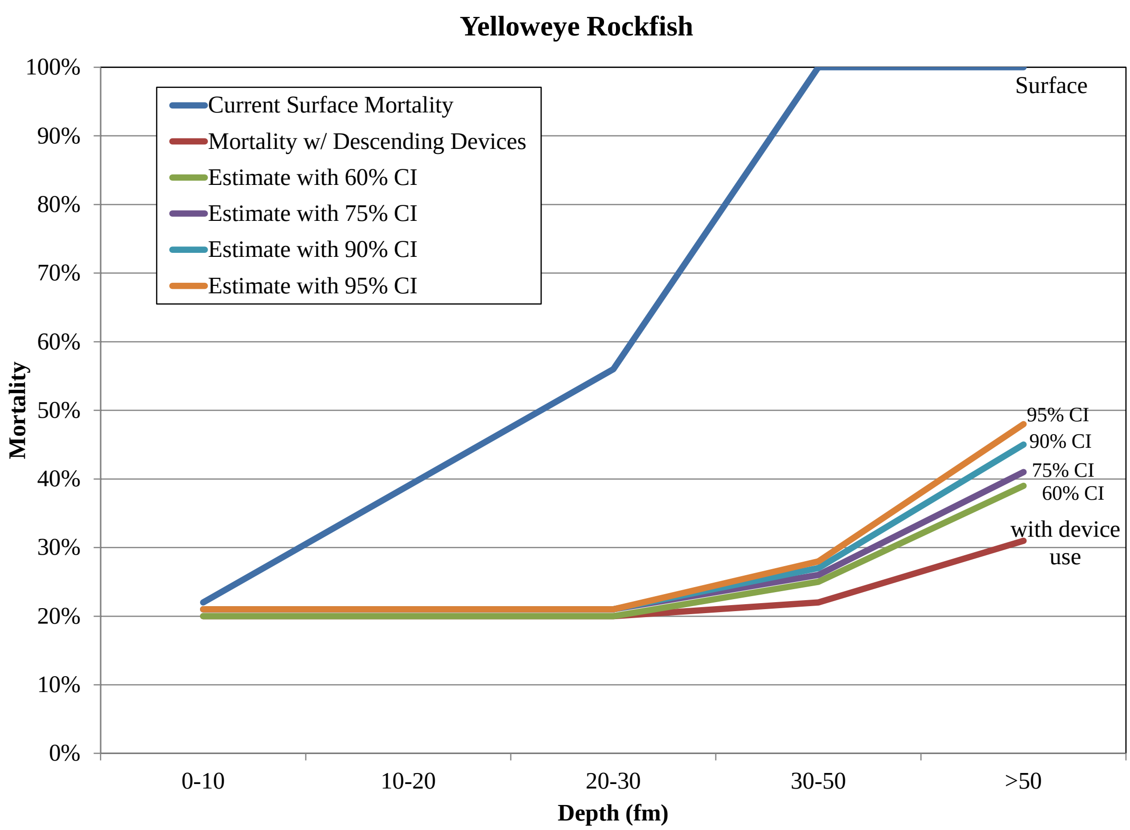
Table 7. Total discard mortality (%) for cowcod, canary and yelloweye rockfish and reflecting the use of descending devices incorporating short-term mortality, long-term mortality, unaccounted for mortality and upper 60, 75, 90, and 95 percent confidence intervals as precautionary buffers for uncertainty.

Species	**Depth (fm)**	**Current Surface Mortality**	**Mortality w/ Descending Devices**	**Estimate with 60% CI**	**Estimate with 75% CI**	**Estimate with 90% CI**	**Estimate with 95% CI**
Canary Rockfish	0-10	21%	20%[1]	20%[1]	21%	21%	21%
	10-20	37%	20%	20%	21%	21%	21%
	20-30	53%	20%	20%	21%	21%	21%
	30-50	100%	33%	35%	36%	37%	37%
	>50	100%	31%	39%	41%	45%	48%
Yelloweye Rockfish	0-10	22%	20%[1]	20%[1]	21%[1]	21%[1]	21%[1]
	10-20	39%	20%	20%	21%	21%	21%
	20-30	56%	20%	20%	21%	21%	21%
	30-50	100%	22%	25%	26%	27%	28%
	>50	100%	31%	39%	41%	45%	48%
Cowcod	0-10	21%	21%[2]	21%[2]	21%[2]	21%[2]	21%[2]
	10-20	35%	35%[2]	35%[2]	35%[2]	35%[2]	35%[2]
	20-30	52%	37%	39%	40%	42%	42%
	30-50	100%	37%	39%	40%	42%	42%
	>50	100%	31%	39%	41%	45%	48%

[1]The value reflects mortality rates from the 10-20 fathom bin since mortality rates are expected to be lower in shallower depths and less than surface mortality.
[2]The value reflects surface mortality since mortality rates for descending devices are not expected to exceed surface release.



Canary Rockfish
Current Surface Mortality
Mortality w/ Descending Devices
Estimate with 60% CI
Estimate with 75% CI
Estimate with 90% CI
Estimate with 95% CI
Surface
95% CI
90% CI
75% CI
60% CI
with device use
Mortality
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0-10
10-20
20-30
30-50
>50
Depth (fm)



Yelloweye Rockfish
Current Surface Mortality
Mortality w/ Descending Devices
Estimate with 60% CI
Estimate with 75% CI
Estimate with 90% CI
Estimate with 95% CI
Surface
95% CI
90% CI
75% CI
60% CI
with device use
Mortality
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0-10
10-20
20-30
30-50
>50
Depth (fm)

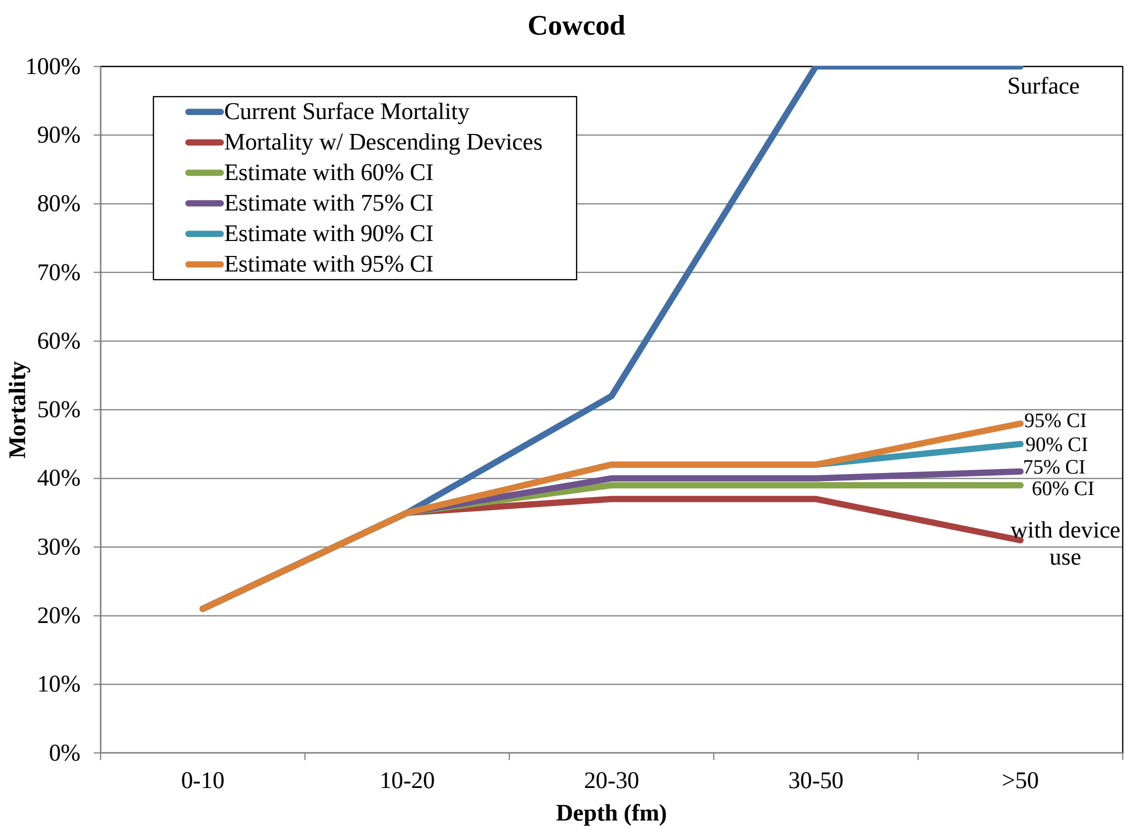


Figure 1. Total discard mortality (%) for cowcod, canary and yelloweye rockfish and reflecting the use of descending devices incorporating short-term mortality, long-term mortality, unaccounted for mortality and upper 60, 75, 90, and 95 percent confidence intervals as precautionary buffers for uncertainty.

GMT Recommended Total Discard Mortality and Associated Risks of Choice

The GMT acknowledges that addressing discard mortality is difficult and that final selection of the most appropriate mortality for rockfishes discarded using descending devices should be made after careful review of Appendix A and after extensive discussion and input from other advisory bodies, the public, and among Council members. The GMT recommends use of a buffer for management uncertainty based on an upper confidence interval be selected by the Council (Table 7 and Figure 1) to mitigate the potential for risk of underestimating mortality, while bearing in mind that there is also the potential to overestimate mortality through the application of confidence interval values from the upper end of the distribution. The risk associated with uncertainty in each estimate of mortality should be carefully considered in selecting a mortality rate that reflects the degree of comfort with the related assumptions. As new data becomes available the estimates should be updated, since current research will continue to provide additional data to inform and improve mortality estimates over time.

Future Analyses and Research

The uncertainty concerning the successful use of descending devices in returning fish to depth should be addressed when mortality rates reflecting successful release are applied. Estimates providing the best estimate of mortality assume that fish were successfully returned to depth. A buffer for failure to return fish to a sufficient depth when using descending devices when they are reported to have been used to release a fish may need to be accounted for when applying the mortality estimate. It may be more appropriate to further explore a buffer for this uncertainty with regard to the estimates of the frequency of use of devices, which will be provided by each state. Thus it is not reflected in the estimates of mortality or buffers provided herein and will be addressed in the application of mortality rates.

The GMT sees the above work for cowcod, canary rockfish, and yelloweye rockfish in the recreational fisheries as a first step. We see the potential for application to other rockfish species in the recreational fisheries, which we would be interested in exploring, when such data become available. Additionally, the Council asked the GMT to consider the applicability of descending devices and associated mortality estimates for the commercial nearshore fishery. The team discussed the application of new mortality estimates reflecting the use of descending devices in the commercial nearshore fishery. However some on the team feel that there are many issues in the commercial fishery that are very different from the recreational fishery, and concluded that mortalities reflecting the use of descending devices and implementation assumptions may be very different between the two fisheries. As such, a full analysis for application to the commercial fishery was not possible in the time frame that the Team was working under. This analysis, if recommended by the Council, would be a separate and distinct analysis from that shown in this document.

Barotrauma and the Magnuson-Stevens Fisheries Management and Conservation Act Reauthorized National Standard Guidelines

Accounting for the use of descending devices and the decreased mortality rates associated with their use fits under National Standards 1, 2, 6, 8, and 9 (Appendix B) of the Magnuson-Stevens Fishery Management and Conservations Act Reauthorized (MSA).

<u>National Standard 1:</u> *Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield (OY) from each fishery for the U.S. fishing industry.* Using the current mortality estimates for fish released at the surface, which are higher than for fish released at depth, may be overestimating the impacts to overfished species from the recreational fisheries. This means that regulatory actions may be taken prior to the individual sector harvest guidelines being actually achieved, and therefore the optimum yield would not be achieved.

<u>National Standard 2</u>: *Conservation and management measures shall be based upon the best scientific information available.* The GMT has examined literature on the use of

descending devices and the effects of barotrauma that have been published to date. Additionally the GMT has contacted researchers currently working on projects to get information on unpublished data. The data available is somewhat limited by species and depth strata, but the best information available at this time (March 2013) has been incorporated into the analysis.

National Standard 6: *Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.* The GMT uses the best information available when setting up season structures and associated management measures during the biennial harvest specifications and management measures cycle. However, what actually occurs in the fisheries often varies from the modeling due to a variety of factors: weather, El Nino, other fishing opportunities, gas prices, state of the economy, and fish movement. The recreational fisheries in recent years have shown this variability in catches of overfished species, particularly yelloweye rockfish. Since this is a species for which retention is prohibited in all three states, anglers must release any they encounter. Currently surface mortality rates are being applied. As more anglers use descending devices for the overfished species they encounter, the mortality of released fish may likely be overestimated. Incorporating mortality estimates for fish released at depth into inseason tracking will help account for the variability in encounters (and discards) and apply a more meaningful mortality percentage to those discarded fish.

National Standard 8: *Conservation and management measures shall, consistent with the conservation requirements of the Magnuson-Stevens Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to: (1) provide for the sustained participation of such communities; and (2) to the extent practicable, minimize adverse economic impacts on such communities.* The current use of surface mortality estimates applied to all released overfished species may result in an overestimation of the impacts, or total mortality. This potential overestimation may cause fisheries managers to unnecessarily restrict or even close fisheries. These restrictions or closures have a negative impact on the coastal economies; fewer anglers go to coastal communities, which decrease their associated expenditures (gas, lodging, bait, meals, tackle).

National Standard 9: *Conservation and management measures shall, to the extent practicable: (1) minimize bycatch; and (2) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.* The use of descending devices may reduce mortality of rockfish that are caught, but not retained. The mortality of rockfish released at depth is less than for fish released at the surface. As more anglers use descending devices, the mortality associated with released rockfish, primarily overfished species, will decrease.

GMT Recommendations

1. **Approve the use of mortality rates reflecting the use of descending devices for canary rockfish, yelloweye rockfish and cowcod in recreational catch accounting.**
2. **Consider the selection of mortality estimates that incorporates confidence intervals according to the level of perceived risk and uncertainty in the estimates to provide a precautionary buffer.**

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Appendix A. Biases and Uncertainty in Discard-Mortality Estimates

Key uncertainties in mortality estimates for fish released with descending devices include the effect of depth of capture, limited species-specific research on cowcod and yelloweye, the effect of time on deck, the effect of thermal shock (e.g., temperate gradient across the thermocline), long-term mortality, potential negative effects to reproduction and productivity, and others. Following is an examination of potential biases between the mortality of fish in the research studies from which discard-mortality rates were derived compared to that expected when descending devices are used on a regular fishing trip. A description of the potential causes for differences between estimates from each study and mortality of fish released by anglers are provided below.

<u>Hannah et al. (2012) Cage Study</u>

Handling of Fish Prior to Release

Fish in this study were handled to remove hooks, measured, tagged prior to release and confined in limited space without food for two to four days. Fish handled by anglers are removed from the hook and returned to depth using a descending device. Recreational anglers will most likely have different impacts on released fish due to handling than researchers do. The difference in stress, injury and resulting mortality due to handling between researchers and anglers using descending devices is variable depending on the experience level of the angler in handling rockfish and their regard for the survival fish, thus a bias in either direction is difficult to quantify.

Anglers Handling Time prior to Release Compared to Researchers

Some information is provided from Jarvis and Lowe 2008. On page 1294 is a figure with probability of survival with deck time from a generalized linear model (GLM) analysis. A point estimate of mortality of 29 percent using data from all species in this study corresponds to a little more than 15 minutes on deck in the curve. How long fish will be left on deck is questionable, but fishermen are likely to return fish to the water by the end of a drift if not immediately before continuing to fish. Drift lengths can vary depending on the size of the reef, orientation of the reef compared to windage and whether they are catching fish or not. Most drifts last between 5-30 minutes. At 30 minutes, the probability of mortality is approximately 50 percent.

Cages Protect Fish from Potential Predation

Most rockfish in lingcod stomachs were smaller than cowcod, yelloweye and canary rockfish encountered in the recreational fishery (Beaudreau 2012). Take by pinnipeds is relatively uncommon as indicated by their infrequent presence around boats fishing for rockfish in the CRFS data. Though pinnipeds do eat rockfish (Love et al. 2002, Lowery et al. 1991), removal of fish from descending devices is not expected to be common since discarded fish are still expected to be available at the surface as not all fish will be released with a device.   Predation by sharks is another consideration, but sharks are rarely caught as bycatch while fishing for rockfish, though they may be in the vicinity.

Many fish that are returned to the seabed take some time to recover from the stress and may lie on their side, venting rapidly, for some time. These fish are protected from large predators by cages, but not small “scavengers” such as sand fleas. Suuronen and Erickson (2010) discuss the possibility of increased scavenging on live but caged fishes held on the seabed by sand fleas (amphipods) and hagfish. While caged fish clearly may not be able to escape scavengers, those that are stunned when returned to depth also may not be able to move at a sufficient speed and distance to get away from them. The Hannah (2012) study relied on a new novel cage designed to protect fish from hagfish and sand fleas, to address increased mortality due to predation.

Stress Induced by Captivity
Fish were subjected to stress of confinement and repeated contact with the walls of barrels in which they were confined. In addition, they did not have access to prey and were unable to feed resulting in the potential for additional stress that would not be experienced by fish released at depth using a descending device.

<u>Wegner et al. (in prep) Acoustic Tagging Study</u>
Equal Mortality Inside and Outside of the Acoustic Array
The estimates of mortality assume fish that left the array area had the same mortality rate as those that remained within the receiver array. This assumption may be valid since fish that left the array appear to have been making diel migrations in the water column within the array prior to leaving the array as indicated by depth and accelerometry data (Wegner, personal communication). However, there is no way to verify whether or not these fish lived or died after they left the array.

Mortality through Day 10 reflects Mortality through the 4 Month Study
After the sixth day of the study, no additional mortality was observed in fish that remained within the array until the end of the four month study. Thus it is assumed that there no additional mortality beyond ten days at which the estimates were made. While 10+ days is noted as the duration of the long-term mortality estimate, the estimate reflects long-term mortality representative of the duration of the four month study.

Effects of Thermal Shock in the Southern California Bight
The results reflect the greater thermocline in the Southern California Bight and potential for exacerbating effects of thermal shock. Data provided by Wegner et al. (in prep) was collected in March when the thermocline is expected to be relatively weak, making the mortality estimates derived from the data low compared to the potentially higher mortality during the summer and early Fall when the thermocline is at a maximum. Data from Jarvis and Lowe was collected in mid summer when the thermocline is at or near its maximum and the results are comparable to that observed in Wegner et al. (in prep). These effects may be less severe for canary rockfish and yelloweye rockfish primarily distributed in the area north of Point Conception where water temperatures differences with depth are typically not as extreme as discussed further below (except in El Nino years). However, changes in water temperature patterns fluctuate over time making the difference in net effects of thermal shock north and south of Point Conception difficult to quantify at a given point in time.

Inclusion of Less Robust Species in the 3-10+ day Mortality Rate Estimate
Estimates from this study reflect potential positive bias from inclusion of the more susceptible bank rockfish in the pool of species used to estimate 3-10+ day mortality rates. A mark- recapture estimate of mortality from Hochhalter et al. (2012) provided a mortality estimate of 1 percent for yelloweye rockfish for 17 days after fish were marked. Results of barometric chamber study by Parker et al. (2006) indicated a mortality rate of 3.3 percent for black rockfish subjected to simulated ascent; re-compression and observation for at least 21 days indicate that the results of this study should be considered to provide estimates of long-term mortality that may be biased high when applied to more robust species.

The 3-10+ Day Long-term Mortality Rates Reflect Depths Greater than those to which they are applied
When the 3-10+ day mortality rates or 10+ day estimates are applied in depths less than 70 fathoms, they may represent a positive bias in the estimate since they were collected in deeper depths where the effects of barotrauma are expected to be more severe.

Other Uncertainties

Overlap in the Period of Mortality Rate Estimation between Short-term and Long-term Estimates
Cage study data from Hannah et al. (2012) and subsequent research by ODFW was representative of fish retained between 2 and 4 days, while the long-term mortality rates from Wegner et al. reflect mortality for day 3 to day 10+. The overlap for day 3 and 4 present the potential for double counting of mortality during this period presenting a positive bias in the estimates. If fish died in days 2 to 4 in both studies, this would be accounting for mortality in the same time frame in two sources resulting in an overestimation of aggregate mortality.

Effects of Repeated Capture on Survival Rates
These concerns surround the question of probability of multiple captures and increased rates of mortality with multiple capture events. This is accounted for to some degree as each encounter has an associated the mortality rate applied to it, but mortality for the second event may be marginally higher than the estimate from research resulting in an underestimation of mortality. Rockfish may be less susceptible to mortality on second contact due to perforation of swim bladder in the short term (John Hyde, Personal Communication). Tagging studies typically result in return rates of 3 percent on average and depending on how heavily a spot is fished, recapture may be relatively infrequent.

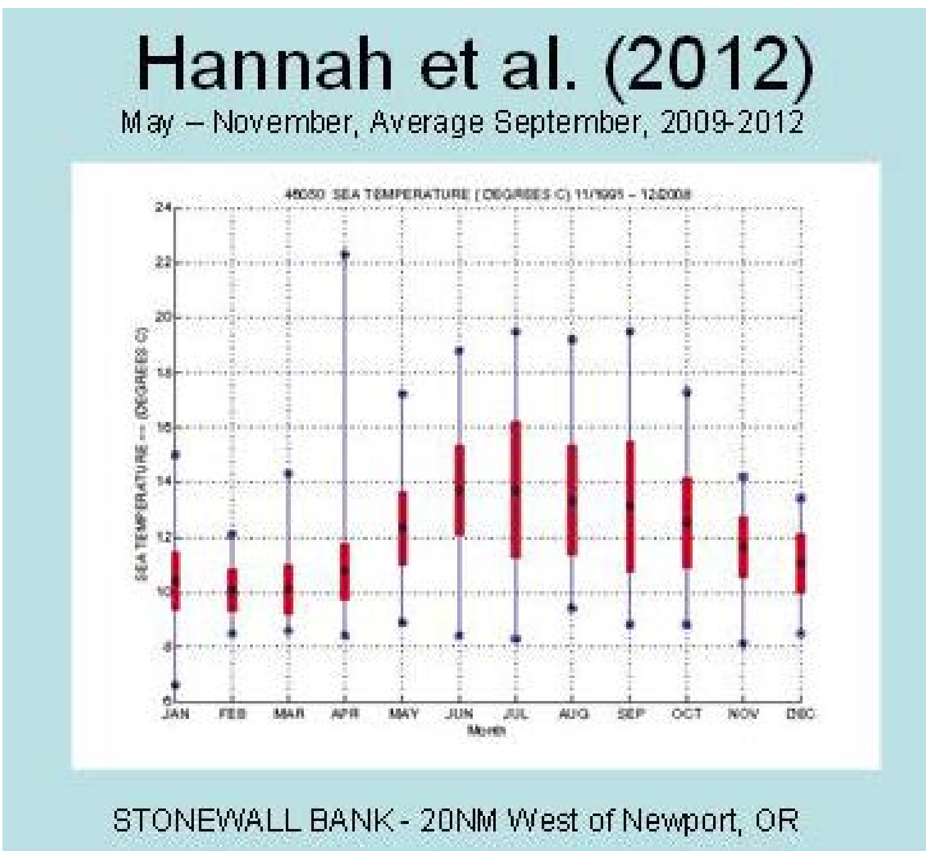
Environmental Conditions at Time of Study
Given the significant contribution of the degree of thermocline posed by the difference in water temperature between surface and the bottom to mortality rates observed in Jarvis and Lowe, the seasonal or inter-annual variability (El Nino, La Nina) may have an effect on survival estimated by the study depending on the environmental conditions at the time the research was conducted and to which it is being applied. The following figures

describe monthly average water temperatures (and standard deviations) for locations near studies referenced in this paper.

Water temperatures observed during the Hannah et al. studies average 11.9^{o} C and ranged between 9.5 – 15.4^{o} C. These observed water temperatures fall between or are within annual monthly mean water temperatures in the area of study (i.e., higher than November – April average temperatures and lower than May – October temperatures; see Figure below). Note that maximum standard errors off southern Oregon may reach or exceed 20 ^{o}C.

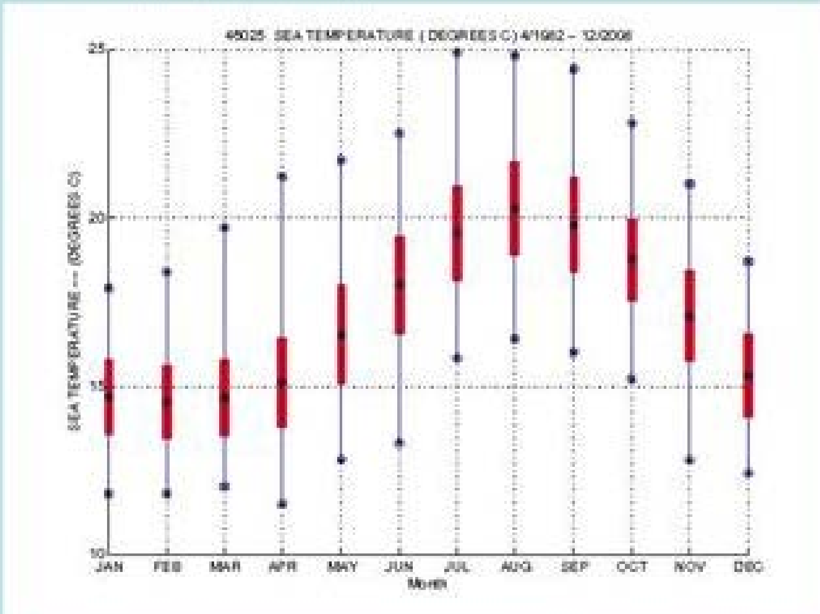
Jarvis and Lowe's study was conducted during summer months in the Southern California Bight. Although we are uncertain what the observed water temperature was during the time of this study, the summer and early fall months represent the high-water temperature months in this region. Studies by Jarvis and Lowe were not conducted during El Nino or La Nina conditions.

Wegner et al., (in prep) was conducted during March 2012 in the San Clemente Basin. This period represents one of the coolest water-temperature months in that area during a single year (see Figure below).



Jarvis and Lowe (2008)

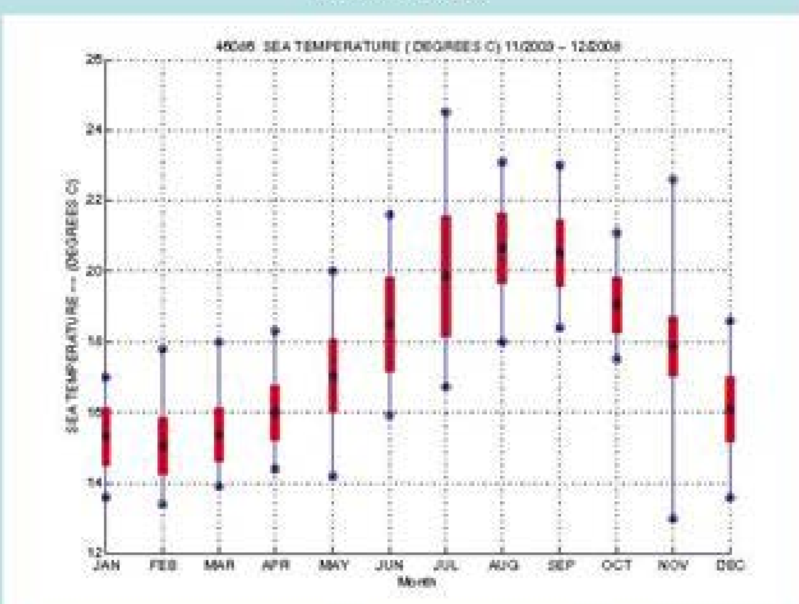
Summer 2005 and 2006



Santa Monica Basin - 33NM WSW of Santa Monica, CA

Wegner et al. (in prep)

March 2012



SAN CLEMENTE BASIN - 27NM SE OF San Clemente Is, CA

Table 8. Sources of bias in studies informing discard mortality rates reflecting the use of descending devices.

Data Source	Affected Estimates	Uncertainty	Direction	Measure	Considerations
Cage Studies: Hannah et al. (2012), Jarvis and Lowe (2008)	All Species in <50 fm	Handling Bias	Neutral	Qualitative	Measuring and Tagging = Assumed Angler Treatment
	All Species in <50 fm	Time on Deck Bias	Negative	Data	Likely released using device immediately if at all.
	All Species in <50 fm	Cage Protection Bias	Negative	Data	Predation upon release at depth appears limited.
	All Species in <50 fm	Stress Induced Mortality from Captivity	Positive	Qualitative	Confined fish may be stressed or deprived of food.
	Canary Rockfish 30-50 fm	Jarvis and Lowe Conducted in Southern California	Positive	Qualitative	Temperature difference due to thermocline is typically lower north of Point Conception where canary rockfish are more common
Acoustic Tagging: Wegner et al. (in prep)	All Species >50 fm	Mortality Inside vs. Outside Array	Neutral	Qualitative	Behavior same as others before departing array
	All Species >50 fm	Mortality at 10 days = 4 month	Neutral	Data	No mortality in array beyond 6 days up to 4 months.
	Canary and Yelloweye >50 fm	Data collected in Southern California	Positive	Qualitative	Temperature difference due to thermocline is typically higher than north of Point Conception
	All Species >50 fm	Estimate Includes Less Robust Species	Positive	Data	Bank rockfish was included in estimate despite higher mortality rate than expected.
	Long-term Mortality All Species <50 fm	Depth of Estimate Greater than Depth Applied	Positive	Data	Rates were developed using data from greater than 70 fm, but is applied to shallower depths where mortality may be lower.

General	All Species <50 fm	Overlap in Mortality between Estimates	Positive	Data	Overlap in time for 0-50 fm short-term and long-term mortality rates for days 3 and 4 included in both studies.
	All Species All Depths	Repeated Capture Bias	Negative	Qualitative	Depends marginal increase rates and probability of multiple encounters
	All Except Yelloweye 30-50 fm, Cowcod >50 fm	Use of Proxy Species	Neutral	Data	Appropriate species were selected as proxies, minimizing potential biases, which could be positive or negative.

Appendix B. National Standard Guidelines in the Magnuson-Stevens Fisheries Conservation and Management Act Reauthorized

(http://www.nmfs.noaa.gov/msa2007/docs/act_draft.pdf)

Standard 1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield (OY) from each fishery for the U.S. fishing industry.

Standard 2. Conservation and management measures shall be based upon the best scientific information available.

Standard 3. To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

Standard 4. Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various U.S. fishermen, such allocation shall be:

(1) Fair and equitable to all such fishermen.

(2) Reasonably calculated to promote conservation.

(3) Carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.

Standard 5. Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.

Standard 6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.

Standard 7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

Standard 8. Conservation and management measures shall, consistent with the conservation requirements of the Magnuson-Stevens Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to:

(1) Provide for the sustained participation of such communities; and

(2) To the extent practicable, minimize adverse economic impacts on such communities.

Standard 9. Conservation and management measures shall, to the extent practicable:

(1) Minimize bycatch; and

(2) To the extent bycatch cannot be avoided, minimize the mortality of such bycatch.

Standard 10. Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

Agenda Item D.5.b
Supplemental CDFW Report
April 2013

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE REPORT ON ACCOUNTING FOR USE of Descending Devices in the California Recreational fishery

Introduction

At its November 2012 meeting, the Pacific Fishery Management Council (Council) reviewed a progress report by the Groundfish Management Team (GMT) regarding development of methods for estimating mortality rates for rockfish released with a descending device. Rockfish discard mortality estimates currently do not take into account the use of descending devices, yet research supports lower mortality rates for those rockfish released with a descending device than for those released without one (Scientific and Statistical Committee, I.3.b. Supplemental SSC Report, November 2012).

Mortality estimates for recreational fisheries could be improved by incorporating credible estimates of the proportions of rockfish released using descending devices. Thus, the Council requested that each state provide a description of their proposed methods for estimating the proportions of fish released using descending devices in the recreational fishery for review by the GMT and SSC at this meeting. The Council recommended methods focus specifically on canary, cowcod, and yelloweye rockfish since they pose the greatest constraint to recreational fisheries.

This report outlines California Department of Fish and Wildlife's (CDFW) proposed methods for estimating the proportion of canary, cowcod and yelloweye rockfish released using a descending device.

California Recreational Fisheries Survey (CRFS) Sampling Methods

CRFS generates estimates of total marine recreational finfish catch and effort in California. Catch and effort data are collected for the four major modes of fishing: party and charter boats (PC; also known as commercial passenger fishing vessels or CPFVs), private and rental boats (PR), man-made structures, and beaches and banks. Monthly estimates are produced for each fishing mode in each of six geographic districts[1]. A detailed description of CRFS sampling design and data collections methods is available at http://www.dfg.ca.gov/marine/crfs.asp.

In March 2012, CDFW started collecting data on descending device use for cowcod in the PC mode. In 2013, CRFS expanded data collection to include use of descending

[1] The southern boundary of District 1 is the California – Mexico border, and the northern boundary of District 6 is the California – Oregon border.

devices for all released rockfish in the boat fishing modes (PC and PR). CRFS is focusing descending device data collection efforts on the boat modes, since they comprise the majority (98 percent) of recreationally-caught rockfish in California, and fish released from shore modes suffer limited if any barotrauma.

Party and Charter Boats (PC)

Party and charter boats are licensed by CDFW to take paying passengers on sport fishing trips. Catch data are collected using an on-site intercept survey, which is conducted either onboard PC vessels at-sea or dockside at the end of the fishing trip. The data are a combination of onboard sampler-observed data, captain-reported data and angler-reported data, unlike the PR survey which exclusively collects angler-reported data. The frequency of sampling varies by month and district.

The following data elements are collected to inform descending device use in PC surveys:

1. Trip-level descending device use information (i.e., whether a descending device was used on the trip): These data are collected in both the onboard and dockside surveys.
2. Numbers of fish released (alive or dead) by species: Numbers are recorded based on angler-reported data and are collected in both the onboard and dockside PC surveys.
3. Species-level descending device use information: While sampling onboard PCs at sea, the sampler observes the fishing activity of a sub-set of anglers at each fishing stop and records numbers of fish released (alive or dead) by species and the number of fish released with a descending device by species.

In addition CDFW is in the process of modifying CPFV logbooks to gather information on the proportion of vessels that report using descending devices at the trip level for comparison to and supplementation of results from CRFS sampling.

Private and Rental Boats (PR)

The primary private and rental boats sites (PR1) include public ramps, hoists, and other launch facilities where at least 90 percent of fishing effort and catch of rockfish occurs in California. Private and rental boat sites where less rockfish catch and effort occurs are designated as PR2 sites. PR1 sites are sampled during daylight hours using an access point survey method (*i.e*., on-site intercept design). Each PR1 site is sampled at least 20 percent of each day type (weekdays and weekends/holidays) in the month, where sampling days are randomly selected by day type.

PR1 catch data are strictly angler-reported unlike in the PC mode where catch data may be recorded by onboard CRFS samplers. Data on descending device use are not being collected at PR2 sites at this time; therefore data from the PR1 mode will be used.

Species-level information, including numbers of fish released (alive or dead) by species, and the number of fish released alive using a descending device are collected to inform descending device use in the PR1 survey.

Data Availability

Data are available to inform descending device use in the recreational fisheries; the amount varies by district and species. While catches of canary, yelloweye and particularly cowcod will continue to be rare events (due to management actions that are intended to avoid interactions with these species), CDFW expects that the use of descending devices will increase in the near-future in part due to extensive outreach and education.

The primary factor for selecting the estimation method for each species, district and fishing mode will be number of encounters. Pooling data across months and districts will be tested prior to application. If pooling isn't valid or does not provide sufficient encounters to generate a reliable estimate using direct observations, then proxies may be used. If the Council approves the use of revised mortality rates in management, CDFW will focus initial efforts on estimating descending device use in those areas where species are most likely to occur.

Canary Rockfish

Direct species-level observations for PC and PR modes are available to estimate the proportion of descending device use in Districts 3-6 (Point Conception to the California/Oregon border). Some pooling of data may be required across months and districts for PC trips.

Cowcod

Since cowcod encounters are rare, there are relatively few direct species-level observations to estimate the proportion of descending device use in either mode for all districts. For those districts where cowcod commonly occur (Districts 1-2, Point Conception to the California/Mexico border) proxies will be used to estimate the proportion of descending device use.

Yelloweye Rockfish

Direct species-level observations for the PR mode are available to estimate the proportion of descending device use in Districts 5-6 (Point Arena to the California/Oregon border) and possibly Districts 3-4 (Point Conception to Point Arena). Pooling of data across months and districts may be required for Districts 3-4. Few direct observations are available for Districts 3-6 for the PC mode and proxies may be used to estimate the proportion of descending device use.

Methods for Estimating Descending Device Use

Two methods are proposed to estimate the catch of fish released with a descending device. The intent of using multiple methods is to allow the use of best available data to estimate descending device use. Estimates will be made for each mode (PC and PR) separately and applied to estimates of released fish. The first method uses direct species-level observations and the other method uses proxies for each mode (PC and

PR). Direct species-level observations are preferred and will be used to estimate descending device use for as many modes and districts as possible; otherwise estimates will be made using proxy data.

The following caveats will apply to determining proportion of catch released using descending devices:

1. Estimates will be made at the end of the year and applied retrospectively. This will maximize the amount of data available for pooling. In addition, it will allow analyses to validate pooling assumptions and evaluate the statistical properties of the proxy methods using data collected in 2013
2. Estimates will not be made for district and months when the groundfish fishery is closed since data reveal that few canary, cowcod or yelloweye rockfish are caught “out-of-season”.
3. Estimates will not be made for individual depth bins. This is likely to result in conservative estimates because it is expected that a higher proportion of fish are released with descending devices in deeper waters compared to shallower waters.

Species-Specific Observations

Species-specific data can be used to estimate the proportion of descending device use. Sampler observations will be used to determine descending device use in the PC mode and angler-reported data will be used for the PR mode. The proportion of descending device use for each species and mode would be calculated as the ratio of the total number of fish released using a descending device to the total number of fish released. Proportion of use may be pooled over different time/district combinations depending upon available data.

For the PR mode, this method assumes that anglers are correctly identifying rockfish species and that anglers are accurately reporting the total number of fish released and the number of fish released with a descending device.

Proxy Data

In the event that species-specific data cannot be used, trip-level data (i.e., whether a descending device was used on the trip) for other species can be used as a proxy for species-specific data on descending device use. It is based on the assumption that if a prohibited species was caught on a trip and a descending device was reported to have been used on the trip the infrequently encountered species would have been released using the descending device. Such an assumption may be valid for cowcod and yelloweye rockfish since they are large, important to management and infrequently encountered. Estimates of the proportion of use in the PC and PR modes would be calculated independently.

Trip-level information on descending device use in the PC mode would be collected from both onboard and dockside sampling; PR trip-level information would be based on angler reports of species released using a descending device. Proportion of use would be calculated as the ratio of the total number of trips with fish released using a descending device to the total number of trips.

Estimates of descending device use derived by this method may be biased low because anglers may be more likely to release prohibited species (especially cowcod and yelloweye rockfish) with a descending device than other species.

In addition, it may be possible to estimate the proportion of descending device use for yelloweye rockfish, using canary rockfish as a proxy. Canary rockfish are encountered more frequently than yelloweye rockfish and it may be possible to apply proportions of descending device use for canary rockfish calculated from species-specific observations to yelloweye rockfish. This approach would only be used when direct estimates of descending device use for yelloweye rockfish cannot be calculated.

This approach assumes that canary and yelloweye rockfish are released with a descending device in the same proportion. Since, encounters with yelloweye rockfish are rare, anglers may be more willing to release them with a descending device than they would canary rockfish. This may result in descending device use estimates that are biased low (i.e., more conservative).

Total Mortality Calculations

Incorporating revised mortality rates will only be applied to the proportion of fish released using a descending device. For the remaining fish released without a descending device, the mortality rate associated with surface release (i.e., more conservative) will be applied. The sum of mortality estimates for fish released at the surface and with descending devices and fish released without a descending device will be combined with retained catch to provide an estimate of total mortality for the recreational fishery.

Future Steps

The proposed methods and applications are based on the best available data under current management. Changes in data availability may precipitate changes in the estimation methods for each district, species and fishing mode; therefore the methods proposed in this report are meant as a starting point and modifications and/or refinements would be expected in the future.

Agenda Item D.5.b
Supplemental GAP Report
April, 2013

GROUNDFISH ADVISORY SUBPANEL REPORT ON BAROTRAUMA DEVICE MORTALITY RATES

The Groundfish Advisory Subpanel (GAP) was briefed by Mr. Ken Franke of the Sportfishing Association of California (SAC) on updated information from the cooperative research project involving the NFMS Southwest Region and local fishermen that is presently taking place off Southern California on the 43 Fathom Bank.

In one study last fall, this group deployed 5 acoustic data receivers to record data from sonotags on fish that have been returned to depth by means of descending devices. They descended 9 sonotagged cowcod last fall. Data has been recovered from these acoustic data devices.

This spring, the program installed 17 acoustic data receivers on the bank. The data from these 17 acoustic data receivers should be available in 3 months. During the duration of these two studies, the program has placed sonotags on 20 cowcod and 12 bocaccio. These sonotags send out signals indicating depth and activity (by accelerometer) of released fish. To date, no mortality has been observed for the cowcod released using these descending devices.

The SAC stated expects that this effort will continue to provide data to inform confidence levels regarding the utility of descending devices on cow cod.

The SAC referred to efforts taking place in California to inform the public regarding the existence of descending devices and to increase their popularity and use among the fishing public. This would also increase confidence in the level of use in the recreational fleet. The CPFV fleet in California is now in full utilization mode and will be required to report their use on their daily state trip reports.

Oregon has been using and recording the use of these descending devices for some time. Washington has also rolled out an aggressive program to utilize descending devices in their recreational fisheries.

Mr. John Budrick of the California Dept. of Fish and Wildlife then addressed the GAP. He presented data and recommendations from the GMT. This data was also supportive of the use of descending devices.

While this historical data did not show 100% survival with regard to mortality rates, it still illustrated the effectiveness of the use of these devices, when compared to surface release. The data also demonstrated that Cowcod, Canary and Yelloweye Rockfish have robust physical characteristics that may contribute to reduced mortality rates when recompressed. Even marginal savings are important in restricted fisheries.

The GMT expressed that their concern less about giving credits for use of descending devices, but more about reflecting the true state of the fishery where these devices are being used.

The Gap would like the Council to apply appropriate mortality credits to cases where, fisheries are using descending devices to provide reduction in mortality.

The GAP would like to point out that the use of devices and methods to facilitate recompression of live discards might also aid in the management of some commercial fisheries.

In addition, support for the mandatory possession of these devices on recreational vessels was expressed.

The GAP supports use of descending devices and, relative to mortality credits, agrees with the approach detailed by the GMT in their report.

This subject of the application of credits for successful release in determining management actions was discussed. The GMT has proposed a framework for giving these credits, and has passed on to the Council a range of confidence levels to consider.

The GAP feels that a moderate and progressive approach to confidence levels, reflecting existing favorable data would be productive. The consistent use of conservative buffers in the GMT analysis assures that the risk of underestimating mortality will remain low.

PFMC
04/07/13

Agenda Item D.5.b
Supplemental GMT PowerPoint
April 2013

Proposed Mortality Estimates Reflecting the Use of Descending Devices in the Recreational Fishery

Groundfish Management Team

Methodological Overview

Components of Mortality Estimates

- Short-term Mortality
  - 0 - 2 or 4 day – cage studies
  - species specific and proxies for other species – varies by depth
- Long-term Mortality
  - 3-10+ day – acoustic tagging, proxies for other species
  - species specific and proxies for other species = 15%
- Unaccounted for Mortality
  - Account for differences in outcomes between studies and anglers
    - research review in BB Attachment 1 Appendix A
    - 5% for cage studies in 0-50 fm
    - 10% for acoustic studies 50+fm
- Buffers for Management Uncertainty
  - Selected by Council on Upper Confidence Limits

Cumulative Mortality

Multiplicative combination of mortality components

Species	Depth (fm)	Short-Term Mortality	Long-Term Mortality	Additional Unaccounted for Mortality	Cumulative Mortality
Canary	0-10	NA	NA	NA	NA
	10-30	1%	15%	5%	20%[1]
	30-50	17%	15%	5%	33%[1]
	>50	23%	NA	10%	31%[2]
Yelloweye	0-10	NA	NA	NA	NA
	10-30	1%	15%	5%	20%[1]
	30-50	3%	15%	5%	22%[1]
	>50	23%	NA	10%	31%[2]
Cowcod	0-10	NA	NA	NA	NA
	10-30	22%	15%	5%	37%[1]
	30-50	22%	15%	5%	37%[1]
	>50	23%	NA	10%	31%[2]

1. M =1 – (1–Short-Term Mortality) x (1–Long-Term Mortality) x (1-Unaccounted for Mortality)

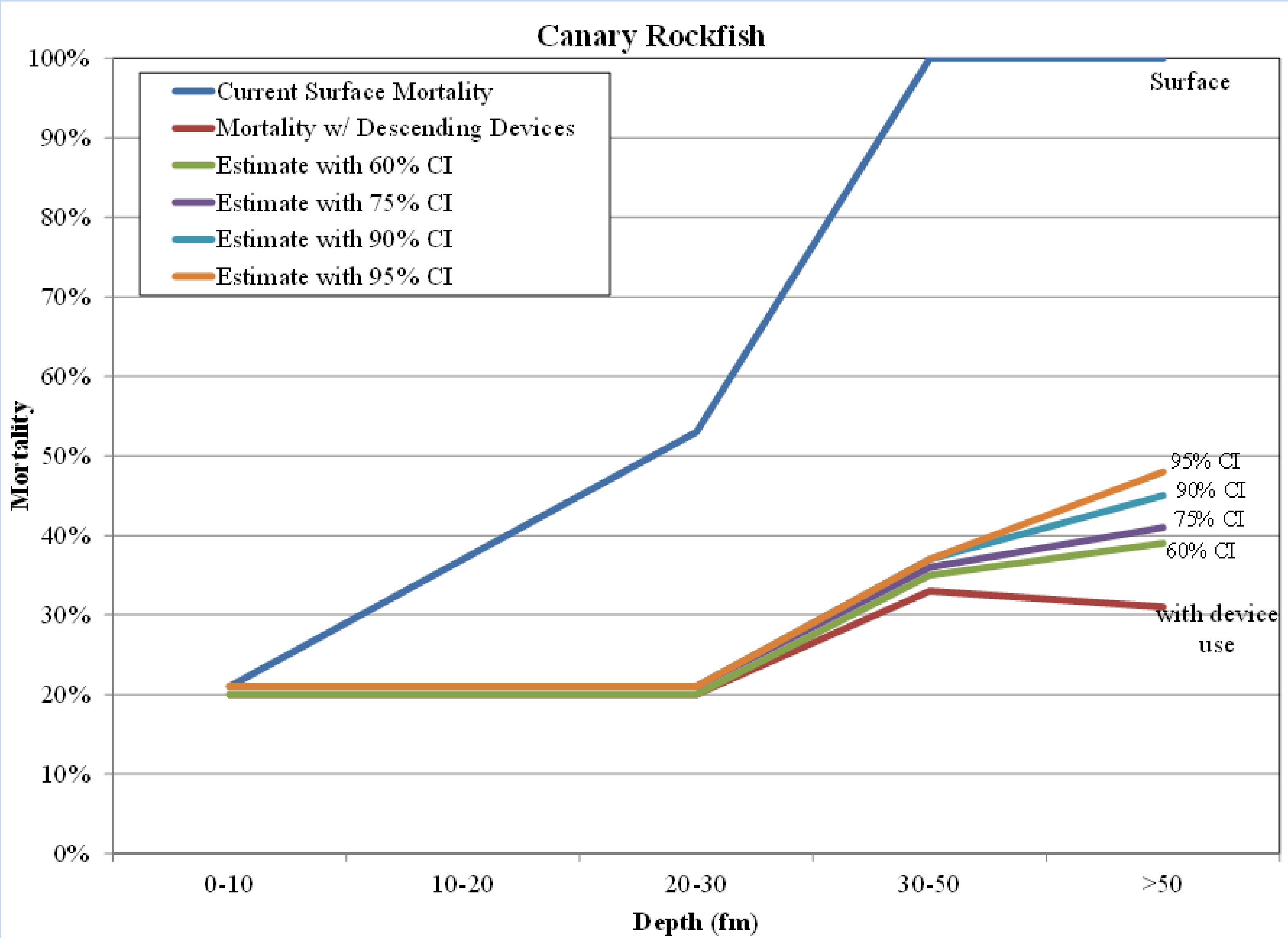
2. M =1 – (1- 0.23 Wegner All RF 10+ Days) x (1-Unaccouted for Mortality))

Buffers based on Upper Confidence Intervals of Mortality Estimates

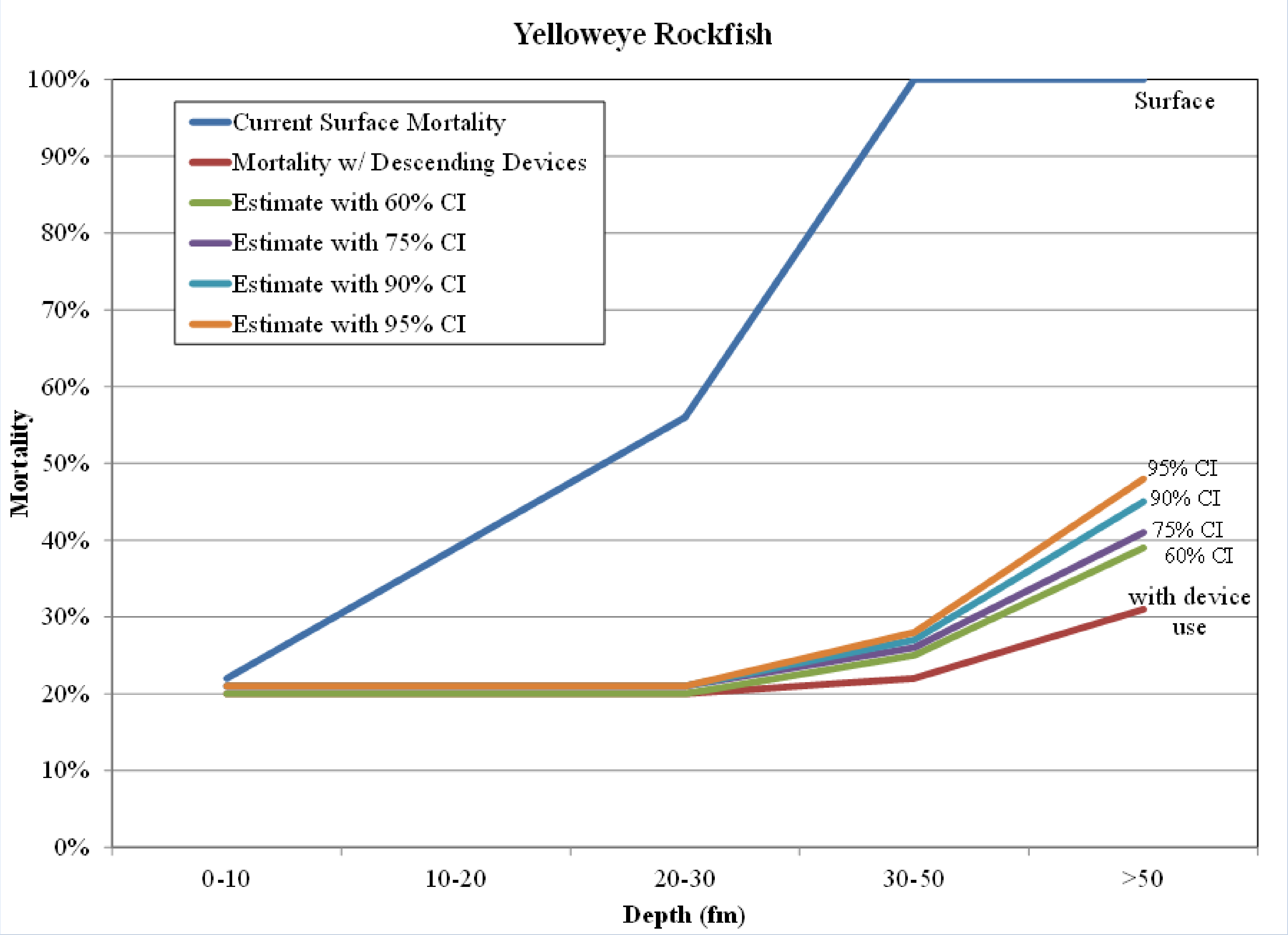
Selected by the Council to address:

- Management uncertainty
- Risk associated with potential underestimation of mortality
- Comfort with methods employed
- Uncertainty from low sample size in greater than 50 fm

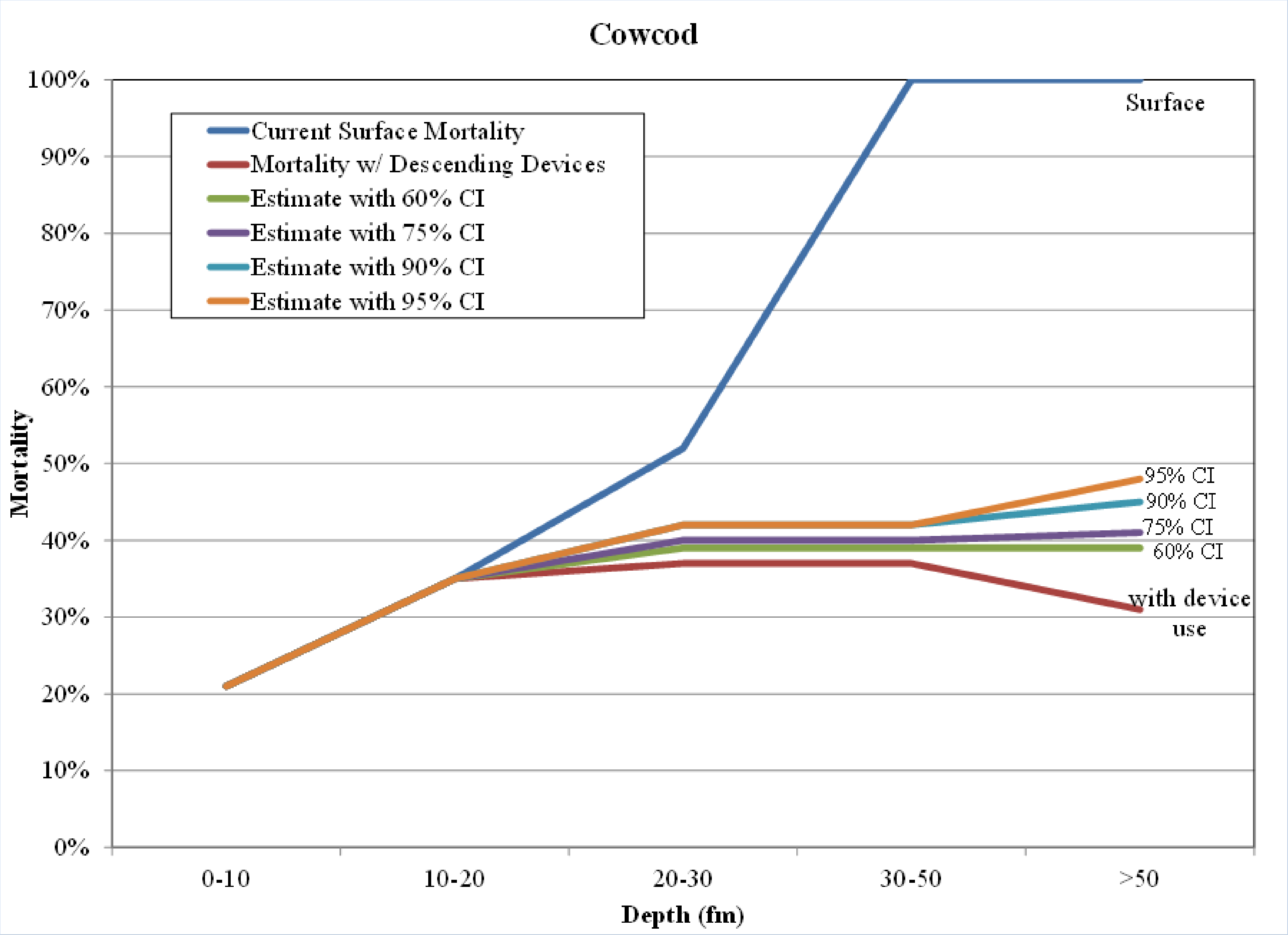
Comparison to Surface Mortality



Comparison to Surface Mortality



Comparison to Surface Mortality



Next Steps in Implementation

- Each state has submitted state reports regarding the methods of applying mortality rates

- Apportion catch by proportion of fish released using descending devices and depth then apply mortality estimate

- Sample programs augmented to provide data on frequency of use

- Application retrospectively to 2013 allowing analyses of statistical properties of direct estimation methods, proxies and pooling rules

- Further review of the methods proposed by each state to be conducted by the RecFIN Technical Subcommittee as well as the GMT and SSC as needed

Implications for Rebuilding and Management

Implications for Rebuilding

- Marginal reduction in total mortality estimate relative to the ACL i.e. Oregon 2011 = <0.58 mt reduction vs 17 mt ACL in 2011

Implications for Management

- Reduction in mortality relative to low harvest guidelines

- Avoid inseason closure and allow longer seasons with tangible economic effects

- Council policy decision regarding how to use the savings

Questions?

Buffers based on Upper Confidence Intervals of Mortality Estimates

Species	Depth (fm)	Current Surface Mortality	Cumulative Mortality w/ Devices	Estimate with 60% CI	Estimate with 75% CI	Estimate with 90% CI	Estimate with 95% CI
Canary Rockfish	0-10	21%	20%	20%	21%	21%	21%
	10-20	37%	20%	20%	21%	21%	21%
	20-30	53%	20%	20%	21%	21%	21%
	30-50	100%	33%	35%	36%	37%	37%
	>50	100%	31%	39%	41%	45%	48%
Yelloweye Rockfish	0-10	22%	20%	20%	21%	21%	21%
	10-20	39%	20%	20%	21%	21%	21%
	20-30	56%	20%	20%	21%	21%	21%
	30-50	100%	22%	25%	26%	27%	28%
	>50	100%	31%	39%	41%	45%	48%
Cowcod	0-10	21%	21%	21%	21%	21%	21%
	10-20	35%	35%	35%	35%	35%	35%
	20-30	52%	37%	39%	40%	42%	42%
	30-50	100%	37%	39%	40%	42%	42%
	>50	100%	31%	39%	41%	45%	48%

Short-Term Mortality

- **Species-specific estimates**
  - **Limited sample size**
    - **Combine Depths**
    - **Proxy Species**
    - **Proxy data <10 fm**
      - **Lower of surface mortality or next deeper bin**

Canary Rockfish

Capture depth (fm)	Alive	Dead	Total	Mortality (%)
0-10	NA	NA	NA	NA
10-20	15	0	15	0%
20-30	30	0	30	0%
30-40	5	1	6	17%
40-50	4	1	5	20%
Grand Total	54	2	56	4%

Yelloweye Rockfish

Capture depth (fm)	Alive	Dead	Total	Mortality (%)
0-10	NA	NA	NA	NA
10-20	5	0	5	0%
20-30	31	0	31	0%
30-40	43	1	44	2%
40-50	18	1	19	5%
Grand Total	97	2	99	2%

Cowcod

Capture Depth (fm)	Alive	Dead	Total	Mortality (%)
0-50	NA	NA	NA	NA
51-70	11	5	16	31%
70-100	4	0	4	0%
Grand Total	15	5	20	25%

Proxy Estimates for Canary

Species	Depth (fm)	Source of Short Term Mortality Data	Reason for Use of Proxy Data	Sample Size	Lived	Died	Mortality
Canary Rockfish	0-10	Surface Release Mortality (PFMC 2009) or 10-30 fm	No data at this depth. Devices likely not needed	NA	NA	NA	NA
	10-30	Canary, yelloweye, copper and quillback rockfish (Hannah et al 2012)	Similar life history and anatomy	119	119	0	0%
	30-50	Bocaccio, flag and vermilion rockfish (Jarvis and Lowe 2008) / yelloweye and canary rockfish (ODFW unpublished data)	Only 11 samples for canary rockfish. Similar life history and anatomy.	256	212	44	17%
	>50	Cowcod, bocaccio, bank, sunset (Wegner et al. in prep)	No observations for subject species. Similar life history and anatomy.	30	23	7	23%

Proxy Estimates for Yelloweye RF

Species	Depth (fm)	Source of Short Term Mortality Data	Reason for Use of Proxy Data	Sample Size	Lived	Died	Mortality
Yelloweye Rockfish	0-10	Surface Release Mortality (PFMC 2009) or 10-30 fm	No data at this depth. Devices likely not needed	NA	NA	NA	NA
	10-30	Canary, yelloweye, copper and quillback rockfish (Hannah et al 2012)	Similar life history and anatomy	119	119	0	0%
	30-50	Yelloweye (Hannah et al. 2012, ODFW, unpublished data)	NA-Sample size sufficient.	63	61	2	3%
	>50	Cowcod, bocaccio, bank, sunset rockfish (Wegner et al. in prep)	No observations for subject species. Similar life history and anatomy.	30	23	7	23%

Proxy Estimates for Cowcod

Species	Depth (fm)	Source of Short Term Mortality Data	Reason for Use of Proxy Data	Sample Size	Lived	Died	Mortality
Cowcod	0-10	Surface Release Mortality (PFMC 2009) or 10-30 fm	No data at this depth. Devices likely not needed	NA	NA	NA	NA
	10-30	Bocaccio, flag and vermilion rockfish 30-50 fm (Jarvis and Lowe 2008)	No observations for subject species. Similar life history and anatomy.	NA	NA	NA	22%
	30-50	Flag, vermilion and bocaccio (Jarvis and Lowe 2008)	No observations for subject species. Similar life history and anatomy.	182	142	40	22%
	>50	Cowcod, bocaccio, bank, sunset rockfish (Wegner et al. in prep)	NA-Limited data available for subject species. Similar life history and anatomy.	30	23	7	23%

Long-Term Mortality

- 15% based on acoustic tagging study by Wegner et al. in prep
- 23 out of 27 fish in the array survived from day 3 to10+ days
- No additional morality observed beyond day six for fish remaining in the array
- Uncertainty in fate of the 20 fish that left the array, though behavior was similar prior.
- Appears conservative compared to some barometric chamber studies and 10 day morality

Unaccounted for Mortality and Uncertainty

- Address negative bias in estimates compared to expected mortality when released by anglers

- Weighed potential sources of positive and negative bias.

- Detailed review in BB report Appendix A

- 5% for cage studies in 0-50 fm
-10% for acoustic studies 50+fm

Data Sources

- **0 - 2 or 4 Day Cage Study Mortality Rates**
  - Hannah et al. 2012
  - Similar ODFW unpublished data
  - Jarvis and Lowe 2008
- **Long-Term Bottom Mortality**
  - Acoustic Tagging Data from Wegner et al. (in prep) presented to the Council in November 2012
- **Unaccounted for mortality**
  - Preponderance of bias and uncertainty between treatment by anglers and results of barotrauma studies informing estimates.
  - See references in BB report

Potential Biases and Sources of Uncertainty

- Addressed by unaccounted for mortality also accounting for potential positive biases.

- Sources evaluated for:
  - Cage studies
  - Acoustic tagging
  - General considerations
  - Water temperature
  - Use failure rates applied to frequency of use

Potential Biases and Sources of Uncertainty

Cage Studies

Data Source	Affected Estimates	Uncertainty	Direction	Measure	Considerations
Cage Studies: Hannah et al. (2012), Jarvis and Lowe (2008)	All Species in <50 fm	Handling Bias	Neutral	Qualitative	Measuring and Tagging = Assumed Angler Treatment
	All Species in <50 fm	Time on Deck Bias	Negative	Data	Likely released using device immediately if at all.
	All Species in <50 fm	Cage Protection Bias	Negative	Data	Predation upon release at depth appears limited.
	All Species in <50 fm	Stress Induced Mortality from Captivity	Positive	Qualitative	Confined fish may be stressed or deprived of food.
	Canary Rockfish 30-50 fm	Jarvis and Lowe Conducted in Southern California	Positive	Qualitative	Temperature difference due to thermocline is typically lower north of Point Conception where canary rockfish are more common

Potential Biases and Sources of Uncertainty

Acoustic Tagging Studies

Data Source	Affected Estimates	Uncertainty	Direction	Measure	Considerations
Acoustic Tagging: Wegner et al. (in prep)	All Species >50 fm	Mortality Inside vs. Outside Array	Neutral	Qualitative	Behavior same as others before departing array
	All Species >50 fm	Mortality at 10 days = 4 month	Neutral	Data	No mortality in array beyond 6 days up to 4 months.
	Canary and Yelloweye >50 fm	Data collected in Southern California	Positive	Qualitative	Temperature difference due to thermocline is typically higher than north of Point Conception
	All Species >50 fm	Estimate Includes Less Robust Species	Positive	Data	Bank rockfish was included in estimate despite higher mortality rate than expected.
	Long-term Mortality All Species <50 fm	Depth of Estimate Greater than Depth Applied	Positive	Data	Rates were developed using data from greater than 70 fm, but is applied to shallower depths where mortality may be lower.

Potential Biases and Sources of Uncertainty

General Considerations

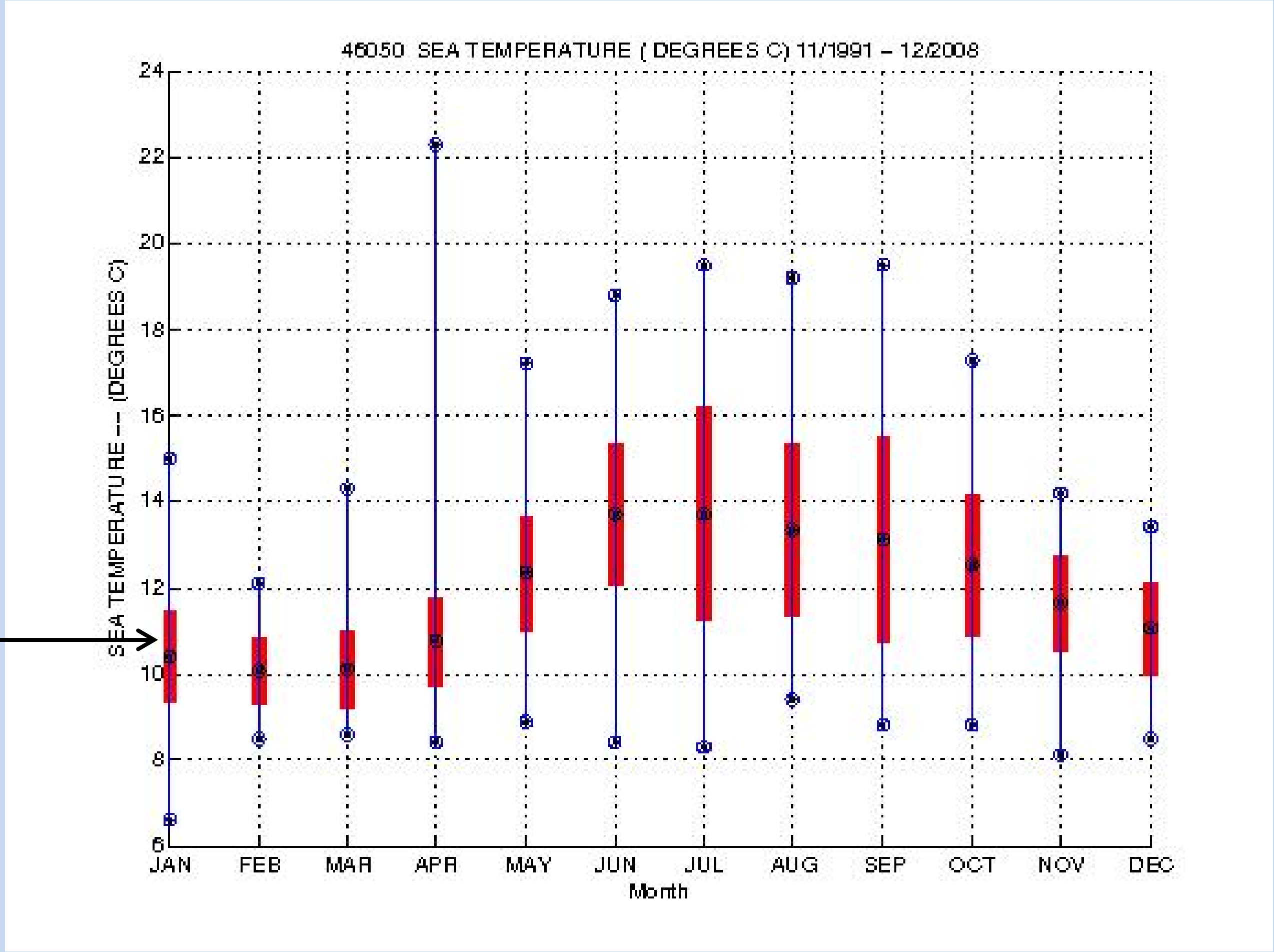
Data Source	Affected Estimates	Uncertainty	Direction	Measure	Considerations
General	All Species <50 fm	Overlap in Mortality between Estimates	Positive	Data	Overlap in time for 0-50 fm short-term and long-term mortality rates for days 3 and 4 included in both studies.
	All Species All Depths	Repeated Capture Bias	Negative	Qualitative	Depends marginal increase rates and probability of multiple encounters
	All Except Yelloweye 30-50 fm, Cowcod >50 fm	Use of Proxy Species	Neutral	Data	Appropriate species were selected as proxies, minimizing potential biases, which could be positive or negative.

- Use failure rates will be considered for application to frequency of use in applying mortality rates
- Water temperature at the time of the study vs. fishing

Hannah et al. (2012)

May – November, Average September, 2009-2012

Mean Temp
= 11.9 C

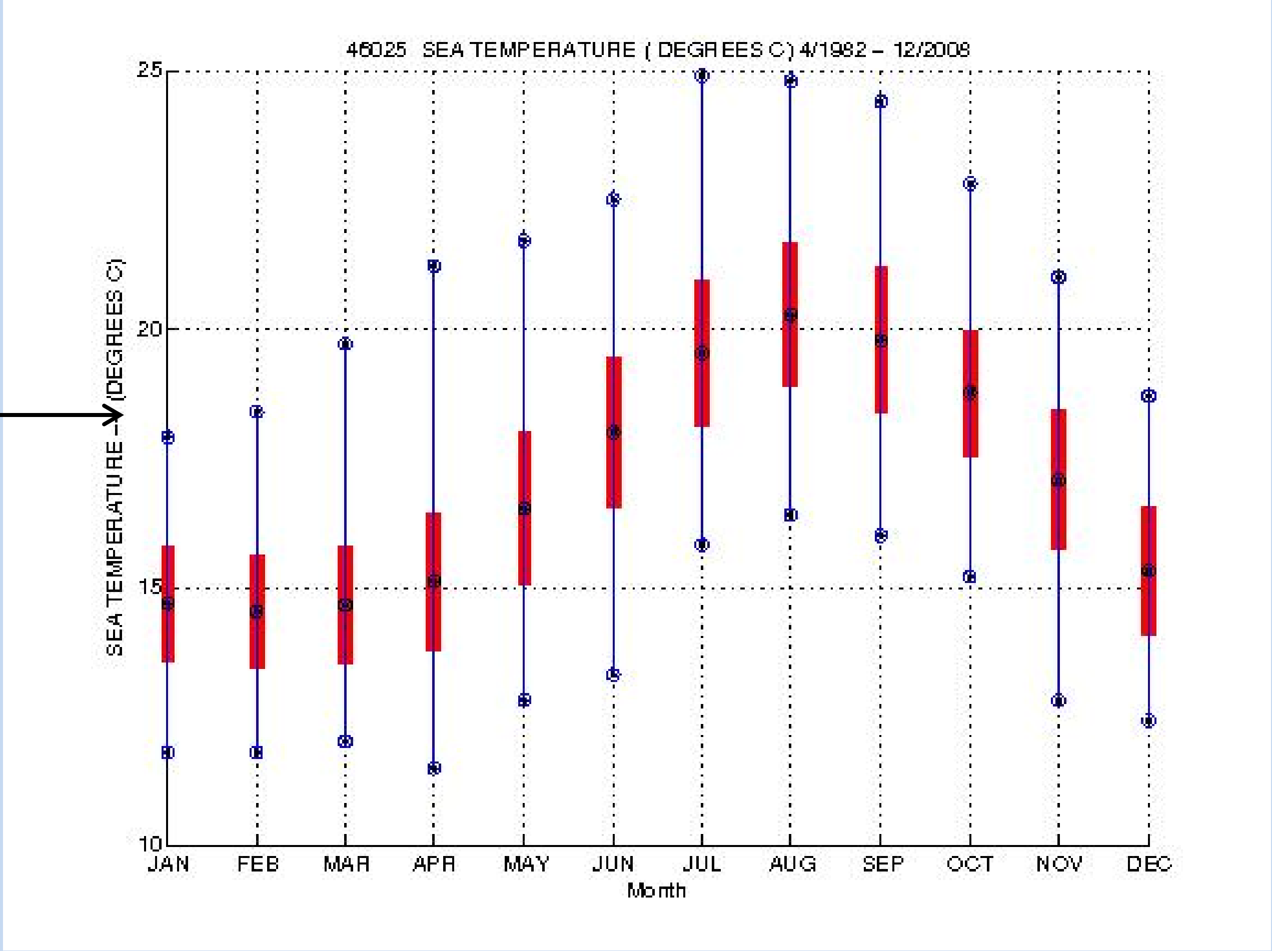


STONEWALL BANK - 20NM West of Newport, OR

Jarvis and Lowe (2008)

Summer 2005 and 2006

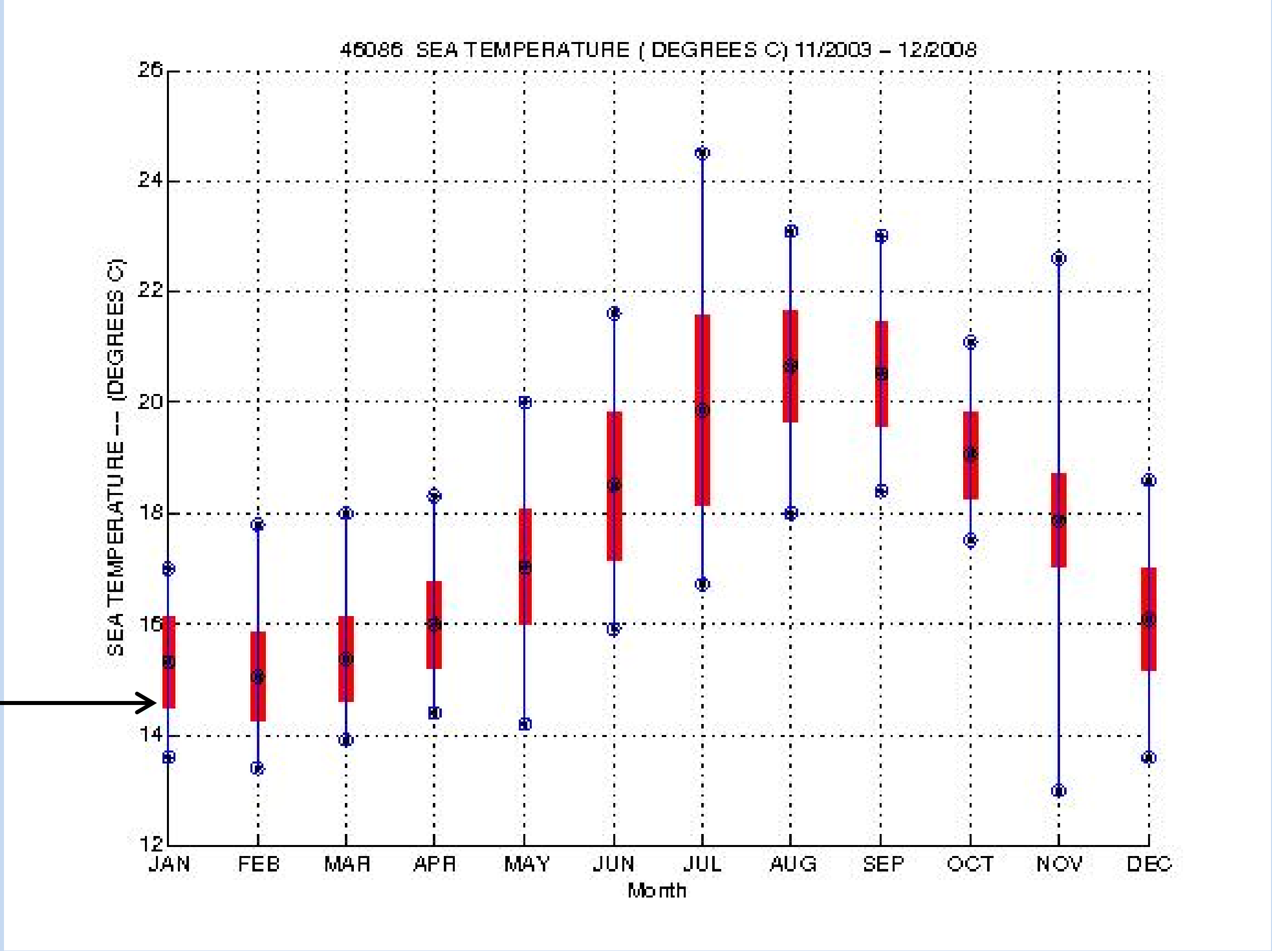
Mean Temp
= 17.9 C
Min = 11.6
Max = 26.1



Santa Monica Basin - 33NM WSW of Santa Monica, CA

Wegner et al. (in prep)

March 2012



Mean Temp = 14.7 C
Min = 13.8
Max = 16.1

SAN CLEMENTE BASIN - 27NM SE OF San Clemente Is, CA

Total Mortality Estimates

- Total mortality estimates reflecting the 60%, 75%, 90% and 95% CI
- Includes upper CI short-term, long-term and unaccounted for mortality

Species	Depth (fm)	Current Surface Mortality	Cumulative Mortality w/ Devices	Estimate with 60% CI	Estimate with 75% CI	Estimate with 90% CI	Estimate with 95% CI
Canary Rockfish	0-10	21%	20%	20%	21%	21%	21%
	10-20	37%	20%	20%	21%	21%	21%
	20-30	53%	20%	20%	21%	21%	21%
	30-50	100%	33%	35%	36%	37%	37%
	>50	100%	31%	39%	41%	45%	48%
Yelloweye Rockfish	0-10	22%	20%	20%	21%	21%	21%
	10-20	39%	20%	20%	21%	21%	21%
	20-30	56%	20%	20%	21%	21%	21%
	30-50	100%	22%	25%	26%	27%	28%
	>50	100%	31%	39%	41%	45%	48%
Cowcod	0-10	21%	21%	21%	21%	21%	21%
	10-20	35%	35%	35%	35%	35%	35%
	20-30	52%	37%	39%	40%	42%	42%
	30-50	100%	37%	39%	40%	42%	42%
	>50	100%	31%	39%	41%	45%	48%

Methods of Applying Mortality Estimates in Catch Accounting

- General Method
  - Apportion catch to depth with proportion of catch by depth
  - Apply corresponding mortality estimates in each depth bin

- Current Management Measures Limit Sample Size
  - Current management measures minimize encounters limiting sample size for estimating frequency of use

- Solutions
  - Pooling across time or area
  - Proxies based on
    - other species
    - trip level use estimates

Agenda Item D.5.b
Supplemental GMT Report 2
April 2013

GROUNDFISH MANAGEMENT TEAM REPORT ON DESCENDING DEVICE MORTALITY IN RECREATIONAL FISHERIES

The Groundfish Management Team (GMT) had the opportunity to further review and discuss the GMT report on proposed discard mortality rates for cowcod, canary, and yelloweye rockfish released with descending devices in the recreational fisheries (Agenda Item D.5.b, GMT Report). Additionally, the GMT had a lengthy discussion with the Scientific and Statistical Committee (SSC).

The GMT report describes how data from current published and ongoing research was used to estimate mortality for cowcod, canary, and yelloweye rockfish that reflect improved survivability of rockfish released with descending devices in recreational fisheries. The final estimates of discard mortality provided in this report benefited from input from the SSC on issues such as: how to handle the limited amount of species-specific estimates of mortality from the studies, the development of buffers to address unaccounted-for mortality, and differences in the study designs.

State Implementation Plans

Council guidance in November was for the states to provide reports outlining implementation that could be reviewed by the GMT and SSC at this meeting, recognizing that the timing of implementation could be different for each state. The GMT had the opportunity to review the California, Washington, and Oregon reports, but had very little time for discussion. The GMT and the SSC discussion focused on issues surrounding the final estimates of mortality, but there was not time to discuss the specifics of the state implementation reports. The GMT recognizes that there may not have been sufficient opportunity to review these reports at this meeting, but that comments could be provided at a future meeting.

In an effort to put the proposed mortality rates into perspective, the GMT used a hypothetical rate of use (based on actual information from the Oregon recreational fishery for May and June of 2012) of descending devices and applied that to depth-specific yelloweye rockfish encounters in Washington and Oregon for 2011, as an example. Table 1 shows estimates of yelloweye rockfish mortality under the range of alternatives being considered by the Council, and the difference from the current surface mortality rates.

It is likely that the difference in mortality for cowcod, canary and yelloweye rockfish resulting from adopting mortality rates reflecting the use of descending devices and the current usage rates, compared to current mortality based on surface release mortalities, will not be sufficient to allow less restrictive management measures. However, it may prevent additional inseason restrictions, including closures, from being necessary. As angler awareness and use of devices increases, some liberalization to current regulations could be considered in the future.

Table 1. Total mortality of yelloweye rockfish under the range of alternatives, using 2011 as an example.

	Oregon		Washington	
Method	**Discard Mortality (mt)**	**Difference from Surface Mortality (mt)**	**Discard Mortality (mt)**	**Difference from Surface Mortality (mt)**
Surface	1.95	--	2.16	--
Mortality Rate w/ Descending Devices	1.37	0.58	1.51	0.65
Estimate w/ 60% CI	1.40	0.55	1.55	0.61
Estimate w/75% CI	1.42	0.53	1.57	0.59
Estimate w/ 90% CI	1.43	0.52	1.59	0.57
Estimate w/ 95% CI	1.45	0.50	1.60	0.56

Public Comment

The GMT received comments from Ken Franke and Michelle Gandola with the Sportfishing Association of California. We appreciate their time and presentation and look forward to the results of their study. The GMT encourages continuation of this study and similar studies to obtain more data on additional depths and species, to inform mortality rates when descending devices are used.

Additional Considerations

Currently, a variety of researchers are conducting work on recompression and descending devices, including at deeper depths and with additional species. These studies may also inform or update the current surface mortality rates. The GMT would like the Council to consider when and how new information from these studies will be incorporated into the mortality rates used. The GMT hopes to avoid a process where an update is expected any time new information becomes available or a new study is published. The GMT suggests that mortality estimates could be revisited in the even year of the biennial cycle (also called the off-year), so that any changes would be made in time to be incorporated into recreational projection models for the biennial harvest specifications and management analysis and documentation. However, if there is new information specific to species and/or depths with limited information, the Council would have the freedom to change the timeline.

GMT Recommendations:

1. **Choose mortality rates for the use of descending devices, using one of the upper confidence intervals to be precautionary.**
2. **Consider how and when to incorporate new information into mortality rates.**

PFMC
04/07/13

Agenda Item D.5.b
Supplemental ODFW Report
April 2013

Incorporation of discard mortality for rockfish released with descending devices into management of Oregon recreational fisheries

Summary

This report outlines information on descending device use in Oregon and a proposed method for incorporating new discard morality estimates into management of Oregon's recreational fisheries in 2013.

Descending device use data collection

In anticipation of development of discard mortality estimates for rockfish released with descending devices, the Oregon Department of Fish and Wildlife (ODFW) began collecting usage data in the recreational fishery in May 2012; specifically the proportion of yelloweye and canary rockfish released with devices by depth. Oregon Recreational Boat Survey (ORBS) creel samplers ask: "Of the X yelloweye rockfish (or canary rockfish) released, how many were released with a descending device?". When coupled with an earlier question that asks the depth where fishing occurred, the proportion of either species released with descending devices by depth can be determined. Since the descending device question is part of the standard interview process, the type of release (i.e., with or without a device) is known for the majority of yelloweye or canary rockfish which feeds into catch expansions. Data exists for all ports, boat types (i.e., charter and private), trip types (i.e., groundfish, salmon, halibut, "combo"), months, and depths that are sampled by the ORBS program (Figure 1).

Proposed method for incorporating descending device use into inseason catch accounting

The proposed method for incorporating descending device use into inseason catch accounting for Oregon recreational fisheries has been reviewed by the Economics Sub-Committee of the Council's Scientific and Statistical Committee (as part of Oregon recreational groundfish model review in March 2012); no revisions were suggested. Further review by the Recreational Fisheries Information Network (RecFIN) Technical Committee will occur following their March meeting.

Currently, discard mortality is only affected by the distribution of catch among four different depth bins with different surface mortality rates ("death-by-depth" mortality matrix). Accordingly, impacts are relatively low if a greater proportion of catch occurs in shallow, low mortality depth bins, whereas impacts are relatively high if a greater proportion of catch occurs in deeper, high mortality depth bins.

If discard mortality estimates for rockfish released with descending devices are approved by the Council, then discard mortality will still be affected by the proportional distribution of catch among depth bins, but also by the type of released method use (i.e., at the surface or with a device).

Proposed discard mortality formula for using dual mortality estimates (for fish released at the surface and with descending devices)

Key: *RS = Released at surface; RD= Released at depth; P = Proportion (of fish); DMP = Discard mortality proportion; Depth is in fathoms; used theoretical values for DMP RD*

Surface release mortality estimates only

Discard mortality = discard mortality proportion * total fish * average weight of fish

Discard mortality proportion = $\sum_{\text{depths}} (\text{P RS}_{\text{depth}} * \text{DMP RS}_{\text{depth}})$

Example:

Depth (fm)	Fish RS	P RS		DMP RS		Product
0-10	6	0.133	x	0.22	=	0.03
11-20	24	0.533	x	0.39	=	0.21
21-30	12	0.267	x	0.56	=	0.15
> 30	4	0.067	x	1	=	0.07
Total	46			Σ	=	0.45

Dual discard morality estimates (surface release plus release using descending devices)

Discard mortality = discard mortality proportion x total fish x average weight of fish

Discard mortality proportion=$\sum_{\text{depths}} ((\text{P RS}_{\text{depth}} * \text{DMP RS}_{\text{depth}}) + (\text{P RD}_{\text{depth}} * \text{DMP RD}_{\text{depth}}))$

Example:

Depth (fm)	Fish	Fish RD	Fish RS	PRD		DMP RD		P RS		DMP RS		Product

0-10	6	3	3	0.065	x	0.05	+	0.065	x	0.22	=	0.02
11-20	24	12	12	0.261	x	0.1	+	0.261	x	0.39	=	0.13
21-30	12	6	6	0.13	x	0.15	+	0.13	x	0.56	=	0.09
> 30	4	2	2	0.043	x	0.2	+	0.043	x	1	=	0.05
Total	46	23	23							Σ	=	0.29

Timeframe for implementation of discard mortality estimates for descending devices into management

If discard mortality estimates for descending devices are approved by Council, these new proportions can be applied to recreationally-caught groundfish estimates for periods in which descending device use (i.e., the proportion by depth and species) data has been collected. Collection of data on the use of descending devices began in May 2012; therefore Oregon recreational groundfish estimates could be calculated from that time on to reflect use of the devices.

Incorporating descending device use into modeling (of future impacts)

The primary reason ODFW began acquiring descending device use data prior to development of discard mortality estimates was to improve the accuracy of projection models. Having data for longer periods of time increases the likelihood that trends can be detected and allows fishery managers greater confidence in their ability to project impacts. The inclusion of descending device use into the projection model will be evaluated as part of the 2015-2016 biennial harvest specifications and management measures process, or the Amendment 24 tiered National Environmental Policy Act (NEPA) analysis being discussed by the Council.

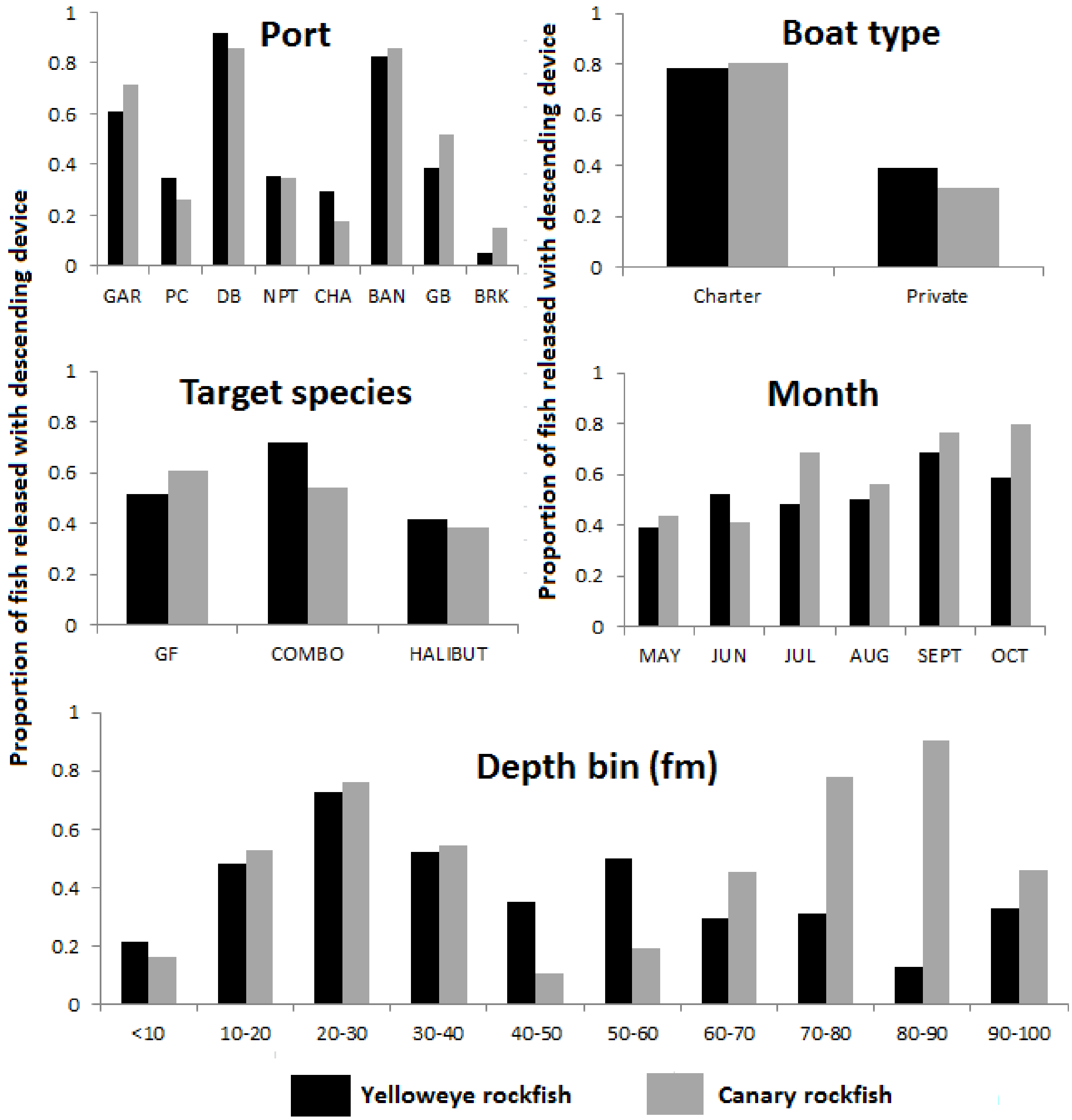


Figure 1. Proportion of yelloweye rockfish (black) and canary rockfish (grey) released with descending devices by port, boat type, target species, month, and depth from May-October 2012.

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON CONSIDER BAROTRAUMA DEVICE MORTALITY RATES

The Scientific and Statistical Committee (SSC) reviewed the Groundfish Management Team (GMT) report on "Proposed discard mortality for cowcod, canary rockfish and yelloweye rockfish released using descending devices in the recreational fishery" (Agenda Item D.5.b) and received a slide presentation by Mr. John Budrick (California Department of Fish and Wildlife [CDFW], GMT). The report condenses and refines information presented to the Council in two previous reports and presents revised values for the mortality of recreationally caught cowcod, canary rockfish and yelloweye rockfish if they were released and returned to depth using descending devices. The GMT report reflects suggestions made in SSC comments to previous reports and resulting from a joint meeting in January of the GMT and SSC Groundfish Subcommittee.

The task of estimating discard mortality rates for these three species is particularly challenging due to the limited number of field studies on the mortality of rockfish released using descending devices. The few studies that include these three particular species provide some data for canary and yelloweye rockfish, but almost no information for cowcod. The mortality estimates developed by the GMT cover four depth bins (0-10 fm, 10-30 fm, 30-50 fm, and >50 fm) and account for three types of mortality: short-term, long-term, and sources not otherwise accounted for.

The information contained in the GMT report is much more clearly presented than in previous versions. The SSC supports the GMT's approach for deriving point estimates of the discard mortality rates by species and depth-bin, with the caveat that the estimates for combined short- and long-term mortality for any of the three species should not decrease with an increase in depth. The mortality estimates for canary rockfish and cowcod taken from depths greater than 50 fm are inconsistent with this principle.

The SSC remains concerned about the lack of information on cowcod. The mortality-by-depth estimates for this species are almost entirely based on proxy species, but the estimates provided in the report do not include an explicit buffer to account for the additional uncertainty due to the use of proxy species. An acoustic tagging study that is currently underway in the southern California bight will provide additional information on the mortality of cowcod released and returned to depth using descending devices. The SSC recommends that the results of this study be examined as soon as possible to evaluate the estimates based on proxy species. Further, the SSC recommends that the Council encourage additional field research to collect information for these three focal species on their mortality after release using descending devices, particularly for capture depths >50 fm.

The SSC notes that the sets of upper confidence limits shown in Table 7 indicate only minor differences in the mortality rates by depth between the different confidence levels (60 percent, 75 percent, 90 percent, and 95 percent). Such small differences imply an implausibly high degree of scientific certainty regarding the mortality rate estimates. The SSC has suggested several methods to the authors of the GMT report for developing more reasonable estimates of the scientific uncertainty. In addition, buffers for bias and scientific uncertainty should be independently delinated.

The SSC was unable to review the supplemental reports from Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife regarding implementation of the new mortality rates in the accounting of catch mortality for management. Should the Council decide to use the new discard mortality rates, the SSC would be willing to review how the rates would be applied in the catch accounting for all three states.

PFMC
04/08/13

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE REPORT ON PROPOSED IMPLEMENTATION OF COUNCIL APPROVED MORTALITY ESTIMATES FOR YELLOWEYE AND CANARY ROCKFISH RELEASED WITH DESCENDING DEVICES

The Washington Department of Fish and Wildlife (WDFW) Ocean Sampling Program (OSP) estimates total ocean recreational effort and catch (retained and released) by boat type (charter and private), port, catch area, and trip type (primary target species). Boat trip sampling is conducted randomly to generate estimates of catch and release for most ocean-caught species: salmon, rockfish and other groundfish, halibut, albacore and sharks. Each month, along with estimates of total catch, OSP provides RecFIN with the raw intercept data that includes the depth of capture by species. RecFIN uses the OSP depth data to estimate the proportion of fish caught in four depth categories and then applies the GMT surface release mortality estimates by depth to produce estimates of discard mortality. Total mortality is the sum of retained catch and discard morality.

If the Council approves the use of mortality estimates for rockfish released with a descending device, implementation of those estimates will require additional data on the proportion of anglers using those devices by depth and species. This year, OSP samplers in all coastal ports will begin collecting that new piece of information during all randomly sampled angler interviews for both charter and private boats targeting halibut and bottomfish. On these trips, when an angler reports releasing a canary or yelloweye rockfish, samplers will follow up with an additional question asking how many of these fish were released using a descending device.

Council approved mortality rates for rockfish released with a descending device will only be applied to released canary and yelloweye rockfish in ports and fishing modes where WDFW is directly collecting data on the proportion of anglers using descending devices. WDFW does not intend to apply proxy estimates of the proportion of descending device use collected from one fishing mode or trip type to areas or trip types where this information is not being gathered. For example, OSP samplers will not ask questions about the use of descending devices when anglers are targeting salmon. At least initially, salmon trips are being excluded to address concerns about the potential negative impacts on sampling rates as a result of increased time spent on angler interviews. This is more of a concern for salmon trips which are typically longer due to the need to observe all retained fish for fin clips, collect coded wire tags (CWT), ask for information on marked and unmarked released fish, collect scale samples and any other biological data. Compared to encounters on trips targeting bottomfish and halibut, there are relatively few encounters with canary and yelloweye rockfish on salmon trips, but for those that do, surface release mortality rates will continue to be applied.

To continue to allow RecFIN to produce the final estimate of total mortality for retained and released fish, which it has since in 2009, data on descending device use will be incorporated into the raw intercept data along with the depth data and provided to RecFIN. The new data will allow RecFIN to estimate the proportion of canary and yelloweye rockfish released with a descending device by depth along with already estimated rockfish released at the surface according to the same depth categories. The total discard mortality estimate for canary and yelloweye rockfish will be the sum of mortality for the proportion of fish released with a descending device and the sum of mortality for the proportion of fish released at the surface.

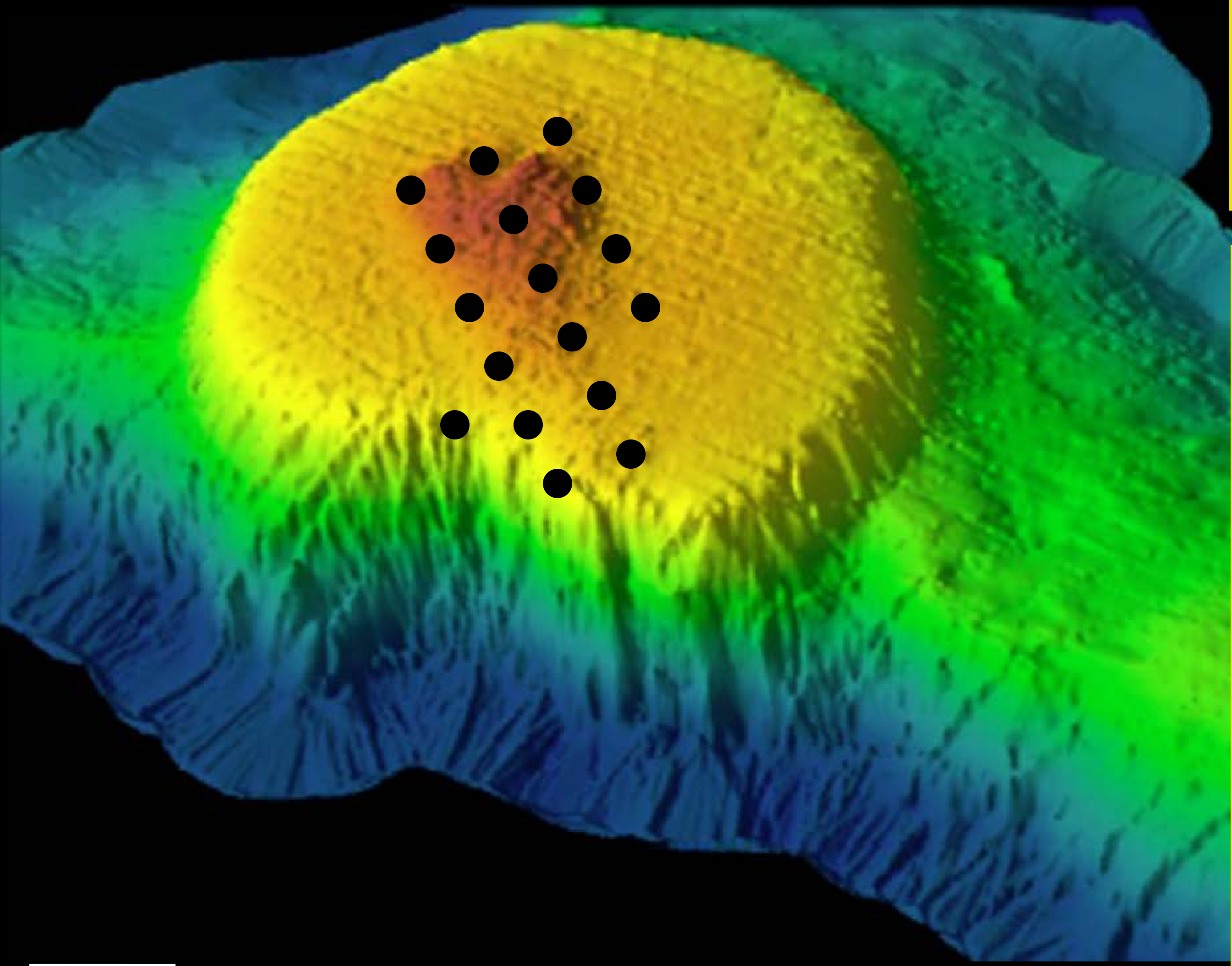
During the first year of this new data collection, WDFW is focused on working through the data collection with the WDFW sampling program and the production of estimates with RecFIN and reviewing the initial data to work out any unforeseen issues. Although the new data may be provided to RecFIN monthly according to status quo data transmission schedules, it is likely that the application of the new mortality estimates, if approved, will not occur until the end of the year or potentially next year during this initial year. The intent is to have the data transmission and production of estimates through RecFIN flow in a way that reflects the current process in the future.

In addition, during this first year, WDFW will consider whether or not to implement a buffer to address the potential for the unsuccessful release of a rockfish using a descending device. In this situation, an angler may report having used a descending device but might not have noticed that the fish later resurfaced. The buffer in this case would be applied to the proportion of fish released with a descending device rather than to the mortality estimates themselves. For example, if 40 percent of anglers report using a descending device to release yelloweye (or canary) rockfish you could assume that only a portion of those were released to depth successfully.

Agenda Item D.5.c
Supplemental Public Comment PowerPoint
(Ken Franke)
April 2013

(3 Slides Follow This Cover Page)

43 Fathom Bank Study Site (2013)



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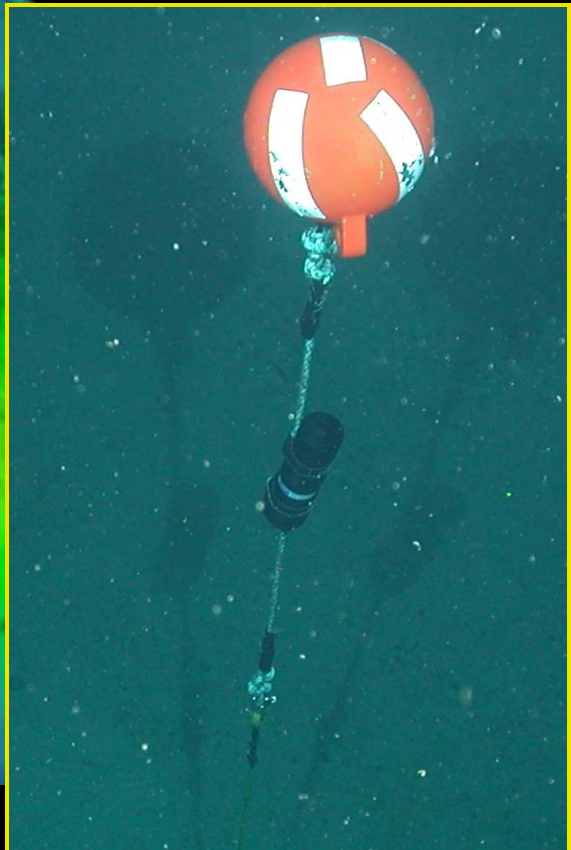
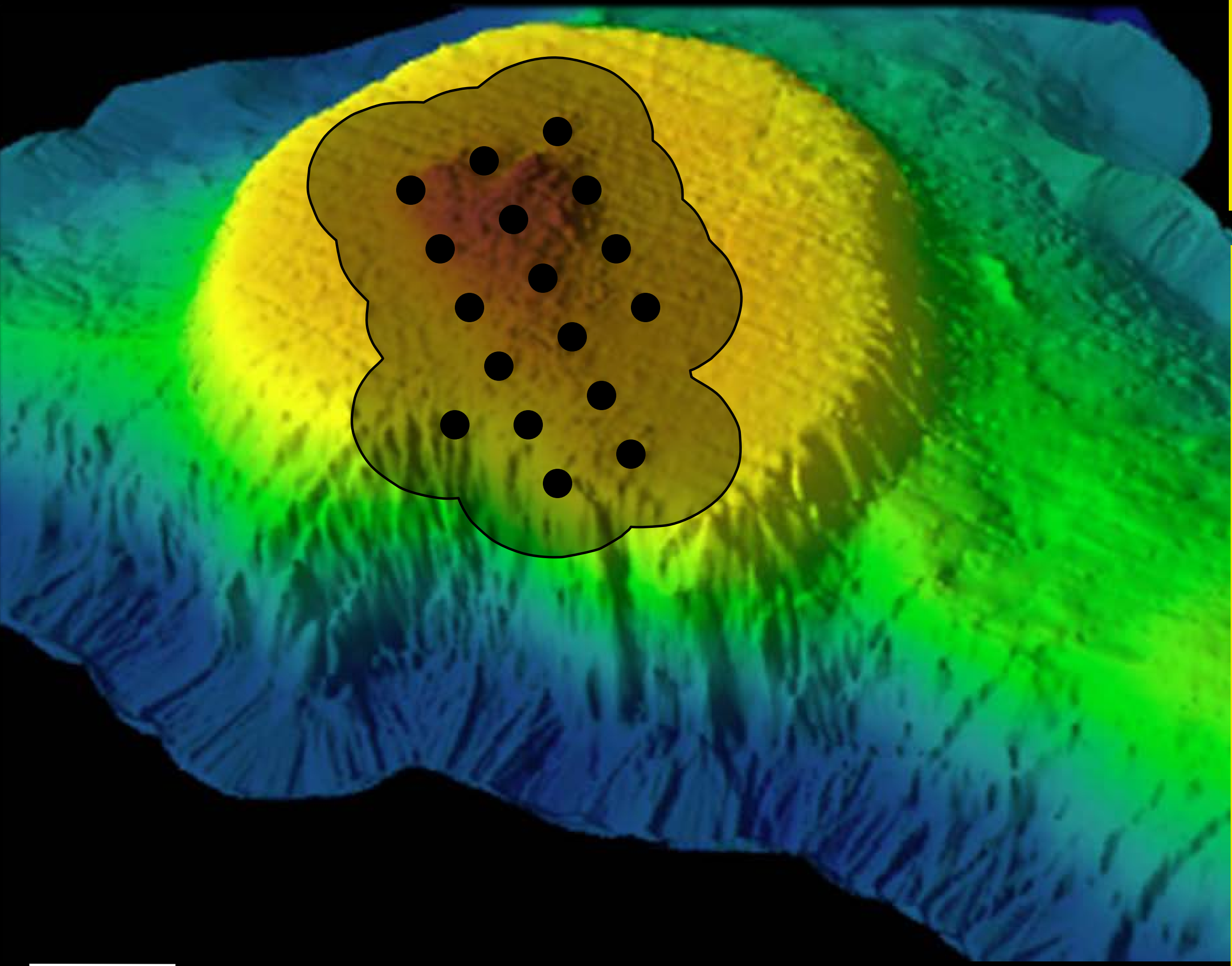


Bathymetry image G. Cutter and D. Demer (NOAA SWFSC)

43 Fathom Bank Study Site (2013)



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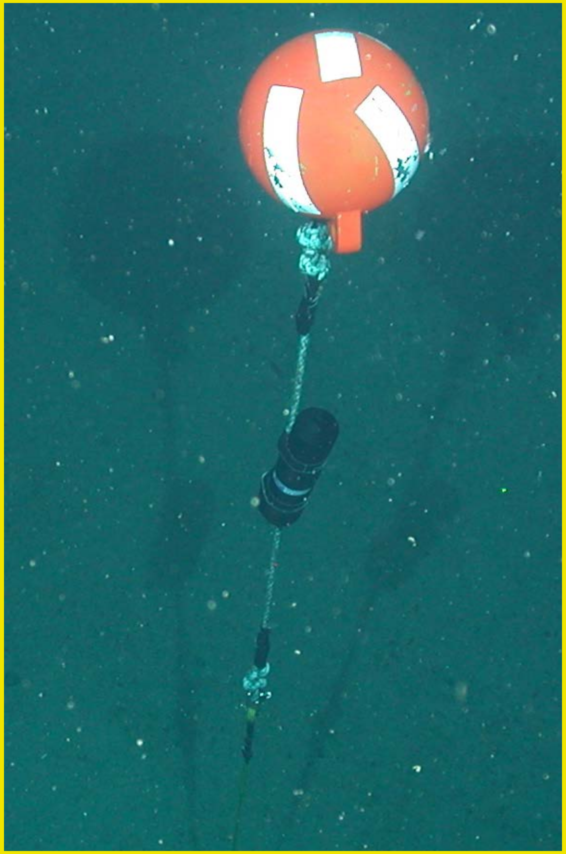

Bathymetry image G. Cutter and D. Demer (NOAA SWFSC)

2013 Tagging of Cowcod and Bocaccio

Tags deployed:

- 20 cowcod
- 12 bocaccio

Tags still to deploy in 2013:

- 9 cowcod

One receiver away from main tagging site was recovered to gather preliminary data on a control tag:

- 1/1 cowcod were alive
- 5/6 bocaccio were alive

Agenda Item D.6
Situation Summary
April 2013

GROUNDFISH ESSENTIAL FISH HABITAT SYNTHESIS REPORT AND REQUEST FOR PROPOSALS

The Pacific Coast groundfish Essential Fish Habitat Review Committee (EFHRC) delivered the Phase 1 Report to the Pacific Fishery Management Council (Council). The Phase 1 Report contains a summary of new and newly-available information compiled by members of the EFHRC, the National Marine Fisheries Service (NMFS), and other contributors, and is intended to serve as the primary source of information for use in developing proposals for any changes to groundfish EFH that the Council may consider.

At the September meeting, NMFS suggested that a synthesis of the information contained in the Phase 1 Report could be helpful to any entities that are considering developing proposals for changes to current groundfish EFH. The Council agreed, and accepted NMFS' offer to develop the synthesis report (Agenda Item D.6.b, NMFS Synthesis Report). The Council will consider the Synthesis Report and may adopt it as a complement to the Phase 1 Report (September 2012 Agenda Item H.6.b, EFHRC Report 1).

Also at the September meeting, the Council considered a revised request for proposals (RFP) that will provide guidance to any entities planning to submit proposals for changes to groundfish EFH. The Council requested some minor changes to the RFP, which are included in Agenda Item D.6.a, Attachment 1. The Council should consider any suggested improvements, and consider issuing the RFP to initiate the proposal develop process.

Council Action:

1. Consider the NMFS Science Center Synthesis Report.
2. Consider and approve the revised RFP.
3. Initiate Phase 2 of the EFH Review.

Reference Materials:

1. Agenda Item D.6.a, Attachment 1: Request for Proposals (RFP) to Modify Essential Fish Habitat for Pacific Coast Groundfish.
2. Agenda Item D.6.b, NMFS Synthesis Report: Groundfish Essential Fish Habitat Synthesis Report. ***(Available on Briefing Book Website and CD Only)***
3. Agenda Item D.6.d, Public Comment 1.
4. Agenda Item D.6.d, Public Comment 2.

Agenda Order:

a. Agenda Item Overview Kerry Griffin
b. NMFS Synthesis Report Michelle McClure, Waldo Wakefield, Ole Shelton
c. Reports and Comments of Advisory Bodies and Management Entities
d. Public Comment
e. **Council Action**: Discussion and Guidance on Groundfish EFH Review Synthesis Report and Initiate Phase 2 of the Review by Approving the Request for Proposals to Modify Groundfish EFH

PFMC
03/25/13

Request for Proposals to Modify Pacific Coast Groundfish Essential Fish Habitat

(Reflecting changes made at the September 2012 Pacific Fishery Management Council Meeting)
9/25/2012

Introduction and Background

The Pacific Fishery Management Council's (Council) Essential Fish Habitat Review Committee (EFHRC) is conducting a review of essential fish habitat (EFH) for Pacific Coast Groundfish managed under the Council's Pacific Coast Groundfish Fishery Management Plan (FMP). This review is being conducted consistent with the Magnuson-Stevens Act and the National Marine Fisheries Service regulatory guidance (50 CFR §600), which states that reviews of EFH should be conducted at least every five years. New scientific research and updated fish and habitat surveys that have occurred since groundfish EFH was established in 2006 may provide new rationale to consider additional measures

Phase I of the review includes a compilation of new and newly-available information, and an assessment of how it compares with the information used to inform the previous EFH identification and descriptions. Upon conclusion of Phase I and issuance of the Phase I report, the Council will issue an RFP to solicit proposals to modify Pacific Coast groundfish EFH. In addition to the Phase I report, data and information (including GIS files if available) gathered in this phase by the EFHRC, will be made available to the public. The report and associated information and data products should be used in developing proposals submitted in response to this RFP.

This RFP should be considered as general guidance for developing proposals, rather than a prescriptive checklist of items that must be included in order for a proposal to be considered. The EFHRC will consider proposals in the context of potential changes to EFH West Coast-wide, in addition to any potential EFH changes recommended for consideration by the EFHRC itself. There may be multiple proposals that are specific to discrete areas. Therefore, the EFHRC must ultimately provide an amalgam of reasonable scenarios to the Council, for consideration of whether to subsequently pursue changes to EFH via an FMP amendment or other relevant process.

Phase II of the EFH review includes evaluation and consideration of proposed modifications to groundfish EFH or its components, based on the new information compiled in Phase I. Proposals may address any of the components identified in the EFH regulations at 50 CFR 600.815(a)(1) – (a)(10). These include:

- Description and identification of EFH
- Council-managed fishing activities that may adversely affect EFH (including practicable measures to minimize adverse effects)
- Non-fishing activities that may adversely affect EFH
- Cumulative impacts

- Conservation and enhancement measures
- Impacts to prey species of Pacific Coast groundfishes
- Habitat areas of particular concern (HAPC)
- Research and information needs

The Council will accept proposals from state, Federal, and Tribal entities, non-governmental organizations, academic institutions, and the public. The Council's EFHRC will conduct an evaluation of proposals received by the deadline, and may develop its own proposal, if warranted. The EFHRC will develop recommendations to be considered by the Council at the appropriate meeting. At that point, the EFH review process will be concluded and the Council will decide whether sufficient new information exists to pursue modifying groundfish EFH, through an FMP amendment or other appropriate process.

Section 7.2 and Appendix B in the FMP describes groundfish EFH, which is generally between the shore line or the limit of saltwater intrusion out to depths of 3,500 m as well as seamounts in depths greater than 3,500 m. HAPCs have been identified for four habitat types: estuaries, canopy kelp, seagrass, and rocky reefs. In addition, several "Areas of Interest" HAPCs have also been identified. Figure 7.2 in the FMP is a map of the approximate location of habitat types identified as HAPCs. The coordinates defining the Area of Interest HAPCs are presented in FMP Appendix B. Several ecologically important areas have been closed to certain bottom contact gear to protect EFH, and are currently categorized as either bottom trawl closed areas or bottom contact closed areas. There are currently 50 such areas along the West Coast; maps showing their locations and coordinates defining their boundaries are in the FMP Appendix C. The bottom trawl footprint closure covers all areas westward of the 1,280 m (700 fm) contour, out to the 3,500 m (1,914 fm) contour, within the EEZ, designed to minimize adverse fishing effects on EFH. The FMP is available on the Council website at:
http://www.pcouncil.org/groundfish/fishery-management-plan/fmp-amendment-19/

Protocol for Submitting and Reviewing Proposals to Modify Groundfish EFH
Proposals will be reviewed in the context of sections A, B, and C, as outlined below. The EFHRC will review all proposals, but will not conduct any analyses of those proposals. Any proposal that depends on analysis of the available data must include documentation and explanation of the methods and outcomes of the analysis.

A. Submission
   1. Proposals for Council review and consideration must be received (tentatively) by a date to be determined and announced by the Council.
   2. Proposals may originate from individuals, non-government organizations, businesses or business organizations, or Federal, state, or Tribal agencies.

B. Proposal Contents

   ~~Proposals may be based on the information compiled by the EFHRC, although other information (including proprietary information not available to the public) may be used as a basis for the proposal. However, any proprietary information used to develop a proposal~~

~~must be available to the EFHRC and ultimately the Council, for review and evaluation. To the extent possible, proposals should include the following information:~~

It is expected that proposals will use the Phase 1 Report and the forthcoming NMFS synthesis document as the primary source of information and as a basis for any proposed changes to EFH or management measures.

Proposals must address items B1 through B4, where applicable. The remaining items under "Proposal Contents" are discretionary, but recommended for inclusion to the extent possible.

1. Date of proposal.
2. Proponent's name, mailing address, email address, and telephone number, including contacts for any cooperating agencies or entities.
3. An explanation why the proposal is warranted, including:

    a. Description of the proposal's objectives.

    b. How it is consistent with the Council's responsibility to identify and protect EFH, and to minimize to the extent practicable, the adverse effects to EFH from Council-managed fishing activities.

    c. How new or newly-available information indicates that the EFH description, its components, or associated management measures should be modified.

4. A detailed description of the proposed action(s), including, where applicable:

    a. Spatial changes to currently protected areas such as boundary modifications, elimination of current areas of EFH, HAPC, or ecologically important habitat closed areas, or addition of new areas of EFH, HAPC, or ecologically important habitat closed areas. Latitude and longitude coordinates (DDD° mm.mmm′) and maps, including before and after change, and digital files if available (e.g., GIS shape files, navigation plotter data).

    b. Gear regulation changes, (e.g., allowing or disallowing gear types, tow technique, mesh size, weight of gear, time of bottom contact, tow time, number of pots or hooks).

    c. Changes to the description and identification of groundfish EFH and its components.

    d. Other changes.

5. Any relevant and applicable information on the following characteristics and topics, including the attendant impacts of the proposed action; or at a minimum, explaining how information in the EFH review report supports the proposal:

    a. Biological and ecological characteristics (e.g., habitat function, vulnerability, index of recovery, species associations, including reference to any ESA-listed species, prey species, and biogenic components).

b. Geological characteristics (e.g., substrate type, grain size, relief, morphology, depth).

c. Physical oceanographic characteristics (e.g., temperature, salinity, circulation, waves).

d. Chemical characteristics (e.g., nutrients, dissolved oxygen).

e. Socioeconomic characteristics (see 6.e below).

6. A discussion of the following topics, as relevant to the proposed actions:

   a. The importance of habitat types to any groundfish FMP stocks for their spawning, breeding, feeding, or growth to maturity.

   b. The presence and location of important habitat (as defined in 6.a, above).

   c. The presence and location of habitat that is vulnerable to the effects of fishing and other activities.

   d. The presence and location of unique, rare, or threatened habitat.

   e. The socioeconomics and management~~-related effects~~ of proposed actions. ~~including changes in the location and intensity of bottom contact fishing effort, the displacement or change in revenue from fishing, and social and economic effects to fishing communities attributable to the location and extent of closed areas.~~ Proponents are encouraged to collaborate with socioeconomic experts as well as affected fishermen and communities. ~~in order to identify socioeconomic costs and benefits.~~ Information on landings and revenues by port area can be found on the Council's website: http://www.pcouncil.org/groundfish/background/document-library/historical-landings-and-revenue-in-groundfish-fisheries/

C. Review and Evaluation

1. The EFHRC will evaluate all proposals with regard to the technical sufficiency and potential biological, ecological, and socioeconomic significance of the proposal. The evaluation will include identifying any deficiencies that should be addressed if the Council desires a full assessment of the proposal for potential adoption. The Groundfish Management Team (GMT), Groundfish Advisory Subpanel (GAP), Habitat Committee (HC), Enforcement Consultants (EC), and Scientific and Statistical Committee (SSC) may also review proposals and provide comments on methodology and relevance to management issues, and make recommendations to the Council accordingly. Public comment will also be accepted at Council meetings.

2. The EFHRC will review proposals and provide an evaluation of the proposals for consideration and final action by the Council at a future Council meeting. ~~The Council is scheduled to take final action at the June 2013 Council meeting, thereby concluding the EFH periodic review process.~~

3. Only those proposals that were received by the RFP deadline may be considered by the EFHRC and the Council.

4. The Council will determine an appropriate process (e.g., biennial specifications, SAFE document, FMP amendment, etc.) for further analysis and consideration of modifications to EFH at a future Council meeting. ~~the June 2013 meeting (tentatively).~~

5. In evaluating proposals, the EFHRC will consider the following questions:

   a. Is the proposal complete?

   b. Is the proposal consistent with the goals and objectives of the FMP and the Council's responsibility to identify and protect EFH and minimize the adverse effects to EFH from Council-managed fishing activities?

   c. Are the coordinates consistent with the proposed actions and do they map out correctly?

   d. What habitat types are affected by the proposal?

   e. Are the data and analyses sufficient to evaluate the proposal effects and objectives, and if not, why?

   f. How well does the available information, including the nature of the data, support the proposal?

   g. What are the biological, ecological, and socioeconomic effects (beneficial and detrimental) of the proposal? For example:

      i. What is the importance of affected habitat types to any groundfish FMP stocks for their spawning, breeding, feeding, or growth to maturity?

      ii. What is the distribution and abundance of important habitat within the areas addressed by the proposal, including substrate types, biogenic habitats, prey items, etc.?

      iii. To what extent is the habitat vulnerable to the effects of fishing and other activities?

      iv. Are there unique, rare, or threatened habitats in areas addressed by the proposal?

      v. What are the changes in location and intensity of fishing effort that may adversely affect EFH?

      vi. What is the estimated displacement, gain, or loss of revenue from fishing?

      vii. What has been the degree of collaboration with affected fishermen, conservation interests, communities, and other stakeholders, to identify socioeconomic costs and benefits?

   h. If models are used in the proposal, are they consistent with the best available information?

   i. How will fishing communities and other stakeholders be affected by the proposal?

j. How will Tribal Usual and Accustomed Areas be affected by the proposal, and how was that determined?

k. How will overfished stocks be affected by the proposal?

l. Is a monitoring plan part of the proposal?

m. Has there been coordination with appropriate state, Tribal, and Federal enforcement, management, and science staff?

n. Are there components of the proposal that require additional expertise beyond the EFHRC for a comprehensive evaluation?

o. Does the proposal address data gaps identified in the original risk analysis such that there is an increased understanding of EFH for one or more species? (e.g., does new data document the importance of a habitat type to groundfish, or has data quality improved enough to change understanding of habitat distribution?).

p. Does the proposal address data quality regarding habitat use (e.g., improves from level 1 (presence/absence) to level 2 (density) or higher?)

q. Does the proposal demonstrate that some elements of groundfish EFH may no longer be precautionary and comprehensive? (e.g., distribution/density no longer matches closed areas, new information shows that some habitats are not being adequately protected, or new information on recovery shows that a habitat type is more or less sensitive than previously known).

Only those proposals received by the RFP deadline will be considered by the EFHRC, for inclusion in its Phase II report to the Council. Proposals may be submitted by mail, email, or fax and must be received at the Council office by close of business on the date to be determined by the Council. Submit proposals to:

Pacific Fishery Management Council
Attention: Kerry Griffin
7700 NE Ambassador Place, Suite 101
Portland, OR 97220-1384
PFMC.comments@noaa.gov
Phone: 503-820-2280
Fax: 503-820-2299

Groundfish Essential Fish Habitat Synthesis Report

TABLE OF CONTENTS

REVIEW DRAFT

MARCH 19, 2013

NORTHWEST FISHERIES SCIENCE CENTER
NMFS, NOAA

TABLE OF FIGURES

TABLE OF TABLES

1.0 INTRODUCTION

This document primarily describes the results of the Northwest Fisheries Science Center's (NWFSC's) effort to summarize the data compiled in the Phase 1 effort of the Essential Fish Habitat Review process. We will also provide, by the supplemental briefing book deadline, a complementary, brief document describing key conclusions and "best uses" of this information.

1.1 PURPOSE AND GOALS

The Sustainable Fisheries Act requires federal agencies to designate specific areas within the range of Council-managed species that are essential to population persistence. These areas are known as ''essential fish habitat'' (EFH), and include ''waters and substrate necessary to fish for spawning, breeding, feeding and/or growth to maturity.'' The Pacific Fisheries Management Council is conducting a 5-year review of current EFH for Pacific Coast groundfishes along the US West Coast.

The goal of this report is to synthesize the existing, spatially explicit data about habitat, species' distributions, fishing effort, and non-fisheries pressures for West Coast groundfishes to provide information germane to evaluating spatial management boundaries. In a Phase 1 effort, the PFMC Essential Fish Habitat Review Committee and NMFS scientists updated and compiled available ecological, habitat, and fishing effort data, and used this information to develop a set of maps intended to support Council decision making related to EFH. This document represents a Phase 2 effort to distill the large volume of data provided in the Phase 1 report into a format that will facilitate effective use by the Council and its stakeholders as they consider revising current EFH designations. We were unable to deal with all aspects of habitat that we would have liked, so associations between groundfishes and biogenic habitat and habitat preferences of YOY juveniles are not treated in this document. Rather, information documented in support of EFH designations in 2006 for these areas is still appropriate.

In an ideal world, analyses supporting spatial management decisions would use relationships between habitat characteristics and species' fecundity, growth and survival over all life stages. These relationships could then be used to project species status (abundance, productivity, spatial structure, and potentially diversity) in a spatially-explicit modeling framework that also includes the impact of various stressors (fishing, noise, pollution, etc.) in order to identify the quantity, location and types of habitats needed to support populations meeting management targets for sustainability and harvest. Unfortunately, the relationships between vital rates and habitat are almost universally lacking for the groundfish species in this FMP. In their absence, we have organized our report around a series of questions designed to allow managers and other stakeholders to assess whether there is a bias in areas protected geographically or with respect to species and to evaluate the relative proportions of habitats for each species that are subject to spatial management. Again, we focus on the adult life stage, as the stage for which new information is available.

- **Section 2.0 – Habitat Distribution**. In this section, we evaluate the distribution and abundance of physical and biogenic habitat on the U.S. West Coast, as updated in the Phase 1 report. It does not include updates to the distribution of macro-algae or eelgrass, which were not available. Specifically, we ask how much area of each habitat type is subject to fishing restrictions, and whether there are any apparent biases in the types of habitat protected.
- **Section 3.0 – Species-Habitat Associations**. This section describes the results of two analyses using fish distribution data coupled with physical habitat information to identify areas with high likelihood of species-specific presence. We asked what the probability of finding each of 6 groundfish species across the West Coast is, and what habitat characteristics have the strongest association with each species' presence.
- **Section 4.0 – Stressors**. Both fishing and non-fishing stressors are included in this section. We describe the distribution of fishing, pollution and other stressors for groundfish across the West Coast, asking where threats are concentrated, and whether there is a bias in the type of habitats affected by these threats. In addition, we ask whether fishing patterns have changed in response to spatial regulations put in place in 2006.
- **Section 5.0 – Ecological Importance, Exposure to Fishing Pressure, and Spatial Management**. In this section, we evaluate each "pixel" (2x2km square) along the West Coast with respect to joint fishing pressure and its suitability for each species. This analysis asks how much habitat appears to be important for each species and is it also subject to high or low fishing pressure. We also look at how pressures have changed before and after the designation of EFH conservation areas under Amendment 19.
- **Section 6.0 – Prey Species of West Coast Groundfish**. This section updates the prey matrix in the Phase 1 report to include more taxonomic specificity for 11 important groundfish species. It is independent of the other work in this report, but provides greater clarity about which prey species are particularly important within groups such as small schooling fishes for groundfish. A next step may be to evaluate preferred habitats for key prey species.
- **Appendices** – Methods, expanded results and additional supporting materials for all sections are detailed in corresponding appendices.

This information can be used in a variety of ways. Probability of occurrence, and associations of species with habitat characteristics can be used to prioritize areas for species of particular concern. The combination of current ecological importance and fishing pressure allows stakeholders to evaluate how much "important" habitat has protections. The inclusion of non-fisheries stressors allows consideration of the suitability of areas for protection – managers may choose to prioritize areas subject to low levels of pollution for highest protection, for example, over areas with high levels of these threats in order to maintain areas of the highest quality. Or, they may determine that non-fishing threats are so great in some areas that reductions in fishing pressure might be needed to maintain the health of the species. Overall, this work is the logical, data-based next step from the HSP work done in the first iteration of EFH analysis. It incorporates more up-to-date seafloor habitat mapping, distribution of threats, and species distribution and abundance information from the annual groundfish bottom trawl survey to identify both the suitability for adults and the pressures that subsets of habitat along the West Coast are experiencing.

1.2 GEOGRAPHIC UNITS EVALUATED: BIOGEOGRAPHIC REGIONS

In order to be able to evaluate habitat distribution and impacts in an ecologically meaningful way, we divided the West Coast into 10 geographic and depth regions, based on biogeographic considerations and depth zones. The biogeographic provinces included the Northern, Central, and Southern coastal areas, along with the Salish Sea. These provinces were selected with an eye toward oceanographic similarities and potential for larval exchange between regions. The Northern and Central provinces were divided at Cape Mendocino, the most prominent headland in California. Cape Mendocino is known to have distinctive oceanographic features such as strong upwelling and cyclonic eddies (Hayward and Mantyla 1990, Magnell et al. 1990), which may act to reduce larval exchange between the provinces and to create phylogeographic breaks (Kelly and Palumbi 2010). Point Conception separated the Central and Southern provinces. This area is widely recognized as an oceanographic convergence zone in which the temperate, southward flowing California Current meets the subtropical Southern California eddy. It is also thought to represent a significant phylogeographic break point for a variety of marine species (Pelc et al. 2009). The final biogeographic province, the Salish Sea, is a semi-enclosed body of marine water subject to strong terrestrial influences from several urban centers (including Vancouver, Canada, and Seattle, Washington, USA) and distinguished by an oceanographic regime unique from the rest of the West Coast (Sutherland et al. 2011). We also included three depth zones: a) Shelf (coastline to continental shelf break), b) Upper Slope (shelf break to 700 ftm, which is the shoreward boundary of the "Bottom Trawl Footprint Closure"), and Lower Slope (700ftm to the EEZ seaward boundary) (Figure 2.1).

We also examined habitat with respect to spatial management boundaries. There are many spatial management designations in the U.S. West Coast marine waters relevant for groundfish. The largest designation is EFH (Figure 1), which is designated to include ''waters and substrate necessary to fish for spawning, breeding, feeding and/or growth to maturity.'' In our region, it encompasses most marine habitats including waters and substrate out to 3,500 m water depth and seamounts deeper than 3,500 m. It does not carry with it any mandatory regulatory implication, other than that NMFS will consult on activities that affect such habitat. Habitat areas of particular concern (HAPCs) are a subset of areas within EFH that are noted to be of special importance. They also carry no regulatory requirements, but in this region are used to alert other entities that these areas are important when they are designing projects in those areas. Amendment 19 of the Groundfish FMP established permanent conservation areas (Marine Protected Areas), in which fishing is regulated – entirely prohibited in some, and restricted to various types of gear in others. In addition, Rockfish Conservation Areas, which are not part of EFH, but rather implemented under the overfishing provisions of the Act, change through space and time, and typically regulate the use of specific gear in areas of importance to species subject to overfishing. Finally, states and other entities (e.g. Marine Sanctuaries) can implement fishing regulations in areas under their jurisdiction. For this synthesis, we developed three sets of "protected" areas:

- Only the 51 EFH conservation areas established in Amendment 19. These are referred to in this document as "EFH conservation areas." Some fishing is allowed in much of these areas.
- All areas in which bottom trawl, mid-water trawl and/or fixed gear is prohibited.
- All MPAs where commercial fishing is either "prohibited" or "restricted," based on the definition and classification system developed by the NOAA's National MPA Center (NMPAC, 2012).

We primarily focus on the first (EFH conservation areas established in Amendment 19) in this document; future work will look at the other sets in greater depth.

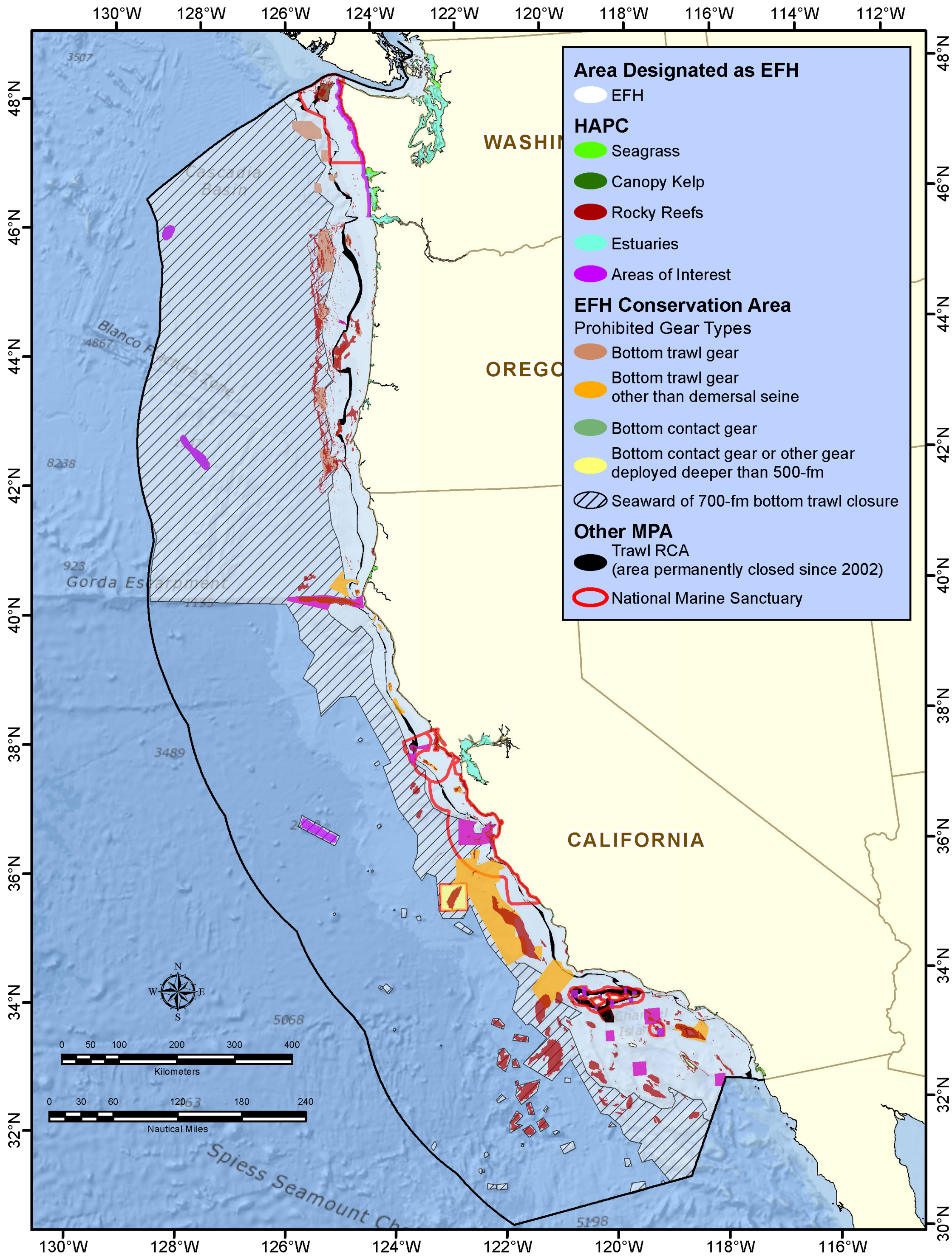

Figure 1. Essential Fish Habitat (EFH) is the largest designation of the many spatial management designations in the U.S. West Coast marine waters relevant for groundfish.

1.3 CHOICE OF SPECIES FOR EVALUATION

We evaluated a subset of species managed under the Council's FMP. We selected six focal groundfishes to represent i) multiple taxonomic groups, ii) the range of depths sampled in the trawl survey, iii) a variety of substrate habitat affinities (from species that prefer rocky, high-relief habitats to those that prefer mud or silt substrates), iv) a range of overall abundance in the trawl survey (from relatively rare to very frequently observed), and v) a range of current stock status (Table 1). These are: darkblotched rockfish (*Sebastes crameri*), yelloweye rockfish (*Sebastes rubberimus*), sablefish (*Anoplopoma fimbra*), longspine thornyhead (*Sebastolobus altivelis*), and greenstriped rockfish (*Sebastes elongatus*).

The chosen species are necessarily a rough proxy for the diversity of species among assemblages of West Coast groundfishes. However, we note that the focal species selected belong to distinct guilds constructed using diet and trophic information (Horne et al. 2010 ATLANTIS) and to 5 different groups based on cluster analyses of the trawl data itself (Cope and Haltuch 2012). Therefore, we view them as a reasonable first group that spans many of the axes of diversity of West Coast groundfish. Future work will expand the number of species analyzed using the techniques developed here.

Table 1. Characteristics of species used in the analyses showing broad taxonomic groupings, depth categories, substrate preferences, occurrence, and stock status. Depth ranges are shelf (shelf and upper slope): 50-400 m and slope: 400-1200m.

Species	Taxonomic Group	Depth Category	Preferred Substrate	Proportion of survey trawls with at least one fish observed	Stock Status
Darkblotched Rockfish (*Sebastes crameri*)	Rockfish	Slope	Soft	~15%	Rebuilding
Yelloweye Rockfish (*Sebastes ruberrimus*)	Rockfish	Shelf	Rocky	~2%	Overfished
Sablefish (*Anoplopoma fimbra*)	Roundfish	Slope	Soft	~65%	Below target of $SB_{40\%}$ and declining.
Longspine Thornyhead (*Sebastolobus altivelis*)	Rockfish	Slope	Soft	~35%	Target
Greenstripe Rockfish (*Sebastes elongatus*)	Rockfish	Slope	Mixed	~25%	Target
Petrale Sole (*Eopsetta jordani*)	Flatfish	Shelf	Soft	~40%	Rebuilding

1.3.1 Using Information in this Synthesis

This information can be used in a variety of ways. Probability of occurrence, and associations of habitat characteristics with species can be used to prioritize areas for species of particular concern. The combination of ecological importance and fishing pressure allows stakeholders to evaluate how much "important" habitat has protections. The inclusion of non-fisheries stressors allows consideration of the suitability of areas for protection – managers may choose to prioritize areas subject to low levels of pollution, for example, over areas with high levels of these threats for highest protection in order to maintain the highest quality habitats. Or, they may determine that non-fishing threats are so great in some areas that reductions in fishing pressure might be needed to maintain the health of the species. Such decisions might be informed via future development of a return-on-investment framework that considers both the costs and benefits of changes in spatial management designations (Withey et al. 2012). Overall, this work is the logical, data-based next step from the HSP work done in the first iteration of EFH analysis – in fact, our species-habitat association analysis is conceptually very similar. It incorporates more up-to-date seafloor habitat mapping, distribution of threats, and species distribution and abundance information from the annual groundfish bottom trawl survey to identify both the suitability and the pressures subsets of habitat along the West Coast are experiencing.

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2.0 HABITAT DISTRIBUTION

Waldo Wakefield, Chris Romsos, Curt Whitmire, Mary Yaklovich

The purpose of this Habitat Section is to characterize the spatial distribution and abundance of seabed habitats and spatial management areas (e.g., marine protected areas) relevant to groundfishes within the US exclusive economic zone (EEZ) off Washington, Oregon and California. A coast-wide database and map series of bathymetry (i.e., seafloor imagery) and lithologic habitat types were compiled for the 2012 EFHRC Phase I Report including 261 new sources of lithologic habitat information updating the 2005 maps. Mapping methods varied widely among sources, and the seabed habitat types mapped are probable soft sediment, probable rock, or a mixture of soft sediment and rock. The analysis of substrate type was performed on the aggregated seafloor lithological data, resulting in a composite map showing the spatial distribution of the three major seabed habitat types (Figure 2.2).

Observations of biogenic habitat (deep-sea corals and sponges) were compiled for 2005, and then updated for the EFHRC Phase I report and considered in the current synthesis. Maps of continuous biogenic habitats were not available, so records of observations of corals and sponges were compiled as presence data and summarized within the four biogeographic sub-regions and three depth zones.

While this report focuses on adult habitat, there is no question that for many species, quantity or quality of juvenile habitat can play a critical role in the population dynamics of groundfishes. In 2005, the Pacific Coast Groundfish EFH FEIS noted a general lack of habitat information for most juvenile groundfishes (Appendix B 1, Assessment Methodology for Groundfish Essential Fish Habitat, December 2005), and used a basic literature review on depth, latitude and substrate (Appendix B 2 Assessment Methodology for Groundfish Essential Fish Habitat, December 2005) to populate a juvenile habitat use database. This information was then used to generate the juvenile habitat suitability profiles used in the 2005 EFH process.

Overall, there has been very little change in the state of our knowledge of juvenile habitat use that would alter the results of the 2005 EFH analysis for juveniles. A general lack of age-0 surveys and habitat-specific survival or growth rates limit our ability to improve on the 2005 analysis. We thus refer the reader to the 2005 document for the best available science on juvenile groundfish EFH.

An important conclusion from the 2005 work is the importance of nearshore, hard-bottom substrate for a number of rockfish species. Much of the habitat use database builds on the observations of Love and colleagues (1991). They reported that 70% of the 58 species of Pacific rockfish they examined used hard substrate. In addition, Love et al. highlight the importance of kelp and other macroalgae for juvenile rockfish—53% of the rockfish they examined were associated with macroalgae. Indeed, observational studies and experimental manipulations of kelp forests confirm the general importance of kelp forests and their understory for rockfishes. The structural complexity of kelp forests influences the recruitment of age-0 rockfish, their density, and their species composition (Ebeling et al. 1991, Carr and Syms 2006). Loss or degradation of kelp forests can result in large decreases in the density of age-0 fish (Carr 1991, Stephens et al. 2006), and can changes rates of predation as well as the importance of predation in population dynamics (Johnson 2006).

The importance of juvenile habitat will likely vary among species with life history strategies. Mangel and colleagues (2006) show that the importance of juvenile rockfish habitat will vary with a number of life history parameters, particularly, life span and age of maturity. In general, longer lifespan and greater age of maturity increases the sensitivity of population dynamics to changes in juvenile survival or growth. Thus, to the extent that juvenile survival and growth are associated with habitat quality, we can infer that juvenile habitat is likely to be more import to the dynamics of those groundfish species with relatively long lives and late reproduction (Mangel et al. 2006).

2.1 PHYSICAL HABITAT

The distribution of seabed habitat types by depth zone, both coast-wide and in four biogeographic sub-regions, is summarized in Table 2.1 and shown in Figure 2.3. With the exception of the Salish Sea, the total area of seabed is divided more or less evenly between the three remaining biogeographic sub-regions, Northern (37.2%), Central (35.7%), and Southern (26.2%) (Table 2.1). However, the area of seabed within each sub-region differs by depth zone. Washington and northern Oregon have the broadest continental shelf, anchoring a north-south trend of decreasing width of the continental shelf reflected in the areas for the three outer coast sub-regions (North = 11.1%, Central 5.8%, and Southern 3.6%) (Table 2.1, Figure 2.3) The Southern sub-region includes the bathymetrically complex region known as the borderland of the Southern California Bight, and differs dramatically from areas to the north. The Shelf generally is very narrow, but widens in some areas of the Bight and includes several offshore islands that are an expression of the ridge and basin topography. The number and size of the basins account for the large area of Upper Slope soft substrate (4,400,561 ha).

Coast-wide, the Lower Slope depth zone dominants the EEZ with 79.8% of the total area for combined habitats followed by the Upper Slope (12.2%) and Shelf (8%). The Lower Slope depth zone extends from the 700 ftm boundary of the Upper Slope seaward across the continental rise and abyssal plain to the seaward boundary of the EEZ, and contains a large area of undefined seabed habitat (57,503,645 ha) (Figures 2.2 and 2.3). Seabed lithologies were only mapped from the shoreline to the base of the continental slope (water depth ~3000 m) accounting for the undefined seabed in deep water. If one excludes the category of undefined substrate, then the Shelf, Upper Slope and Lower Slope depth zones represent 24.2%, 41.4% and 34.4% of the continental margin. Only the shallowest (Shelf) depth zone is present in the Salish Sea.

Hard and mixed substrates appear to be relatively rare (7.2% and 3.3%, respectively) when compared coast-wide to soft substrate (89.5%) (Figure 2.3, Table 2.1). The north to south decrease in the areal extent of soft substrate on the shelf mirrors the latitudinal decrease in width of the continental shelf; however, relative proportions of all three substrates on the shelf are fairly consistent across sub-regions despite large changes in total area (Figure ES-3, Table ES-2). For the Lower Slope depth zone, only hard and soft substrates were coded. The relatively large area of hard substrate in the Lower Slope depth zone of the Northern sub-region (324,537 ha) is partly due to the classification of seabed as "inferred rock" derived from a model that was applied to the Oregon and Washington margin (PFMC 2012).

The distribution of seabed habitat types, both inside and outside EFH conservation areas, and by depth zone and habitat type for each of the sub-regions is presented in Figure 1.4 and Appendix 1: Tables A1.3.2a-d). No EFH Conservation Areas are located in the "Salish Sea", and no "mixed" habitat types are known to occur with the Lower Slope of any biogeographic sub-region. Between 15-35% of hard and mixed shelf habitats are protected by EFH conservation areas, Protections of hard and mixed habitats on the upper slope vary widely between 3% (central, mixed) and 63% (southern, mixed). The two bottom trawl prohibition types make up the largest proportions of area coast-wide. Due to the 700-ftm bottom trawl closure, large portions of the lower slope in the northern, central and southern sub-regions are closed to either all bottom trawls or bottom trawl except demersal seines (central and southern sub-regions). All known areas of hard habitat in the lower slope are closed to trawling.

The distribution of seabed habitat types, both inside and outside areas prohibiting the use of three main commercial fishing gear types (bottom trawl, mid-water trawl and fixed gear), and by depth zone and substrate type for each of the sub-regions is presented in Appendix 1: Tables A1.3.3a-d and Appendix 1: Figures A1.3.5-1.3.8). Again, the 700-ftm bottom trawl closure accounts for a large proportion of the area in each of the sub-regions. Shoreward of the 700 ftm depth contour and at Shelf and Upper Slope depths, bottom trawling is prohibited in 4.3%, 21.3%, and 25.3% of the Northern, Central and Southern sub-regions, respectively. Bottom trawling is prohibited in 100% of the Salish Sea. The proportion of hard substrate closed to bottom trawling shown in Appendix 1: Figure A1.3.5 in the Shelf and Upper Slope depth zones is a reflection, in part, of the Amendment 19 prohibition of bottom trawl gear in rocky reef areas. This can also be seen in Appendix 1: Figure A1.3.6, the map showing the composite area closed to bottom trawling overlain on the three seabed habitat types. In addition, the map figure clearly shows the area along the continental shelf break where bottom trawling is prohibited in the Rockfish Conservation Area. Bottom trawl prohibitions in the territorial seas of Washington and California are also shown. The aerial extent of the prohibition for bottom trawling far exceeds the two other fishing gear types (Appendix 1: Figure A1.3.8).

The distribution of seabed habitat types, both inside and outside areas where commercial fishing is either allowed, restricted or prohibited, and by depth zone and substrate type for each of the sub-regions is presented in (Appendix 1: Tables A1.3.4a-d, Appendix 1: Figure A1.3.9, and Appendix 1: Figure A1.3.10). The map shows the composite area where commercial fishing is either restricted or completely prohibited over lain on the three seabed habitat types. Prohibitions accounted for only a small fraction of the total area within the four sub-regions, whereas commercial restrictions accounted for 84.5%, 25.4%, 27.9% and 100% of the Northern, Central and Southern, and Salish Sea sub-regions, respectively. The large area of commercial restriction on the Lower Slope along the open coast is due to the Bottom Trawl Footprint Closure seaward of the 700ftm depth contour. The “Salish Sea” is entirely within Washington’s state territorial sea and encompasses only the shelf depth zone. Commercial fishing is restricted and bottom trawling is prohibited within the entire territorial sea off Washington and almost the entire territorial sea off California.

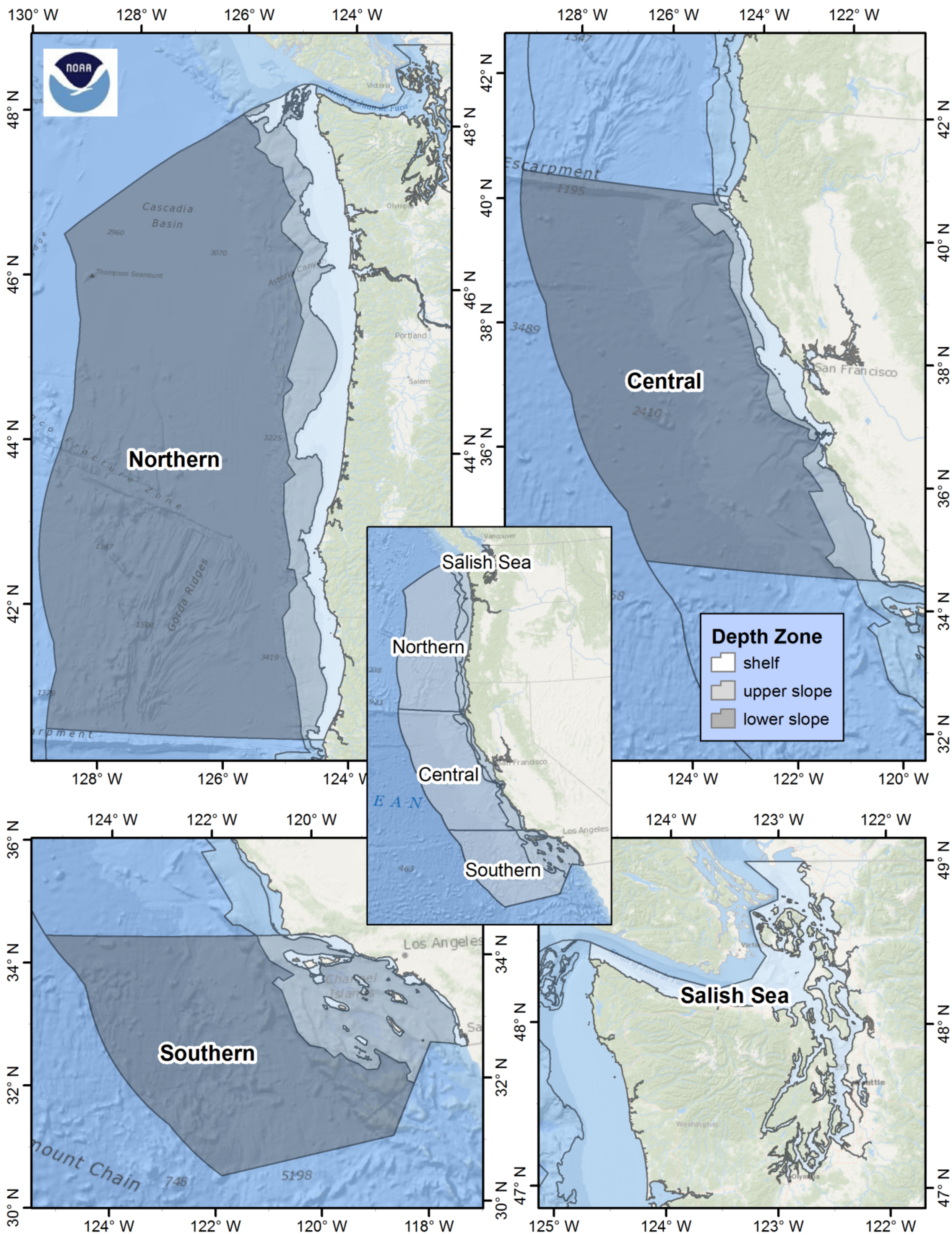

Figure 2.1. Map showing the spatial stratification, including four biogeographic sub-regions and three depth zones.

2.2 BIOGENIC HABITAT

Biogenic habitats are very diverse, and include sponges, corals, macroalge (including kelp beds), eelgrass beds and more. Kelp beds are known to be important for many species of groundfishes, especially YOY juveniles. Little new information since the initial West Coast Groundfish EFH review has been collected about other biogenic areas; the previous work is still the best compilation of this information.

Here, we summarize direct and indirect observations of deep-sea corals and sponges. Not all areas within the FMP area have been surveyed for presence of corals and sponges, and areas that are surveyed but found not to support coral and sponge communities are not always documented. Much of what is known about the overall spatial distribution of corals and sponges in the region has been compiled by NOAA's Deep-Sea Coral Research & Technology Program (NOAA, 2013). Roughly 95% of its 174,000 records are direct, visual observations of corals and sponges in situ, while most of the remaining records (5%) are from surveys using benthic trawls, dredges, or grabs. Differences in how data were collected make it challenging to estimate relative abundance. For example, some studies summarized counts over individual photo or video frames, while others summarized over the course of entire dive. In order to compare the distributions in a standardized manner, presence data were summarized within 1x1 km contiguous grid cells (Figure 1.5). Because of differences in habitat affinities, observations were summarized for two groups of taxa: 1) corals (excluding pennatulids) and sponges (Figure 2.5a), and 2) pennatulids (Figure 2.5b).

Out of the over 843,000 1x1 km cells within the FMP area, just over 4,103 (0.5%) had records of coral-sponge presence, and 3,943 (0.5%) had records of pennatulids (sea pens). This only represents where corals and sponges have been observed over the last 23 years, not necessarily where they don't occur. Most (62%) areas of coral and sponge presence are located within the upper slope, with 28% and 10% of presence in the shelf and lower slope, respectively (Table 2.2). The northern biogeographic sub-region had the most (48%) areas with coral and sponge presence, followed by the southern, central and Salish Sea. This rank order may be largely influenced by survey effort. Pennatulid presence shows a similar relative distribution to that of corals and sponges with about half of known areas on the upper slope, 38% on the shelf and 12% on the lower slope (Table 1.2). Distribution of pennatulids by sub-region was also similar to that of corals and sponges, with the northern sub-region having 45% of cells, followed closely by the central (42%). Only 11% and <1% of cells where pennatulids have been observed are within the southern sub-region and Salish Sea, respectively.

Similar to physical habitats, the distribution of two coral-sponge taxonomic groups was compared to the three types of MPA categories: 1) EFH conservation areas (Figure 1.6a-b and Appendix 1: Table A1.3.6a-b), 2) areas prohibiting one or more of three major commercial gear types (Appendix 1: Figure A1.3.14a-b-1.3.15a-b and Appendix Table A1.3.7a-b), and 3) areas where commercial fishing is either allowed, restricted or prohibited (Appendix 1: Figure

A1.3.16a-b and Appendix 1: Table A1.3.8a-b). Out of the over 4,100 grid cells with coral-sponge presence, 71% remain outside EFH conservations areas, and 55% of those occur in the northern sub-region (Appendix 1: Table A1.3.6a). Out of the over 4,100 grid cells with coral-sponge presence, 62% are in areas open to all commercial gear types, and 60% of those occur in the northern sub-region (Appendix 1: Table A1.3.7a). While 38% of grid cells with coral-sponge presence are in areas closed to bottom trawls, only 1.3% of cells are in areas closed to fixed gears or mid-water trawls (Appendix 1: Table A1.3.7a). For grid cells with pennatulid presence, 73% are outside EFH conservation areas, and 52% of those occur in the northern sub-region (Appendix 1: Table A1.3.6b). Roughly 65% of cells with pennatulids are in areas open to all three commercial gear types, and 58% of those are in the northern sub-region (Appendix 1: Table A1.3.7b). While only 24 cells are in areas closed to fixed gears or mid-water trawls, 1,385 (35%) are in areas closed to bottom trawling (Appendix 1: Table A1.3.7b).

Because of the 700-ftm closure, all biogenic habitats in the northern lower slope are protected from bottom trawling, while a large majority (≥ 90%) of the lower slope is protected in the central and southern sub-regions (Appendix 1: Figures A1.3.14a-b and A1.3.16a-b). Since bottom trawling is prohibited in the state territorial sea of Washington, all biogenic habitats in the Salish Sea are protected from that gear type (Appendix 1: Figure A1.3.14a-b).

There are numerous sites outside EFH conservations areas where corals and sponges have been observed in higher relative numbers (see Appendix 1: Figure A1.3.17 map plates). These include just west of the Olympic 2 area and just north of the Grays Canyon area (Map A2), Hydrate Ridge (B2), off Cape Arago, OR (C2), north of the Eel River Canyon area (D2), in the Gulf of the Farallones National Marine Sanctuary (E2), portions of Monterey Bay and near the shoreward boundary of the Big Sur Coast/Port San Luis area (E3), and several sites on the shelf and offshore banks in the southern California Bight (F3, F4, G4).

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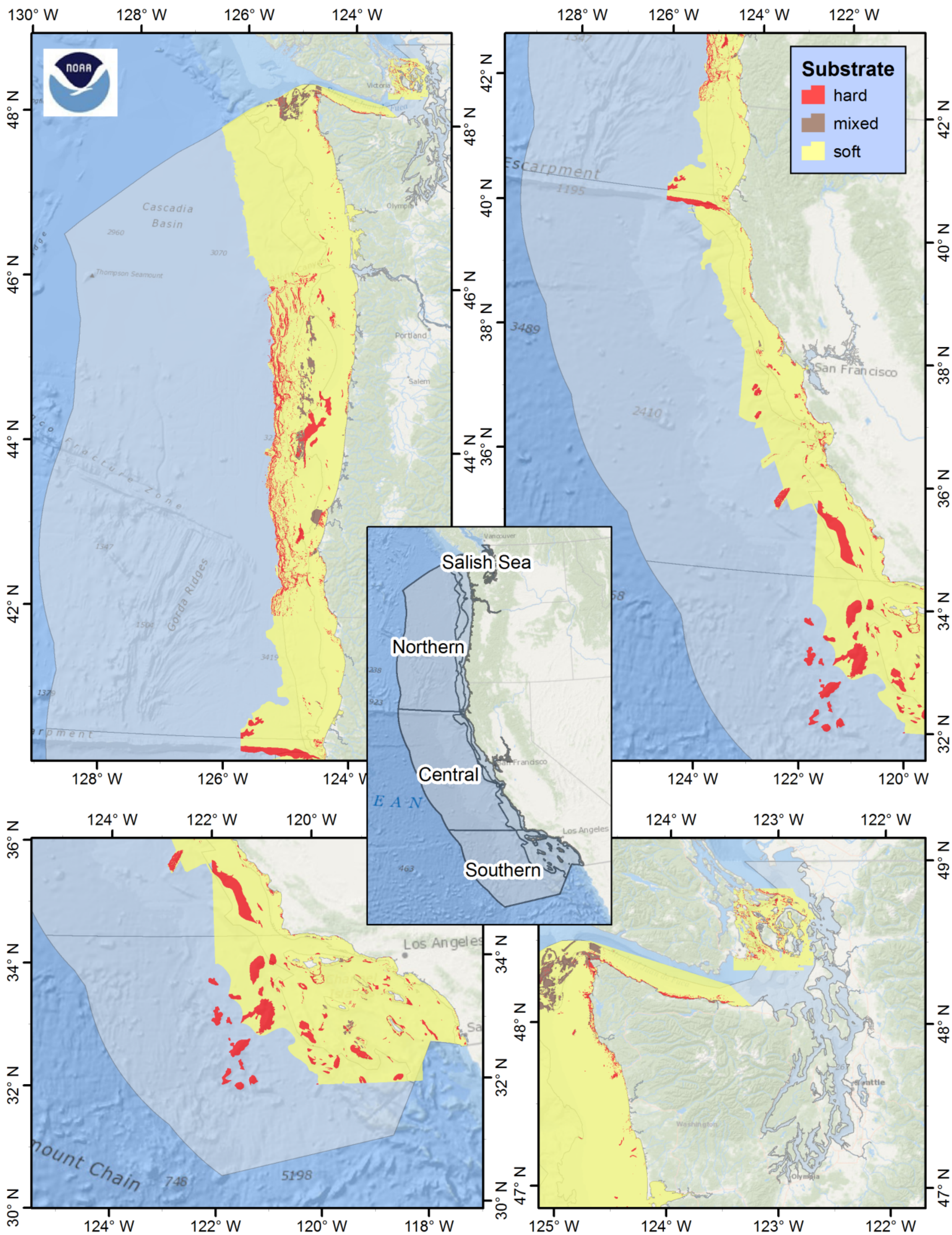

Figure 2.2. Spatial distribution of three major seabed habitat types: hard, mixed and soft.

Table 2.1. Distribution of seabed habitat types by depth zones both coast-wide and in four biogeographic sub-regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Percentage values represent relative contribution to the sub-region. The "Salish Sea" only encompasses the shallowest ("shelf") depth zone. Last row shows relative contribution to the sub-region.

		BIOGEOGRAPHIC SUB-REGION								COAST-WIDE	
		Northern		Central		Southern		Salish Sea		Combined	
Depth Zone	Substrate	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Shelf[1]	Total	3,404,867	11.1%	1,715,270	5.8%	775,396	3.6%	739,957	100.0%	6,635,491	8.0%
	hard	170,661	0.6%	104,228	0.4%	52,064	0.2%	15,701	2.1%	342,655	0.4%
	mixed	94,430	0.3%	5,277	0.0%	15,054	0.1%	7,469	1.0%	122,230	0.1%
	soft	3,049,609	9.9%	1,469,779	5.0%	691,704	3.2%	213,668	28.9%	5,424,760	6.6%
	undefined	90,167	0.3%	135,986	0.5%	16,574	0.1%	503,119	68.0%	745,846	0.9%
Upper Slope[2]	Total	3,021,125	9.8%	2,389,292	8.1%	4,669,633	21.6%	0	0.0%	10,080,050	12.2%
	hard	103,766	0.3%	267,468	0.9%	242,023	1.1%	0	0.0%	613,257	0.7%
	mixed	105,496	0.3%	3,175	0.0%	18,555	0.1%	0	0.0%	127,226	0.2%
	soft	2,811,725	9.1%	2,107,156	7.1%	4,400,561	20.3%	0	0.0%	9,319,442	11.3%
	undefined	138	0.0%	11,493	0.0%	8,495	0.0%	0	0.0%	20,125	0.0%
Lower Slope[3]	Total	24,311,081	79.1%	25,381,145	86.1%	16,184,376	74.8%	0	0.0%	65,876,603	79.8%
	hard	324,537	1.1%	143,068	0.5%	578,992	2.7%	0	0.0%	1,046,598	1.3%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	2,525,125	8.2%	2,681,556	9.1%	2,119,680	9.8%	0	0.0%	7,326,361	8.9%
	undefined	21,461,420	69.8%	22,556,521	76.5%	13,485,704	62.3%	0	0.0%	57,503,645	69.6%
Column Total		30,737,074	100.0%	29,485,708	100.0%	21,629,405	100.0%	739,957	100.0%	82,592,144	100.0%
Sub-Region		30,737,074	37.2%	29,485,708	35.7%	21,629,405	26.2%	739,957	0.9%	82,592,144	100.0%

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

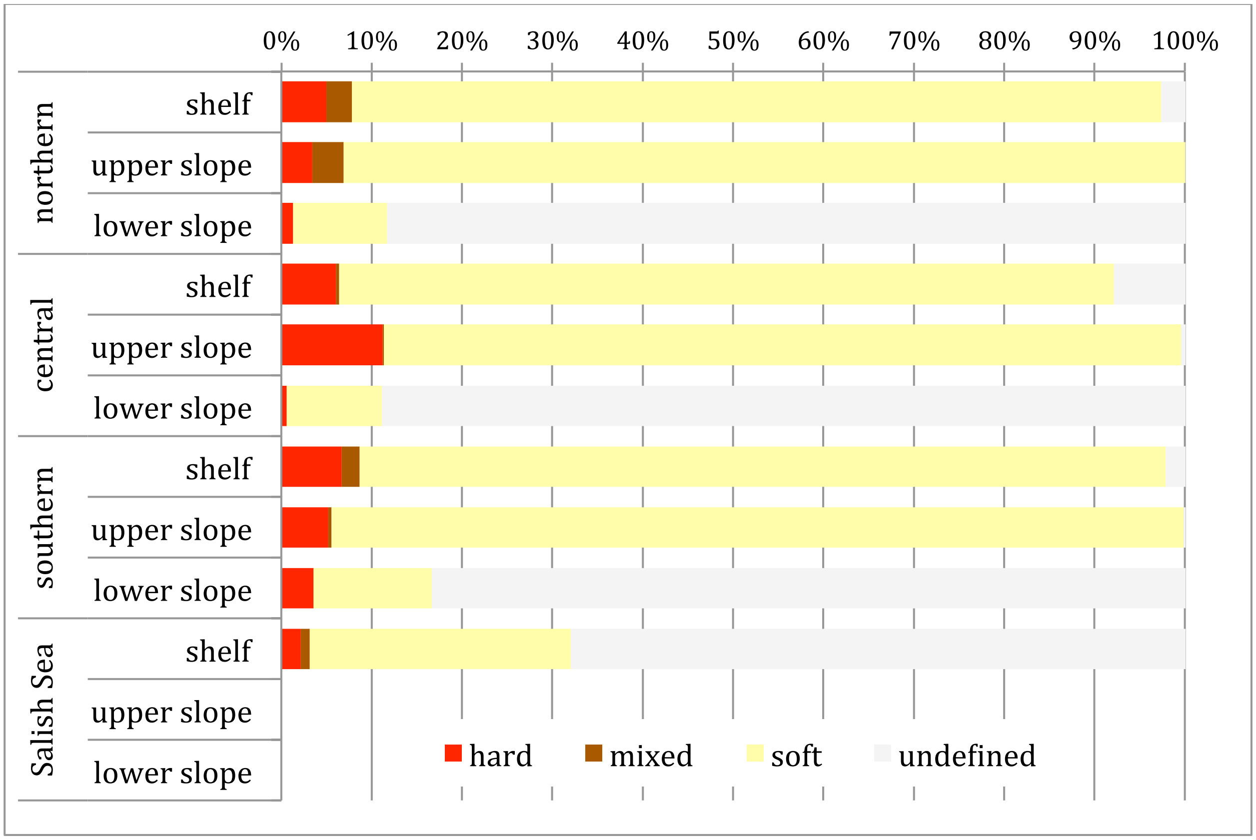

Figure 2.3. Relative distribution of seabed habitat types by depth zones in four biogeographic sub-regions. The "Salish Sea" only encompasses the shallowest ("shelf") depth zone.

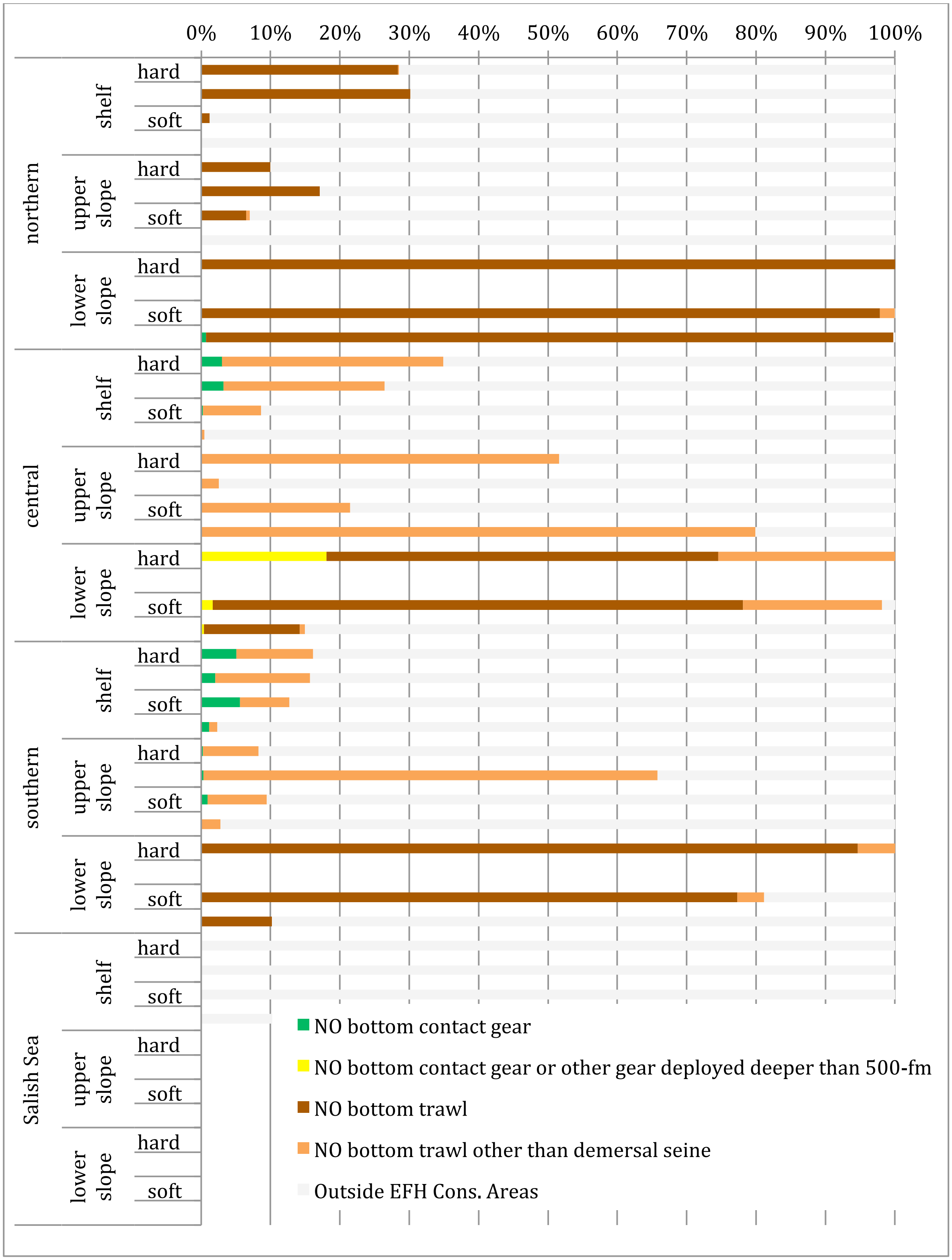

Figure 2.4. Percentages of seabed habitat areas by depth zone and biogeographic sub-regions where EFH-specific gear prohibitions apply. No EFH Conservation Areas are located in the “Salish Sea” and no “mixed” substrate types are known to occur with the lower slope of any biogeographic sub-region.

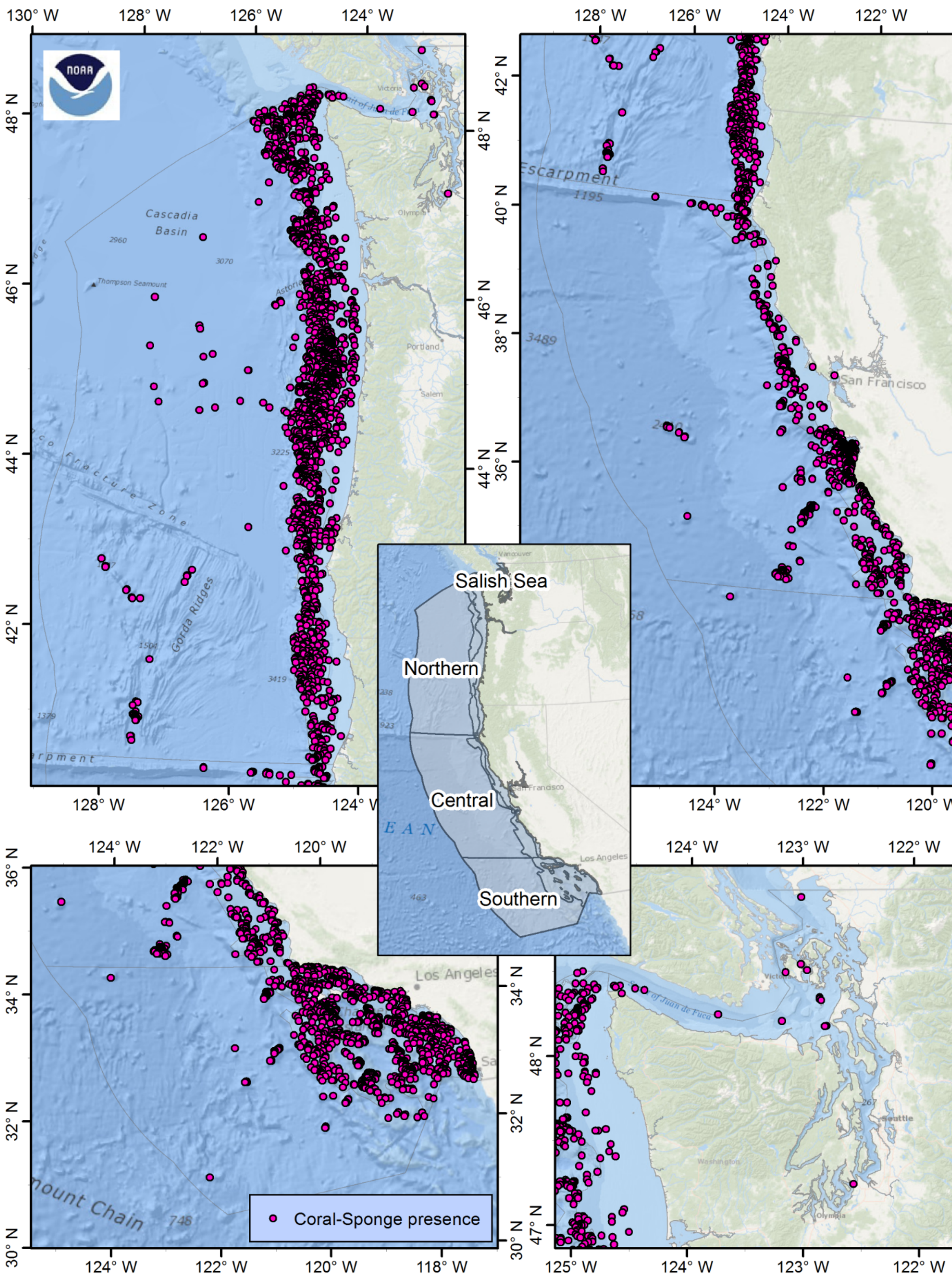

Figure 2.5a. Map showing the spatial distribution of coral (excluding pennatulids) and sponge presence, summarized by 1x1 km cells.

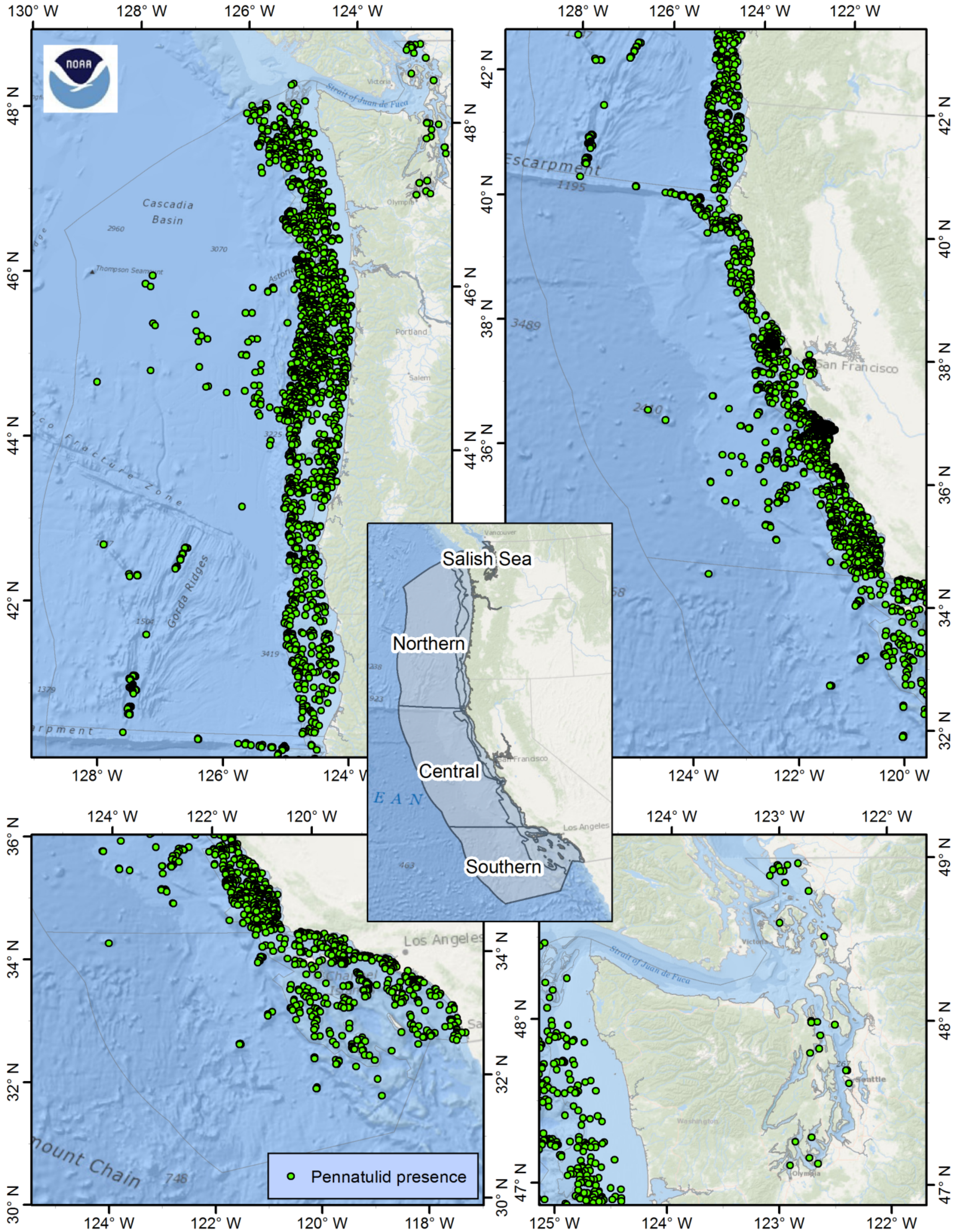

Figure 2.5b. Map showing the spatial distribution of pennatulid presence, summarized by 1x1 km cells.

Table 2.2. Distribution presence of two groups of biogenic taxa [coral (excluding pennatulids) and sponge (top); pennatulid (bottom)] by depth zones both coast-wide and in four biogeographic sub-regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). The "Salish Sea" only encompasses the shallowest ("shelf") depth zone. Percentage values represent relative contribution to the sub-region. Counts represent the number of 1x1 km grid cells where coral and/or sponge were present.

	BIOGEOGRAPHIC SUB-REGION								COAST-WIDE	
	Northern		Central		Southern		Salish Sea		Combined	
Depth Zone	Count	%	Count	%	Count	%	Count	%	Count	%
Shelf[1]	426	21.7%	395	38.4%	323	29.4%	16	100.0%	1,160	28.3%
Upper Slope[2]	1,448	73.8%	396	38.5%	697	63.5%	0	0.0%	2,541	61.9%
Lower Slope[3]	87	4.4%	238	23.1%	77	7.0%	0	0.0%	402	9.8%
Total	**1,961**	**47.8%**	**1,029**	**25.1%**	**1,097**	**26.7%**	**16**	**0.4%**	**4,103**	**100.0%**
Coral (excluding pennatulids) and Sponge Presence [above] | Pennatulid Presence [below]										
Shelf[1]	586	32.7%	736	44.0%	149	33.1%	27	100.0%	1,498	38.0%
Upper Slope[2]	1,060	59.1%	660	39.5%	258	57.3%	0	0.0%	1,978	50.2%
Lower Slope[3]	148	8.2%	276	16.5%	43	9.6%	0	0.0%	467	11.8%
Total	**1,794**	**45.5%**	**1,672**	**42.4%**	**450**	**11.4%**	**27**	**0.7%**	**3,943**	**100.0%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

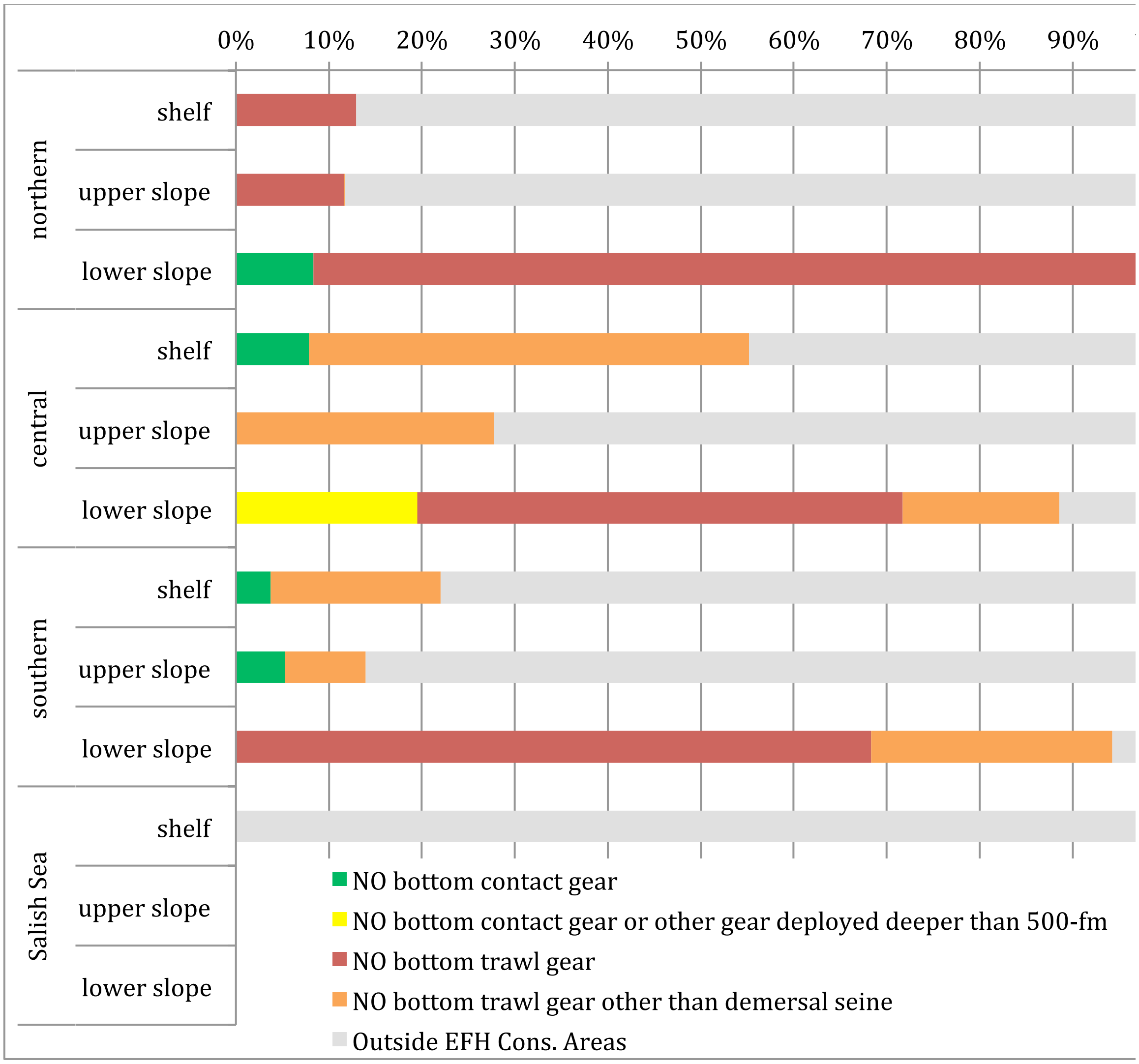

Figure 2.6a. Percentages of coral (excluding pennatulids (sea pens)) and sponge presence by depth zc biogeographic sub-regions where EFH-specific gear prohibitions apply. No EFH Conservation Areas ar in the "Salish Sea".

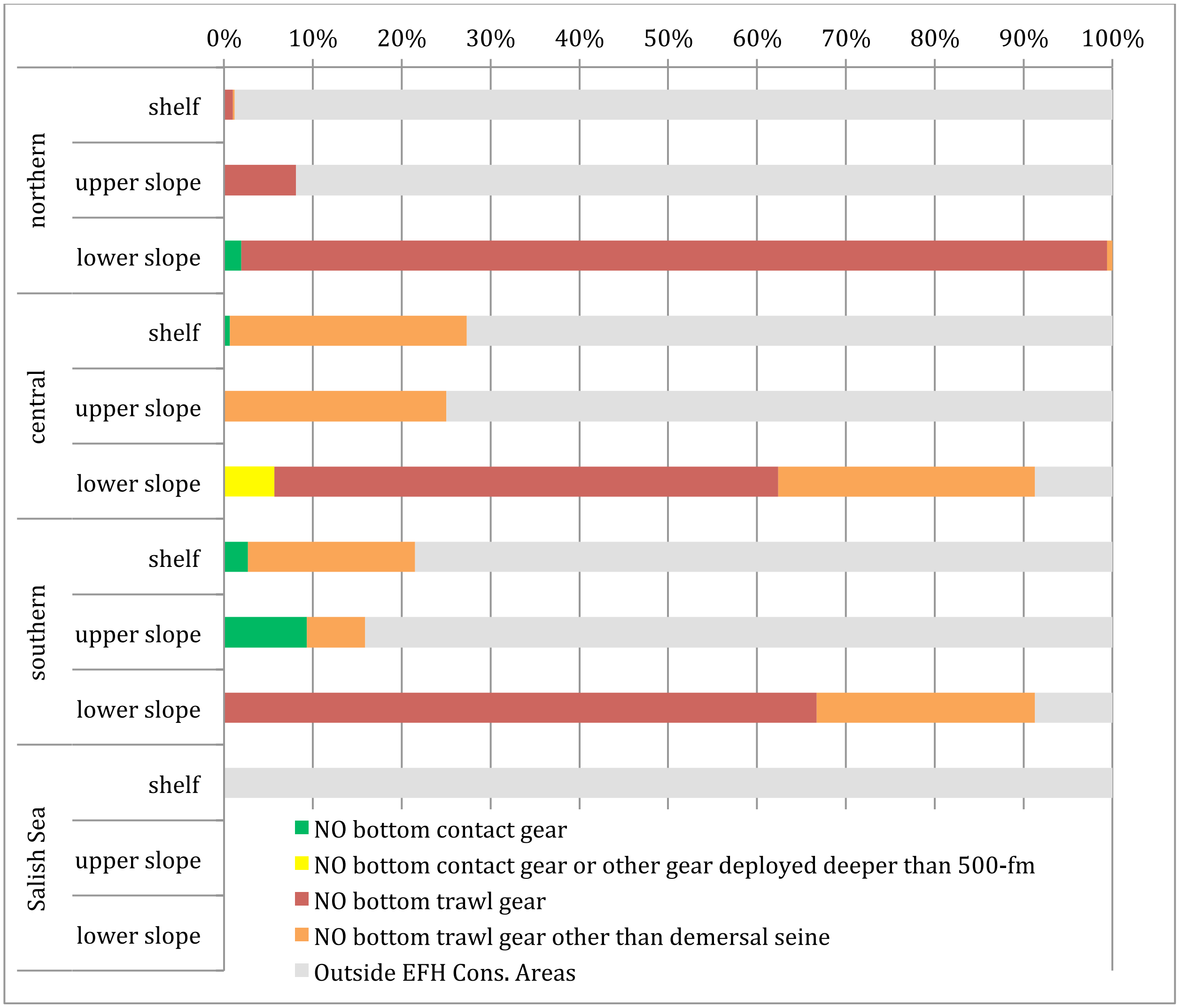

Figure 2.6b. Percentages of pennatulid presence by depth zone and biogeographic sub-regions where EFH-specific gear prohibitions apply. No EFH Conservation Areas are located in the "Salish Sea".

3.0 SPECIES-HABITAT ASSOCIATIONS

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Charles Menza, Brian Kinlan, National Centers for Coastal Ocean Science

Overview:

- We identify habitat variables that are important predictors of occupancy and abundance for six focal groundfish species as measured primarily by the NOAA trawl survey (years 2003 to 2011), but also including some visual observation data (e.g. ROV surveys).
- Due to available data we focus on age 1+ juvenile and adult life stages (individuals > ~15 cm standard length).
- We provide statistically well-supported spatial maps of occurrence and abundance for each species using two new models.
- Despite methodological differences, the two modeling approaches show strong agreement in the predicted occurrence of each species.
- Patterns of occurrence and abundance vary among species but show high probability of occurrence for at least one of the six species at virtually all locations along the coast.
- For all species considered, depth, bottom temperature, and sediment grain size were important covariates in predicting probability of occurrence (Table 3.1). Depth and bottom temperature were also key predictors of abundance for all species considered, but sediment grain size was not (Table 3.2).

3.1 SPECIES-HABITAT RELATIONSHIPS FOR SEVERAL EXAMPLE SPECIES:

3.1.1 Introduction

We use observed patterns of occurrence and abundance to estimate the importance of a set of habitat variables for the occupancy and abundance of each species. Past approaches have focused on estimating probabilities of habitat suitability for each species and life stage as a function of a number of covariates, including depth, latitude and substrate, and expert opinion (NMFS 2005). In our approach, we also use a number of habitat covariates to estimate the probability that a species will be found at a particular location. Since species show habitat preferences, their presence or absence can be used as an indicator of habitat preferences and potentially suitability. [We also evaluate abundance, but interpretations are more complicated since removal of fish by the fishery can affect abundance and interpretations thereof.] Nonetheless, evaluating likelihood of occupancy is a data-drive, testable approach to determining habitat associations. Here we provide two new frameworks to address the EFH problem (referred to as the NWFSC model and the NCCOS model). Both approaches use spatial regression approaches and use habitat variables to explain both the occurrence and abundance of each species. Both models provide patterns of species occurrence and abundance at the scale of the US West Coast and use the NOAA Fisheries West Coast Bottom Trawl Survey (WCBTS) as the primary data source.

However, the two models make different assumptions about the mathematical structure and interaction between model structure and data that have real consequence for model estimation, interpretation, and prediction. Very briefly, we can summarize the main differences between the NWFSC and NCCOS models in three points (see Appendix 3 for a more detailed explanation of all three points): 1) The models use slightly different data sets. The NWFSC model includes survey trawl data from 2003-2011 while NCCOS only uses data from 2003-2010. Additionally, NWFSC includes a small set of non-trawl data from direct count visual surveys using human occupied submersibles, resulting in more observations in untrawlable habitat, and improving upon one of the challenges inherent in using the trawl survey data (e.g. Figure 3.4). 2) The NCCOS model assumes that all trawl survey samples are from a single stationary distribution while the NWFSC model attempts to explicitly model among year variation in the occurrence and abundance. As a result, the NCCOS model will be able to identify smaller scale spatial clustering than the NWFSC model. However, the NWFSC model accounts for year to year variability in occurrence more transparently. (Appendix 2). 3) The NCCOS model is developed, estimated, and evaluated in a maximum likelihood framework while the NWFSC model uses a Bayesian framework. Consequently, NCCOS will generally identify more habitat variables as important descriptors of species-habitat relationships than the NWFSC model while the NWFSC model will generally have larger spatial variability than the NCCOS model. Overall, it will be important to consider results from both models, but the NWFSC model will be more reliable in areas of untrawlable habitat.

Further methodological details and references for the NWFSC and NCCOS models can be found in the methods appendix (Appendix 3).These analyses use available data well, but, like all analyses, have limitations due to the data that can be used. Because trawls sample over large areas, these results smooth potentially important small-scale habitat variation. The somewhat larger scale in our analyses is more relevant to the large-scale decision-making in EFH, however. Second, rocky, high relief and deep (>1,300m) habitats are not well-sampled by the trawl survey, so species that are more restricted to these habitats are not well represented. The poor sampling in these areas does not mean that these habitats are unimportant, and clearly, better data in these areas would be of great value. Finally, while the trawl survey does sample 1+ juvenile fishes, it does not sample pelagic juveniles and the smaller size range of newly settled juveniles well. However, it is known that kelp beds are important for many groundfish at this stage; again, the best information currently available is that compiled for the most recent EFH designation effort (NMFS 2005).

3.1.2 General Results

We were able to estimate species-habitat relationships for the age 1+ juvenile and adult life stages (individuals > ~15 cm standard length) and to identify habitat covariates that helped describe their occurrence and abundance for all six focal species. For each of our focal species, we present three main figures. First, we show the predicted mean probability of occurrence for all years and the predicted mean estimated abundance from the NWFSC model (e.g. Figure 3.1 for sablefish). For the second, we show the predicted mean probability of occurrence for all years and the predicted mean abundance from the NCCOS model (e.g. Figure 3.2 for sablefish). For both models, the probability of occurrence map is interpreted as the predicted probability of observing at least one individual of the species if you were to sample 1 hectare (0.01 km^2) of seafloor. The abundance map is interpreted as the expected biomass (kg) that would be collected if 1 hectare of seafloor were sampled. Since the NWFSC makes a prediction of probability of occurrence and abundance for each year, these plots present the average of the mean prediction in the individual years (2003 to 2011). Unlike the NWFSC model, the NCCOS model uses all years of the trawl data simultaneously to present a single prediction map that represents the long-term mean probability of occurrence and abundance. The NCCOS effort also uses a slightly different set of years (2003-2010) than the NWFSC model. The third figure (e.g. Figure 3.3 for sablefish) shows the probability of occurrence maps from NWFSC (from Figure 3.1) and NCCOS (from Figure 3.2) in the first two panels while the third panel shows the location and magnitude of difference between the NWFSC and NCCOS model predictions. We do not present a comparison of the abundance portion of the models because the results for abundance were poorly resolved in some cases. Overall, the differences between the modeling efforts emphasize that there is uncertainty associated with the probability of occurrence and abundance of each species at each location.

Both models agree that areas with highest probability of occurrence and abundance are not coincident among species (Figures 3.1 to 3.18) – a reassuring conclusion, since species were chosen to represent different ecological characteristics. Petrale sole tend to be in the shallow waters of the continental shelf, darkblotched and greenstriped rockfishes occupy the middle depths, and longspine thornyhead and sablefish inhabit deeper waters. Each species occupies a distinct habitat with respect to the other habitat covariates as well (Tables 3.1 to 3.4). Taken together, at least one of the focal species is predicted to occur with reasonably high probability in each predicted grid cell – indirectly confirming that our choice of proxy species spanned a wide range of ecological axes. Designation of spatial management boundaries will thus likely involve prioritization and potentially trade-offs in protection among species (or species groups).

In general, the models have similar predictions of areas occupied by each species. For abundant, well-sampled species such as sablefish and longspine thornyhead, differences between the models tended to be within ± 5% (e.g. Figures 3.3, 3.12). For species with lower overall abundance the differences between models are larger, with the NCCOS model tending to estimate slightly lower probability of occurrence than the NWFSC model. This is a systematic bias arising from the link function used in the NCCOS GLM model. The details accounting for this and to make adjustments are described in greater detail in Appendix 2. The models also tend to differ along the edges of the prediction area and in areas where the predicted probabilities of occurrence are changing rapidly. Model differences are particularly pronounced in yelloweye rockfish (Figure 3.6) – a species associated with rocky, untrawlable habitats. These differences largely reflect the inclusion of non-trawl survey information in the NWFSC model but not the NCCOS model, and again emphasize the importance of additional sampling. Given the inclusion of this additional information, the NWFSC model is likely to be more reliable in these areas.

In all cases and both models, spatial models (models that explicitly account for spatial autocorrelation, or likelihood of an individual of a species being found near other individuals of the same species) were preferred over non-spatial models, indicating that incorporating the spatial organization of observations was an important determinant of species occurrence and abundance. Depth and some aspect of temperature were important predictors of occupancy in all models for all species; proximity to rocky outcrops was an apparent driver for several species.

To summarize the intersection of the probability of occurrence and EFH Conservation Areas, we calculated the proportion of high probability of occurrence that occur within those areas. We summarized the probability of occurrence on a 2x2km grid for the entire coast and overlaid the amendment 19 regulation areas (see also sections 3 and 5). For the EFH conservation areas, we included all areas where bottom trawl or bottom contact gear were prohibited. As in section 5, if any portion of each grid cell contained gear restrictions, we designated it as protected. For each species, we had to define a cutoff for classifying each grid cell as containing a high probability of occurrence. This choice of a cutoff is a subjective exercise. For the three abundant focal species (sablefish, longspine thornyhead, and petrale sole) we used a cutoff probability of occurrence of 0.50. For the three less abundant species (yelloweye, greenstriped and darkblotched rockfish), we used a cutoff of 0.25. We found the following proportion of high probability areas falling within EFH conservation areas: yelloweye rockfish 35%; sablefish 20%; longspine thornyhead 22%; petrale sole 7%; darkblotched rockfish 7%; and greenstriped rockfish 10%. The apparent trend is that both greater depth and some affinity for rocky habitats (either being found in rocky habitats, or with proximity to rocky habitats as a significant predictor) increase the proportion of 'high probability' areas that have these protections.

Sablefish (*Anoplopoma fimbra*)

Sablefish are a widespread species in deep-water habitats along the entire west coast (present in ~65% of survey trawls; Figures 3.1 to 3.3). They are among the most commonly observed species in the trawl survey (Table A2.1.4) and were well described by both the NWFSC and NCCOS models. For both models, the preferred model incorporated a large number of habitat covariates to explain both probability of occurrence and abundance (Tables 3.1 to 3.4), with depth and bottom temperature being particularly important habitat covariates. There is a notable decline in both the probability of occurrence and abundance in sablefish south of Pt. Conception that is not well explained by the explicit habitat variables included in either model. However, such regional variation is well captured by the regional position effect in the NCCOS model and the spatial variance in the NWFSC model. Both NWFSC and NCCOS found the abundance model difficult to estimate due to rare occasional extremely high catches in the trawl survey (occasional trawl survey catches of > 1000 kg/ha).

Yelloweye Rockfish (*Sebastes ruberrimus*)

Yelloweye Rockfish exhibit strong site fidelity to rocky bottoms and steep outcrops that are poorly sampled by the trawl survey (present in ~2% of survey trawls; Figs 3.4 to 3.7), and this rarity made estimating species-habitat relationships difficult. As a result, NWFSC did not attempt to estimate year effects or year-specific spatial covariances for the probability model and did not estimate an abundance model at all. Instead, the NWFSC contrasts the probability of occurrence model that includes only data from the trawl survey with a model that includes both the trawl survey and visual surveys that disproportionately sample rocky, high relief habitats (Figure 3.4). Though the visual surveys only include 81 additional observations, these data are disproportionately influential in determining the probability of occurrence map. The NCCOS model, which does not include visual survey data, produced a map qualitatively similar to the NWFSC model that did not include visual survey data (Figures 3.5 and 3.6). For both models, depth and association with rocky habitats were important covariates for yelloweye, with the highest probability of occurrence associated with the offshore banks of Washington and Oregon (e.g. Heceta Bank). The abundance model results from the NCCOS model are considered somewhat unreliable due to low sample sizes and should be interpreted with caution (see Appendix 3).

Petrale Sole (*Eopsetta jordani*)

Petrale sole are a widespread, abundant species in the shallow shelf waters along the entire coast (present in ~40% of survey trawls; Figures 3.7 to 3.9). The NWFSC model used a fairly simple statistical model that includes only depth and bottom temperature as explanatory variables. The NCCOS model also found depth and bottom temperature to be important habitat variables but included additional predictors and interaction terms in the model such as alongshore position, regional position, and chlorophyll a concentration. The highest probabilities of occurrence were found in a relatively continuous band from the northern most extent of the study area to Point Conception and from 150 m to the shallowest extent of the study area. Abundance models were more heterogeneous with catch hotspots predicted off of Cape Flattery, the Columbia River, Point Reyes, Monterey Bay, and Point Sur.

Longspine Thornyhead (*Sebastolobus altivelis*)

Longspine thornyhead occur regularly in the trawl survey (present in ~35% of survey trawls) and are well described by both modeling efforts (Figures 3.10 to 3.12). Both NWFSC and NCCOS models predict a band of high probability of occurrence in the deeper waters (>400m deep) of the trawl survey (Figures 3.10 to 3.12). This species is notable for a lack of variation in probability of occurrence and abundance along the coast. Depth and bottom temperature were important predictors of longspine thornyhead in both models. The NWFSC model also included sediment characteristics as explanatory variables and NCCOS included a number of additional variables including alongshore position, sea surface temperature, regional position, and a number of interaction terms. With a small exception for some areas off southern California, the NWFSC and NCCOS models were very similar for longspine thornyhead.

Greenstriped Rockfish (*Sebastes elongatus*)

Greenstripe rockfish are generally found in habitats well sampled by trawls and are well represented in the trawl dataset (present in ~25% of survey tows; Figures 3.13 to 3.15). While greenstriped are susceptible to trawl gear, both the NWFSC and NCCOS models found depth and proximity to rocky outcrops to be important predictors of occurrence. Furthermore, both models found evidence of regional variation in probability of occurrence and abundance that was not well explained by habitat variables. Generally, greenstriped are most common and abundant north of Monterey Bay in moderate depths (100-250m).

Darkblotched Rockfish (*Sebastes crameri*)

Darkblotched are generally found in habitats well sampled by trawls and are reasonably represented in the trawl dataset (present in ~15% of survey tows; Figures 3.16 to 3.18). The most notable aspects of darkblotched distribution are the narrow range of depths they occupy (from ~100m to 400m) and their virtual disappearance south of approximately Pt. Reyes. This geographic associated change can be modeled by both NWFSC and NCCOS but it is poorly explained by any of the habitat variables in either model. Perhaps due to this strange observed distribution, the maps of predicted probability of occurrence maps differ substantially in many places between the NWFSC and NCCOS models (Figure 3.18). NCCOS found sea surface temperature to be an important explanatory variable while the NWFSC model included bottom temperature and sediment grain size.

Other species

In addition to the six species discussed here, we include results for the NCCOS model applied to five additional species in Appendix 3 (lingcod, *Ophiodon elongatus*; Dover sole, *Microstomus pacificus*; shortspine thornyhead, *Sebastolobus alascanus;* Pacific ocean perch, *Sebastes alascanus;* chilipepper, *Sebastes goodei*).

Table 3.1: Habitat covariates included in the preferred NWFSC probability of occurrence model for the six focal species. "X" indicates the covariates included in the preferred model. All columns are habitat covariates except "Year" which designates a categorical offset for each year, and "Single Variance?" which designates if a single spatial variance parameter was estimated for all years ("Y") or if a spatial variance parameter was estimated for each year ("N").

Species	Year	Depth and Depth^2	Bottom Temperature	(Bottom Temperature)^2	Sediment Grain Size	(Sediment Grain Size)^2	Sqrt(km to rock)	Single Variance?
Sablefish	X	X	X	X	X	X	X	N
Yelloweye rockfish		X	X		X		X	Y
Petrale sole	X	X	X	X				N
Longspine thornyhead		X	X	X	X	X	X	Y
Greenstriped rockfish	X	X	X	X	X		X	N
Darkblotched rockfish		X	X	X	X	X	X	N

Table 3.2: Habitat covariates included in the preferred NWFSC abundance model. "N/A" indicates that the abundance model was not estimated. See Table 2.1 for more explanation.

Species	Year	Depth and Depth^2	Bottom Temperature	Bottom Temperature^2	Sediment Grain Size	(Sediment Grain Size)^2	Sqrt(km to rock)	Single Variance?
Sablefish	X	X	X	X	X		X	N
Yelloweye rockfish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Petrale sole		X	X	X				N
Longspine thornyhead		X	X	X	X	X	X	Y
Greenstriped rockfish		X	X				X	N
Darkblotched rockfish	X	X	X					Y

Table 3.3: Probability of occurrence parameters included in the plotted NCCOS models. "X" indicates a covariate used as a main effect, "Y" indicates a covariate used as part of an interaction term, and "N/A" indicates a term that was omitted from the model.

Species	Depth	Depth Polynomial	Alongshore distance	Region	Bathymetric Position Index	Rugosity	Slope	Near-bottom temperature	Surface temperature	Surface Chlorophyll	Distance to hardbottom
Sablefish	X	X	Y	X	Y	Y	Y	X	Y	Y	
Yelloweye rockfish	X		X		X				X	X	
Petrale sole	X	Y	Y	X	Y	Y	Y	X	Y	X	Y
Longspine thornyhead	X	X	X	X	Y	X	X	X	X	Y	
Greenstriped rockfish	X	N/A	X	Y	X	X		X	Y	X	X
Darkblotched rockfish	X	X	X	X					X		
Dover sole	X	X	Y	X	X	Y	X	X	Y	X	X
Lingcod	X	Y	X	X	Y	X	X	X	X	X	
Shortspine thornyhead	X	X	X	X	Y		X	Y	Y	X	Y

Pacific ocean perch		X	Y	X				X			
Chilipepper	Y	X	X	X	X	Y		X	X		X

Table 3.4: Abundance parameters included in the plotted NCCOS models. “X” indicates a covariate used as a main effect, “Y” indicates a covariate used as part of an interaction term, and “N/A” indicates a term that was omitted from the model.

Species	Depth	Depth Polynomial	Alongshore distance	Region	Bathymetric Position Index	Rugosity	Slope	Near-bottom temperature	Surface temperature	Surface Chlorophyll	Distance to hardbottom
Sablefish	X	X	Y	Y			X		Y	Y	Y
Yelloweye rockfish			X		X		X	X			
Petrale Sole	X	Y	Y	X	Y	X	Y	Y	X	X	Y
Longspine Thornyhead	X	Y	Y	X	Y	X	X	X	X	Y	Y
Greenstriped rockfish	Y	N/A	Y	X	X		Y	X	X	X	X
Darkblotched rockfish	X	X			X			X			
Dover sole	X	X	Y	X		Y	X		Y	Y	X
Lingcod		X			X			Y	X	X	
Shortspine thornyhead	Y	Y	X		Y		Y	Y	X	X	Y
Pacific ocean perch		X	X				X	X	X		
Chilipepper	Y	X		X	X	Y		Y			

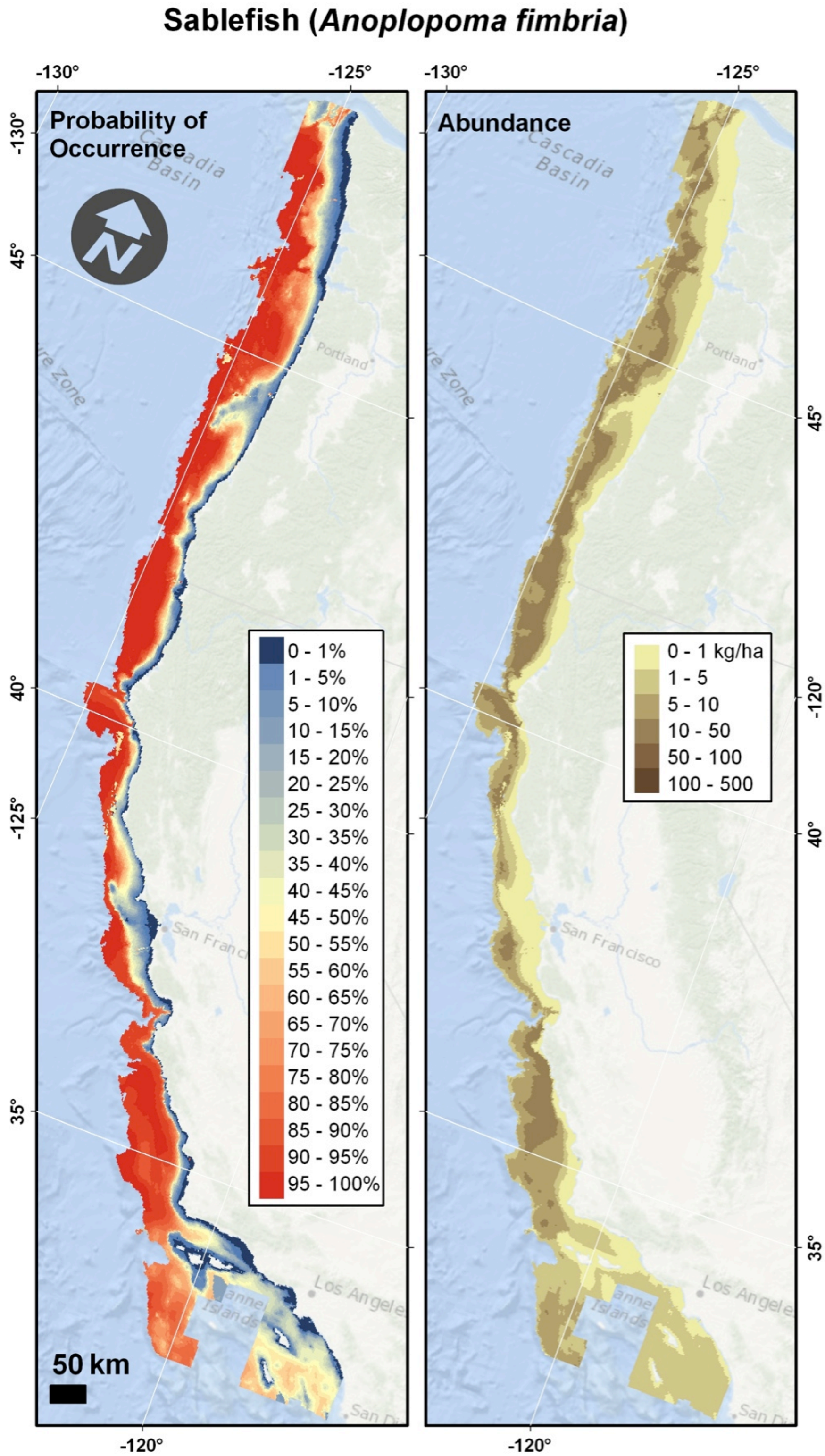

Figure 3.1: Sablefish mean predicted probability of occurrence and mean predicted abundance. NWFSC model projections.

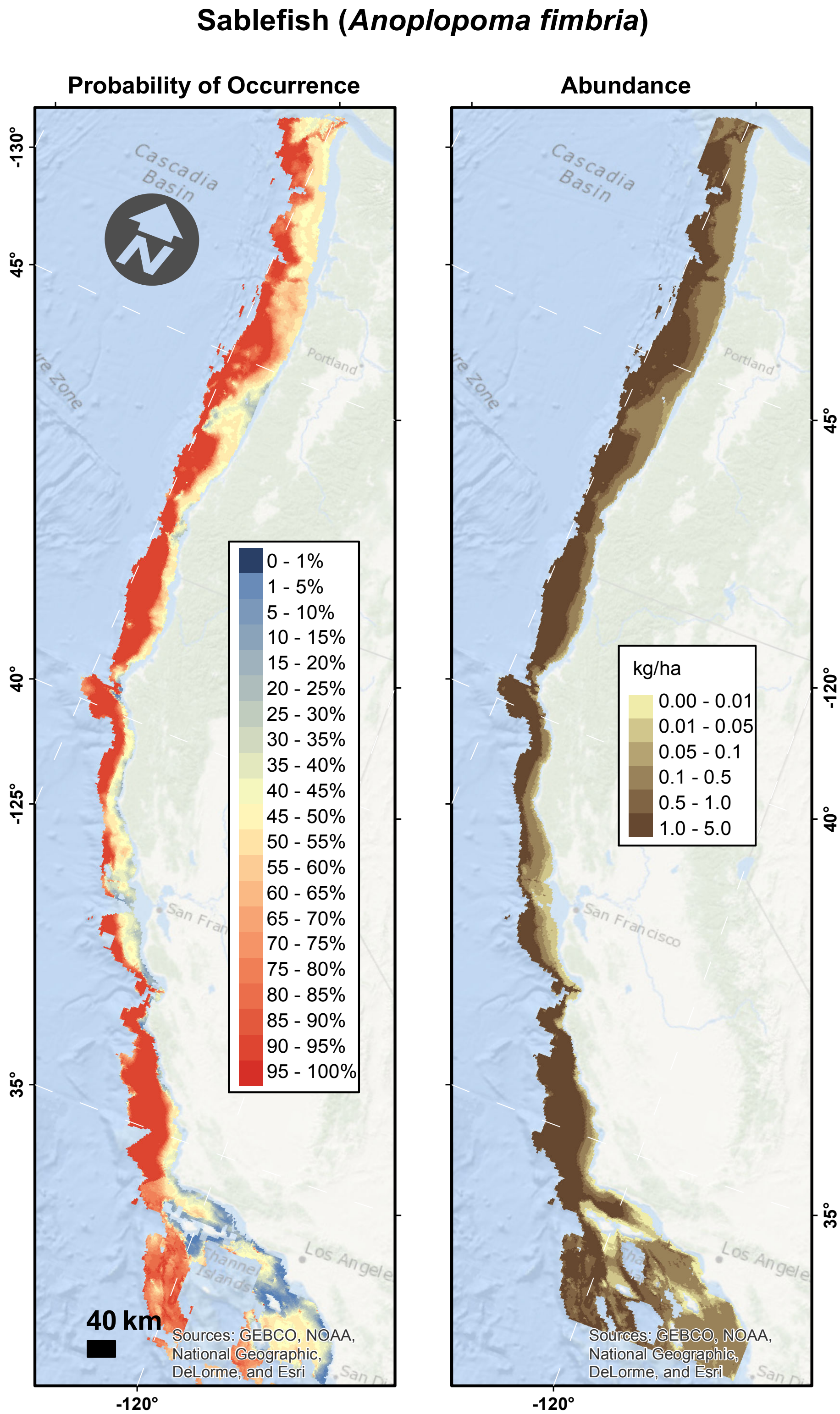

Figure 3.2: Sablefish mean predicted probability of occurrence and mean predicted abundance. NCCOS model projections.

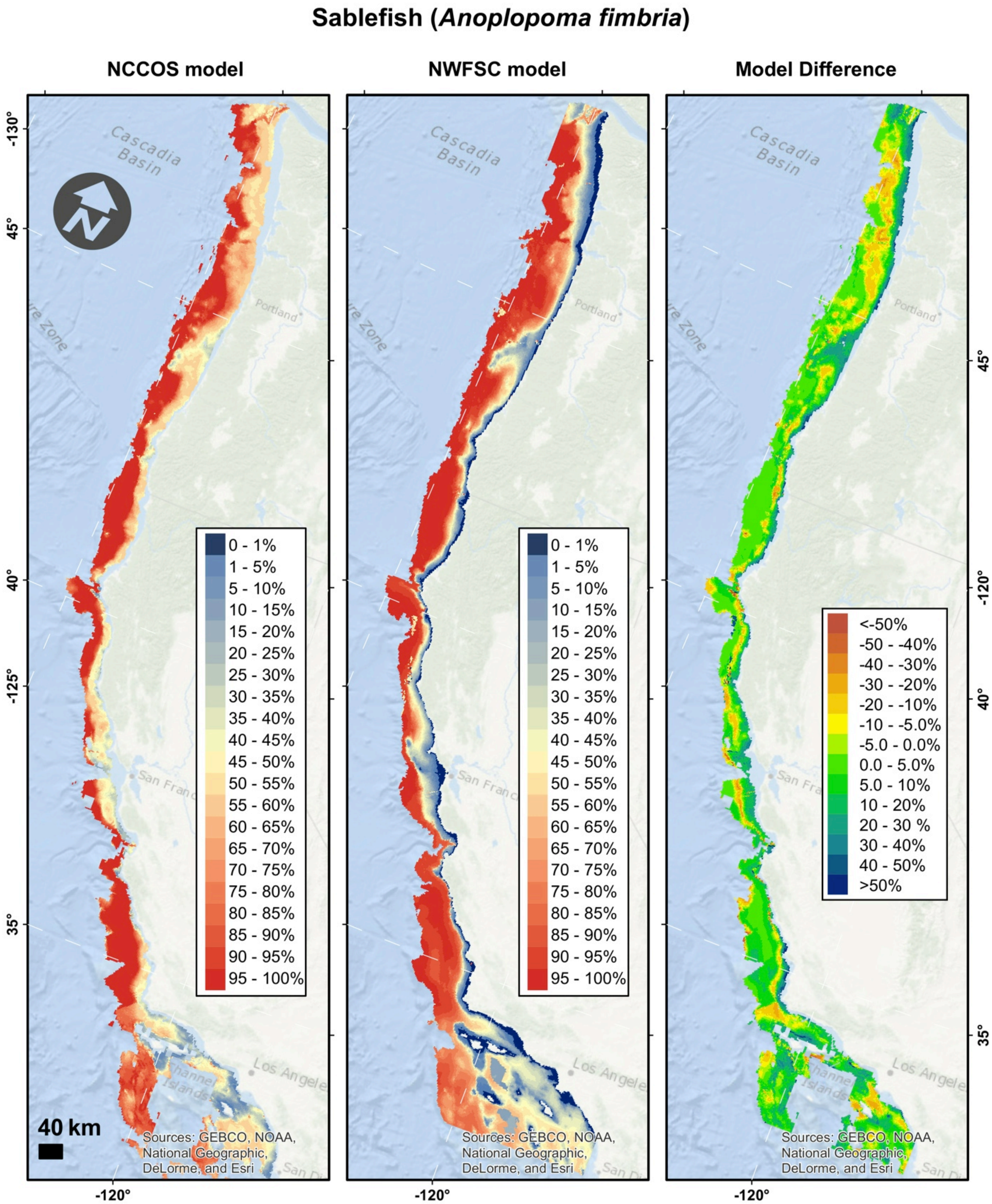

Figure 3.3: Sablefish predicted mean probability of occurrence from the NCCOS (left) and NWFSC (center) models. Right panel shows a plot of the difference between the NCCOS and NWFSC models (NCCOS – NWFSC). Positive values indicate NCCOS is greater than NWFSC.

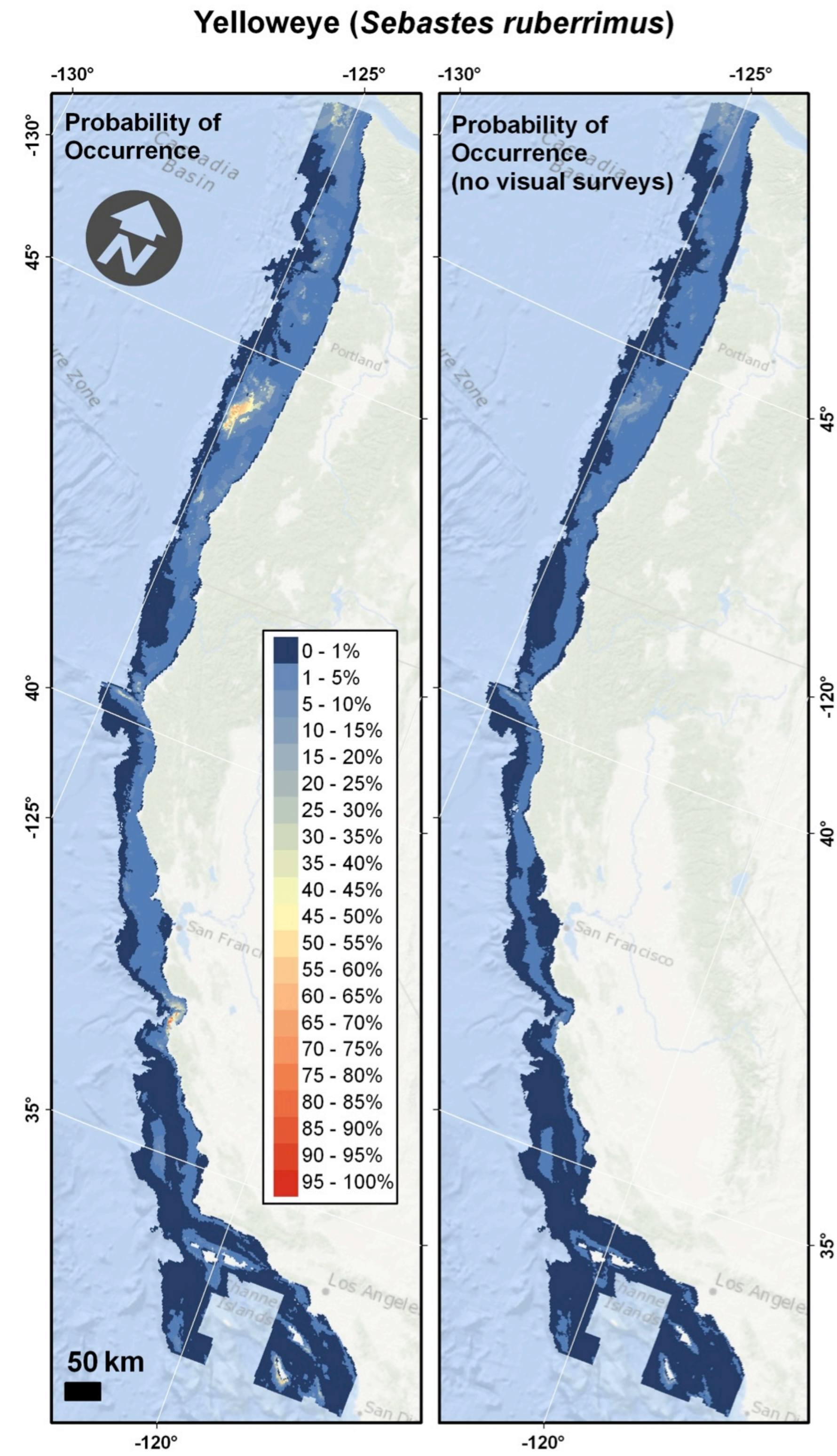

Figure 3.4: Yelloweye rockfish mean predicted probability of occurrence. NWFSC model projections. Left panel shows results using trawl survey data and visual survey data from submersible transects. Right panel shows results using only trawl survey data. NWFSC did not construct an abundance model for yelloweye.

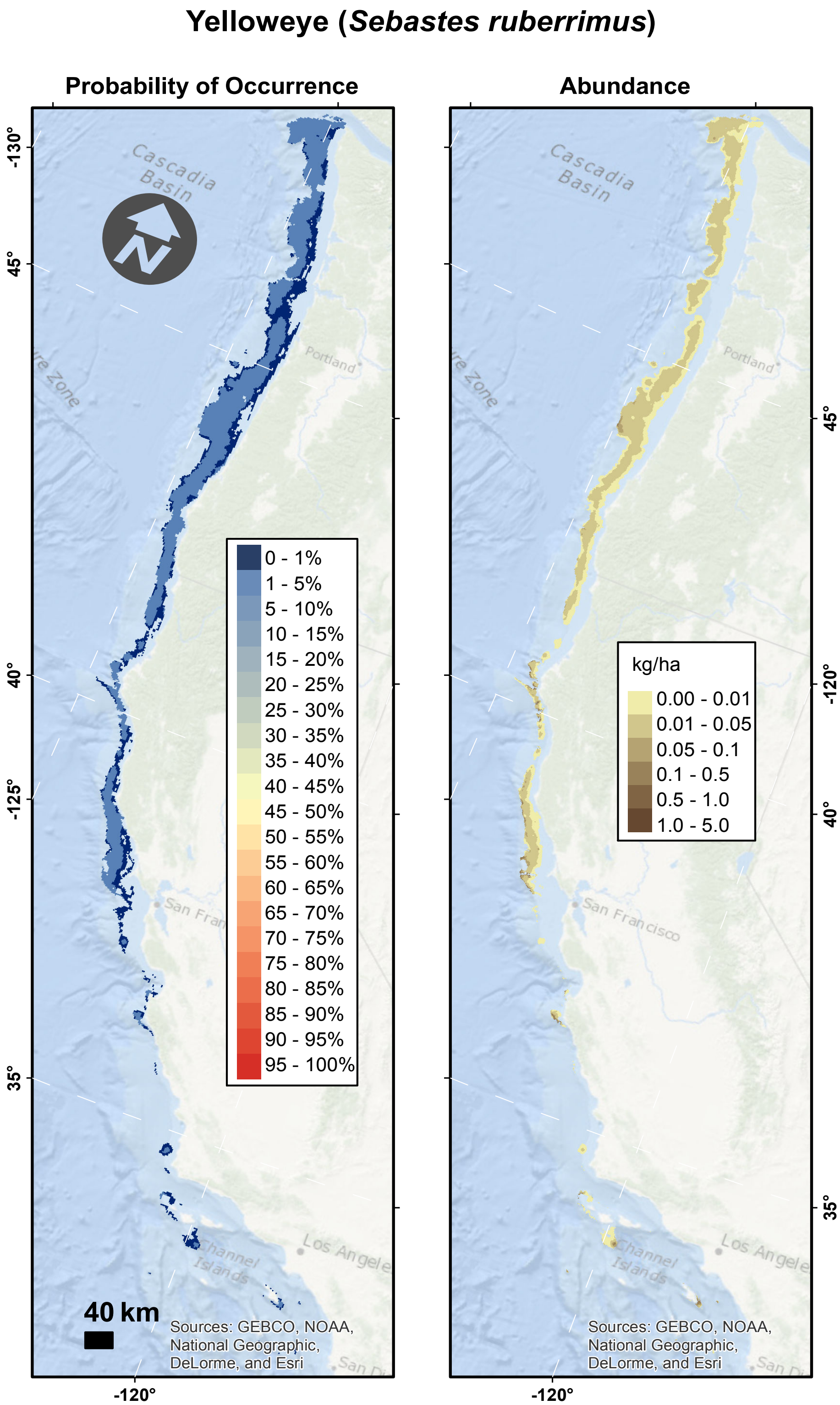

Figure 3.5: Yelloweye rockfish predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

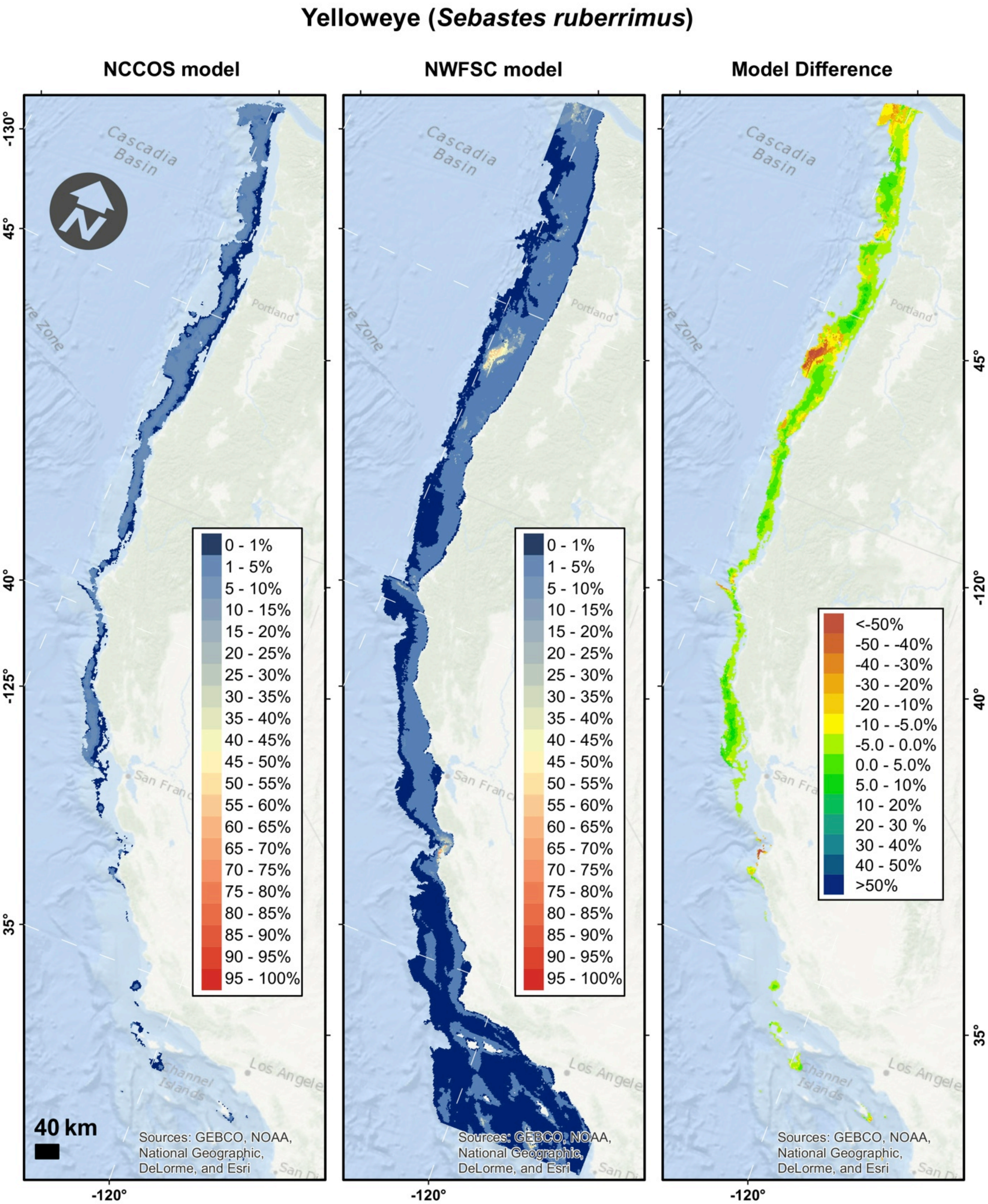

Figure 3.6: Yelloweye rockfish predicted mean probability of occurrence from the NCCOS (left) and NWFSC (center) models. Right panel shows a plot of the difference between the NCCOS and

NWFSC models (NCCOS – NWFSC). Positive values indicate NCCOS predicts higher probability of occurrence than NWFSC.

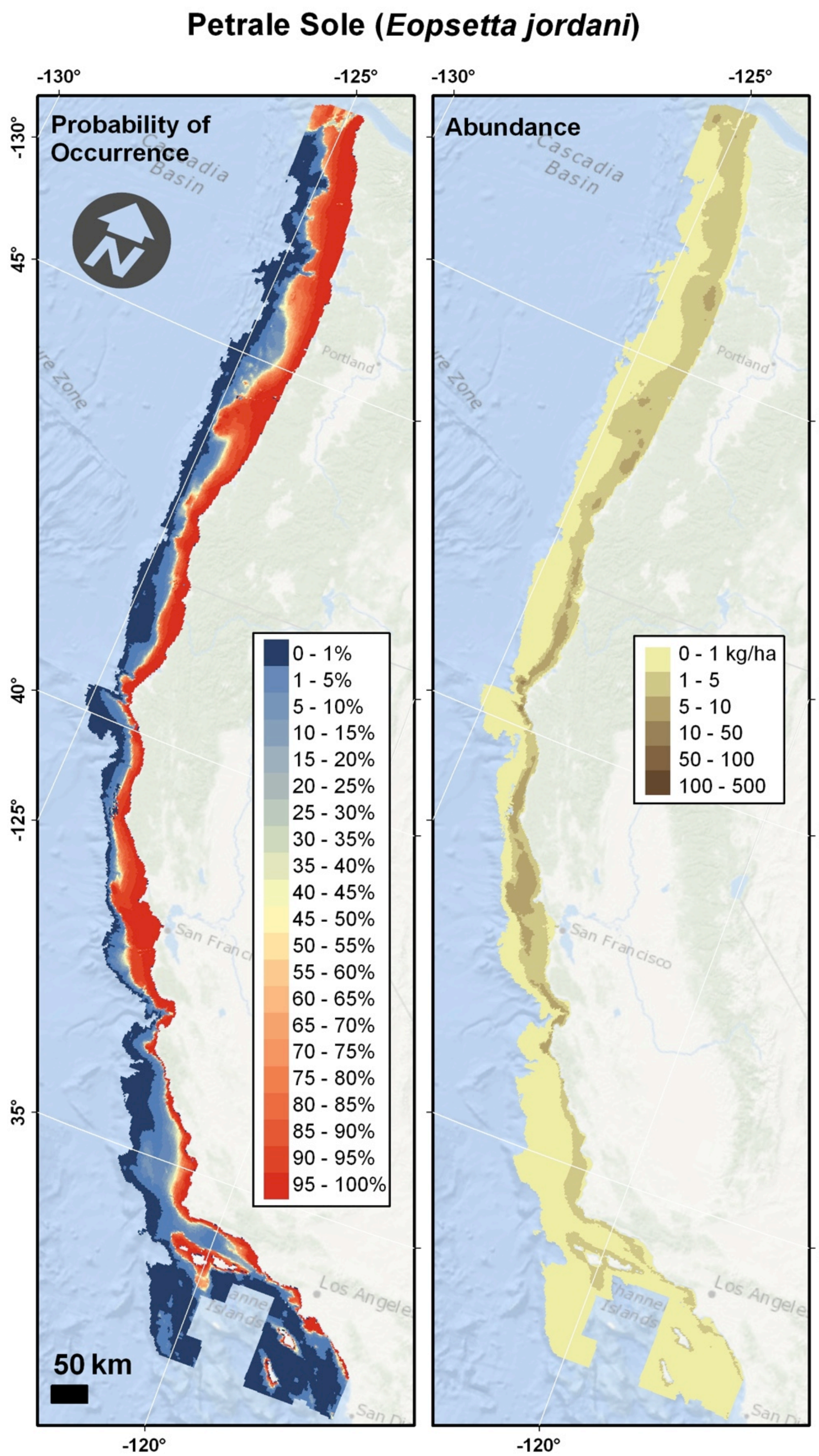

Figure 3.7: Petrale sole mean predicted probability of occurrence and predicted mean abundance. NWFSC model projections.

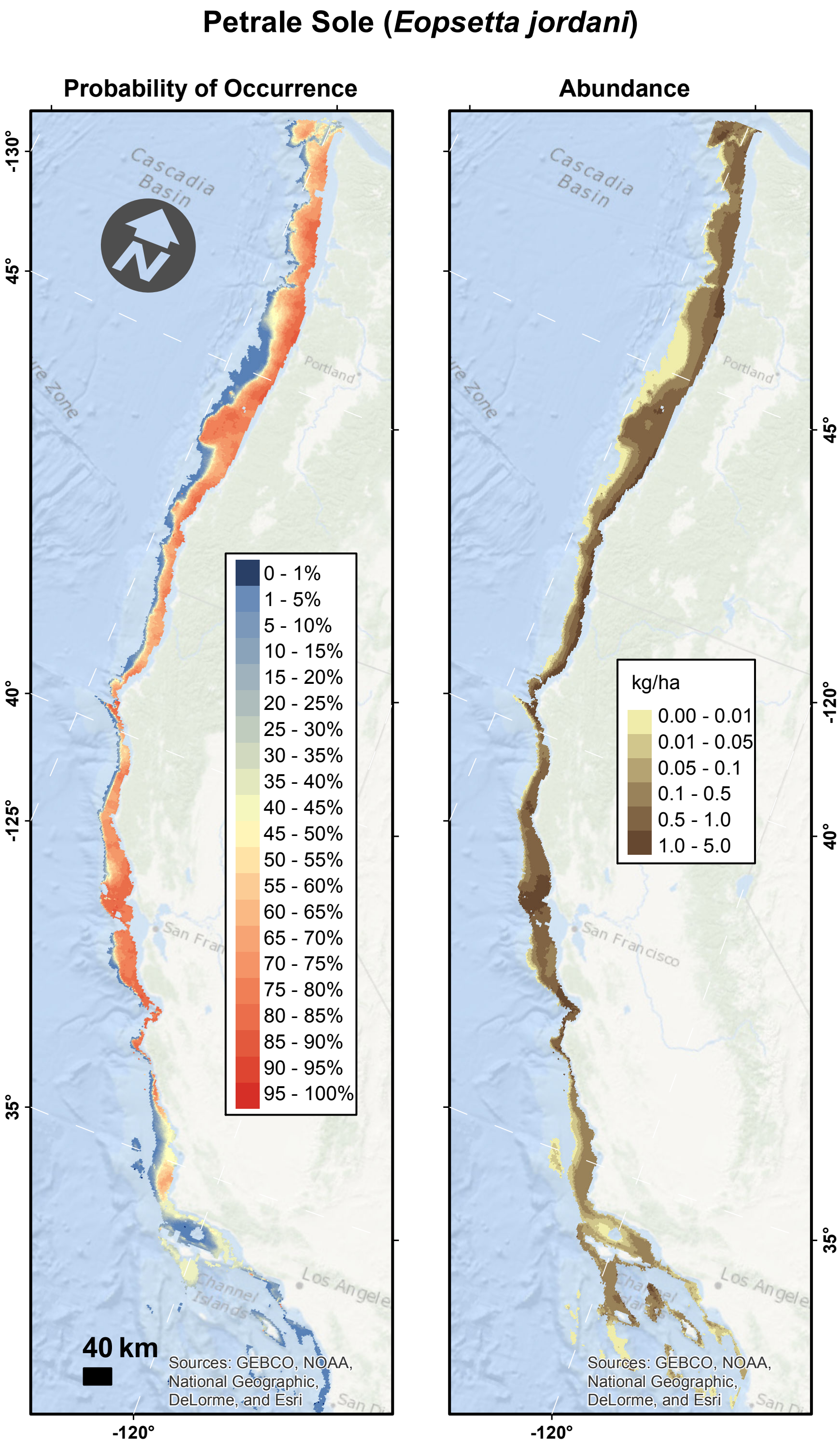

Figure 3.8: Petrale sole predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

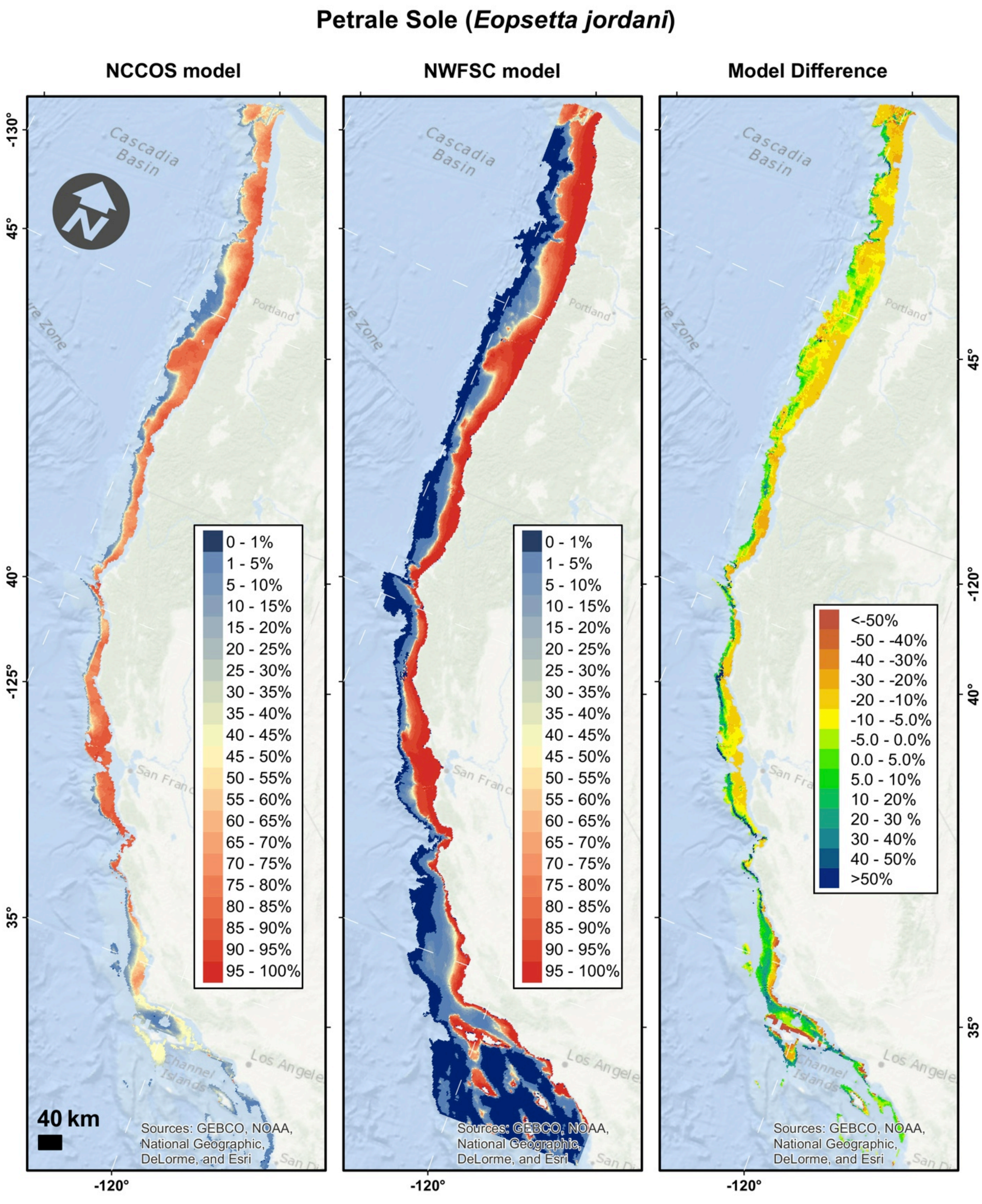

Figure 3.9: Petrale sole predicted mean probability of occurrence from the NCCOS (left) and NWFSC (center) models. Right panel shows a plot of the difference between the NCCOS and NWFSC models (NCCOS – NWFSC). Positive values indicate NCCOS predicts higher probability of occurrence than NWFSC.

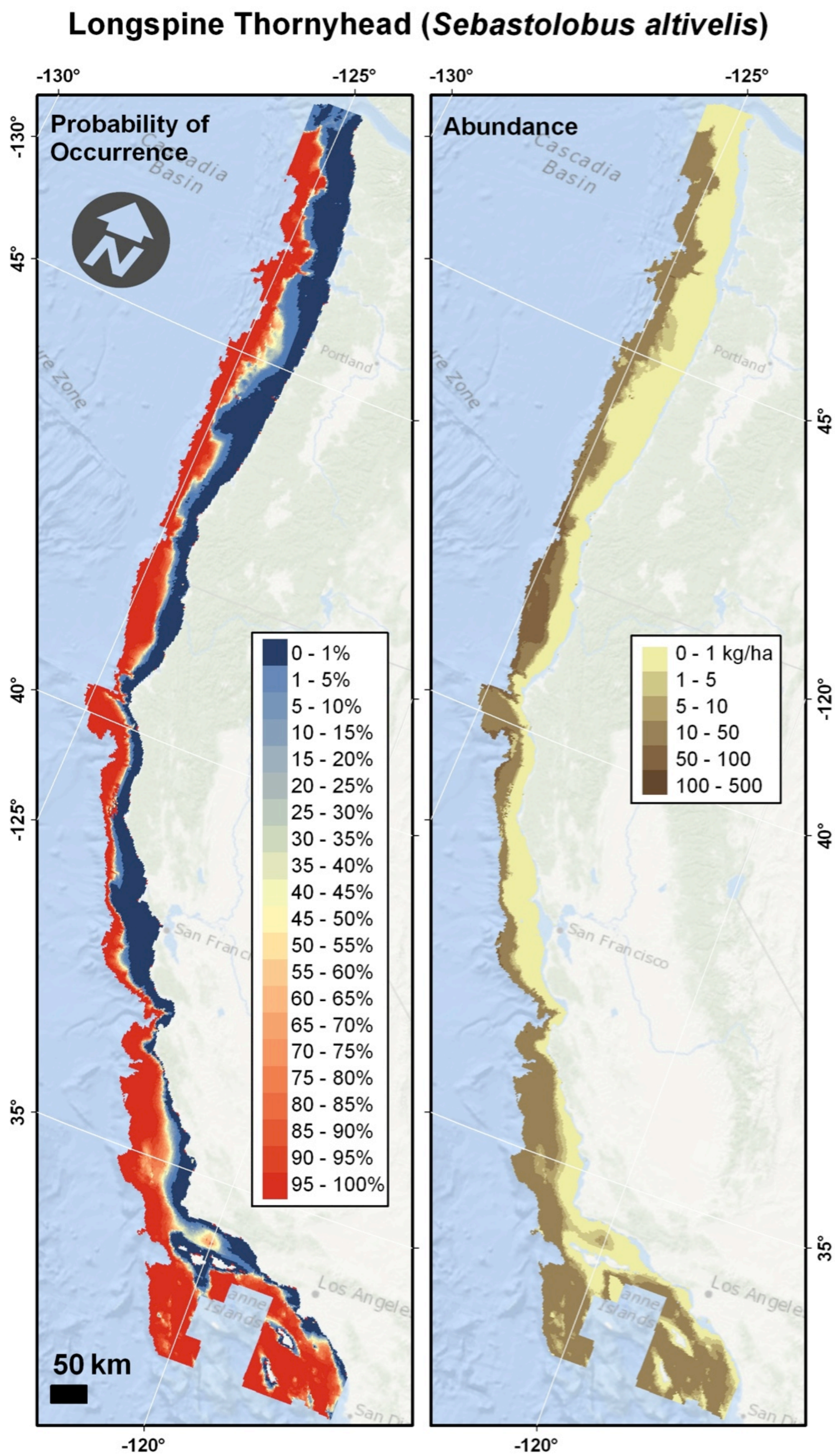

Figure 3.10: Longspine thornyhead mean predicted probability of occurrence and predicted mean abundance. NWFSC model projections.

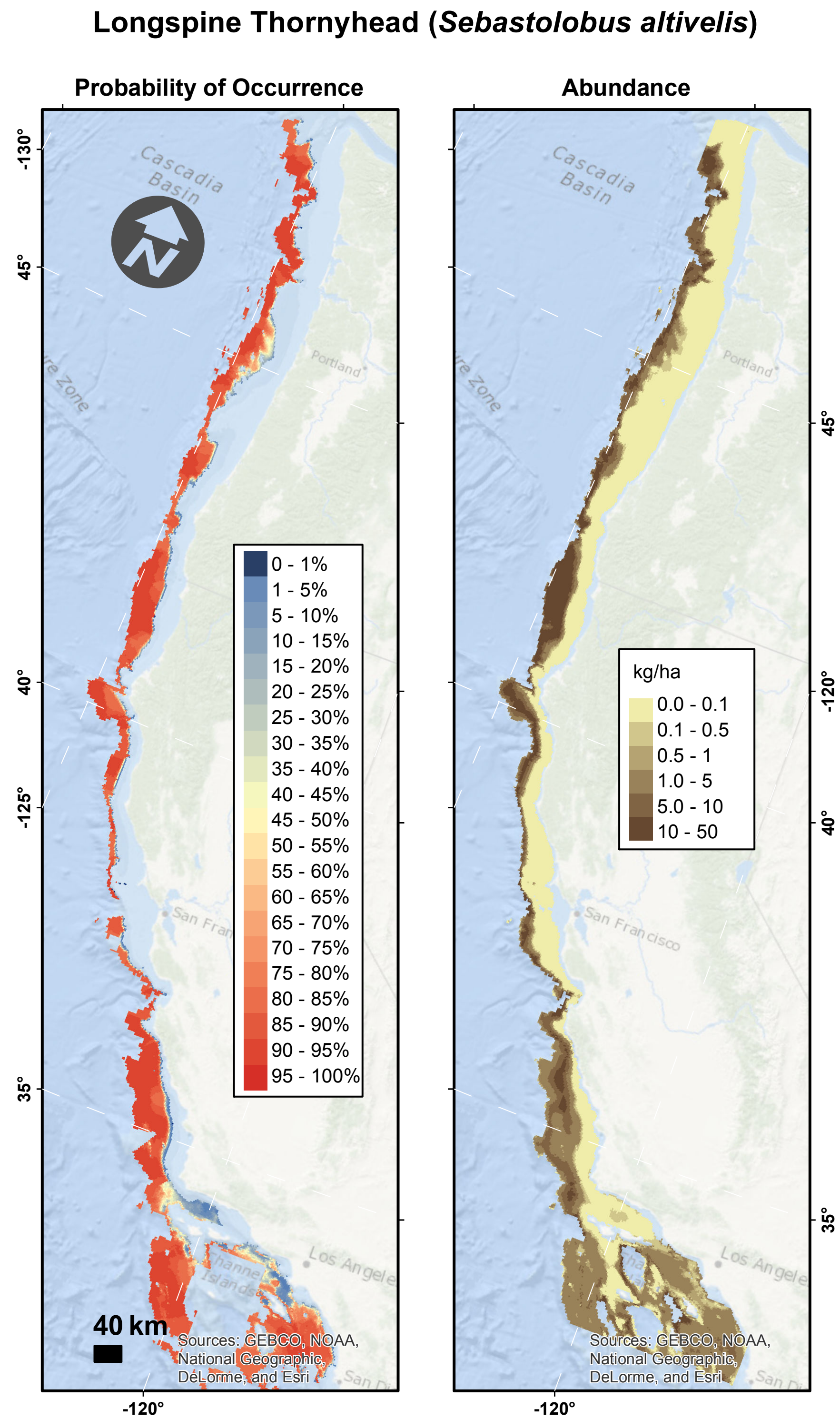

Figure 3.11: Longspine thornyhead predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

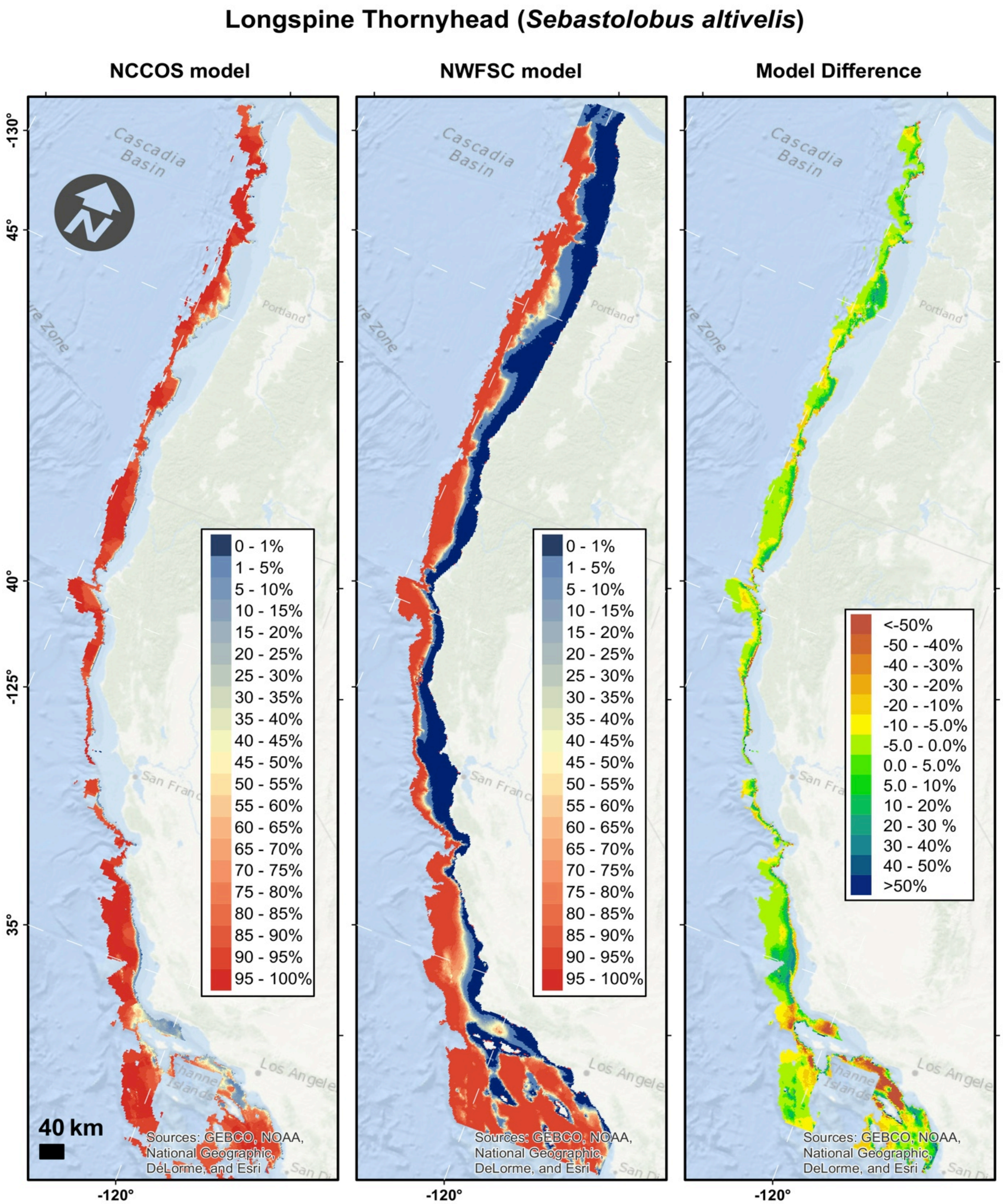

Figure 3.12: Longspine thornyhead predicted mean probability of occurrence from the NCCOS (left) and NWFSC (center) models. Right panel shows a plot of the difference between the NCCOS and NWFSC models (NCCOS – NWFSC). Positive values indicate NCCOS predicts higher probability of occurrence than NWFSC.

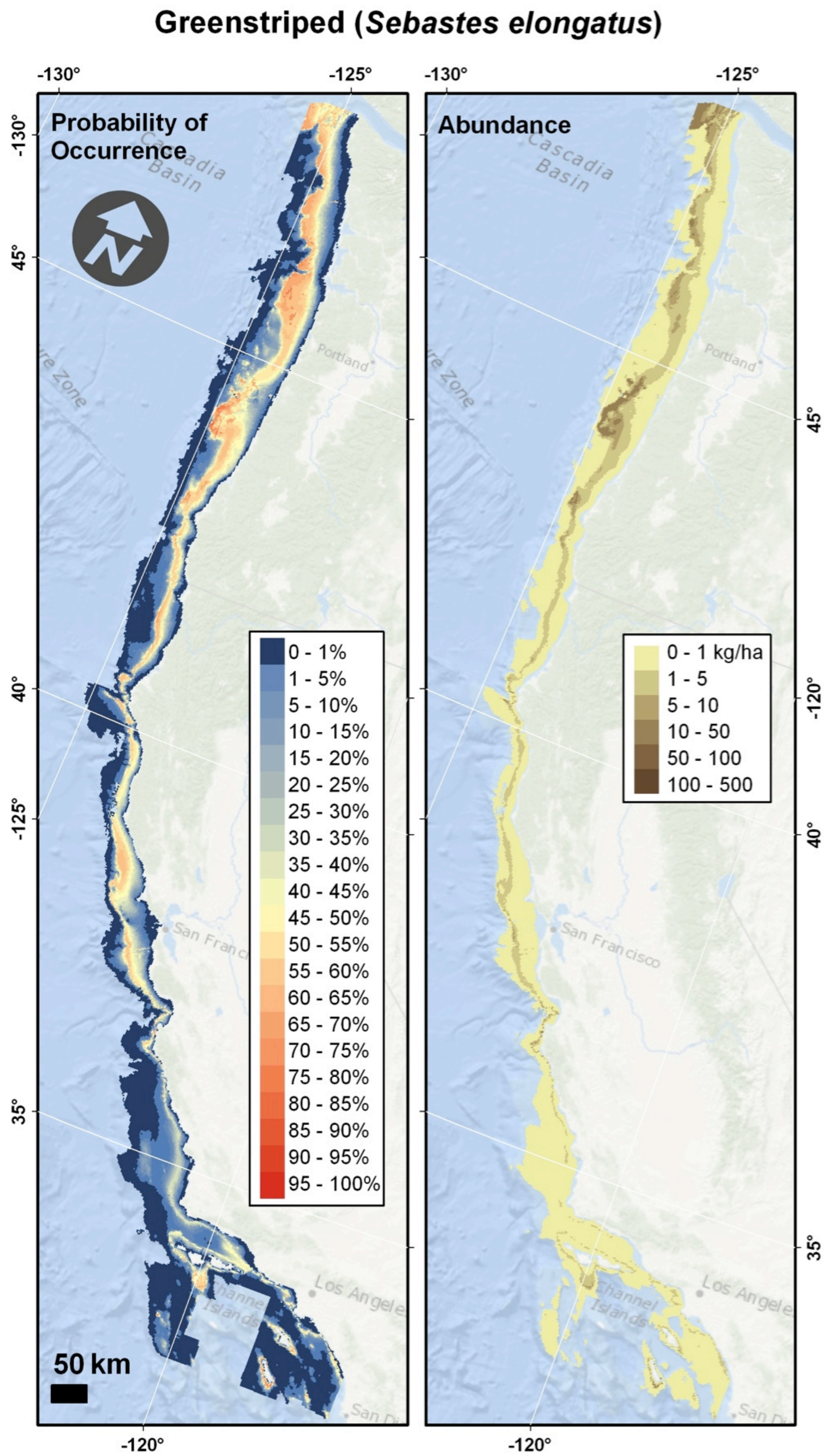

Figure 3.13: Greenstriped mean predicted probability of occurrence and predicted mean abundance. NWFSC model projections.

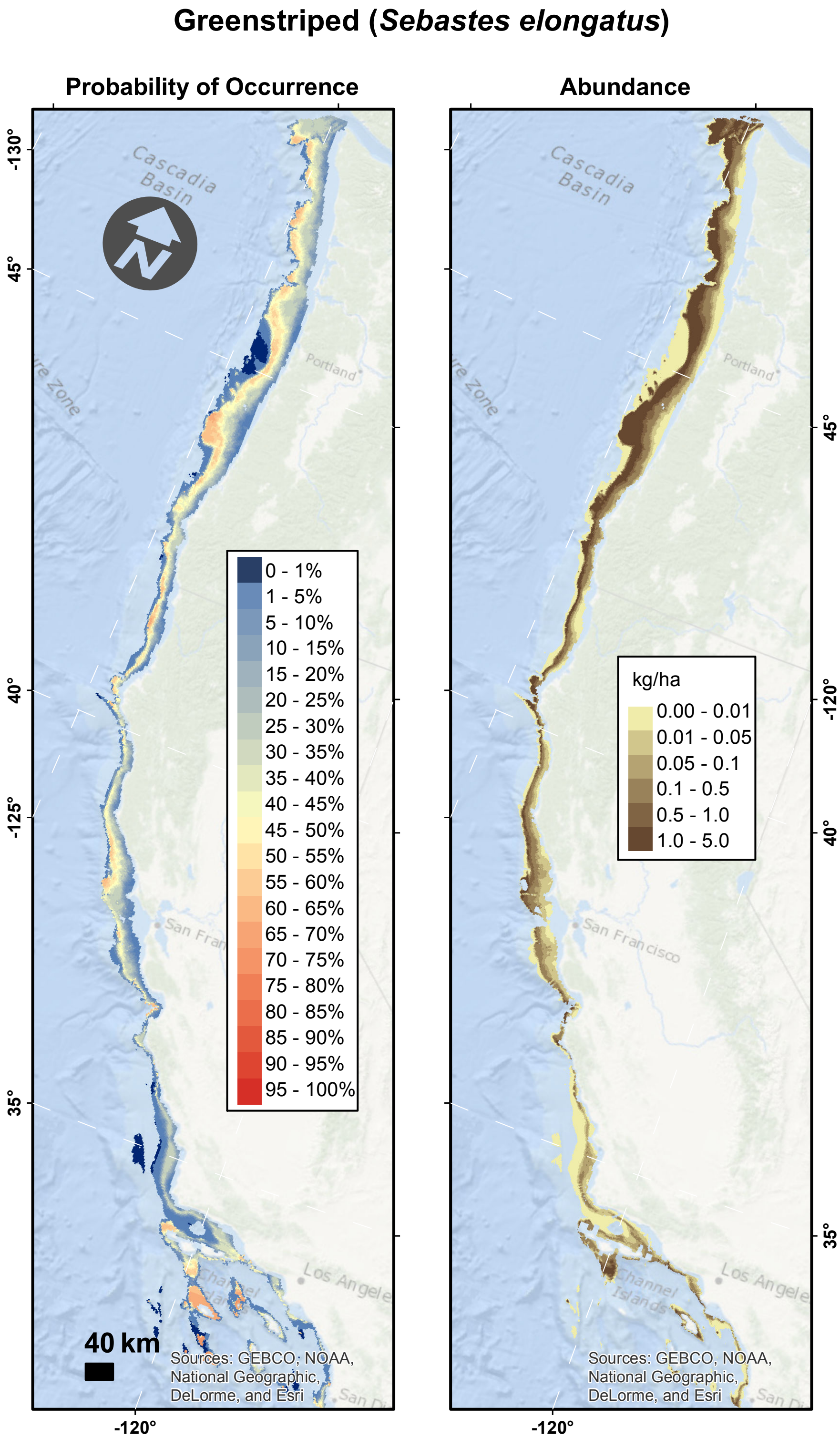

Figure 3.14: Greenstriped predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

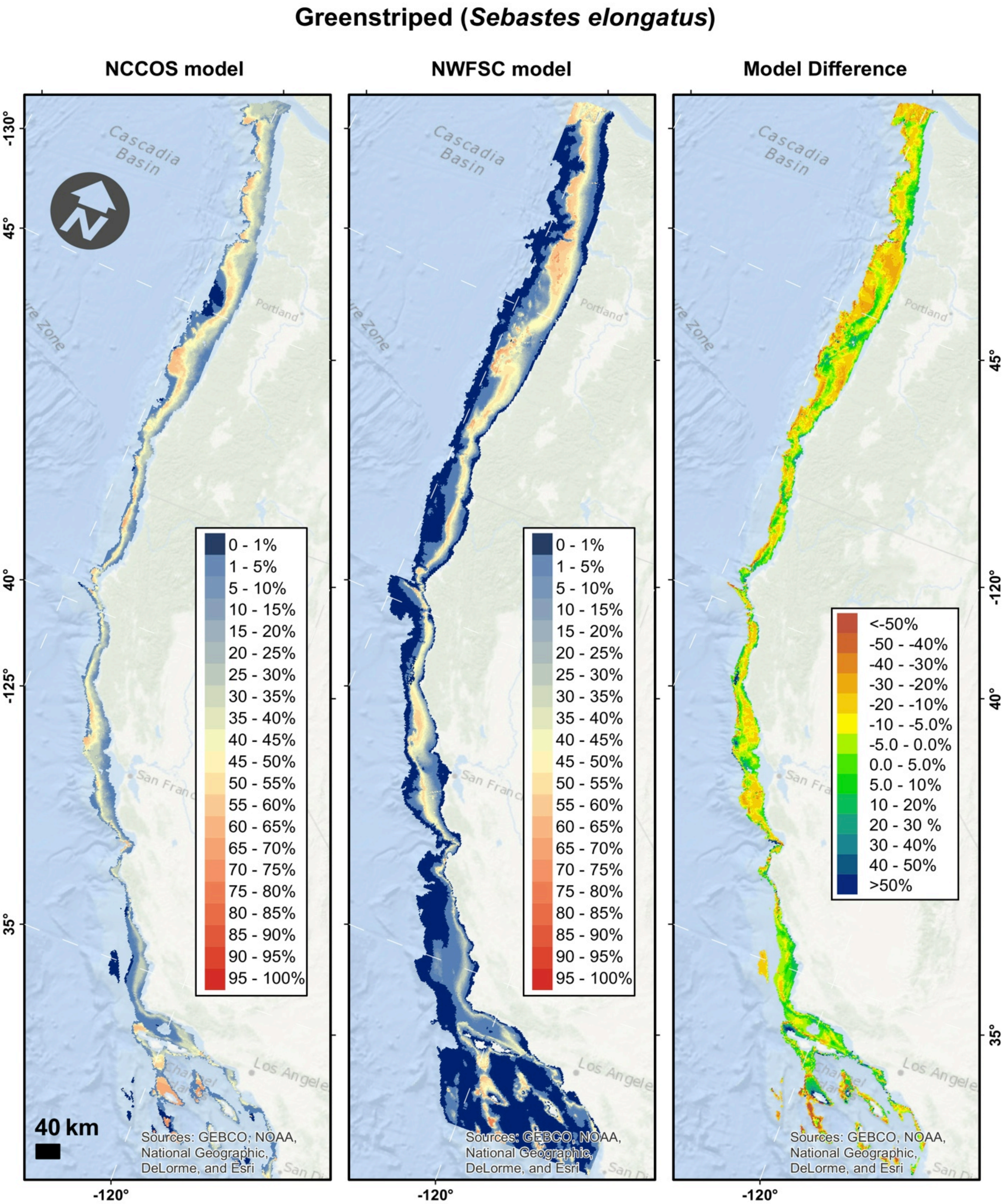

Figure 3.15: Greenstriped predicted mean probability of occurrence from the NCCOS (left) and NWFSC (center) models. Right panel shows a plot of the difference between the NCCOS and NWFSC models (NCCOS – NWFSC). Positive values indicate NCCOS predicts higher probability of occurrence than NWFSC.

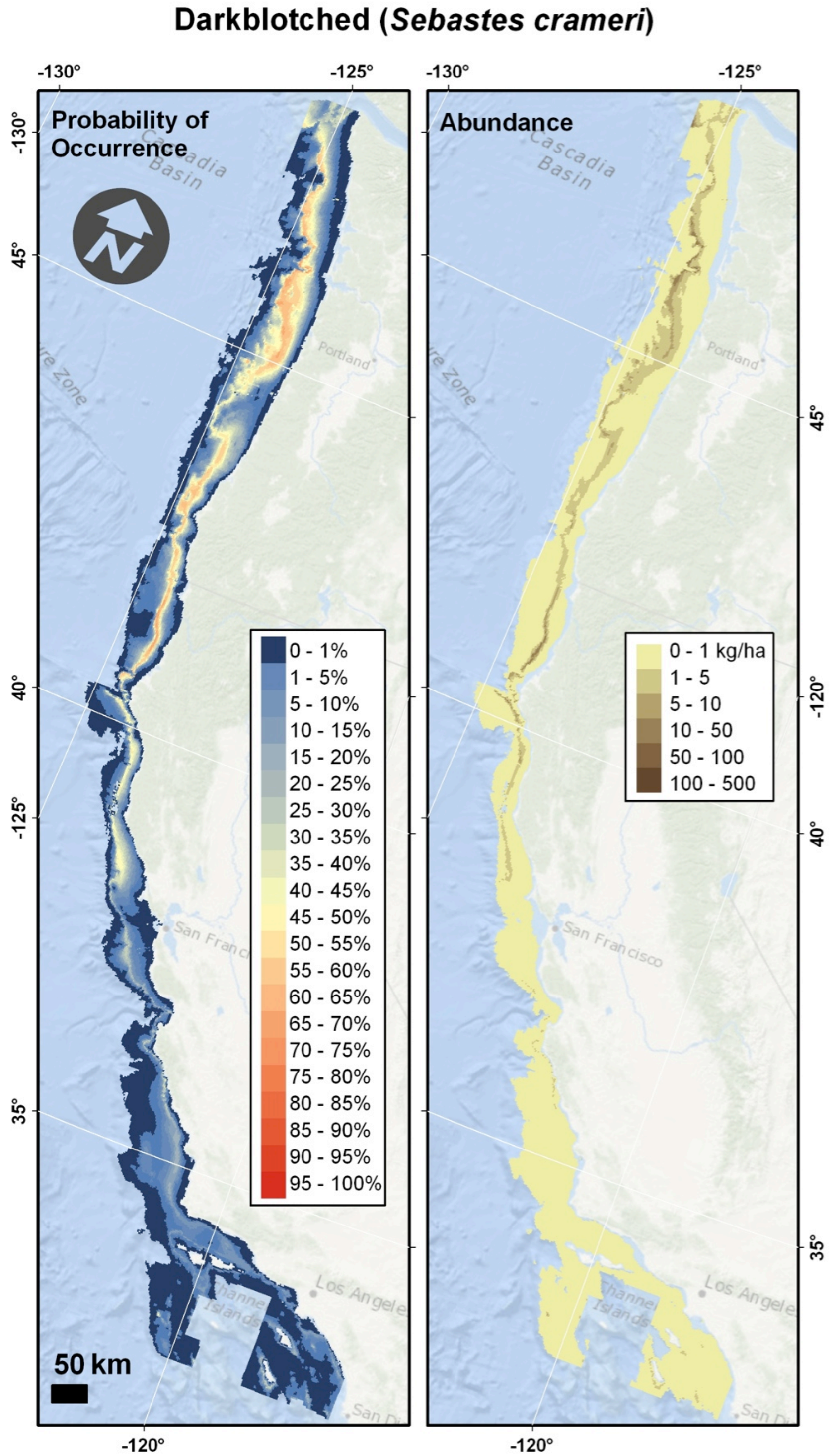

Figure 3.16: Darkblotched mean predicted probability of occurrence and predicted mean abundance. NWFSC model projections.

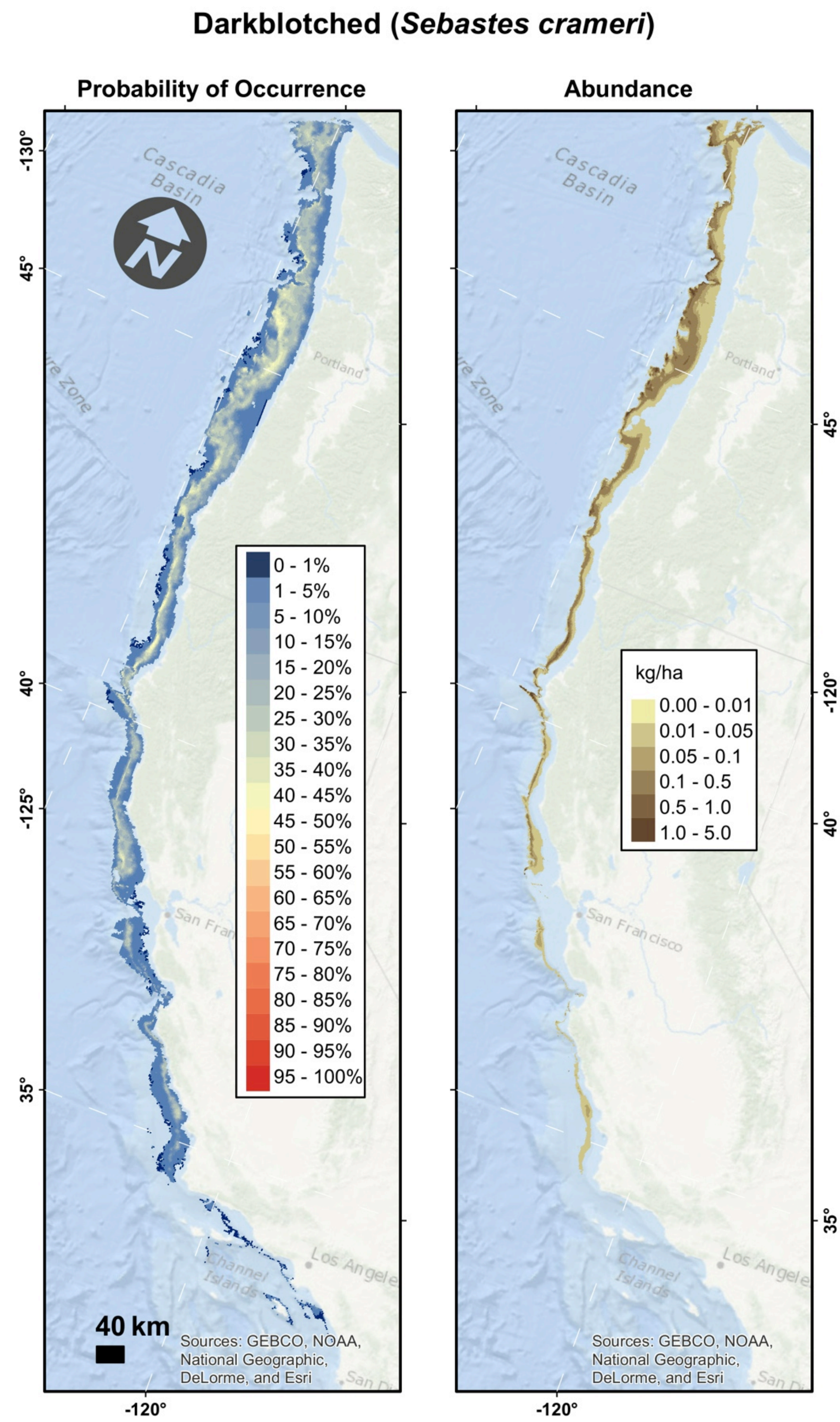

Figure 3.17: Darkblotched rockfish predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

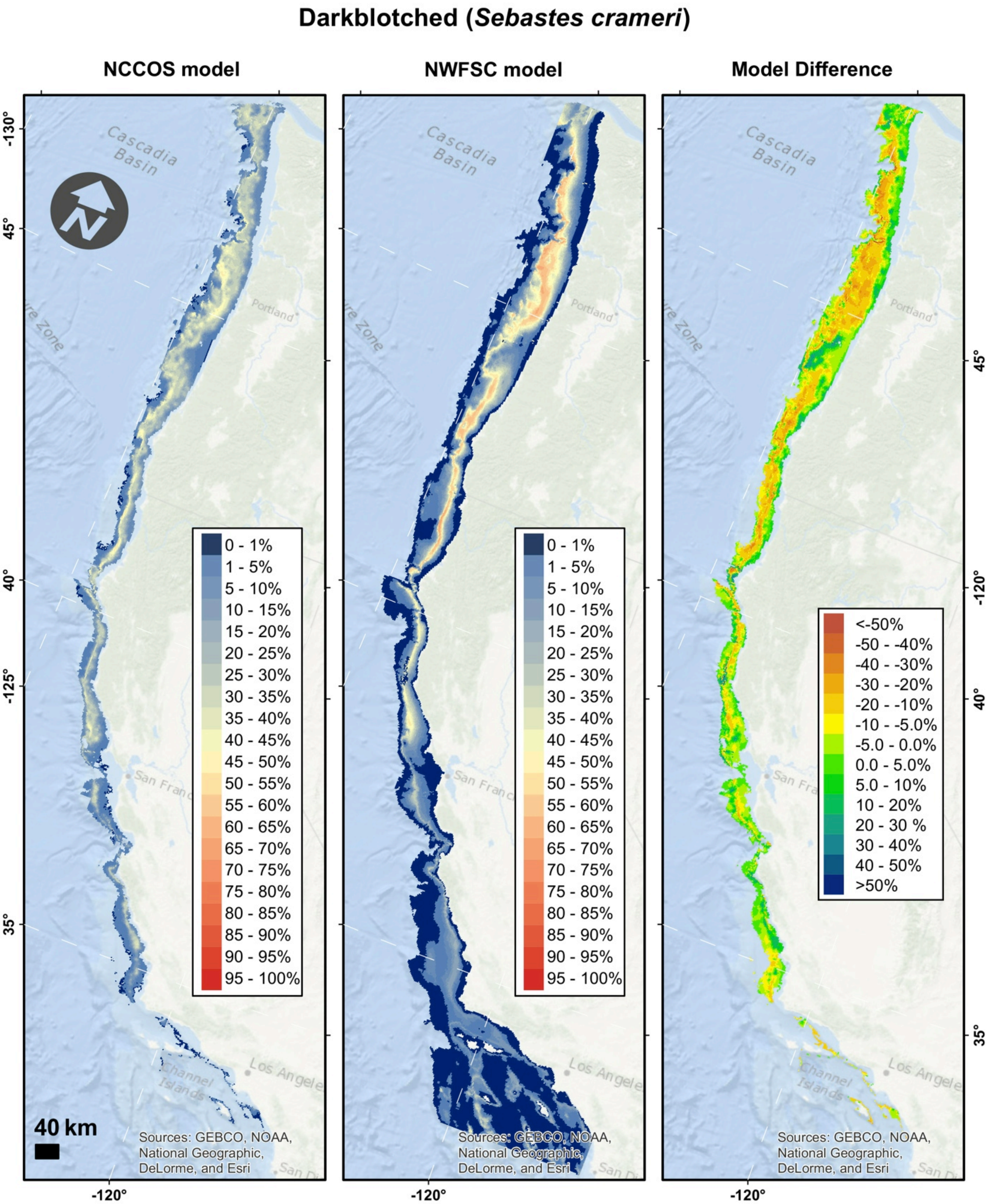

Figure 3.18: Darkblotched rockfish mean probability of occurrence from the NCCOS (left) and NWFSC (center) models. Right panel shows a plot of the difference between the NCCOS and NWFSC models (NCCOS – NWFSC). Positive values indicate NCCOS predicts higher probability of occurrence than NWFSC.

References

National Marine Fisheries Service (NMFS), 2005, Pacific Coast Groundfish Fishery Management Plan; Essential Fish Habitat Designation and Minimization of Adverse Impacts; Final Environmental Impact Statement: NOAA NMFS Northwest Region, 7600 Sand Point Way NE, Seattle, WA.

4.0 STRESSORS

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Overview:

- We compiled new and existing information on US West Coast fisheries, including the federal limited entry groundfish bottom trawl fishery, midwater trawl fishery, and observed fixed gear effort in the groundfish fishery, with a focus on before and after EFH closures.
- The majority of each fleet's fishing effort occurred in the northern biogeographic region over the upper slope.
- The majority of bottom trawling effort occurred over soft seafloor habitats on the shelf and upper slope before EFH conservation areas were enacted, but shifted to the upper slope post-2006.
- The majority of observed fixed gear effort occurred over soft seafloor habitat.
- Midwater trawling ranges from 8-31% annually over EFH conservation areas where bottom trawling is prohibited.
- Bottom trawl effort did not appear to occur where bottom contact gear was prohibited either before or after the EFH conservation areas were established. A low level of bottom trawl fishing in these areas is likely attributable to having only start and end points of trawl sets.
- In areas were only fixed gear is allowed, effort has ranged annually from 4 – 18% of the total fixed gear effort.

4.1 FISHERY PRESSURES

In this synthesis, we focused our efforts on commercial fishing effort information in federally-managed groundfish fisheries. This included bottom trawl fishing effort, midwater trawl fishing effort, and observed fixed gear effort.

4.2 GEAR-TYPE-SPECIFIC DISTRIBUTION

Groundfish fishing effort (not surprisingly) is strongly constrained by bottom type. Nearly all bottom trawl fishing effort occurs over the shelf and upper slope in soft habitats. There is also a trend of decreasing effort from north to south, though effort exists in all regions (Table 4a.1). Within depth-area strata, the highest effort relative to hard habitat was in the northern upper slope stratum (10%). Over soft habitat, a clear effort shift to the upper slope has been evident since 2007.

Mid-water trawl fishing is conducted off the Washington and Oregon coasts, in the northern biogeographic region (Table A4a.6.) and does not occur in other regions. (A small effort in the Salish Sea region is an artifact of the trawl towlines crossing over the entrance to the Strait of Juan de Fuca boundary at Cape Flattery, WA.) Like the bottom trawl, nearly all occurs over soft bottom, on the upper slope and shelf. The majority occurs over the upper slope, secondly over shelf, and lastly over the lower slope. Over time, an increase in effort over the upper slope occurred from 2002 to 2008 (Figure A4a.2.). A drop in fishing effort during 2009 was related to a reduction in Pacific hake quota in the at-sea fishery.

Fixed gear fishing effort in the groundfish fishery is observed in the following subsectors or state fisheries: limited entry sablefish-endorsed primary season (April-October), limited entry non-sablefish-endorsed fixed gear, open access fixed gear, and Oregon and California nearshore fisheries. Annual coverage of fixed gear sectors and fisheries (calculated as the observed proportion of fleet-wide landings) can be found online at:
http://www.nwfsc.noaa.gov/research/divisions/fram/observer/sector_products.cfm. Since all fishing operations are not observed, neither the maps nor the data can be used to characterize the fishery completely, but provide the current best available knowledge on the spatial aspects of these fleets.

Observed fixed gear fishing was also biased toward the northern biogeographic region over the upper slope in soft sediments (Table 4a.1.). However, in the northern, central, and southern regions, at least 5% of observed fixed gear fishing effort on both the shelf and upper slope occurred over hard habitat (Table A4a.7.). The highest effort relative to hard habitat occurred over the central shelf (23.7%).

4.3 FISHING EFFORT RELATIVE TO SPATIAL MANAGEMENT BOUNDARIES

4.3.1 Fishing effort relative to Amendment 19 MPAs

We examined fishing effort within the 51 Pacific Coast Groundfish Fishery Management Plan (FMP) Amendment 19 conservation areas. Trawl effort and observed fixed gear effort were summarized from either towline models, which depict a line from the gear deployment to retrieval coordinates, or points representing the average of these coordinates. Because these are straight lines or averages, the "edge" of fishing effort can be fuzzy, and some small margin of fishing effort can still be represented within EFH closure areas, even though a prohibition may exist (Table 4a.2.). Also since 2007, fixed gear fishing effort ranges annually from 0.1 – 0.2 % within EFH closures where bottom contact gear is prohibited. In each case, some of this (but not necessarily all) may be due to our mapping methods.

Midwater trawl fishing is permissible within all Amendment 19 EFH conservation areas since it is assumed to have no contact with the seafloor. Midwater trawl effort ranges annually from 7.7 – 30.8% over EFH areas where bottom trawling is prohibited (Table 4a.1.). However, midwater trawl effort does not appear to occur over EFH conservation areas where either bottom contact gear or bottom trawl gear other than demersal seine are prohibited.

Bottom trawl effort has ranged annually from 1.6 – 3.3% (since EFH closures) where bottom trawl gear is prohibited. From 2002 to 2010, bottom trawl effort did not appear to occur within EFH conservation areas where bottom contact gear (including bottom trawl) was prohibited. Thus, the EFH closures did not displace any bottom trawl fishing effort from these areas. This is likely due to the footrope restrictions put in place in 2000 that appears to have altered fishing behavior (Hannah 2003, Bellman et al. 2005). A long term examination of fishing restrictions and fishing behavior, in order to evaluate which restrictions are associated with behavioral changes would be a very useful next step. Some bottom trawl effort does appear within EFH areas where bottom trawl gear is prohibited, which may be partly attributed to methodology, but may also represent enforcement issues. The level of fishing effort within these prohibited areas is fairly consistent both pre- and post- EFH conservation areas.

Fixed gear fishing effort is permissible within Amendment 19 EFH conservation areas prohibiting only bottom trawl gear or bottom trawl gear other than demersal seine. Since 2002, fixed gear effort in both designated areas combined has ranged annually from 4 – 18.2% (Table 4a.1.). In 2006, the year that EFH conservation areas went into effect, the lowest effort occurred within these areas (4%).

Table 4a.2. Distribution of bottom trawl fishing effort (distance, meters) from 2002-2010 by seabed habitat type, and by depth zones both coastwide and in four biogeographic sub-regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Percentage values represent relative contribution to the sub-region. The "Salish Sea" only encompasses the shallowest ("shelf") depth zone. Data source: PacFIN trawl logbooks, based on a towline model which depicts a line from the gear deployment to retrieval coordinates.

		BIOGEOGRAPHIC SUB-REGION								COASTWIDE	
		Northern		Central		Southern		Salish Sea		Combined	
Depth Zone	***Substrate***	*Distance (m)*	*%*	*Distance (m)*	*%*	*Distance (m)*	*%*	*Distance (m)*	*%*	*Distance (m)*	*%*
Shelf[1]	**Total**	**465,744,267**	**34.5%**	**135,584,061**	**39.4%**	**57,556,112**	**98.2%**	**3,652,788**	**100.0%**	**662,537,227**	**37.7%**
	hard	4,168,770	0.3%	1,103,097	0.3%	281,647	0.5%	5,767	0.2%	5,559,281	0.3%
	mixed	3,730,922	0.3%	89,351	0.0%	238,597	0.4%	9,969	0.3%	4,068,840	0.2%
	soft	457,844,575	33.9%	134,391,612	39.1%	57,035,868	97.4%	3,637,052	99.6%	652,909,107	37.1%
	undefined	0	0.0%	0	0.0%	0	0.0%		0.0%	0	0.0%
Upper Slope[2]	**Total**	**884,755,328**	**65.5%**	**208,141,081**	**60.5%**	**1,026,193**	**1.8%**	**0**	**0.0%**	**1,093,922,602**	**62.2%**
	hard	22,508,956	1.7%	3,738,955	1.1%	14,917	0.0%	0	0.0%	26,262,828	1.5%
	mixed	32,343,926	2.4%	128,515	0.0%	1,393	0.0%	0	0.0%	32,473,835	1.8%
	soft	829,902,445	61.4%	204,273,611	59.4%	1,009,883	1.7%	0	0.0%	1,035,185,939	58.9%
	undefined	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Lower Slope[3]	**Total**	**1,279,842**	**0.1%**	**198,966**	**0.1%**	**4,716**	**0.0%**	**0**	**0.0%**	**1,483,524**	**0.1%**
	hard	118,706	0.0%	1,155	0.0%	4,716	0.0%	0	0.0%	124,577	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	1,161,136	0.1%	197,812	0.1%	0	0.0%	0	0.0%	1,358,947	0.1%
	undefined	0	0.0%	0	0.0%		0.0%	0	0.0%	0	0.0%
Total		**1,351,779,436**	**100.0%**	**343,924,108**	**100.0%**	**58,587,021**	**100.0%**	**3,652,788**	**100.0%**	**1,757,943,353**	**100.0%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.

[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.

[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

4.3.2 Fishing effort changes in time relative to EFH closures

The overall time periods from before EFH conservation closures (2002-Jun 2006) and after implementation (Jul 2006-2010) were compared for relative fishing intensity, as presented in the Phase 1 report. The majority of large or moderate increases in bottom trawl fishing effort after EFH conservation areas were established are found within fishing grounds over the continental slope. After 2006, there appear to have been large decreases in bottom trawl effort off the northern WA coast Appendix 4: Figure A4a.4, plate A2) and on the Oregon continental shelf (plates B2, C2). There were also decreases in areas on the continental shelf that have traditionally supported the state-permitted California halibut trawl fishery by limited entry groundfish trawl vessels. Large decreases in California state and federal waters south of Point Conception, CA (plates F3, F4) are also part of the state-permitted California halibut trawl fishery fished by open access groundfish vessels, and may be attributed to area-specific closures in the state fishery.

For the midwater trawl fleet, there were large decreases in effort off the northern WA coast (Appendix 4: Figure A4a.5, plates A2) and on the Oregon continental shelf (plates B2, C2). The majority of increases in midwater trawl fishing effort after EFH closures were over the continental slope.

Changes in observed fixed gear fishing after EFH closures were more patchy in distribution than trawl gears (Appendix 4: Figure A4a.6). They were evident on a coast-wide basis but with a smaller spatial extent of change overall. Some areas of increase were in nearshore waters off Oregon in the state-permitted nearshore groundfish fishery (plates B2, C2). Other areas of increase were in deeper waters fished by the limited entry and open access federal fixed gear sectors.

Table 4a.2. Annual distribution of fleet bottom trawl, fleet midwater trawl, and observed fixed gear fishing effort from 2002-2010 by Pacific Coast Groundfish Fishery Management Plan Amendment 19 prohibition type within Essential Fish Habitat Conservation Area closures. Data source: West Coast Groundfish Observer Program (NWFSC), based on either a towline model which depicts a line from the gear deployment to retrieval coordinates (longlines or pot strings), or on points representing the average of gear deployment and retrieval coordinates (other hook-and-line gears or pot/trap gears), depending on gear type.

Fleet Bottom Trawl Effort

Amendment 19 Prohibition	2002	2003	2004	2005	2006	2007	2008	2009	2010
Outside EFH Cons. Areas	93.5%	94.2%	97.2%	97.3%	97.5%	97.0%	96.1%	97.3%	96.1%
Bottom contact gear	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bottom trawl gear	4.8%	4.1%	2.0%	1.9%	1.4%	1.6%	2.6%	2.6%	3.3%
Bottom trawl gear other than demersal seine	1.8%	1.7%	0.8%	0.8%	1.1%	1.4%	1.3%	0.2%	0.6%

Fleet Midwater Trawl Effort

Amendment 19 Prohibition	2002	2003	2004	2005	2006	2007	2008	2009	2010
Outside EFH Cons. Areas	92.3%	87.2%	91.2%	90.9%	81.2%	69.2%	86.4%	84.0%	86.4%
Bottom contact gear	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bottom trawl gear	7.7%	12.8%	8.8%	9.1%	18.8%	30.8%	13.6%	16.0%	13.6%
Bottom trawl gear other than demersal seine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Observed Fixed Gear Effort

Amendment 19 Prohibition	2002	2003	2004	2005	2006	2007	2008	2009	2010
Outside EFH Cons. Areas	91.5%	81.8%	89.4%	86.7%	96.0%	93.2%	85.9%	87.0%	88.9%
Bottom contact gear	0.0%	0.0%	0.2%	0.0%	0.0%	0.2%	0.0%	0.2%	0.1%
Bottom trawl gear	5.1%	11.1%	3.7%	8.6%	0.8%	3.0%	9.6%	6.6%	3.1%
Bottom trawl gear other than demersal seine	3.5%	7.1%	6.7%	4.8%	3.2%	3.7%	4.5%	6.2%	7.9%

4.3.2.1 Cumulative fishery pressures

Fishing pressures act upon groundfish essential fish habitat collectively and thus quantifying a cumulative pressure index is an important tool in assessing overall fishing impacts. We used a weighted approach by assuming that fishing pressures were additive, but with a weighting scheme applied for the sensitivity of various habitat types to individual fishing gears. The weighting scheme was adapted from information summarized for a report on the effects of fishing gear on habitats developed for the 2005 groundfish EFH Environmental Impact Statement (PSMFC 2004, NMFS 2005). See Appendix 4a. for more details.

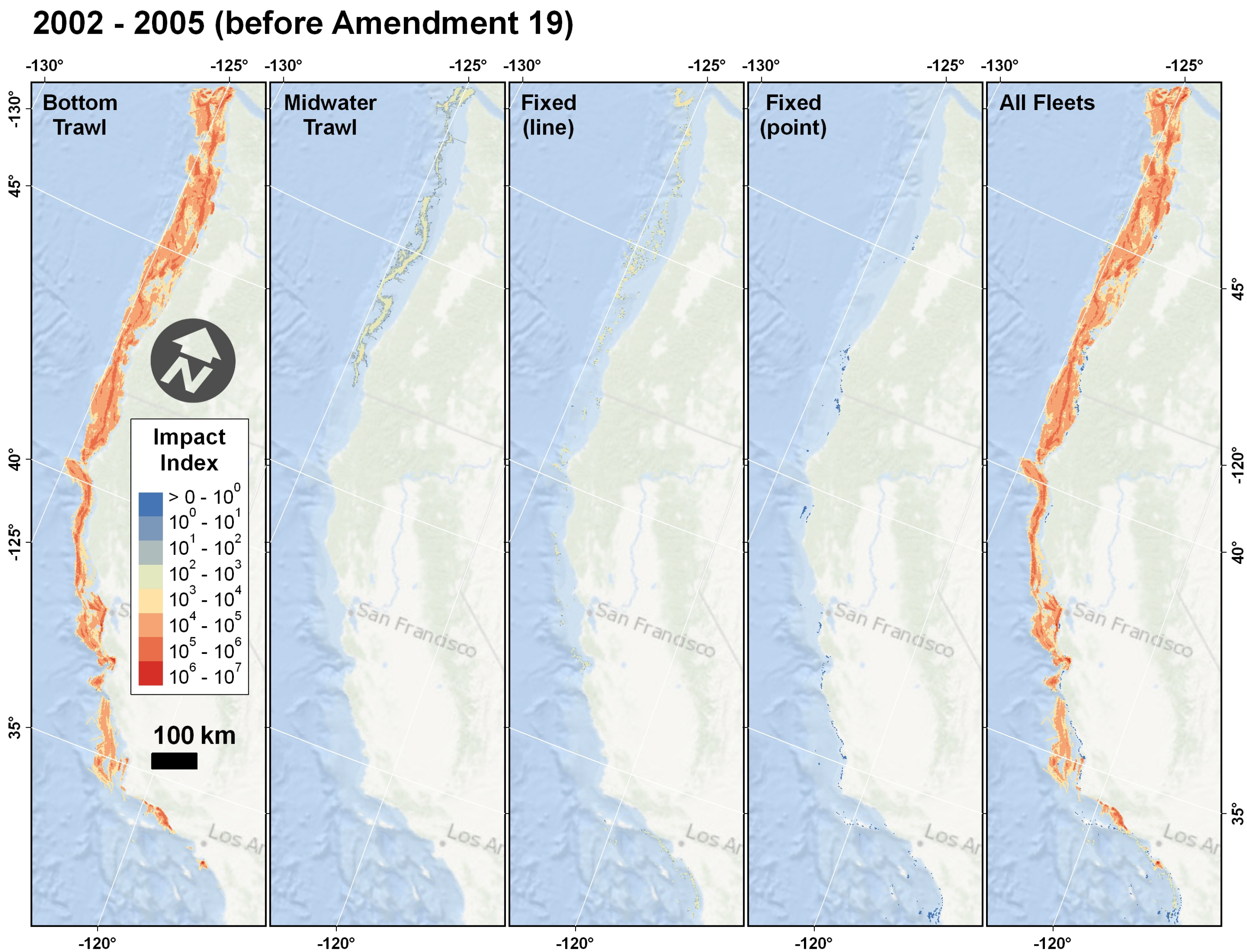

Figure 4a.1. Distribution of cumulative fishing pressure prior to EFH closures (2002-2005) relative to seafloor habitat and depth, based on a summary of bottom trawl, midwater trawl, and observed fixed gear fishing impact layers weighted according to Table A4a.1.

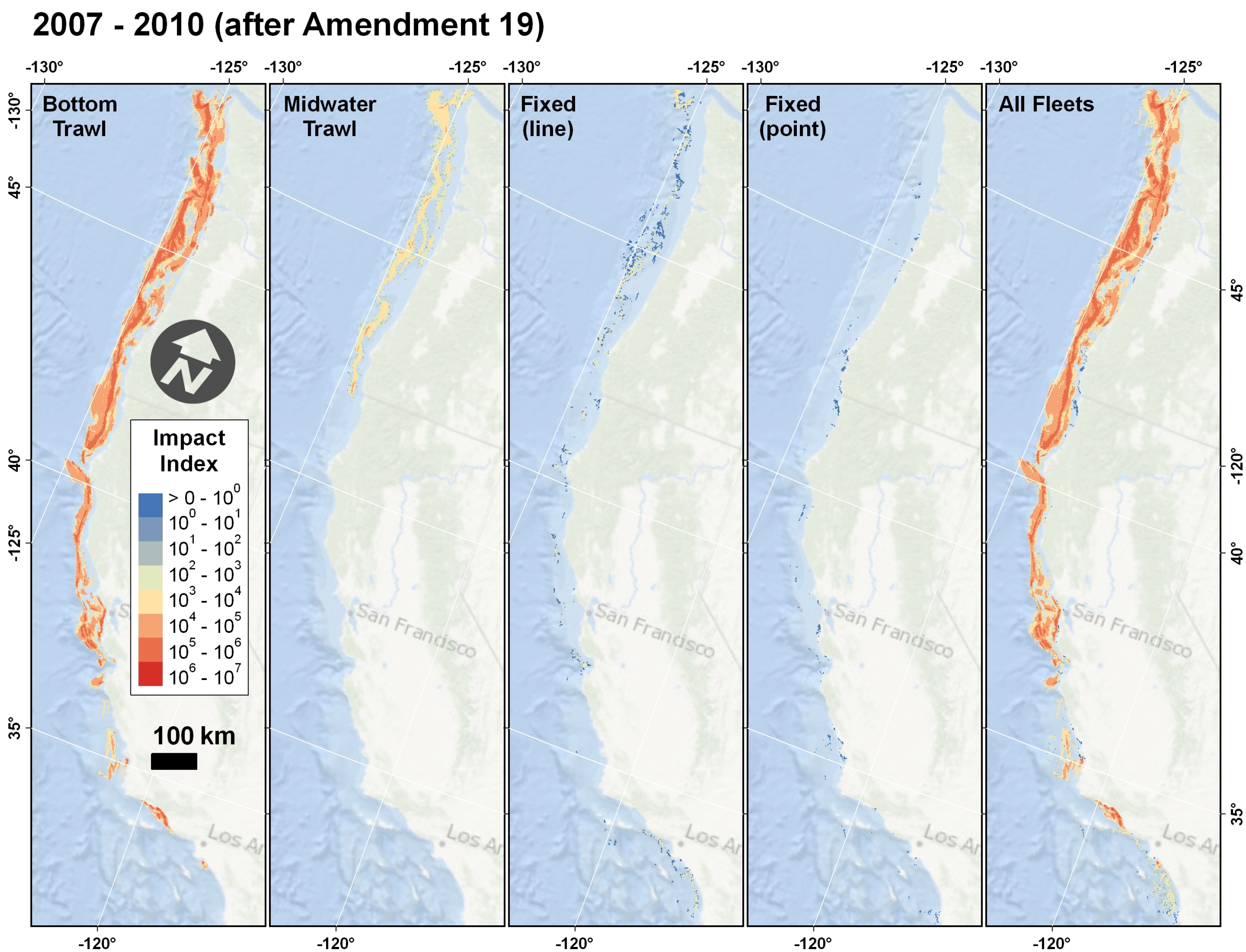

Figure 4a.2. Distribution of cumulative fishing pressure following EFH closures (2007-2010) relative to seafloor habitat and depth, based on a summary of bottom trawl, midwater trawl, and observed fixed gear fishing impact layers weighted according to Table A4a.1.

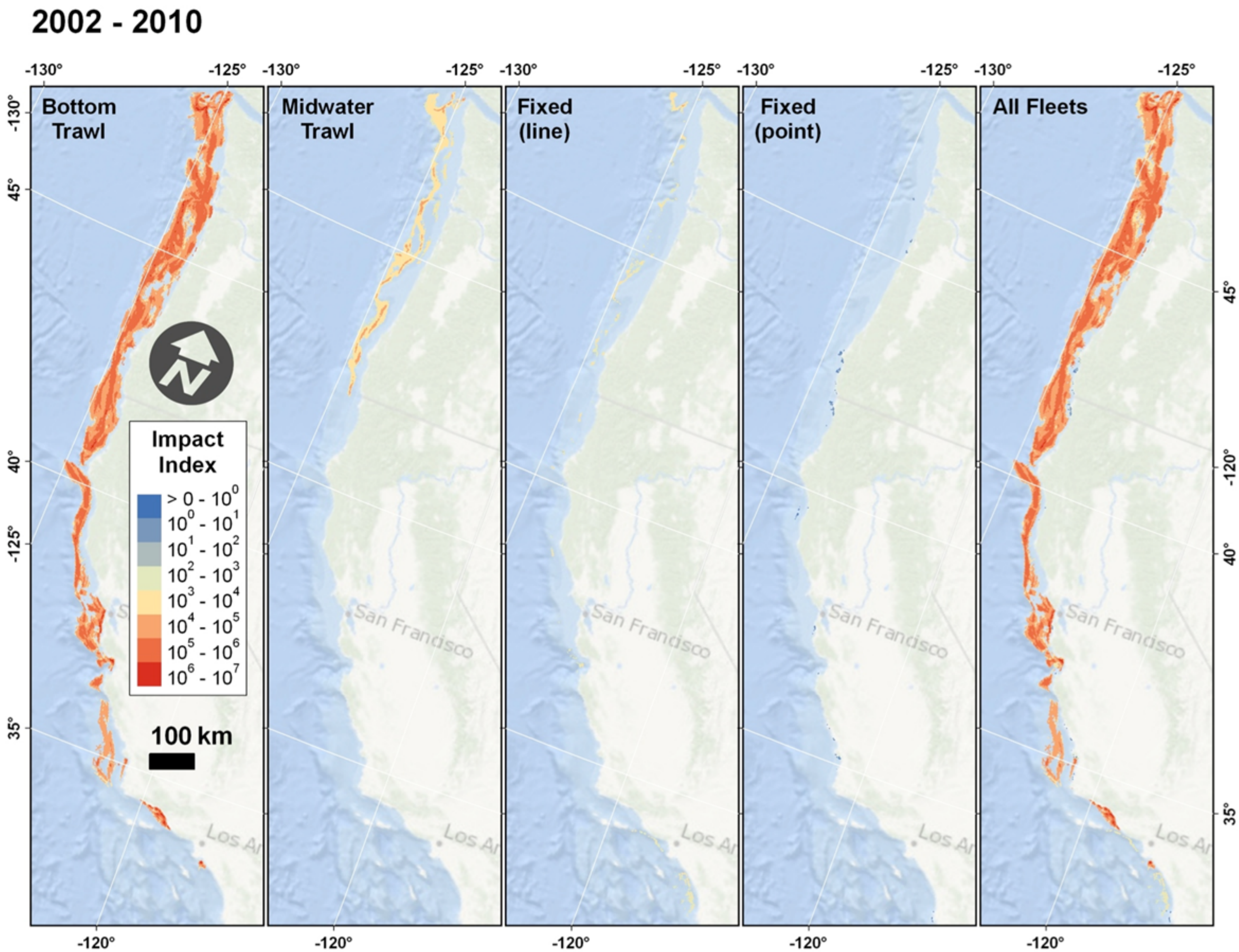

Figure 4a.3. Distribution of cumulative fishing pressure (2002-2010) relative to seafloor habitat and depth, based on a summary of bottom trawl, midwater trawl, and observed fixed gear fishing impact layers weighted according to Table A4a.1.

References

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4.4 NON-FISHERIES PRESSURES

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4.4.1 Main Findings

- Non-fisheries pressures were greatest in the Salish Sea sub-region, which is entirely]in shelf habitat and is consequently highly exposed to numerous land-derived pressures.
- Among other sub-regions, offshore pressures were more intense in the north, while nearshore pressures were more intense in the south. For example, lower slope habitat was exposed to higher pressure intensity values in the northern sub-region, while shelf and upper slope habitat was exposed to higher pressure intensity values in the southern sub-region.
- There was little variation in the mean intensity of non-fisheries pressures across EFH conservation areas compared to other spatial management regions. This was likely because EFH conservation areas were located offshore and relatively unexposed to land-based pressures.
- Habitat areas of particular concern (HAPCs) were proportionately more exposed to high non-fisheries pressures than other spatial management areas, and this is generally true across other individual pressures.

4.4.2 Introduction

As human population size and demand for marine resources and waterways increases along the coast, numerous human activities in the ocean (e.g., fishing and shipping activity) and on land (e.g., pollutants from industrial activities and runoff from agricultural activities) need to be recognized and incorporated into management of marine resources. There are numerous non-fisheries related pressures acting upon groundfish essential fish habitat (EFH) along the West Coast of the United States (PFMC 2005). We present an example of how some non-fisheries pressures can be analyzed in order to be incorporated into the management framework for West Coast groundfish EFH, and a synthesis of readily available information about threats in these marine areas. This work has been modified from its previous application in the Integrated Ecosystem Assessment (REF).

First, we take advantage of 16 spatially-explicit data layers available from Halpern et al. (2009) to quantify the intensity of non-fisheries pressures among various regions, depth strata, habitat substrate types, and spatial management boundaries related to West Coast groundfish EFH. The pressure data layers were produced from data collected prior to 2007, but represent the most standardized and rigorous analysis of the relative spatial intensity of non-fisheries pressures across the West Coast of the United States. These data layers are currently being updated and will provide estimates for future analyses of non-fisheries pressures on West Coast groundfish EFH.

From the 16 non-fisheries related pressures, we identified seven (Table 4b.1) that were most relevant to West Coast groundfish EFH and which had enough data to be useful for a coastwide analysis. We report on these pressures along with two climate change pressures individually in *Appendix 4*. In order to summarize the distribution of non-fisheries pressures, we combined all 16 non-fisheries pressures into a “combined” pressures data layer and report on the findings below. Each pressure data layer was normalized to values between 0 and 1 so they could be compared and combined into a cumulative impact layer for the Halpern et al. (2009) project; thus, the data layers were easily combined for our purposes.

For specific methods related to each pressure, see the *“Methods for Non-fisheries Pressures”* in *Appendix 4*, but briefly, we used GIS data layers developed in *“Section 1: Habitat”* to delineate sub-regions, depth strata, habitat substrate type, and management boundaries. We then overlaid pressure layers and calculated the mean value for each non-fisheries pressure among all the combinations of sub-regions, depth strata, habitat substrate, and management boundaries.

Table 4b.1. Non-fisheries pressures data layers from Halpern et al. (2009).

NON-FISHERIES PRESSURES DATA LAYERS	
Pressures reported individually	Brief description of data used to create data layer
Atmospheric pollution	Deposition of sulfates derived from the National Atmospheric Deposition Program.
Inorganic pollution	Point source pollution from factories and mines and non-point source pollution that scales with the amount of impervious surface area.
Organic pollution	Input of pesticides.
Ocean-based pollution	Combination of “Commercial shipping activity” and “Invasive species” below.
Nutrient input	Nitrogen input from farming and atmospheric deposition.
Sediment decrease	Sediment input from watersheds with dams.
Sediment increase	Sediment input from watersheds without dams.
Combined pressures	Sum of all 16 pressures.
Additional pressures for calculating “Combined Pressures”	
Coastal trash	Amount of trash collected from beach clean-up efforts in CA.
Recreational beach use	Beach attendance.
Power plants	Locations of coastal power plants.
Light pollution	Stable lights at night database (National Geophysical Data Center).
Coastal engineering	Location of hardened shorelines.
Commercial shipping activity	Vessel track lines from the World Meteorological Organization Voluntary Observing Ships Scheme and ferries.
Oil rig platforms	Locations of offshore oil rigs.
Aquaculture – fish net-pens	Locations of fish net-pens.
Species invasions	Based on annual tonnage of goods passing through each port.

4.4.3 Distribution of non-fisheries pressures

Importantly, pressures do not act upon groundfish essential fish habitat (EFH) individually, but collectively. Pressures from terrestrial-based pollution, shipping, offshore energy development, fisheries and coastal development exert cumulative effects on the ecosystem and should be managed in a holistic way (Vinebrooke et al. 2004, Crain et al. 2008, Halpern et al. 2008, Curtin and Prellezo 2010, Stelzenmüller et al. 2010). However, quantifying the cumulative effects of these pressures is a difficult task primarily because our understanding of whether effects among multiple pressures are additive, synergistic, or antagonistic is relatively poor (Darling and Côté 2008, Hoegh-Guldberg and Bruno 2010).

Instead of trying to calculate the cumulative effects of non-fisheries pressures on groundfish EFH, we used a simplified approach by assuming that pressures were additive and each had equal weight. Thus, we simply summed the pressure intensity values across all 16 non-fisheries pressures (Table 4b.1) for each 1 km^2 cell within the U.S. economic exclusive zone (EEZ) to calculate a "combined pressures" data layer.

The distribution of combined pressures showed the distinct influence of land-based pollution pressures in nearshore habitats and the exposure of offshore habitats to ocean-based pollution and commercial shipping activity (Fig. 4b.1). Overall, mean intensity values were highest in the Salish Sea biogeographic sub-region and in the shelf depth strata (Fig. 4b.2a). The Salish Sea was most exposed because the vast majority of the region is exposed to highly populated areas and is completely locked within the shelf habitat, which is the most exposed depth stratum. The northern sub-region was the next most-greatly exposed region, but this varied among depth strata (Table 4b.2). For example, pressure intensity values were highest in lower slope habitat in the north, but pressures were higher in the southern sub-region in shelf and upper slope habitat. High values in the lower slope of the northern sub-region were most likely the result of high atmospheric pollution values (see *'Atmospheric pollution'* in *Appendix 4*), whereas multiple land-based pressures (see individual pressures in *Appendix 4*) were responsible for high values in the shelf and upper-slope in the southern sub-region. Within each depth stratum, pressure intensity values varied across habitat types, but showed no clear trend.

We used EFH conservation areas (EFH CA), rockfish conservation areas, and state territorial sea restrictions to define management areas that were prohibited, restricted, or had no restrictions on fishing. Identifying differences in pressure intensity values among management boundaries were more difficult to determine, but pressure intensity values seemed to be higher in areas where commercial and recreational fishing was prohibited (Fig. 4b.2b). This was likely because many prohibited areas were located nearshore or inside bays where pressure intensity values were relatively high because of numerous land-based pressures. We also found there was relatively little variation in non-fisheries pressures in EFH CA compared to nearly all other habitat or management regions (Fig. 4b.2). This was likely because EFH CA are located offshore and are not exposed to most land-based pressures along the coast (Fig. 4b.1). It should be noted that mean intensity values were simply calculated using all cell values (units were ~1km^2 cells across the entire U.S. EEZ) within the habitat or management boundaries; this analysis does not take spatial autocorrelation into account. Future work will account for spatial autocorrelation and make explicit statistical comparisons among habitats and management boundaries.

We also calculated what proportion of various management areas were exposed to the highest pressure intensity values (i.e. the "high" values in Fig. 4b.1 represent the top 20% of all pressure intensity values coastwide). EFH CA and non-EFH CA were equally exposed to the highest combined non-fisheries pressures, but this pattern varied among individual pressures (Fig. 4b.3). Habitat areas of particular concern (HAPC) were most exposed to the highest non-fisheries pressures with nearly 40% of all area within HAPC boundaries exposed to the highest combined pressures intensity values (Fig. 4b.3). This was most distinct across land-based pressures as most

HAPCs are located in nearshore habitats. However, differences observed coastwide among management areas varied among sub-regions (Table 4b.3). For example, in the northern sub-region, the proportion of EFH CA exposed to the highest combined pressures (23%) was less than the proportion of areas with no commercial fishing restrictions exposed to high pressures (58%), whereas in the central and southern sub-regions we found that EFH CA and areas with no commercial fishing restrictions were equally exposed.

Overall, we found four main findings from non-fisheries pressures that may potentially affect management of West Coast groundfish EFH. First, non-fisheries pressures were greatest in the Salish Sea, because the entire region is in shelf habitat and is highly exposed to numerous land-derived pressures. Second, among other sub-regions, pressure intensity values varied across depth strata. Lower slope habitat was exposed to higher pressure intensity values in the northern sub-region (offshore pressures), while shelf and upper-slope habitat was exposed to higher pressure intensity values in the southern sub-region (nearshore pressures). Third, we found little variation in mean intensity values for non-fisheries pressures across EFH conservation areas compared to other spatial management regions. This was likely because EFH conservation areas were located offshore and relatively unexposed to land-based pressures. Fourth, we found that HAPCs were proportionately more exposed to high non-fisheries pressures than other spatial management areas, and this is generally true across other individual pressures.

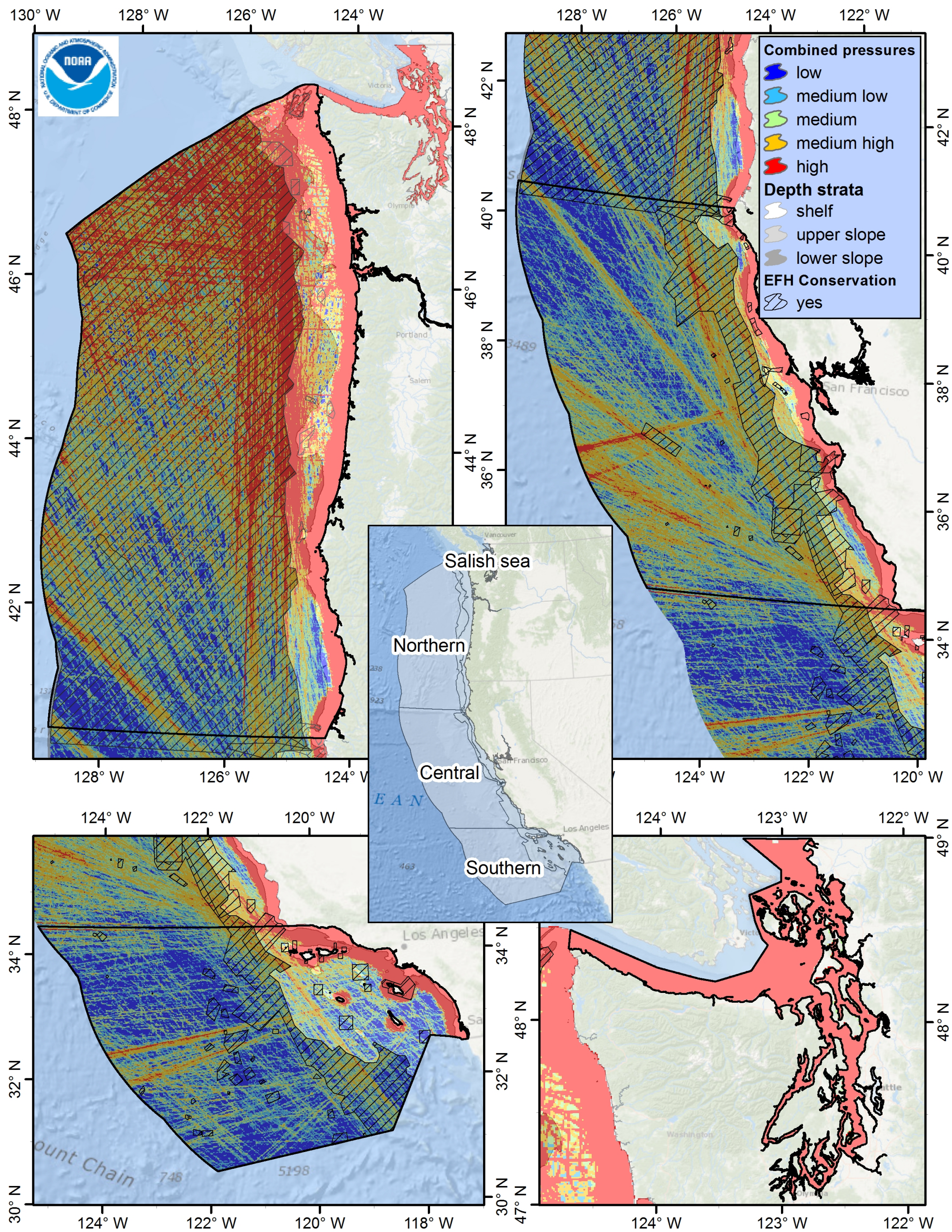

Figure 4b.1. Distribution of combined pressures intensity values among biogeographic sub-regions, depth strata and essential fish habitat (EFH) conservation areas. Combined pressures data is the sum of 16 non-fisheries pressures identified in Table 4b.1. Data for each pressure comes from Halpern et al. 2009. "Streaks" result from vessel shipping lanes.

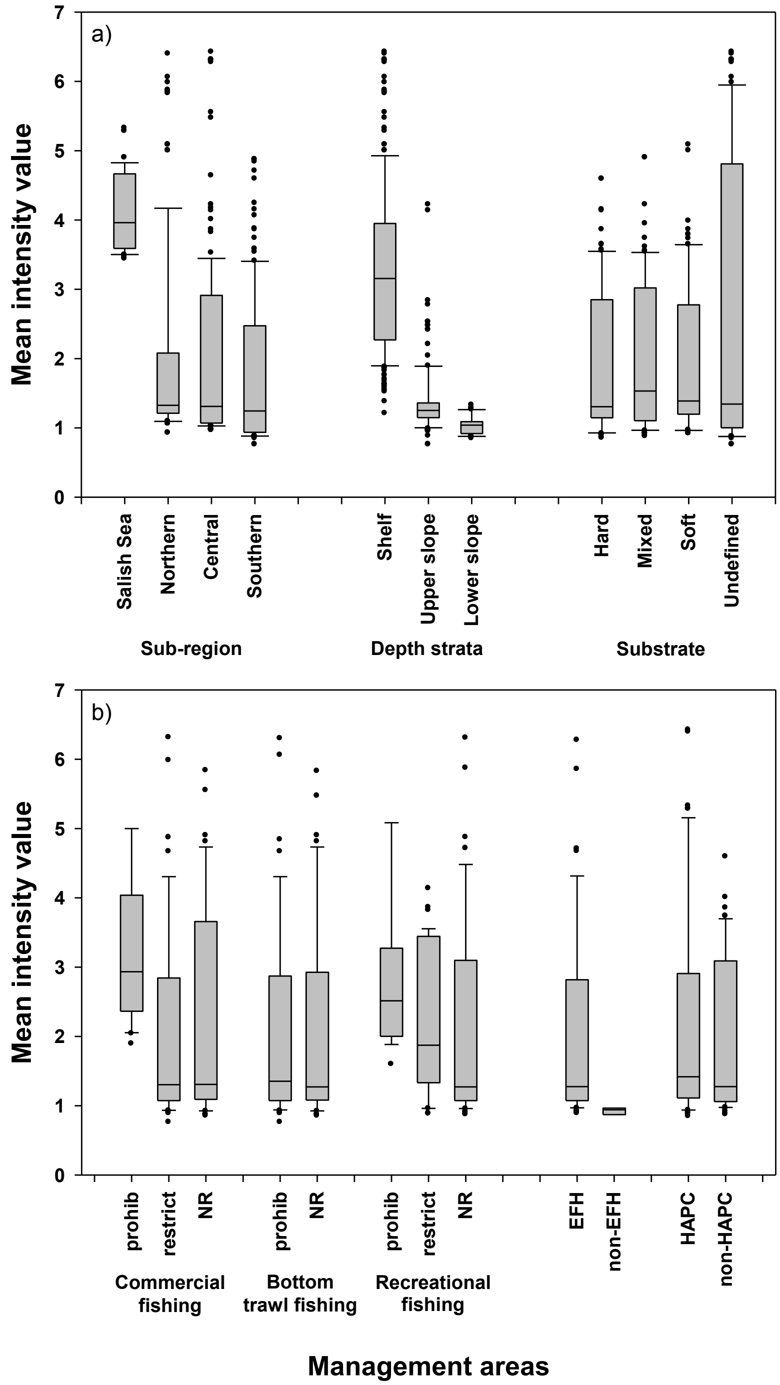

Figure 4b.2. Mean intensity values of combined pressures across a) sub-regions, depth strata, substrate, and b) management areas. The shaded box indicates the 25th to 75th percentile, the line within the box marks the median, the whiskers indicate the 10th and 90th percentiles, and the dots indicate all outliers. prohib: type of fishing is prohibited; restrict: type of fishing is restricted; NR: type of fishing has no restrictions; EFH CA: essential fish habitat conservation areas for West Coast groundfish; HAPC: habitat areas of particular concern. Fishing restrictions include areas within EFH CA, rockfish conservation areas (RCAs), and state territorial sea restrictions.

Overall, we found three main findings from non-fisheries pressures that may potentially affect management of West Coast groundfish EFH. First, non-fisheries pressures were greatest in the Salish Sea, but this is because the entire region is in shelf habitat and is highly exposed to numerous land-derived pressures. Second, among other sub-regions, pressure intensity values varied across depth strata. Lower slope habitat was exposed to higher pressure intensity values in the northern sub-region (offshore pressures), while shelf and upper-slope habitat was exposed to higher pressure intensity values in the southern sub-region (nearshore pressures). Third, we found that EFH was proportionately more exposed to high non-fisheries pressures than other spatial management areas, and this is generally true across other individual pressures.

Table 4b.2. Mean intensity values for combined non-fisheries pressures by depth zones and seabed habitat types across 4 biogeographic regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from the sums of 16 pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1.

Combined pressures						
Depth Zone	*Habitat*	Northern	Central	Southern	Salish Sea	Coastwide
Shelf[1]	All	2.20	2.71	2.92	4.31	2.63
	hard	1.76	3.00	2.57	3.57	2.30
	mixed	1.98	3.04	2.41	3.55	2.31
	soft	2.18	2.45	2.93	3.64	2.40
	undefined	5.85	6.27	4.71	4.67	5.03
Upper Slope[2]	All	1.22	1.22	1.28	NA	1.25
	hard	1.28	1.15	1.17	NA	1.18
	mixed	1.34	1.37	0.98	NA	1.29
	soft	1.21	1.23	1.29	NA	1.25
	undefined	NA	1.05	1.00	NA	1.03
Lower Slope[3]	All	1.08	0.98	0.88	NA	1.00
	hard	1.26	1.05	0.90	NA	1.03
	mixed	1.10	1.09	0.91	NA	0.99
	soft	1.26	1.06	0.95	NA	1.10
	undefined	1.06	0.97	0.87	NA	0.98
Grand mean	All	1.22	1.10	1.04	4.31	1.15

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

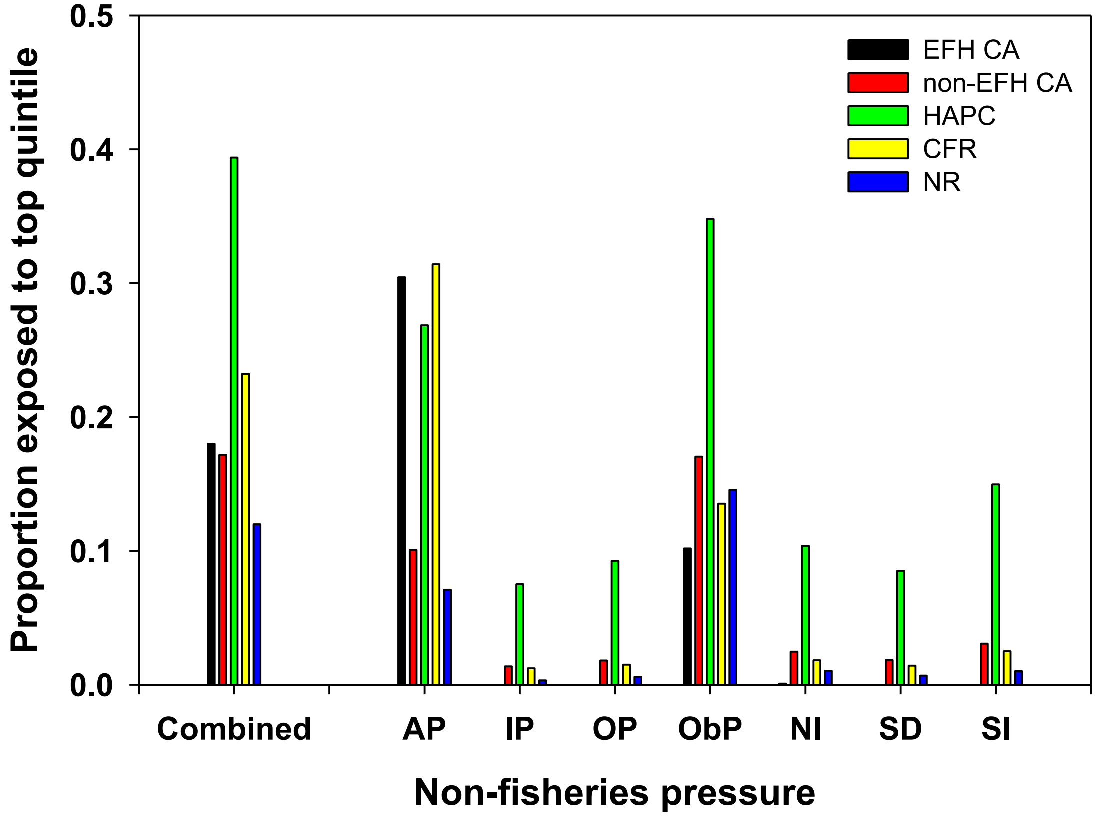

Figure 4b.3. Proportion of coastwide habitat in each management area exposed to the highest intensity values (top 20% - "high" values in Fig. 3b.1) for each pressure. EFH CA: essential fish habitat conservation areas; HAPC: habitat areas of particular concern; CFR: all commercial fishing restricted areas, including EFH CA, Rockfish Conservation Areas and state territorial sea restrictions; NR: areas with no commercial fishing restrictions.

Table 4b.3. Proportion of habitat within management boundaries exposed to the top quintile (20%) of intensity values for each pressure within each biogeographic sub-region and across the entire U.S. West Coast. EFH: designated essential fish habitat; CFR: commercial fishing restricted areas; NR: no commercial fishing restrictions; NA: no habitat in this category.

	BIOGEOGRAPHIC SUB-REGIONs														
	Northern			Central			Southern			Salish Sea			Coastwide		
Pressures	EFH CA	CFR	NR	EFH CA	CFR	NR	EFH CA	CFR	NR	EFH CA	CFR	NR	EFH CA	CFR	NR
Atmospheric pollution	0.44	0.46	0.64	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.98	N/A	0.30	0.31	0.07
Inorganic pollution	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.02	0.00	N/A	0.23	N/A	0.00	0.01	0.00
Organic pollution	0.00	0.00	0.04	0.00	0.02	0.00	0.00	0.02	0.00	N/A	0.29	N/A	0.00	0.01	0.01
Ocean-based pollution	0.03	0.05	0.27	0.36	0.38	0.19	0.09	0.11	0.05	N/A	0.96	N/A	0.10	0.14	0.15
Nutrient input	0.00	0.00	0.05	0.00	0.03	0.00	0.00	0.03	0.01	N/A	0.32	N/A	0.00	0.02	0.01
Sediment decrease	0.00	0.00	0.03	0.00	0.02	0.00	0.00	0.02	0.01	N/A	0.27	N/A	0.00	0.01	0.01
Sediment increase	0.00	0.01	0.06	0.00	0.05	0.01	0.00	0.02	0.00	N/A	0.51	N/A	0.00	0.02	0.01
Combined pressures	0.23	0.26	0.58	0.06	0.14	0.06	0.06	0.14	0.06	N/A	0.98	N/A	0.18	0.23	0.12

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5.0 ECOLOGICAL IMPORTANCE, EXPOSURE TO FISHING PRESSURE, AND SPATIAL MANAGEMENT

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5.1 INTRODUCTION

Determining where there is a coincidence of highly suitable habitat and high (or low) pressures (fishing or otherwise) is a key element of determining important areas for changes in restrictions, if any. Here we provide a summary of how the change in exposure to fishing impacts has interacted with species occupancy patterns over the past decade. We divide our analyses into two parts. First, we summarize the interaction of fishing effort and species occurrence over the entire time series and then address how this interaction responded to a major shift in spatial management in 2006. We examine changes in fishing effort relative to the occurrence of the six focal species identified in Section 3. Here, we restrict our discussion to three of the six species (sablefish, petrale sole, and yelloweye rockfish), which show the most notable patterns. See Appendix 5 for results for all six species.

For each species, we provide two visualizations of the intersection of fishing effort and species occupancy. First, we provide a series of three maps that show the probability of occurrence, the cumulative fishing effort from 2002-2010, and the intersection of the probability of occurrence and the cumulative fishing effort (e.g. Figure 5.1 for sablefish). We refer to the intersection of occurrence and fishing effort as “pressure” for the remainder of this section. For the purpose of this analysis we assume that the probability of occurrence for each species is a proxy for the quality of the habitat at a given location. We acknowledge that the probability of occurrence is an imperfect proxy for habitat quality. Since each species has a distinct probability of occurrence distribution, the areas considered high quality will vary among species (see Section 3, Appendix 3); this number implicitly incorporates the contribution of habitat variables (e.g. depth, bottom temperature, etc.) to the occurrence of each species. Fishing effort and the probability of occurrence are summarized in 2x2km grid cells along the coast. In these plots cumulative fishing effort includes all gear types (bottom trawl, midwater trawl, and fixed gear) and is expressed in linear km of fishing gear deployed (see Section 3). In this section, we weight the impact from each fishing gear equally, so the cumulative fishing effort is the linear length of gear deployed summed across bottom trawl, midwater trawl, and fixed gear. Thus, the data in these plots will differ slightly from some of plots of cumulative impact that weight the impacts from each gear type (see Section 4, Appendix 4). For the predicted probability of occurrence, we used the across year mean prediction from the NWFSC model (see Section 3, Appendix 3 for details).

Second, we provide a non-spatial summary of the intersection of probability of occurrence from the NWFSC model and cumulative fishing effort. This allows us to determine how different levels of fishing effort coincide with areas of high quality for each species. For this comparison we restrict our analysis to bottom trawl effort and also evaluate the changes in fishing pressure that occurred in response to spatial gear restrictions implemented in 2006. We divided our data into two time periods - before spatial gear restrictions were enacted in 2006 (years 2002-2005) and after 2006 (years 2007-2010) – and classified grid cells as containing or not containing bottom contact restrictions. Since management boundaries did not align with the grid cell boundaries used for the predicted probability of occurrence maps, there are individual grid cells that contain both areas open to fishing and areas closed to fishing. For simplicity, if any portion of the grid cell had fishing restrictions in it, we classified the cell as having fishing restrictions. Of the 38,600 grid cells for which we have a predicted probability of occurrence and fishing effort data, the majority (~85%) had no fishing restrictions while the remainder (~15%) have some variety of gear restrictions. The NWFSC model extent does not overlap with the large 700-ftm bottom trawl closure. We refer interested readers to Section 4 and Appendix 4 for a full description of the various gear types and management implementation of fishing restrictions. We exclude fishing effort in 2006 due to the fact that the management regime was implemented in June of that year.

Each panel in Fig. 5.1 to 5.3 takes on the same basic form: the colors on each plot indicate the density of points with red indicating that many grid cells occur in that vicinity. A high density of points in the upper right of the panel indicates there are many areas that have both a high probability of occurrence and experience high fishing effort. A high density of points in the upper left of the plot indicates area that experience high fishing effort but a low probability of occurrence while points in the lower right of the plot indicate the converse. Finally, an area of high density near the plot origin indicates both low fishing effort and low probability of occurrence.

5.2 RESULTS

Sablefish, petrale sole, and yelloweye rockfish (Figures 5.1, 5.2, and 5.3, respectively) show distinct patterns of fishing pressure. Areas of coincidence between fishing effort and species occurrence are highest for sablefish and concentrated in deep water offshore areas (Figure 5.1). Petrale pressure are lower than those for sablefish and are focused in shallow waters with particularly high effort located near the mouth of the Columbia River and near San Francisco (Figure 5.2). In contrast, yelloweye rockfish have a relatively low cumulative pressure throughout their range (Figure 5.3). This low overall value is a function both of the limited impact trawl gear has on the rocky high relief habitat utilized by yelloweye and the overall low probability of occurrence of yelloweye. We caution that pressure posed by any one fishing gear category may differ significantly from their cumulative effects. We also note that due to confidentiality rules, some grid cells with low fishing participation are omitted from the maps and appear as clear cells in the figures (as do cells with zero effort).

Overall exploitation patterns varied among species. Sablefish are a species targeted by bottom trawling and consequently, a large proportion of high trawl effort locations coincide with areas of high probability of occurrence (Figure 5.4a). Petrale sole show a bimodal distribution, with many areas of high abundance experiencing substantial trawl effort, but also many areas of low probability of occurrence seeing high trawl effort (Figure 5.5a). In contrast, nearly all trawl effort falls on locations where yelloweye are predicted to be absent (Figure 5.6a) (although obviously, yelloweye are caught in some trawls. It is important to note that all three species have areas with relatively high probability of abundance that are subject to low or no bottom trawl threat.

Examination of the non-spatial summaries provides a method for contrasting the intersection of occurrence and bottom trawl effort before and after EFH conservation areas were implemented in 2006 (Figures 5.4, 5.5 and 5.6). For each figure, comparing panels *A* and *B* provides a way to examine the distribution of fishing effort and probability of occurrence prior to Amendment 19. The most notable aspect of this comparison is that the level of fishing effort is much lower in the areas designated for gear restrictions in 2006 (e.g. Figure 5.4b for sablefish) than in grid cells not designated for gear restrictions (e.g. Figure 5.4a for sablefish). This indicates that the locations protected in 2006 tended to be areas that were not experiencing high fishing pressure. This is true for all species examined (Figures 5.4, 5.5, 5.6; see also Appendix 5). This is likely to be related to the footrope restrictions put in place in 2000, which may have displaced effort before these areas were more permanently protected.

A comparison of panels *A* and *C* informs how the intersection of fishing and probability of occurrence in unrestricted areas differs before and after Amendment 19. In all species, panels *A* and *C* are very similar, indicating minimal aggregate changes in fishing effort outside EFH conservation areas. Also note that even outside conservation areas (panels *A* and *C*), there are many areas that are predicted to have high probability of occurrence but limited (near zero) fishing pressure (see Figures 5.4a and 5.4c for sablefish, Figures 5.5a and 5.5c for petrale sole, and Figures 5.6a and 5.6c for yelloweye rockfish).

The final contrast of interest compares panels *B* and *D*. This comparison shows how bottom trawl effort has changed inside conservation areas. Panels *B* and *D* describe only the EFH conservation areas before and after their implementation, respectively. In all cases and as expected, there is decidedly lower fishing effort post Amendment 19; a larger portion of the probability density is concentrated along the x-axis. However, the qualitative pattern of fishing effort is very similar between the two time periods[1]. These figures suggest that when aggregated across the entire range of the fleet, the spatial management implemented as part of Amendment 19 has done relatively little to change the overall bottom trawl effort with respect to the occurrence of the six focal species. Areas that were heavily exploited from 2002-2005 tend to remain heavily exploited while areas that experience minimal fishing pressure in 2002-2005 tend to remain lightly exploited in 2007-2010. Again, these results hold for a coast-wide summary of trawl effort. Section 3 and Appendix 3 provide figures that illustrate how local changes in fishing effort have occurred within this larger background of consistent overall fishing effort. Again, other changes in regulations may have changed the pattern of fishing effort prior to the implementation of Amendment. 19.

[1] A reasonable question is: why there are any grid cells with non-zero effort in panel *D?* Recall that panels

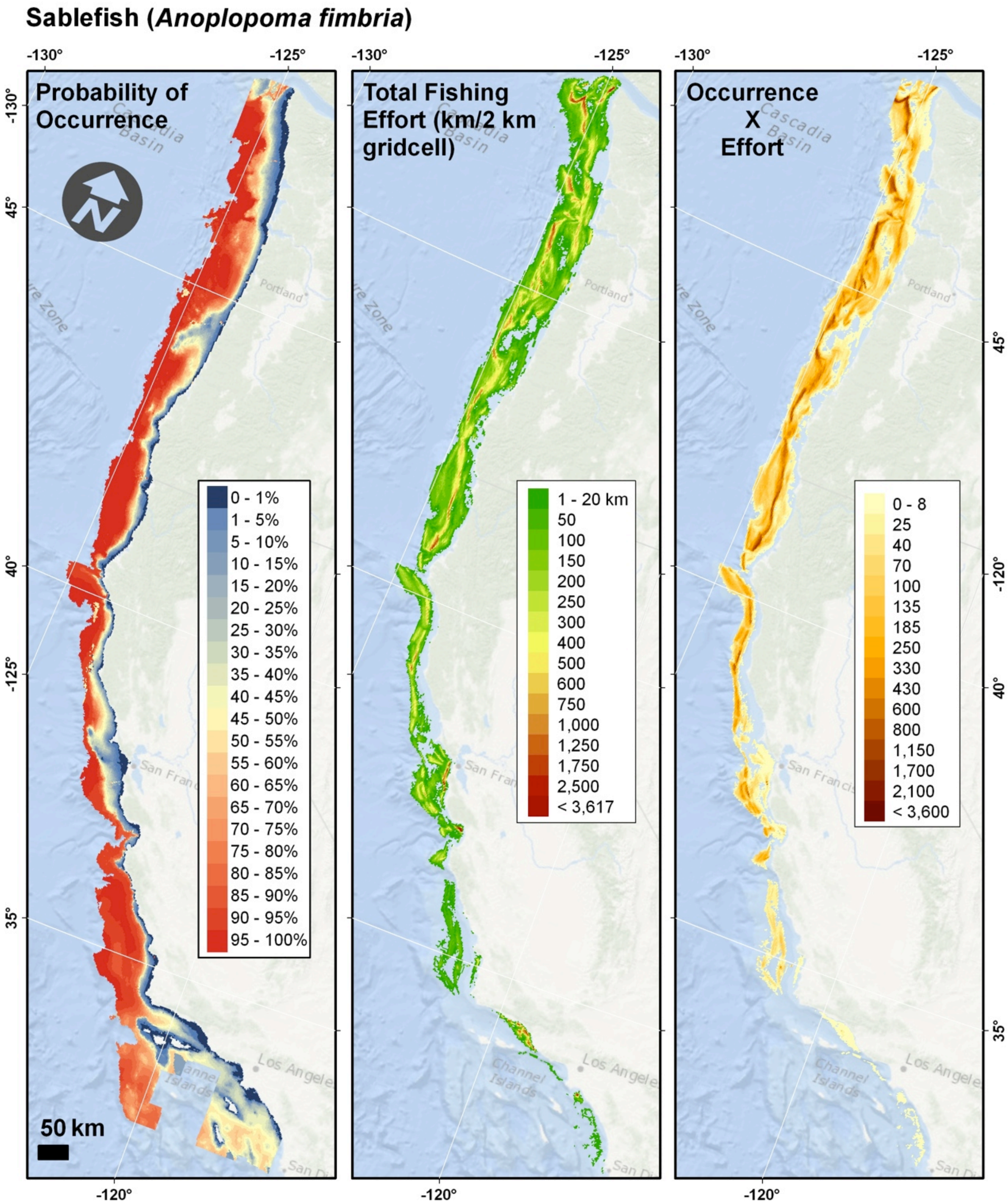

Figure 5.1: Sablefish. A comparison of the predicted probability of occurrence from the NWFSC model (*left panel*), the cumulative fishing effort (*middle; units = km*) and the intersection of probability of occurrence and cumulative effort for sablefish (*right*; units = km * probability of occurrence). Cumulative fishing effort includes bottom trawl, midwater trawl, and fixed gear.

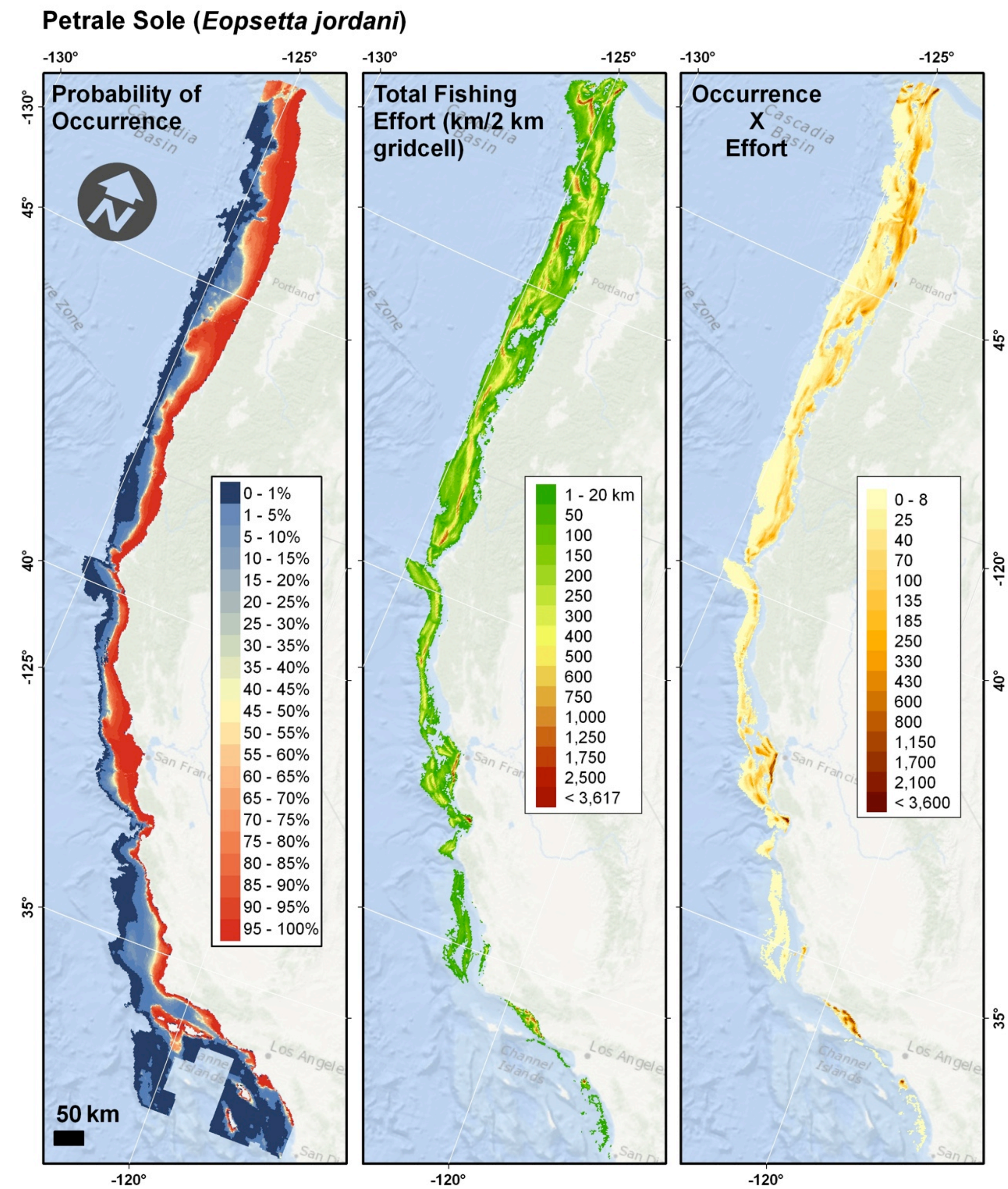

Figure 5.2: Petrale sole. A comparison of the predicted probability of occurrence from the NWFSC model (left panel), the cumulative fishing effort (middle; units = km) and the intersection of probability of occurrence and cumulative effort for petrale sole (*right*; *units = km * probability of occurrence*). Cumulative fishing effort includes bottom trawl, midwater trawl, and fixed gear.

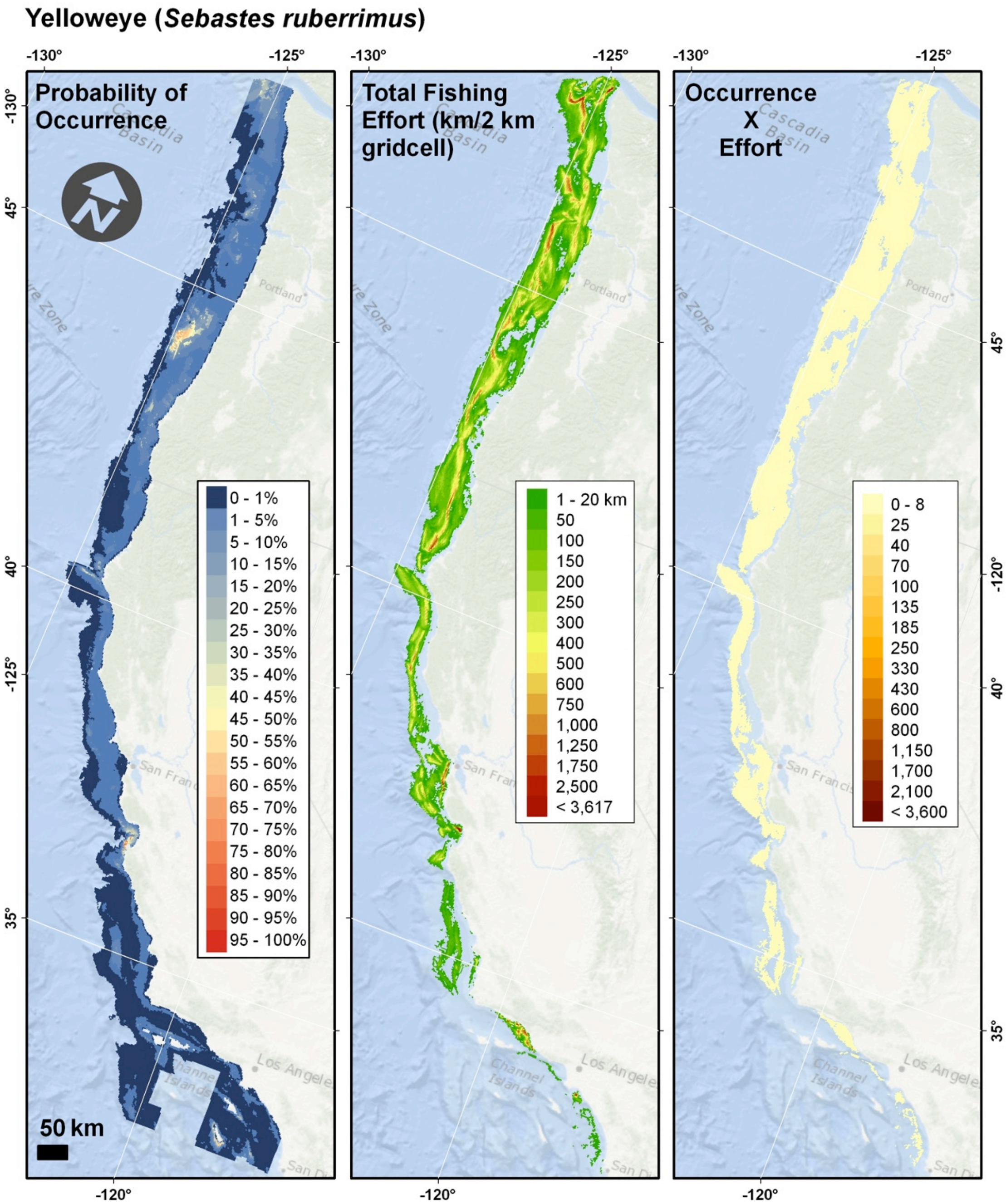

Figure 5.3: Yelloweye rockfish. A comparison of the predicted probability of occurrence from the NWFSC model (*left panel*), the cumulative fishing effort (*middle; units = km*) and the intersection of probability of occurrence and cumulative effort for yelloweye (*right*; units = km * probability of occurrence). Cumulative fishing effort includes bottom trawl, midwater trawl, and fixed gear.

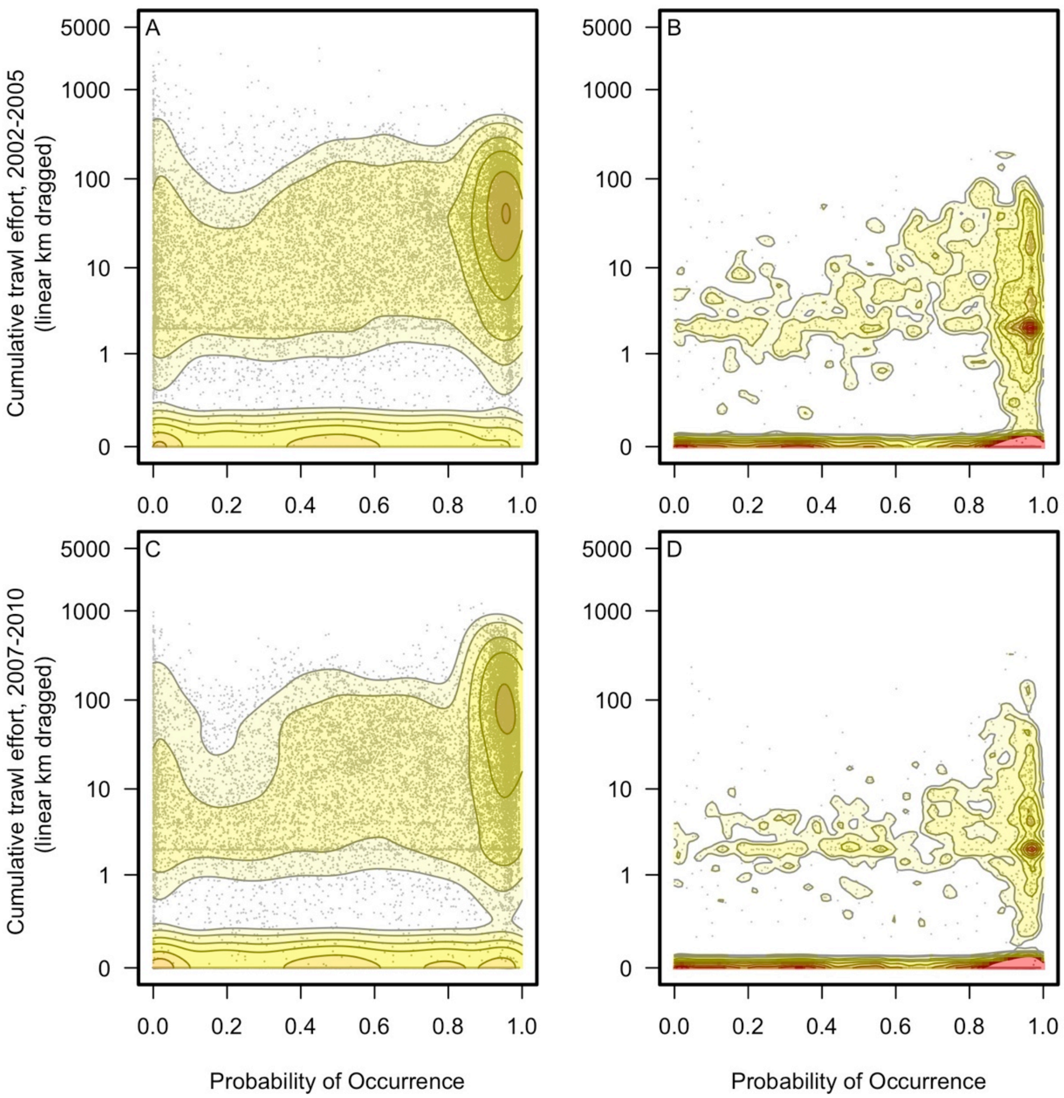

Figure 5.4: Sablefish. A comparison of the predicted probability of occurrence for sablefish (NWFSC model) and the cumulative bottom trawl effort with respect to fishing restrictions imposed by Amendment 19 in 2006. In each panel a point indicates the cumulative trawl effort and predicted probability of occurrence for a 2km x 2km grid cell on the West Coast. Contour lines and shading are derived from a bivariate normal kernel density estimate; white indicates probability density near zero and colors change from white to yellow to red as density increases. All panels have identical color scales. The two panels on the left side (*A* and *C)* represent grid cells with no gear restrictions from 2002-2010. *A)* Cumulative effort from 2002-2005 and *C)* Cumulative fishing effort from 2007-2010. Panels on the right side (*B* and *D)* show areas for which fishing restrictions were imposed in 2006. *B)* Cumulative fishing effort for these grid cells before restrictions were imposed (2002-2005). *D)* Cumulative effort after restrictions were imposed (2007-2010).

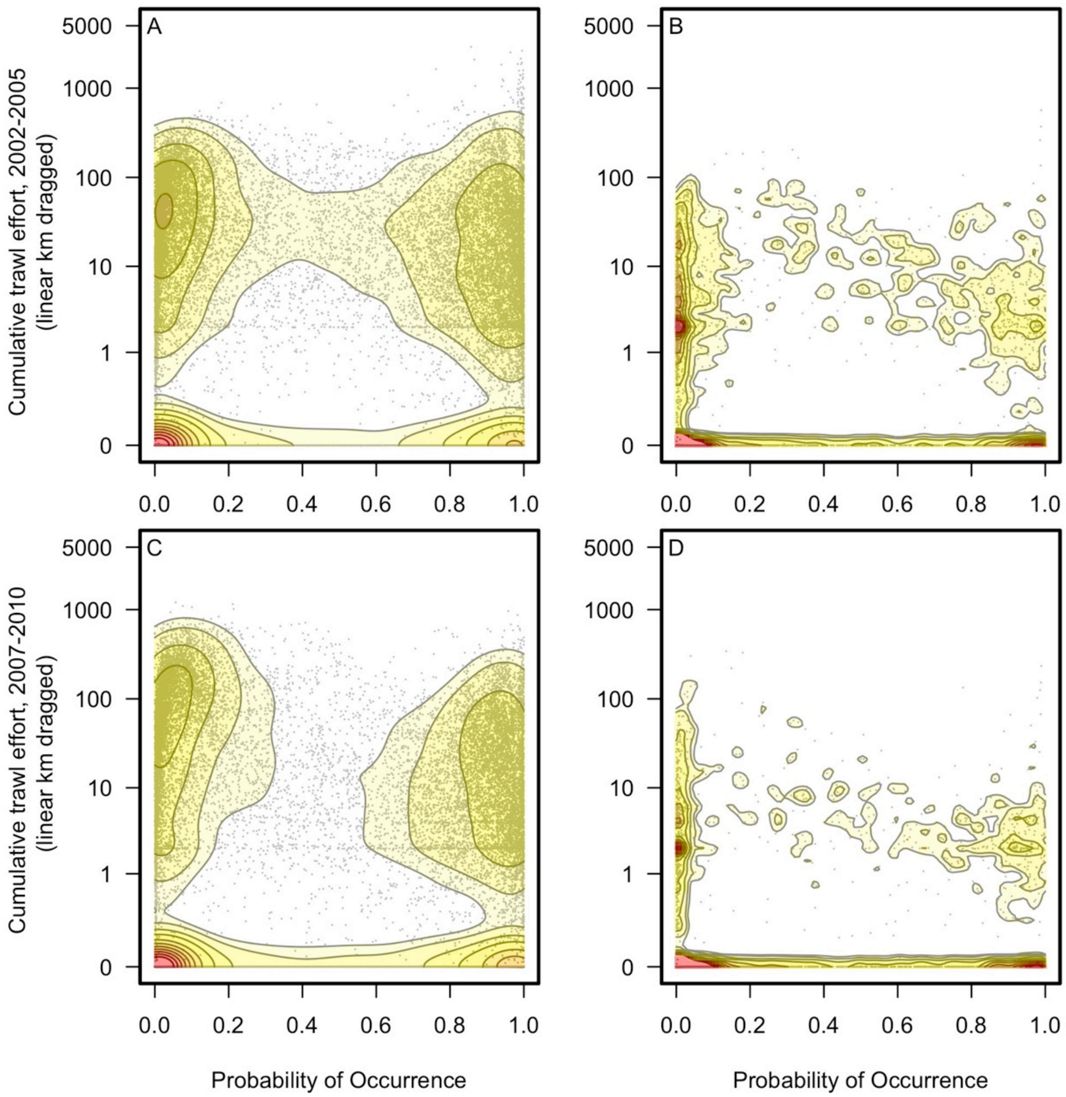

Figure 5.5: Petrale sole. A comparison of the predicted probability of occurrence for petrale sole (NWFSC model) and the cumulative bottom trawl effort with respect to fishing restrictions imposed by Amendment 19 in 2006. In each panel a point indicates the cumulative trawl effort and predicted probability of occurrence for a 2km x 2km grid cell on the West Coast. Contour lines and shading are derived from a bivariate normal kernel density estimate; white indicates probability density near zero and colors change from white to yellow to red as density increases. All panels have identical color scales. The two panels on the left side (*A* and *C)* represent grid cells with no gear restrictions from 2002-2010. *A)* Cumulative effort from 2002-2005 and *C)* Cumulative fishing effort from 2007-2010. Panels on the right side (*B* and *D)* show areas for which fishing restrictions were imposed in 2006. *B)* Cumulative fishing effort for these grid cells before restrictions were imposed (2002-2005). *D)* Cumulative effort after restrictions were imposed (2007-2010).

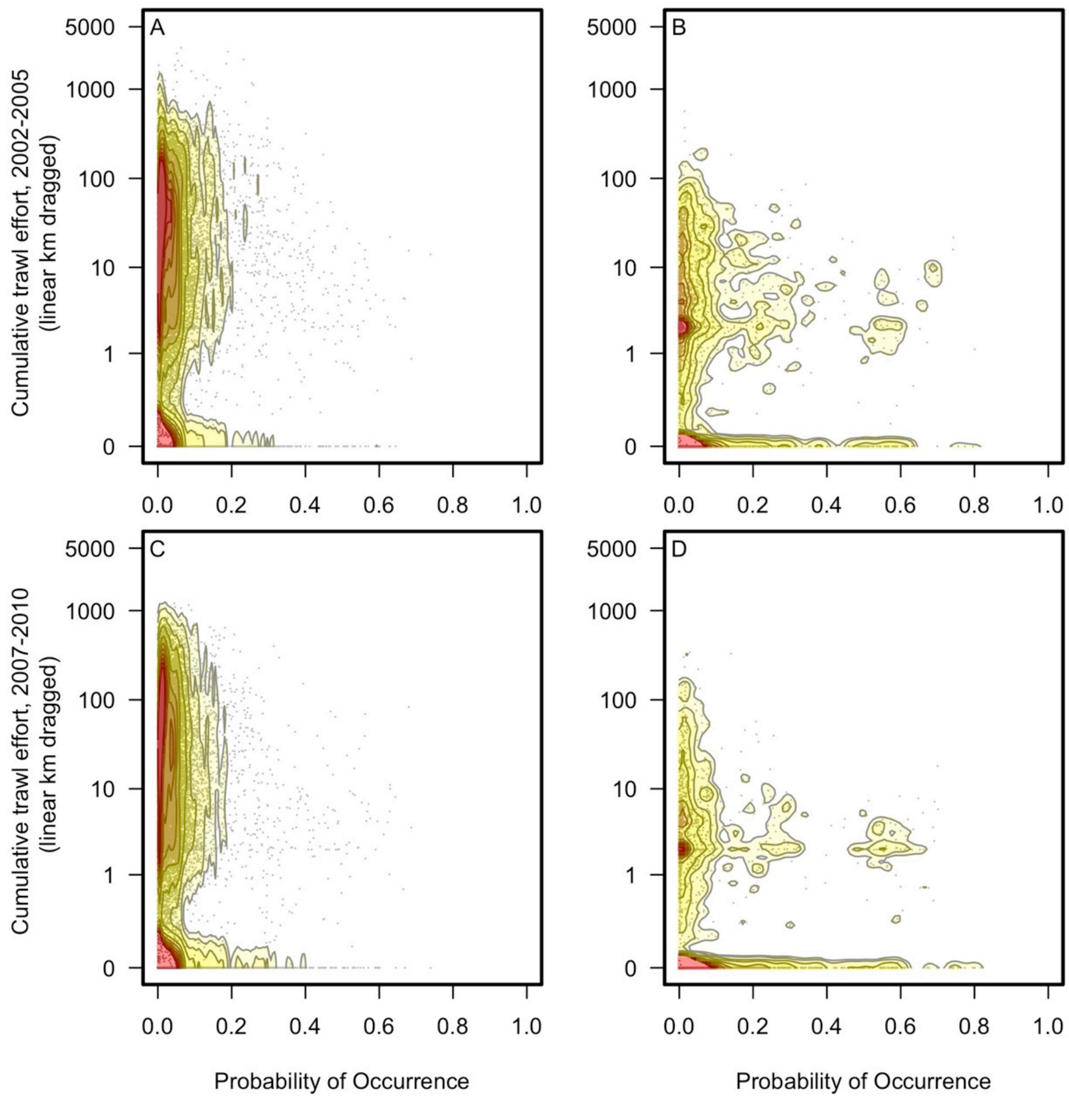

Figure 5.6: Yelloweye rockfish. A comparison of the predicted probability of occurrence for yelloweye (NWFSC model) and the cumulative bottom trawl effort with respect to fishing restrictions imposed by Amendment 19 in 2006. In each panel a point indicates the cumulative trawl effort and predicted probability of occurrence for a 2km x 2km grid cell on the West Coast. Contour lines and shading are derived from a bivariate normal kernel density; white indicates probability density near zero and colors change from white to yellow to red as density increases. All panels have identical color scales. The two panels on the left side (*A* and *C)* represent grid cells with no gear restrictions from 2002-2010. *A)* Cumulative effort from 2002-2005 and *C)* Cumulative fishing effort from 2007-2010. Panels on the right side (*B* and *D)* show areas for which fishing restrictions were imposed in 2006. *B)* Cumulative fishing effort for these grid cells before restrictions were imposed (2002-2005). *D)* Cumulative effort after restrictions were imposed (2007-2010).

6.0 PREY SPECIES OF WEST COAST GROUNDFISH

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Overview:

- Prey is a component of fish habitat and is being considered in the 5-year review of Pacific Coast Groundfish EFH. We improved the level of taxonomic diversity of a diet matrix presented in Phase 1, at the Council's request. A key next step will be to determine habitat associations for important prey species.
- Diet composition, at a high level of prey specificity, is reported for 11 of the 91 FMP groundfish species. These 11 had medium-to-high amounts of diet information, and represent various habitat guilds on the continental shelf and slope of the West Coast.
- The breadth of the diets of some species was narrow and included just a few prey taxa (e.g., polychaete worms dominated the diet of Dover sole), whereas other groundfishes consumed a diverse array of prey types.
- In general, the dominant prey groups were crustaceans (e.g., copepods, euphausiids, shrimps, and crabs) and fishes (e.g., sand lance, flatfishes, sculpins, herring, anchovy, and smelts). Sardines had no trophic significance in the diets of these 11 groundfish species.
- Ontogenetic differences in diet were evident for sablefish, darkblotched rockfish, lingcod, and Pacific hake. Juveniles of these species consumed more small pelagic organisms (e.g., euphausiids, copepods, jellyfish) than the older life stages, which became increasingly piscivorous.
- Diet composition differed substantially among these groundfish species, and therefore such information should not be combined among species for subsequent analysis.
- Quantitative information on diet composition is limited for most of the other 80 species in the groundfish FMP. Additional studies are needed to establish trophic linkages for these species throughout the California Current system.

6.1 DIET COMPOSITION OF SELECT GROUNDFISH SPECIES

The prey of groundfishes are being considered in this 5-year review of Pacific Coast Groundfish EFH. Quantifying major prey is dependent on the availability of appropriate data on diet composition. The primary goal of this project was to provide more taxonomic specificity to supplement the prey reports in the Phase 1 EFH reports by quantifying prey in the diets of groundfish species based on available literature. The key goal here is to identify prey species appropriately. As additional information about the habitat requirements for key prey species is developed, managers can consider prey species' needs in the design and implementation of spatial management regulations.

We prioritized 11 species of groundfishes based on data availability and ecological diversity: petrale sole, Dover sole, sablefish, lingcod, greenstriped, rosethorn, sharpchin, darkblotched, and yelloweye rockfishes, longspine thornyhead, and Pacific hake (Table 6.1). These species represent various habitat guilds that have been described based on seafloor substratum (e.g., low relief mud; cobble fields; complex rock outcrops) and water depth of the continental shelf and slope (Allen et al. 2006).

TABLE 6.1. Species and life stages of Pacific coast groundfishes evaluated for diet composition. *n* = number of studies; N = number of stomach samples with prey.

COMMON NAME	SCIENTIFIC NAME	SPECIES GROUP	Life Stage	*n*	N
Petrale sole	*Eopsetta jordani*	Flatfishes	Juvenile - Adult	2	43
Dover sole	*Microstomus pacificus*	Flatfishes	Juvenile - Adult	6	1,446
Sablefish	*Anoplopoma fimbria*	Other Groundfish	Juvenile	2	40
Sablefish	*Anoplopoma fimbria*	Other Groundfish	Juvenile - Adult	5	3,153
Lingcod	*Ophiodon elongatus*	Other Groundfish	Juvenile	2	24
Lingcod	*Ophiodon elongatus*	Other Groundfish	Juvenile - Adult	3	457
Greenstriped rockfish	*Sebastes elongatus*	Other Rockfish	Juvenile - Adult	3	110
Rosethorn rockfish	*Sebastes helvomaculatus*	Other Rockfish	Juvenile - Adult	2	68
Sharpchin rockfish	*Sebastes zacentrus*	Other Rockfish	Juvenile - Adult	2	44
Darkblotched rockfish	*Sebastes crameri*	Rockfishes	Juvenile	1	18
Darkblotched rockfish	*Sebastes crameri*	Rockfishes	Juvenile - Adult	1	20
Yelloweye rockfish	*Sebastes ruberrimus*	Rockfishes	Juvenile - Adult	2	37
Longspine thornyhead	*Sebastolobus altivelis*	Rockfishes	Juvenile - Adult	2	1,240
Pacific hake	*Merluccius productus*	Other Groundfish	Juvenile	5	1,526
Pacific hake	*Merluccius productus*	Other Groundfish	Juvenile - Adult	7	4,031
Pacific hake	*Merluccius productus*	Other Groundfish	Adult	4	778
Total:					13,035

We conducted a literature review (Appendix I) using summarized life history information in three recent publications (McCann et al. 2005; Love 2011; PFMC 2012), and from a thorough search of Aquatic Science and Fisheries Abstracts, Biosis, Web of Science, and Zoological Record databases. The geographic range of this analysis was restricted to the waters off the continental U.S. West Coast; literature on groundfish diets specifically from other regions was not considered. However, studies that included some fish samples from Canada or Mexico were included when data only from US waters could not be discerned. Details for each study are in Appendix I. Only studies that reported quantitative estimates of weight or volume were included in our analysis because these metrics generally track energetic importance of the prey taxa (Hyslop 1980; Cailliet et al. 1986). By contrast, frequency metrics (e.g., percent frequency of occurrence and relative number of a prey taxon) are typically a proxy for feeding behavior, but do not necessarily represent the relative importance of each prey type in the fish's diet (Hyslop

1980; Cailliet et al. 1986). Compound measures that incorporate weight or volume (such as Index of Relative Importance [IRI]) were considered only if volume or weight were not individually reported.

Volume or weight of each prey category, as originally designated in a study, was converted to a percentage and then reclassified among 47 prey categories (Table 6.2) to standardize our evaluation. When possible, diet composition data were calculated by life stage (i.e., juvenile or adult). If maturity stage or size of the fish was not reported, diet was analyzed from juvenile and adult life stages together. A weighting scheme was applied to the final diet composition data when more than one diet study was available for a species or life-stage; that is, if the number of samples = 1, data were weighted by 1; 2-10 samples (weight of 2), 11-25 samples (weight of 4); 26-50 samples (weight of 8); 51-100 samples (weight of 16); > 100 samples (weight of 32).

Quantitative information on diet composition was limited for most species. Notable exceptions were juvenile, adult, and juvenile-adult Pacific hake, and juvenile-adult Dover sole and sablefish, which were each represented by several studies and large sample sizes (Table 6.1). There were 1-3 suitable diet studies from which to draw for the other species, and of these only lingcod, greenstriped rockfish, and longspine thornyhead had aggregate sample sizes > 100 stomachs (Table 1). By comparison, a vastly larger amount of comparable information is available in other US regions, such as the Northwestern Atlantic, Gulf of Alaska, and Bering Sea, where diet sampling has been conducted routinely for many years. Overall, 23 suitable publications were used in our study (Appendix I), some of which provided data for multiple groundfish species. The lack of replicate studies and generally low sample sizes result in estimates of diet composition that may not accurately reflect either historical, seasonal, or geographic prey spectrums for some of these species. In addition, the majority of the studies did not characterize diet by life stage. Even when data on fish lengths were available, life stages often spanned size ranges that encompassed juveniles and adults and therefore could not be segregated.

Although diet composition data were limited for most species, the identification of important prey taxa emerged from our analyses. Diets comprised a wide range of prey taxa from polychaete worms to finfish (Table 3). The breadth of the diets of some groundfish species was very narrow and included just a few prey taxa. Other groundfish species consumed a diverse array of prey taxa. The diet of Dover sole was dominated by infaunal polychaetes and echinoderms and differed considerably from that of the other groundfish species, including the other flatfish (petrale sole) that consumed small flatfishes and crustaceans. Other groundfish species with diets largely comprising fishes included juvenile and juvenile-adult lingcod (61 and 92%, respectively), juvenile-adult sablefish (64%) and yelloweye rockfish (63%), and adult Pacific hake (71%). Fish prey for lingcod, sablefish, and yelloweye mostly included small benthic fishes (e.g., sand lance, flatfishes, sculpins) and a relatively small amount of pelagic forage fishes (herring, anchovy, and smelts). These small pelagic species comprised 47% of the diet of adult Pacific hake. Sardines had no trophic significance in the diets of these 11 groundfish species. Diets of juvenile hake, darkblotched rockfish, sablefish, and lingcod differed considerably from those of their combined juvenile-adult life stages, although the low sample sizes for juveniles (other than hake) may be cause for some misinterpretation. The prey spectrum of juvenile darkblotched rockfish included jellies and other small midwater organisms in contrast to the juvenile-adult darkblotched that mostly ate euphausiids (76%) and sand lance (12%). Crustaceans, a group that includes copepods to crabs, were dominant in the diets of juvenile-adult hake (58%) and rosethorn (91%), darkblotched (88%), greenstriped (80%), and sharpchin (62%) rockfishes, and of juvenile hake (69%), darkblotched rockfish (69%), and sablefish (56%). Euphausiids and shrimps generally were the main crustaceans preyed upon by these species; juvenile hake also consumed a considerable proportion of copepods (19%). Cephalopods, bivalves, and gastropods made relatively small contributions to (or were absent altogether from) the diets of most of these 11 groundfish species. However, loligonid squid (largely the market squid, *Doryteuthis opalescens*) was 8% of juvenile sablefish and 12% of juvenile-adult greenstriped rockfish diets.

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TABLE 6.2. Prey categories, abbreviations, and color codes used in the analysis of diets of Pacific coast groundfish species. Colors organize prey categories into broad taxonomic or functional groups.

Prey Category	Abbreviation	Color Code
Invertebrates, unidentified	INV	
Jellyfishes and other unidentified gelatinous zooplankton	JELL	
Polychaetes (annelid worms)	POLY	
Other marine worms (e.g., Nematoda, Sipuncula)	WORM	
Echinoderms (sand dollars, sea urchins, stars, cucumbers)	ECHINO	
Bivalves (clams, oysters, mussels, scallops)	BIVAL	
Gastropods (snails)	GAST	
Bivalves or gastropods, unidentified	MOLL	
Cuttlefishes	CUTT	
Loligonid squids	LOLI	
Squids (Oegopsina)	OEGO	
Squids, unidentified	SQUID	
Octopi	OCTO	
Cephalopods (squids and octopi, unidentified)	CEPH	
Copepods	COPE	
Amphipods	AMPH	
Isopods	ISO	
Mysids	MYSID	
Euphausiids (krill)	EUPH	
Penaeid and sergestid shrimps	SHRIMP PS	
Caridean shrimps	SHRIMP C	
Shrimps, unidentified	SHRIMP	
Thalassinidea (ghost shrimp, mud shrimp)	THALA	
Anomuran crabs	CRAB A	
Brachyuran crabs	CRAB B	
Crabs, unidentified	CRAB	
Other decapods	DECA	
Other and unidentified crustaceans	CRUST	
Tunicates (sea squirts)	TUN	
Agnathan fishes (lampreys, hagfishes)	AGNATH	
Chondrichthyan fishes (sharks, skates, rays, ratfishes)	CHOND	
Herrings	HERR	
Sardines	SARD	
Clupeidae (herrings, unidentified)	CLUP	
Engraulidae (anchovies)	ENGR	
Osmeriformes (smelts)	OSMER	
Myctophidae (lanternfishes)	MYCT	
Gadiformes (grenadiers, hake, cods)	CODS	
Zoarcidae (eelpouts)	ZOAR	
Poachers	AGON	
Sculpins	SCULP	
Hexagrammidae (greenlings)	HEX	
Rockfishes and thornyheads	ROCK	
Ammodytidae (sand lance)	AMMO	
Scorpaeniformes, other and unidentified	SCORP	
Pleuronectiformes (flatfishes)	FLAT	

Other and unidentified fishes	TELE	

TABLE 6.3. Diet composition (%) of Pacific coast groundfish species. Prey categories and color codes as in Table 2. J=juvenile and A=adult life stage of fish species.

COMMON NAME	INV	JELL	POLY	WORM	ECHINO	BIVAL	GAST	MOLL	CUTT	LOLI	OEGO	SQUID
Petrale sole (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0
Dover sole (J-A)	0.0	0.5	53.2	0.5	30.1	1.7	0.7	3.6	0.0	0.0	0.0	0.3
Sablefish (J)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	0.0	0.0
Sablefish (J-A)	0.0	0.3	1.2	0.1	0.3	0.1	0.9	0.0	0.0	0.9	0.6	3.1
Lingcod (J)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lingcod (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Greenstriped rockfish (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	0.0	0.0
Rosethorn rockfish (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Sharpchin rockfish (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Darkblotched rockfish (J)	0.0	31.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Darkblotched rockfish (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yelloweye rockfish (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Longspine thornyhead (J-A)	6.5	0.0	9.4	0.0	6.2	0.7	0.1	0.0	0.0	0.0	4.2	2.0
Pacific hake (J)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
Pacific hake (J-A)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.8
Pacific hake (A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0

Table 6.3 (continued)

COMMON NAME	OCTO	CEPH	COPE	AMPH	ISO	MYSID	EUPH	SHRIMP PS	SHRIMP C	SHRIMP	THALA	CRAB A
Petrale sole (J-A)	0.0	0.0	0.0	0.0	0.0	8.0	2.8	0.0	11.3	0.0	0.0	0.0
Dover sole (J-A)	0.0	0.0	0.0	0.8	0.3	0.0	0.4	0.3	0.2	0.0	0.1	0.9
Sablefish (J)	2.1	1.1	0.0	0.0	0.0	0.0	44.9	0.0	0.0	0.0	0.0	0.0
Sablefish (J-A)	1.7	4.0	0.0	2.8	0.1	0.1	8.0	0.0	0.8	1.1	0.1	0.2
Lingcod (J)	0.0	0.0	19.1	0.0	0.0	0.0	19.3	0.0	0.0	0.0	0.0	0.0
Lingcod (J-A)	3.7	0.5	0.0	0.0	0.0	0.0	0.1	0.0	4.0	1.0	0.0	0.0
Greenstriped rockfish (J-A)	0.0	0.8	0.4	0.1	0.3	0.2	13.7	30.7	27.2	3.0	0.0	3.1
Rosethorn rockfish (J-A)	0.0	0.0	1.1	0.3	0.3	0.0	9.4	5.3	29.6	3.7	0.0	35.6
Sharpchin rockfish (J-A)	0.0	0.0	1.7	0.0	0.0	0.0	34.3	3.9	3.2	3.7	0.0	5.0
Darkblotched rockfish (J)	0.0	0.0	9.3	19.7	0.0	0.0	15.3	0.0	0.0	0.0	0.0	0.0
Darkblotched rockfish (J-A)	0.0	0.0	4.1	5.7	0.0	0.0	75.5	3.0	0.0	0.0	0.0	0.0
Yelloweye rockfish (J-A)	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.3	0.0	0.0
Longspine thornyhead (J-A)	0.0	0.7	0.0	2.5	1.1	0.2	0.1	0.7	5.6	9.5	8.5	0.0
Pacific hake (J)	0.0	0.0	19.2	0.0	0.0	0.1	63.8	0.0	0.0	4.6	0.0	0.0
Pacific hake (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	45.1	1.6	2.0	7.6	0.0	0.0
Pacific hake (A)	0.0	0.0	0.0	0.0	0.0	0.0	19.4	0.0	2.4	2.8	3.3	0.0

Table 6.3. (continued)

COMMON NAME	CRAB B	CRAB	DECA	CRUST	TUN	AGNATH	CHOND	HERR	SARD	CLUP	ENGR	OSMER
Petrale sole (J-A)	0.0	0.0	0.0	9.4	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0
Dover sole (J-A)	0.0	0.0	0.2	5.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sablefish (J)	9.1	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	12.6	0.0
Sablefish (J-A)	2.4	0.4	0.1	1.6	5.3	2.4	0.7	0.0	0.0	5.7	2.6	0.3
Lingcod (J)	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lingcod (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0	12.1	0.1	1.2
Greenstriped rockfish (J-A)	0.5	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rosethorn rockfish (J-A)	2.1	0.0	0.0	3.3	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sharpchin rockfish (J-A)	0.0	0.0	0.0	10.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Darkblotched rockfish (J)	0.0	0.0	0.0	24.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Darkblotched rockfish (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yelloweye rockfish (J-A)	26.6	0.0	0.0	0.0	0.0	0.0	0.0	10.6	0.0	2.2	0.0	0.3
Longspine thornyhead (J-A)	13.4	0.1	0.7	2.8	0.7	0.0	0.0	0.0	0.0	0.0	0.0	7.5
Pacific hake (J)	0.0	0.0	0.4	0.3	0.2	0.0	0.0	0.0	0.0	0.6	0.0	0.0
Pacific hake (J-A)	0.2	0.1	0.0	1.0	0.0	0.0	0.0	6.0	0.0	1.2	9.0	2.4
Pacific hake (A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.6	0.0	11.5	10.3	7.4

Table 6.3 (continued)

COMMON NAME	MYCT	CODS	ZOAR	AGON	SCULP	HEX	ROCK	AMMO	SCORP	FLAT	TELE
Petrale sole (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	43.0	17.3
Dover sole (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Sablefish (J)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.3
Sablefish (J-A)	0.3	6.0	0.4	0.1	0.0	0.0	12.3	0.0	7.5	5.4	20.1
Lingcod (J)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.7	0.0	0.0	4.3
Lingcod (J-A)	0.4	8.6	0.0	0.0	16.2	14.5	0.5	3.5	14.7	6.2	9.3
Greenstriped rockfish (J-A)	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1
Rosethorn rockfish (J-A)	1.9	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	6.3
Sharpchin rockfish (J-A)	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.7
Darkblotched rockfish (J)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Darkblotched rockfish (J-A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.7	0.0	0.0	0.0
Yelloweye rockfish (J-A)	0.0	0.0	0.0	0.0	21.8	4.3	11.2	0.0	0.0	11.9	0.6
Longspine thornyhead (J-A)	3.7	0.3	1.4	0.0	0.0	0.0	2.6	0.0	0.0	0.0	8.7
Pacific hake (J)	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0
Pacific hake (J-A)	0.6	8.1	0.0	0.0	0.0	0.0	0.8	0.0	0.2	0.8	11.3
Pacific hake (A)	0.0	7.4	0.0	0.2	0.1	0.0	0.5	0.0	1.2	4.7	10.0

Science, Service, Stewardship

Agenda Item D.6.b
Supplemental NMFS PowerPoint
April 2013

Synthesis – Groundfish Essential Fish Habitat information

April 2013

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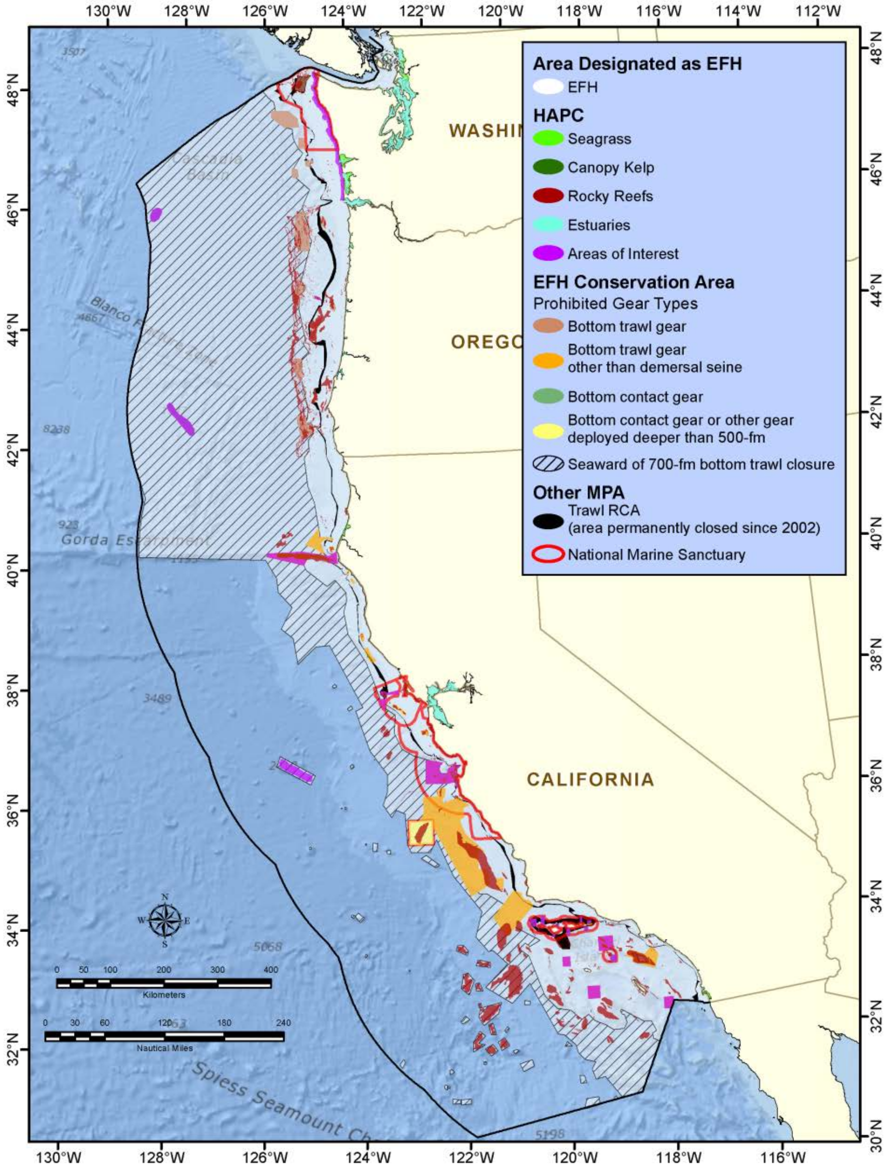
Purpose

- Characterize distribution of habitat, threats to habitat, and habitat occupancy.
  - Geographically
  - With respect to boundaries
- Support development and evaluation of EFH proposals



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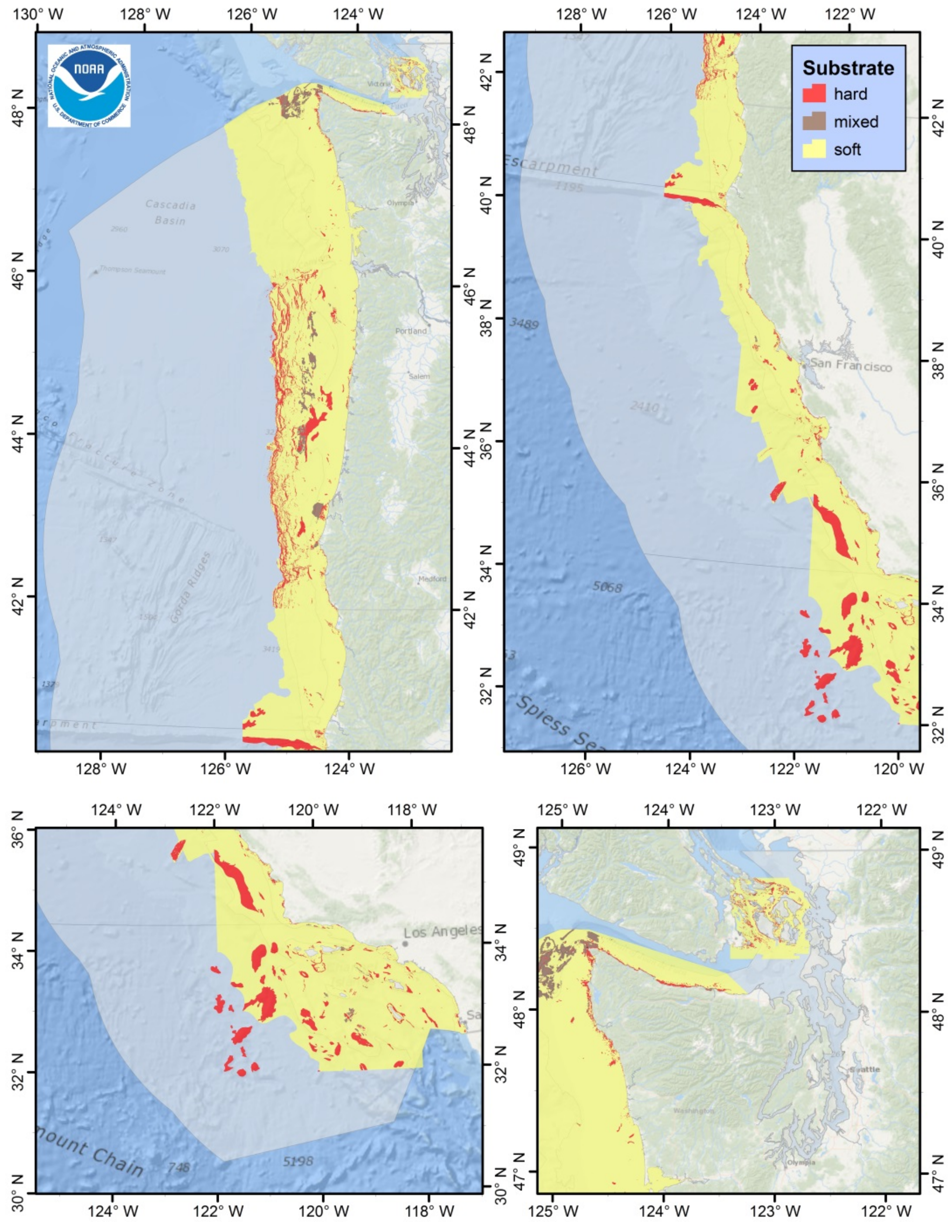
3 Habitat Types

- Greatest percentage – soft habitat.
- Lower slope less well-described.
- Habitat types distributed relatively similarly across regions.



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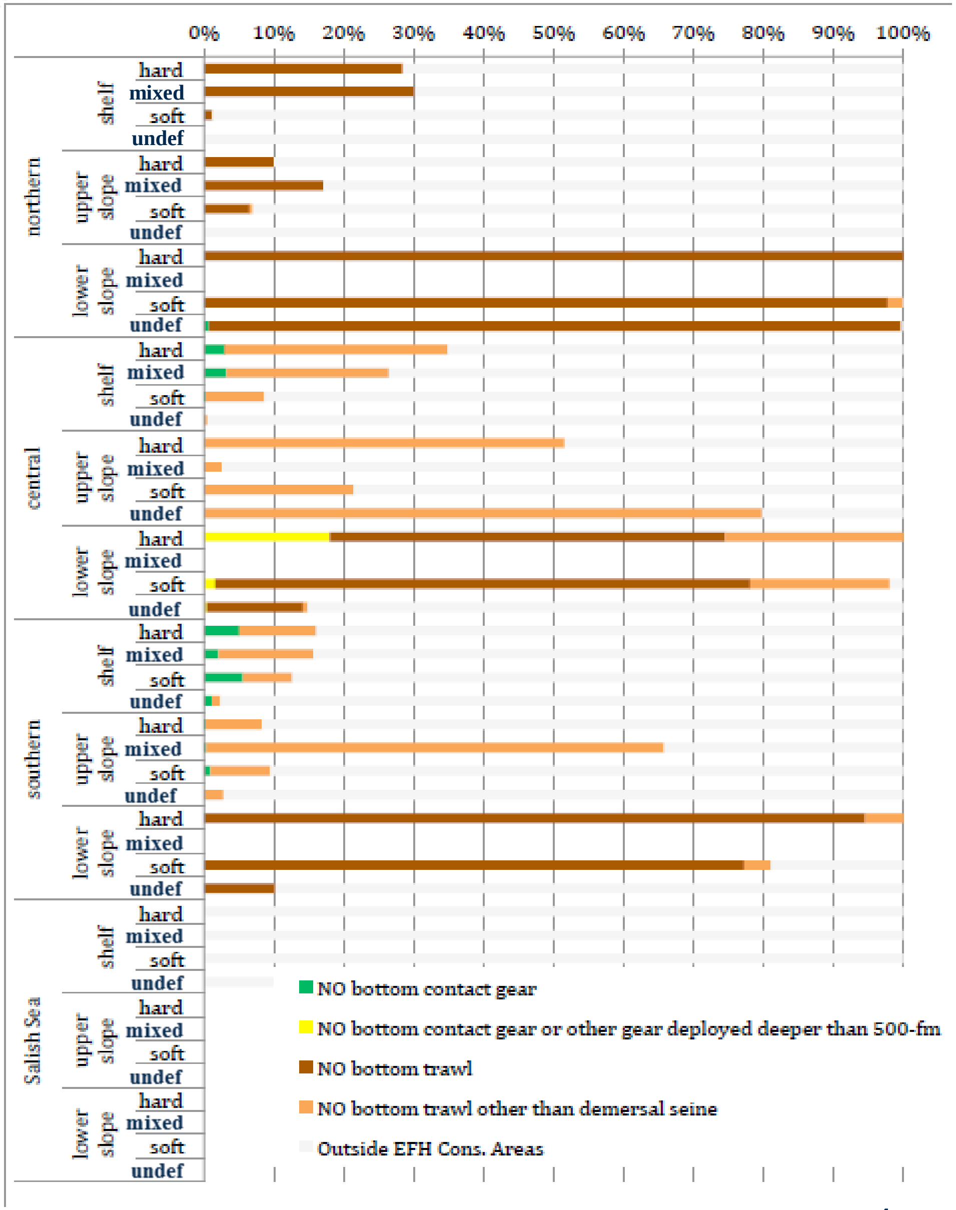
Where Do EFH-Specific Gear Prohibitions Apply?

- Lower slope (obviously) has greater fishing protections
- ~10% of shelf and upper slope habitats have protection
- Greater percentage of hard habitat protected in shelf and upper slope regions
- Current EFH conservation areas protect some biogenic habitats; additional areas remain open to some bottom contact gears.



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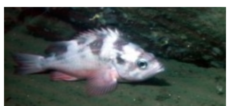
Determining Current Habitat Associations

	Species	Taxonomic Group	Depth Category	Preferred Substrate	Proportion of survey trawls with at least one fish observed	Stock Status
	Darkblotched Rockfish (*Sebastes crameri*)	Rockfish	Slope	Soft	~15%	Rebuilding
	Yelloweye Rockfish (*Sebastes ruberrimus*)	Rockfish	Shelf	Rocky	~2%	Rebuilding
	Sablefish (*Anoploma fimbra*)	Roundfish	Slope	Soft	~65%	Below target of $SB_{40\%}$ and declining.
	Longspine Thornyhead (*Sebastolobus altivelis*)	Rockfish	Slope	Soft	~35%	Target
	Greenstriped Rockfish (*Sebastes elongatus*)	Rockfish	Slope	Mixed	~25%	Target
	Petrale Sole (*Eopsetta jordani*)	Flatfish	Shelf	Soft	~40%	Rebuilding

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Habitat Variables

- Depth
- Bottom Temperature
- Sediment grain size
- Distance to rocky bottom
- No interactions

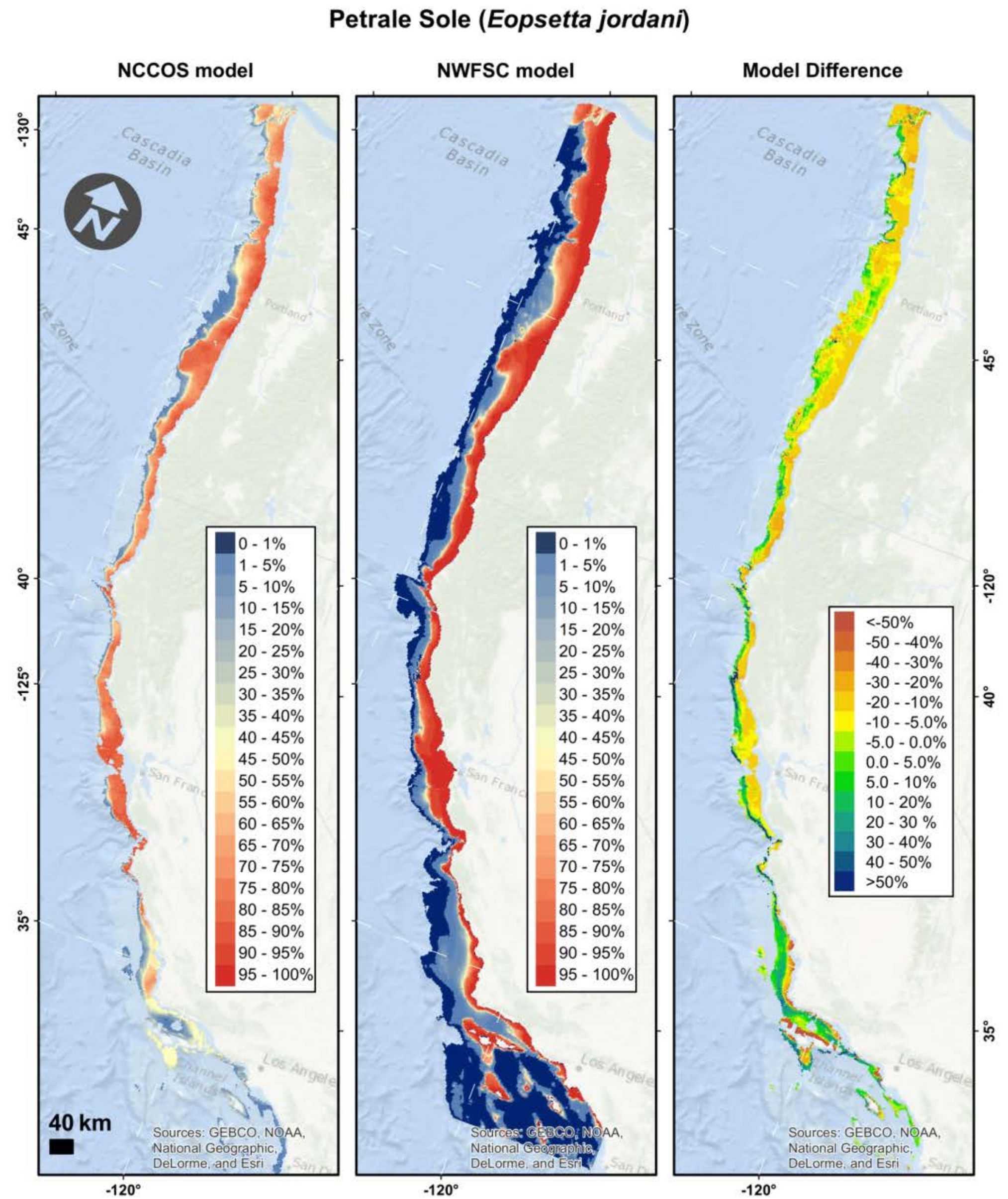
- Projected probabilities on 2x2 grid

Caveats

- Primary data = trawl survey
  - Adults and juveniles > ~15 cm
  - Summer sampling (May-October)
  - High relief areas poorly sampled

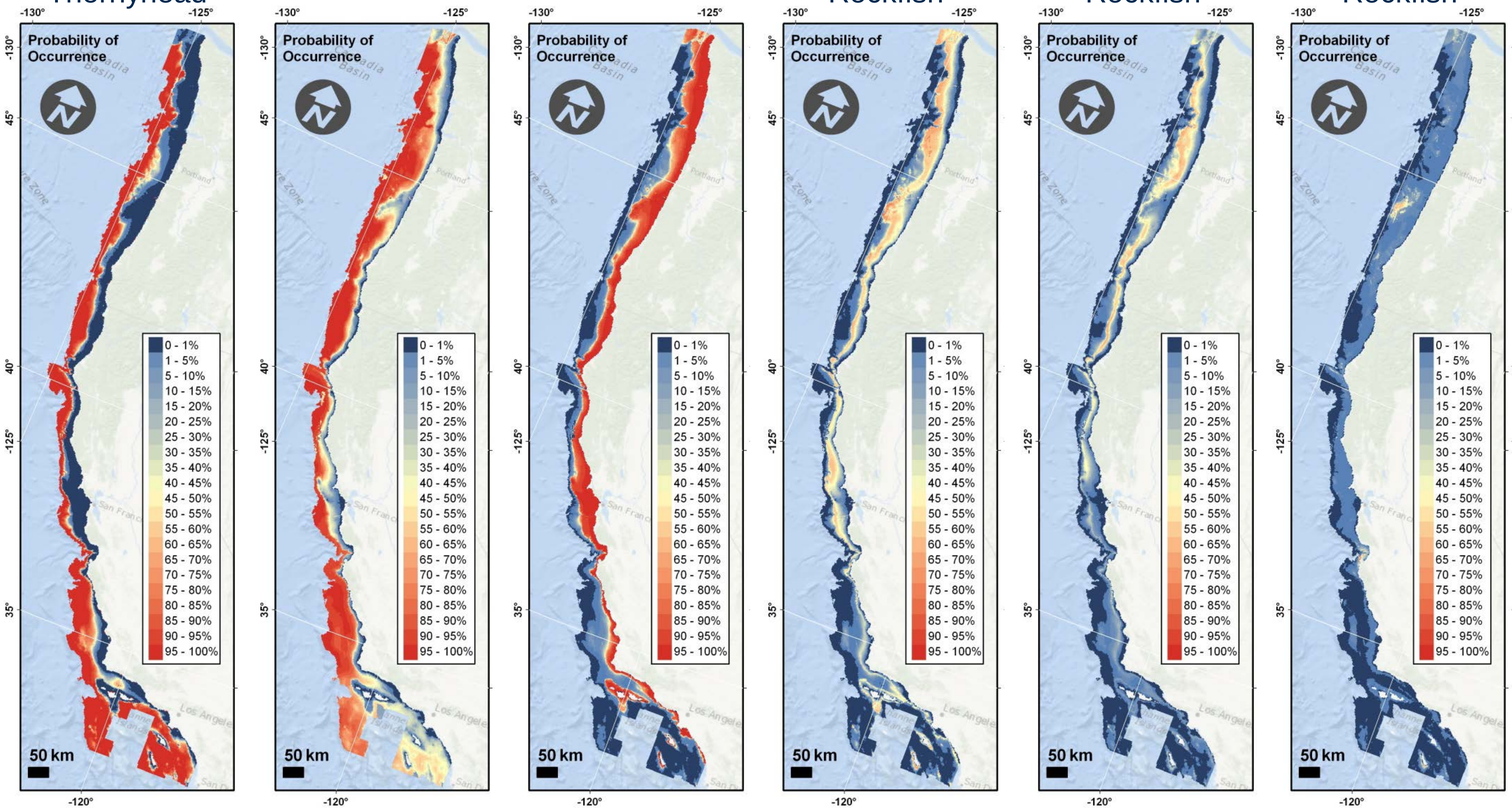
NOAA FISHERIES SERVICE

NWFSC and NCCOS Models and differences between the two for petrale sole.



NOAA FISHERIES SERVICE

Longspine Thornyhead	Sablefish	Petrale Sole	Greenstriped Rockfish	Darkblotched Rockfish	Yelloweye Rockfish



Habitat Occupancy

- Areas with high probability of occurrence varied across species, but:
  - Nearly all habitats had a high % for at least one of the six we evaluated;
  - Trade-offs or prioritization may be necessary

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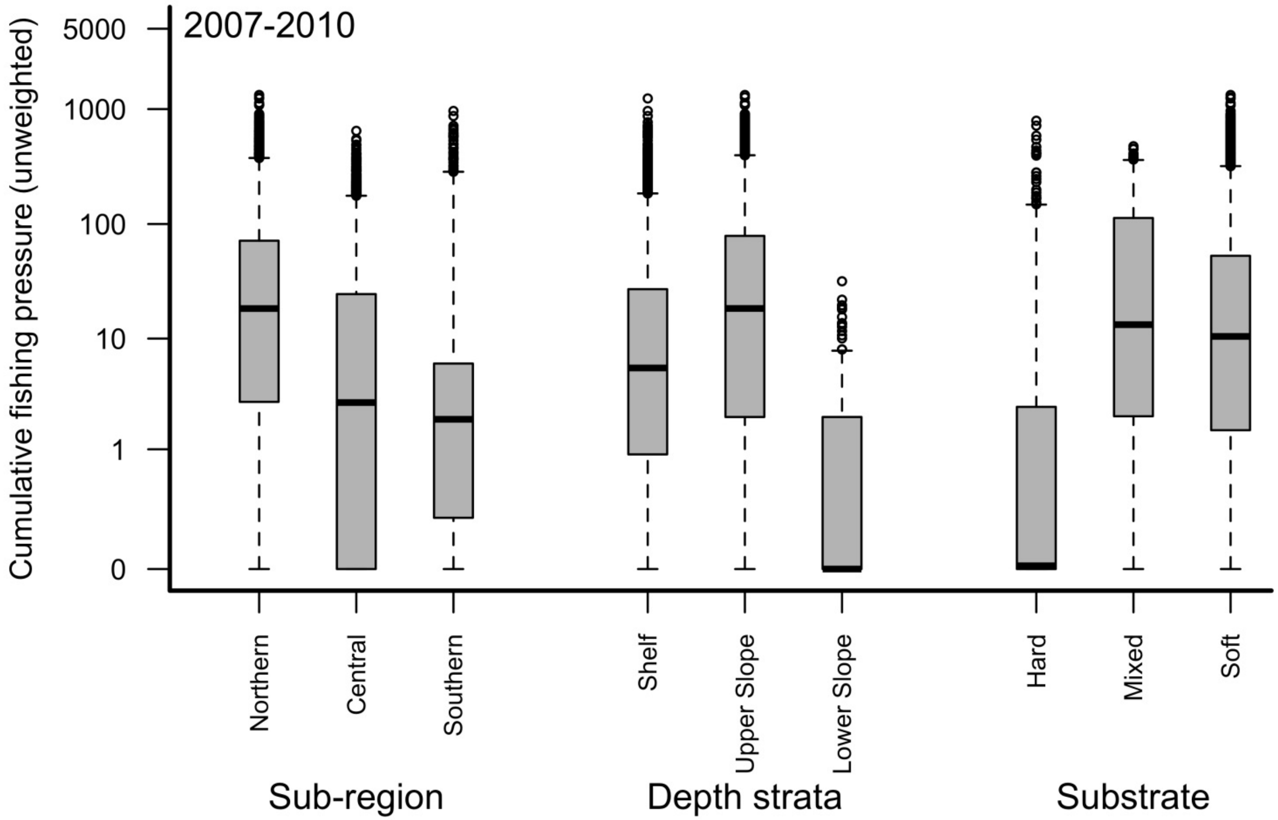
Cumulative Fishing Pressures by Sub-region



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- Bottom Trawl Change

Some displacement seaward, associated with RCAs

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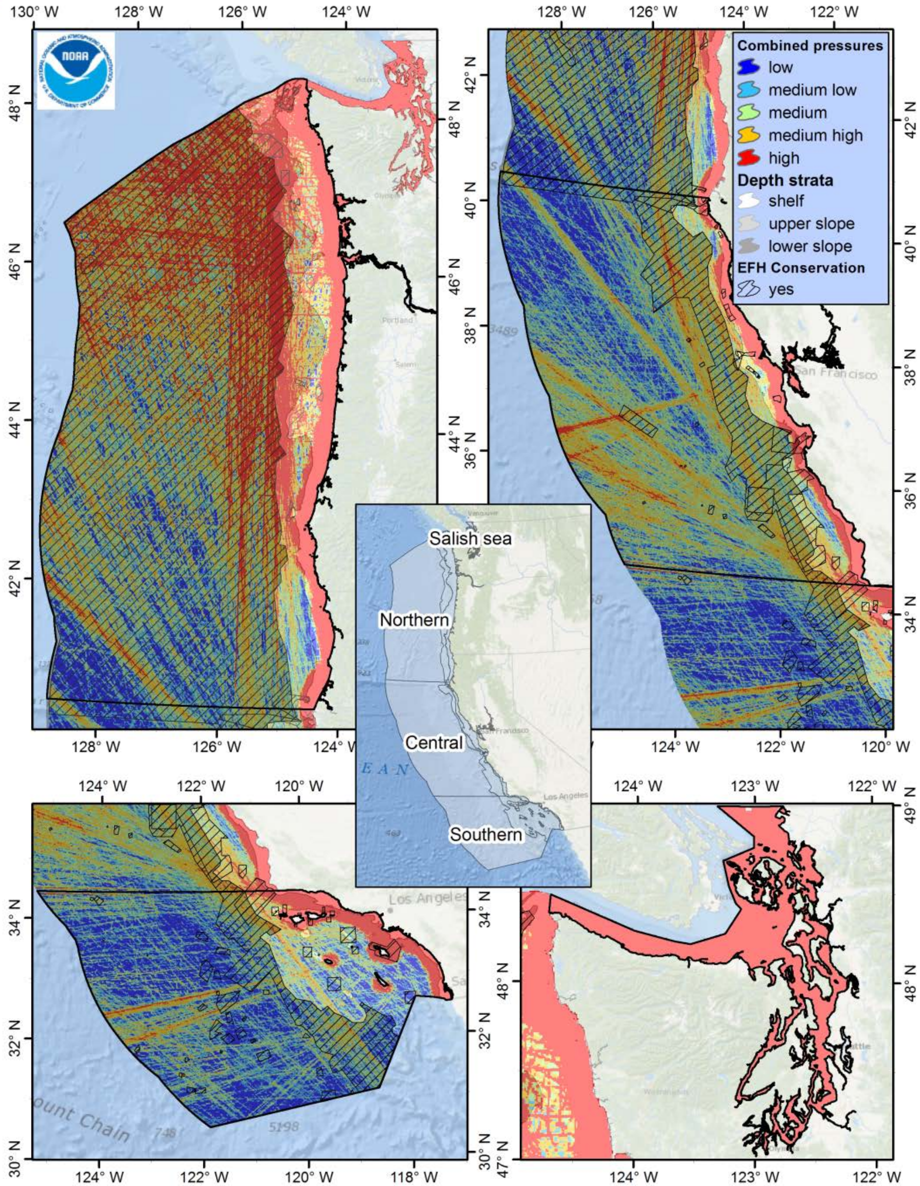
Distribution of combined pressures intensity values among biogeographic sub-regions, depth strata and essential fish habitat (EFH) conservation areas. Combined pressures data is the sum of non-fisheries pressures.



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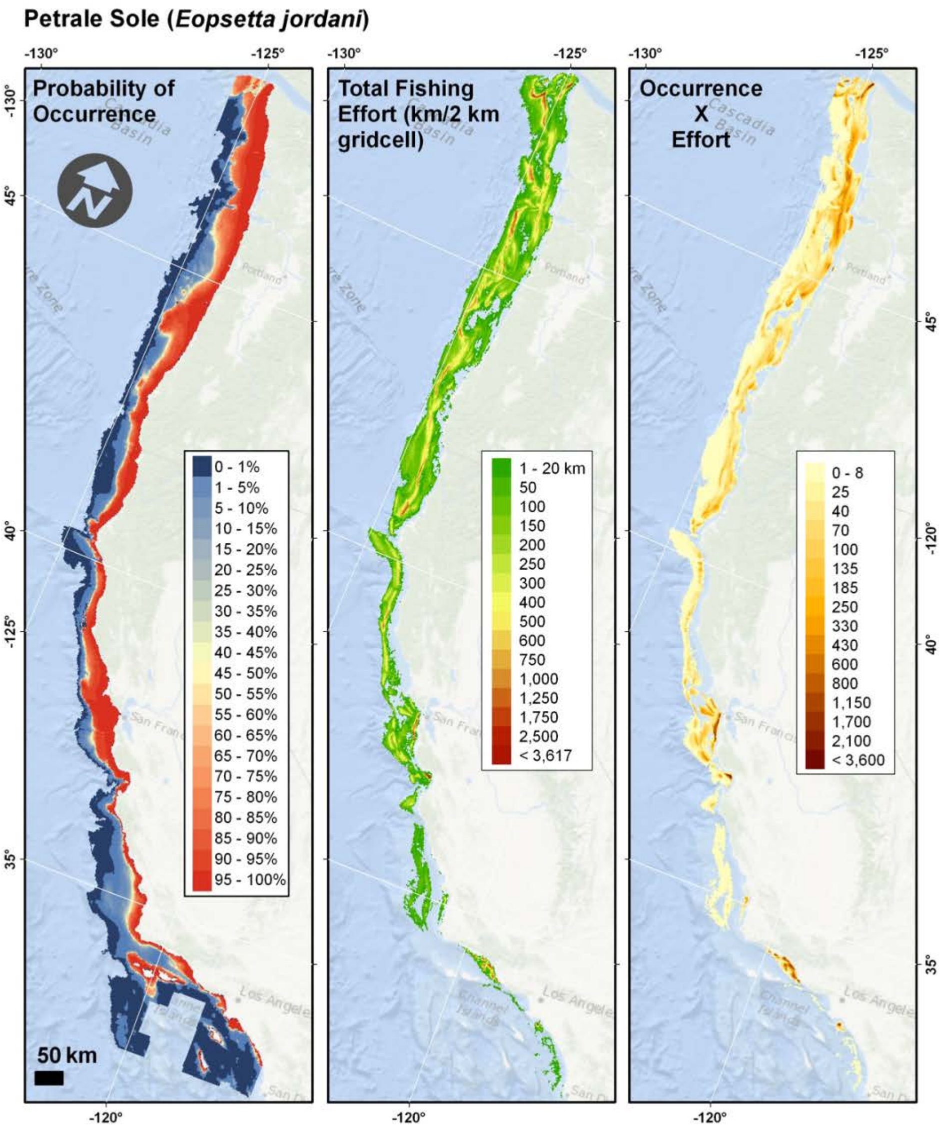
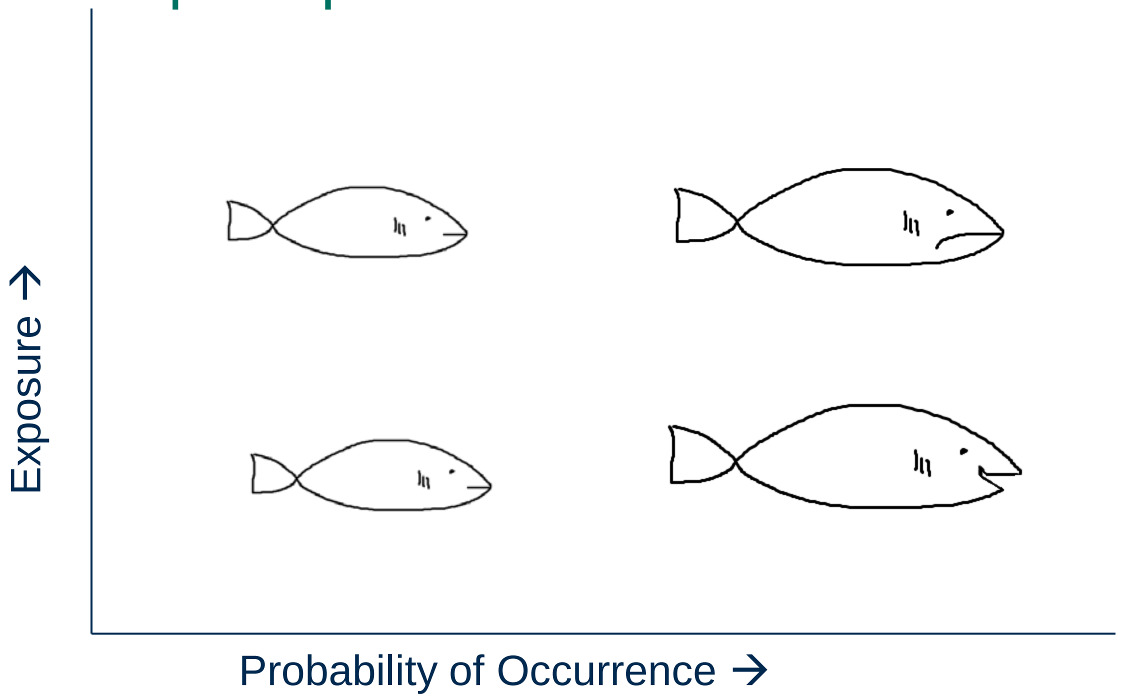
Non-Fishing Pressures

- These threats greatest in Salish Sea
- Offshore threats higher, N
- Inshore threats higher, S
- HAPCs more exposed to high intensity threats than other areas
- EFH Conservation Areas similar in non-fisheries threats to other areas

Comparison of the predicted probability of occurrence using NWFSC model (left), the cumulative fishing effort (middle; units = km), and the intersection of probability of occurrence and cumulative effort for petrale sole (right: *units = km* probability of occurrence*).

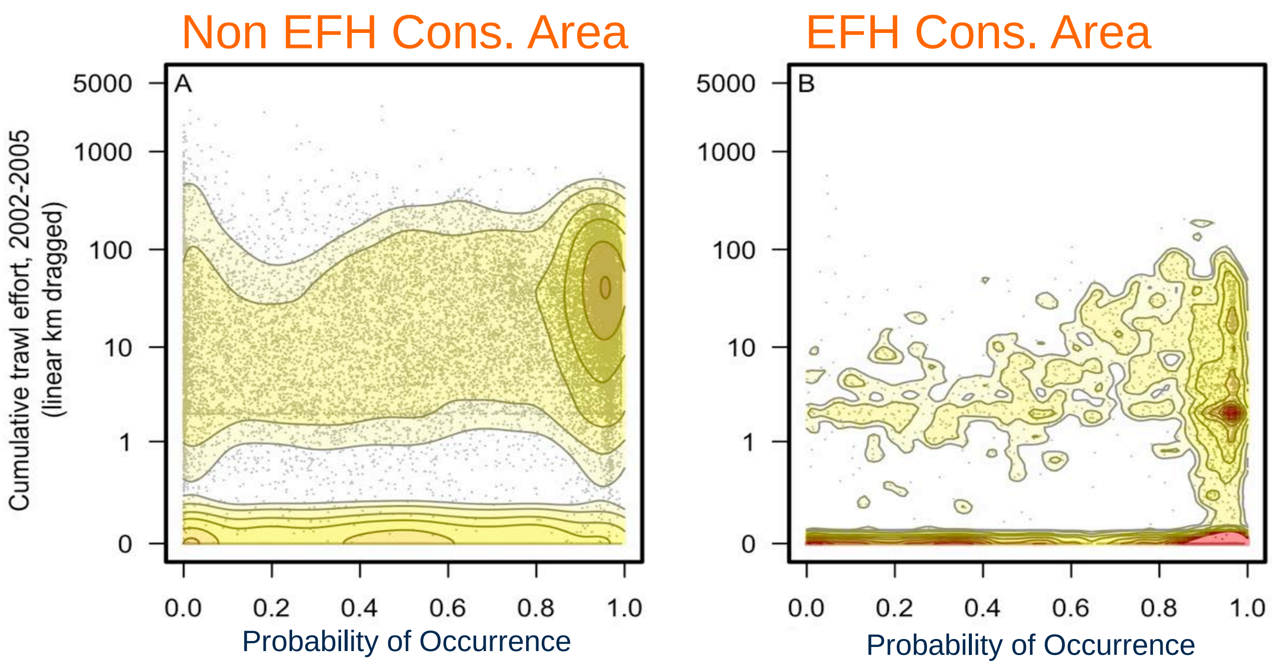


Cartoon – Individual fish perspective



Sablefish

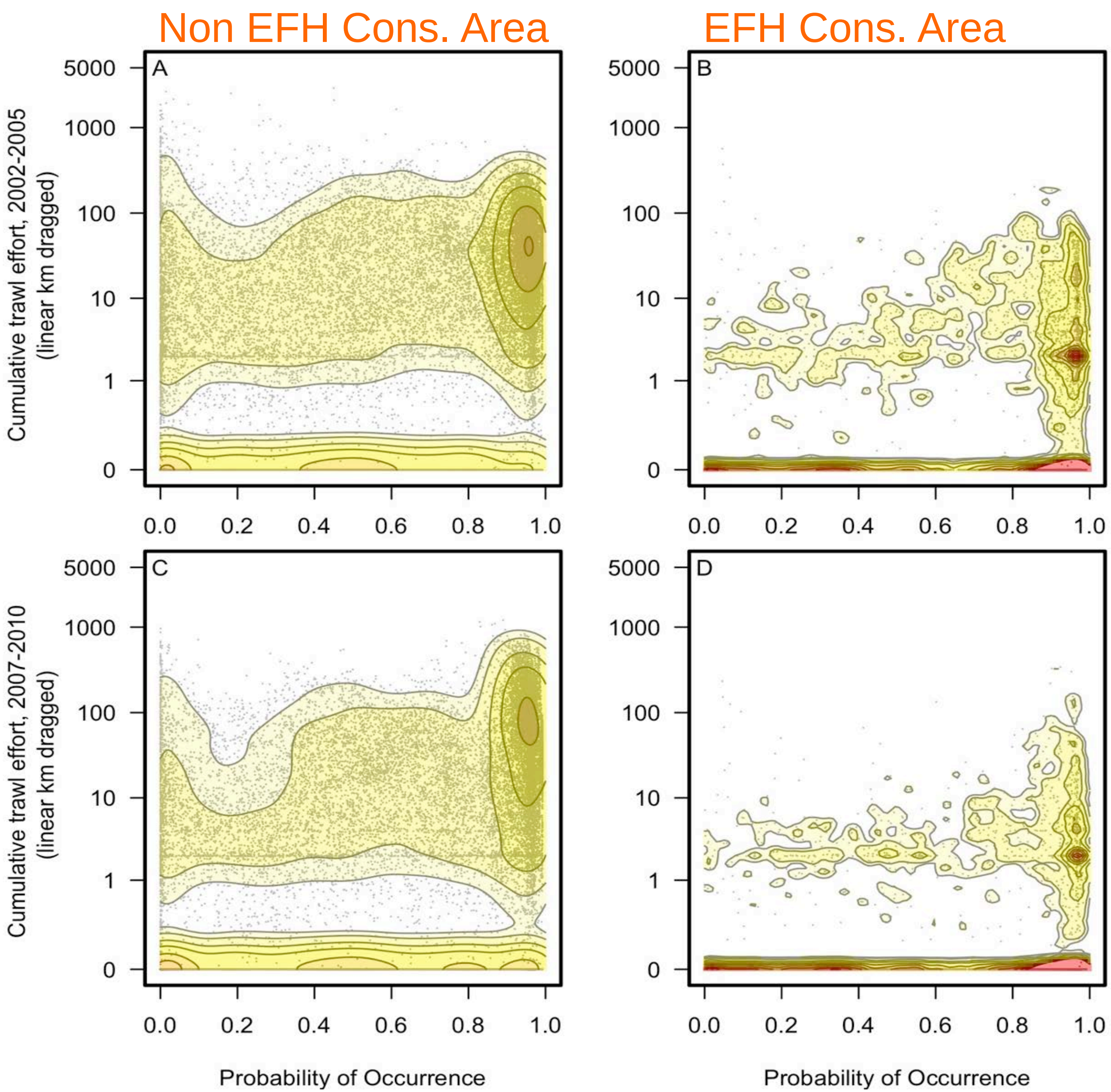
Pre-2006



Sablefish

Pre-2006

Post 2006



- EFH Conservation Areas protect some species more than others
  - Species preferring rocky, deep habitats have more proportional area protected
- Fishing pressure high in high-probability area for some species, but not others

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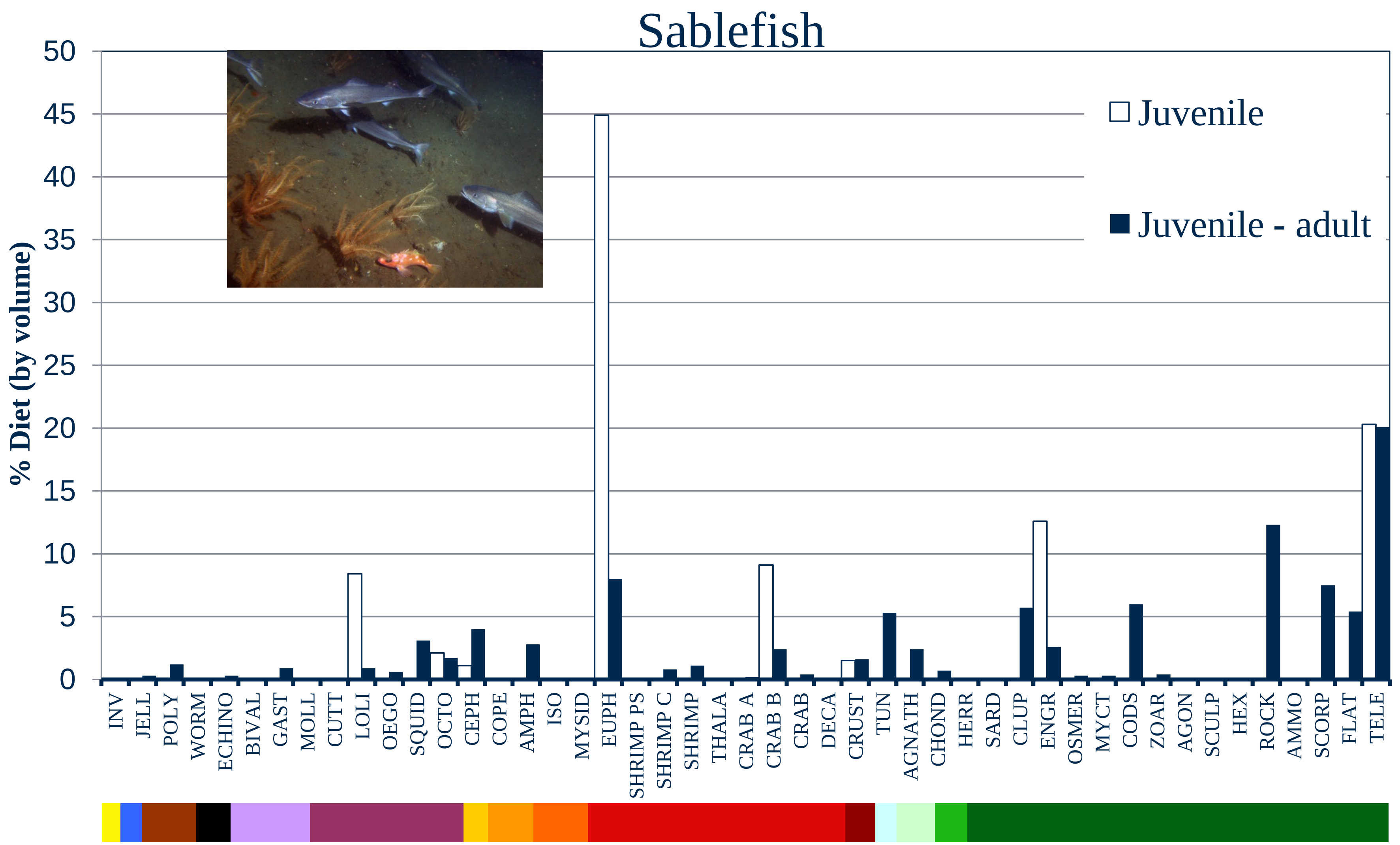
Predator-Prey Relationships

- Prey, as a component of feeding habitat, is being considered in the 5-year review of Pacific Coast Groundfish EFH.
- At the Council's request, we improved the level of taxonomic diversity of the diet matrix presented in Phase 1 in the Synthesis Report.
- We prioritized 11 species of groundfishes based on the six focal groundfishes, data availability, and ecological diversity.
- Next step is to evaluate prey composition for the other 80 spp in the FMP.
- A future step will be to determine habitat associations for important prey species.

Science, Service, Stewardship



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- Dominant prey groups were crustaceans (e.g., copepods, euphausiids, shrimps, and crabs) and fishes (e.g., sand lance, flatfishes, sculpins, herring, anchovy, and smelts).
- Ontogenetic differences in diet were evident for sablefish, darkblotched rockfish, lingcod, and Pacific hake.
  - Juveniles - consumed more small pelagic organisms (e.g., euphausiids, copepods, jellyfish)
  - Older life stages - increasingly piscivorous.
- Diet composition differed substantially among these groundfish species, and therefore such information should not be combined among species for subsequent analyses.

Using It All

- State goals clearly;
- Look for patterns in protected and unprotected areas;
  - Assess protections relevant for individual species;
- Identify areas of high and low impact from stressors;
- Evaluate correspondence of threats and probability of occurrence;
- Consider prey species only for prey-based changes;

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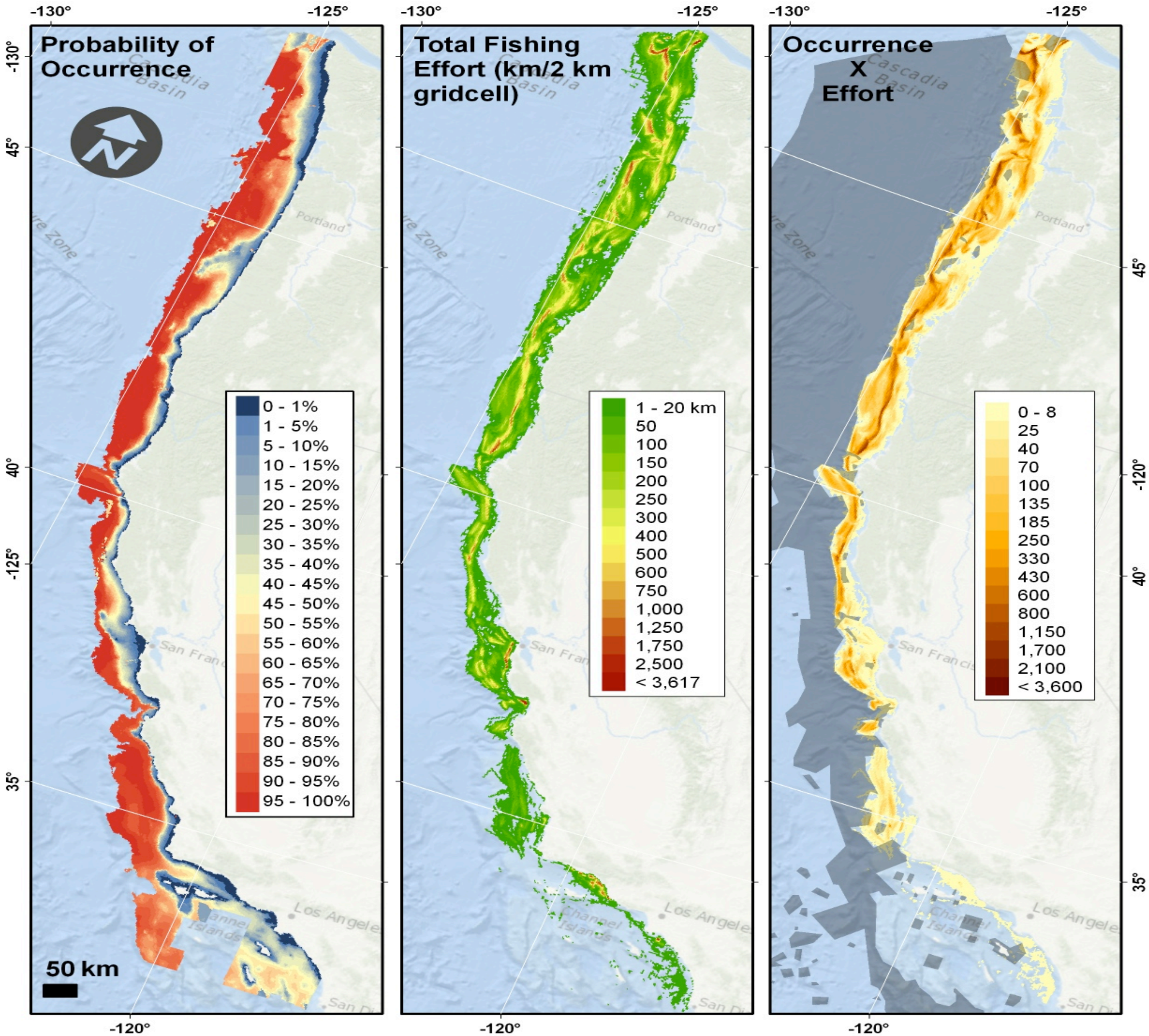
Sablefish (*Anoplopoma fimbria*)



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Online Data Catalog and Map Service

http://efh-catalog.coas.oregonstate.edu/synthesis

New Tab – Synthesis Data!

Overview	Substrate Maps	Biogenic Maps	Effort Maps	MPA Maps	Substrate Data	Imagery Data	Biogenic Data	Effort Data	Synthesis Data	Map Services	Metadata

Briefing Book: Quick links to Synthesis Documents at the PFMC website

- Agenda Item D.6.b: Groundfish Essential Fish Habitat Synthesis Report
- Agenda Item D.6.b: User Guide and Conclusions: Groundfish Essential Fish Habitat Synthesis Report
- Appendix

Download an ESRI Map Package containting Synthesis Report datasets below:

Please note that if you experience problems unpacking the map package with ESRI tools, you may alternately "unzip" the package with a zip tool like 7Zip or WinZip.

Theme	Map Author	Map Description	Download	Metadata
Base Layers	Curt Whitmire - NOAA NWFSC	Background Data Layers	data	All GIS data layers include ESRI format metadata! See Synthesis Appendix for more information.
Physical Habitat	Chris Romsos - OSU	Substrate Layers	data	All GIS data layers include ESRI format metadata! See Synthesis Appendix for more information.
Biogenic Habitat	Curt Whitmire - NOAA NWFSC	Biogenic Habitat Layers - Corals & Sponges	data	All GIS data layers include ESRI format metadata! See Synthesis Appendix for more information.
Modeled Species	Ole Shelton - NOAA NWFSC	NWFSC and NCOS Species Models	data	All GIS data layers include ESRI format metadata! See Synthesis Appendix for more information.
Fishing Impacts	Marlene Bellman - NOAA NWFSC	Fishing Effort - Cumulative and Change	data	All GIS data layers include ESRI format metadata! See Synthesis Appendix for more information.
Non-Fishing Impacts	Kelly Andrews - NOAA NWFSC	Non-Fishing Pressures	data	All GIS data layers include ESRI format metadata! See Synthesis Appendix for more information.

Groundfish Essential Fish Habitat Synthesis Report

Appendices

Table of Contents

1.0 METHODS FOR SYNTHESIS OF HABITAT INFORMATION

1.1 PHYSICAL HABITAT: DATA AND METHODS

Results from the Pacific Coast Groundfish 5-Year Review of Essential Fish Habitat Report to the Pacific Fishery Management Council Phase 1: New Information (PFMC, 2012), provided access to 261 new sources of seabed habitat type for US west coast EEZ waters including the Puget Sound/Salish Sea inland waters. Seabed habitat maps from these sources update large regions of the “Version 1” regional habitat maps used during the 2005 EFH Review. However, owing to the wide range of map sources and mapping programs from which this new set has been collected, the mapping methods and interpretive schemes are not standardized under any single classification scheme like the Coastal and Marine Ecological Classification Standard (FGDC, 2012) or the Classification Scheme for Deep Seafloor Habitats (Greene, 1999).

Regionally, the coast-wide Surficial Geologic Habitat Maps for Oregon and Washington, covering outer coast continental shelf and slope areas from Cape Flattery, WA south to the Oregon-California border, have been upgraded periodically since 2005’s Version 1 to today’s Version 3.6. California’s coast-wide habitat map remains unchanged since 2005. However, in all 3 states new mapping at local scales modifies and improves the regional maps by refining our knowledge of rocky outcrop, mixed seabed types, and sediment distribution locally. The aerial extent of this new information may be examined graphically in a set of map plates from the EFH Phase 1 Report, appendix C-2. Full resolution (Adobe PDF) copies of this map set and GIS data are available at:

http://efh-catalog.coas.oregonstate.edu/overview/

To support the synthesis goals of characterizing the spatial distribution of hard, soft, and mixed seabed habitat types and characterizing groundfish species-habitat relationships (report sections 1 and 2, respectively), several data preparation steps were necessary.

1. The complete set of shapefile and raster habitat maps, new local maps overlying 2005 or updated regional maps, was reduced to a unified raster format GIS layer under the common Phase 1 Report categorical classification scheme of probable: Hard Seabed, Mixed Seabed, and Soft Seabed.
2. A continuous seabed sediment grain size surface, derived from the USGS usSEABED database, was adopted to further describe the soft seabed habitat type.
3. A conceptual framework for understanding the variable thematic map accuracy of the integrated habitat map was developed and implemented in a map product.

1.1.1 Habitat Map Integration

A raster format habitat map was developed unifying EFH Review datasets under the categorical classification scheme: Probable Hard Seabed, Probable Mixed Seabed, and Probable Soft Seabed (see: EFH Phase I report, Appendix C, Bathymetry and Seafloor Habitat Maps). A fourth class, Predicted or Inferred Rock, has been mapped in Oregon and is treated as Probable Hard Seabed in this synthesis. To develop this data layer individual habitat map data sets from the Phase 1 Report set were converted from polygon to raster format at 25m by 25m cell size. For cells where multiple habitat types were present within the 25m by 25m neighborhood, the combined habitat type feature with the largest area determined the final value of the cell. Seabed habitat map layers of native raster format and resolutions less than the target were resampled to 25m x 25m cell size. Resultant raster layers were mosaicked in the same layer order that the EFH Report presents, such that the most modern and descriptive data took precedence over underlying regional data (Figure A1.1.1).

1.1.2 Sediment Grain Size

The unified raster map of seabed habitat type provides a broad categorical representation of habitats in three principal types. The modeling team sought a more descriptive and continuous seabed environmental covariate for their characterization work. Several methods for transforming the categorical types were considered including; using acoustic reflectivity or backscatter as a proxy for hardness, calculating % cover for each habitat within a moving window, or simply assigning a mean sediment grain size to each class. Each of these initial transformation methods was rejected in favor of using a continuous surface of sediment grain size interpolated from regional sample data. An interpolated grain size image covering the study area at 100m by 100m grid resolution area was identified from previous unpublished work (Active Tectonics and Seafloor Mapping Lab) providing a better alternative than assigning ideal mean grain size values to seabed classes (Figure 1.1.2).

The sediment grain size data layer is available for download at the PaCOOS West Coast Habitat Server (http://pacoos.coas.oregonstate.edu/archive/woc_sgh_grsz2.zip) and was derived from an interpolation of USGS usSEABED (Reid, 2006) and OSU (unpublished) sediment seabed sample databases. While the sample data inputs to this interpolation are not uniformly distributed spatially or temporally, the compilation is understood to be comprehensive, totaling 16,997 sample points and drawing from academic and agency sources.

1.1.3 Thematic Habitat Map Confidence

Estimating the thematic map accuracy of the final integrated habitat map was not possible without either reserving a portion of the input data or developing a program of sampling for this purpose. Instead, a first principles approach to understanding the likely thematic map accuracy or map confidence was developed. The assumption that guides this framework is simple; that high quality remotely sensed data backed up with local reference information produce maps that describe the distribution of seabed habitat types more confidently than maps that extrapolate information and knowledge into un-surveyed areas. This framework is an adaptation of Tobler's first law of geography, "Everything is related to everything else, but near things are more related than distant things." The framework described in Table 1.1 provided a simple means to score individual seabed habitat map data layers. Data layers were scored then mosaicked in a 25m by 25m raster map (Figure 1.1.3) companion to the integrated seabed habitat map.

1.2 BIOGENIC HABITAT: DATA AND METHODS

1.2.1 Observations of Deep-Sea Corals and Sponges

Much of what is known about the overall spatial distribution of corals and sponges in the region has been compiled by NOAA's Deep-Sea Coral Research & Technology Program (NOAA, 2013). The data set contains almost 174,000 records of corals and sponges collected between 1888 and 2012 off the west coast, with a large majority (99.5%) collected since 1989 (Figure A1.2.1). These records originate from a number of federal agencies, academic institutions and non-governmental organizations (Table A1.2). Roughly 95% of these records are direct, visual observations of corals and sponges in situ, while most of the remaining records (5%) are from surveys using benthic trawls, dredges, or grabs. With these records, we created two summary data products: one summarizing presence only data within contiguous 1x1 km cells, and the other summarizing relative observed abundance within contiguous 2x2 km cells.

Differences in how data were collected make it challenging to estimate relative abundance or density of corals and sponges. For example, some studies summarized counts over individual photo or video frames, while others summarized over the course of entire dive. Furthermore and in contrast to information available for physical seabed habitats, no map of continuous areas of biogenic habitats exists for the region. In order to compare the distributions in a standardized manner, coral-sponge presence was summarized within 1x1 km contiguous grid cells (Figure A1.2.2). If any observation, represented by a point with geographic coordinates (e.g., latitude, longitude), was located within a 1x1 km cell, the entire cell was categorized as having presence. This summarization technique facilitated the analysis of presence information in the context of various protected areas (see Tables A1.3.6a-b – A1.3.8a-b) similar to what was done for the physical habitat information.

Due to the lack of density values or available information on survey effort, we developed a metric of relative observed abundance defined as mean counts of corals and sponges observed per km. Records representing direct observations of corals and sponges in situ using either submersibles, ROVs or AUVs were categorized by dive and 1 km intervals. For records from dives of length <1 km or records where observations were summarized over an entire dive, counts of corals and sponges were used as the metric of relative abundance. If a dive transect was greater than 1 km in length, counts were apportioned into 1 km increments (Figure A1.2.2). Individual count values were summarized within 2x2 km cells (similar to other data themes [e.g., fishing and non-fishing stressors]) and mean values per cell were calculated. For 2x2 km cells with only one count value, the mean value was equal to the count, with a variance of 0. Because effort varied widely between cells, mean values rather than sum of counts were used as the metric in order to standardize the abundance values per cell. The resulting metric of relative abundance (mean counts per km) is depicted in Figure 1.3.17 map plates.

1.3 HABITAT: ADDITIONAL SUMMARY TABLES AND FIGURES

An extensive series of tables with complementary charts and maps were developed to compare and contrast the spatial distribution of physical and biogenic seabed habitat types within sub-regions and depths zones, and in relation to current commercial fishing prohibitions and restrictions. A subset of those tables and figures was presented in the report, but the full complement is included in this appendix. For the purposes of this synthesis, areas of commercial fishing prohibitions or restrictions were categorized in three different ways. The first category includes the 51 EFH conservation areas implemented as part of Amendment 19 of the groundfish FMP, including areas with four gear specific prohibitions. The second category includes MPAs prohibiting one of three main commercial gear types: bottom trawl, mid-water (pelagic) trawls, and fixed gears. The third category includes marine protected areas (MPA) where commercial fishing is either “prohibited” or “restricted”, based on the definition and classification system developed by the NOAA’s National MPA Center (NMPAC, 2012).

References

FGDC (Federal Geographic Data Committee). 2012. Coastal and Marine Ecological Classification Standard (June 2012). FGDC-STD-018-2012. Federal Geographic Data Committee. Washington, D.C.

Greene, H.G., M.M. Yoklavich, R.M. Starr, V.M. O’Connell, W.W. Wakefield, D.E. Sullivan, J.E. McRea Jr., and G.M. Cailliet. 1999. A classification scheme for deep seafloor habitats. Oceanol. Acta 22(6): 663-678.

NMPAC (National Marine Protected Areas Center). 2011. Definition & Classification System for U.S. Marine Protected Areas. May 2011. http://www.mpa.gov/pdf/helpful-resources/factsheets/mpa_classification_may2011.pdf

NOAA Deep Sea Coral Research and Technology Program. Deep Sea Coral National Geodatabase. [4 Feb 2013] Dan.Dorfman@noaa.gov

PFMC (Pacific Fishery Management Council). 2012. Pacific coast groundfish 5-year review of essential fish habitat Phase 1: New information. Final Report to Pacific Fishery Management Council, September 2012. Portland, OR. 416 p.

Reid, J.A., Reid, J.M., Jenkins, C.J., Zimmermann, M., Williams, S.J., and Field, M.E., 2006, usSEABED: Pacific Coast (California, Oregon, Washington) offshore surficial-sediment data release: U.S. Geological Survey Data Series 182, version 1.0. Online at http://pubs.usgs.gov/ds/2006/182/

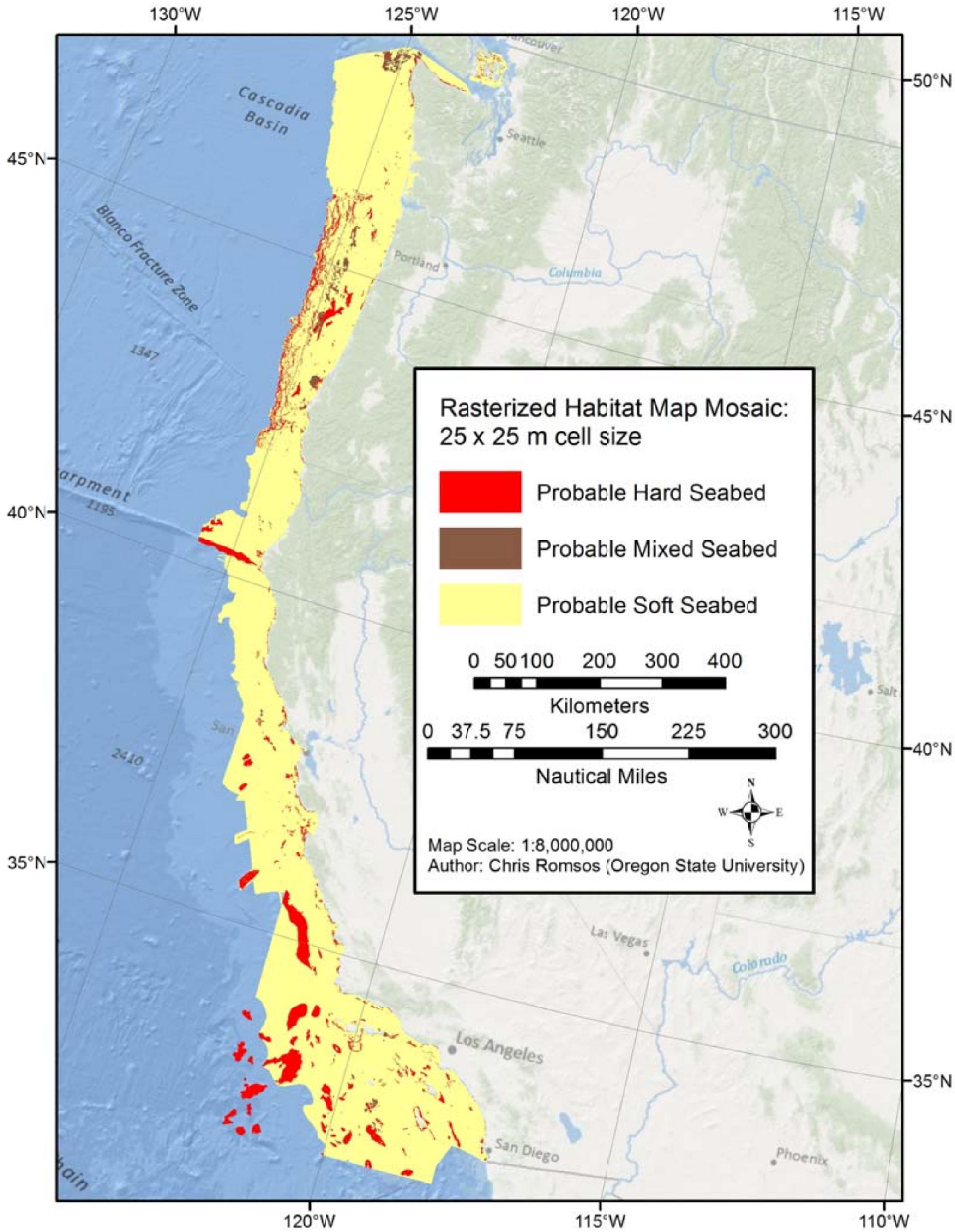


Figure A1.1.1. Each individual habitat map from the Phase 1 Report set was converted from polygon to raster format at 20m by 20m cell size. For cells with more than one habitat type present, the combined feature with the largest area determined the value of the cell. Maps of native raster format were resampled to 20m x 20m cell size. Resultant raster layers were mosaicked such that the most modern data took precedence.

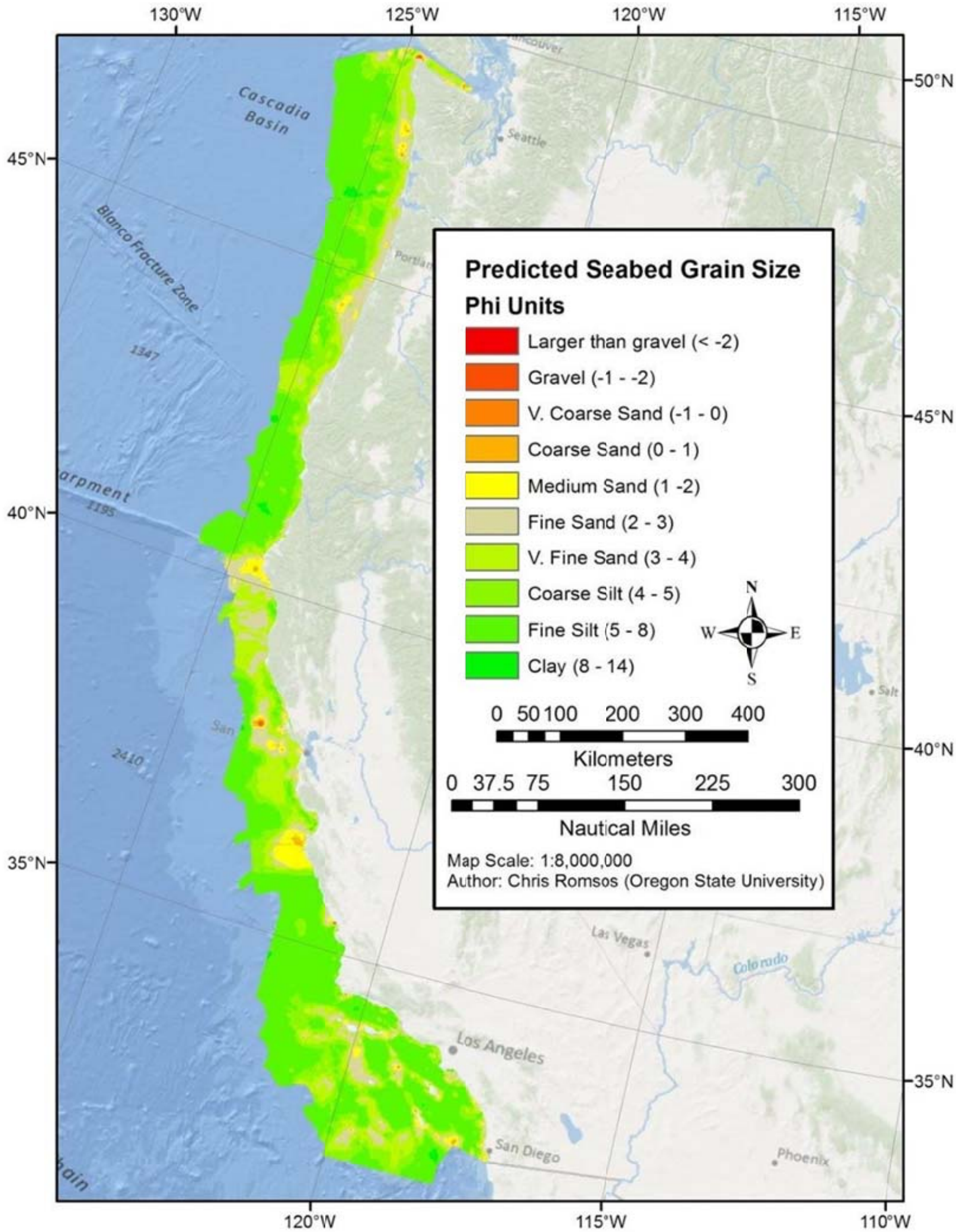


Figure A1.1.2. Grain size distribution predicted from usSEABED and Oregon State University databases. This map product was developed under funding from the Cooperative Institute for Marine Resources Studies at OSU (http://pacoos.coas.oregonstate.edu/archive/woc_sgh_grsz2.zip).

Table A1.1. A thematic seabed habitat map confidence framework is built upon the principle that habitat map confidence increases with increasing quality inputs. Maps of highest confidence are developed where high-resolution data inputs and reference datasets (groundtruth) are applied. Maps developed through interpretation of sparse or extrapolated data are more abundant than targeted high-resolution mapping studies, are necessary and useful, and may indeed be of excellent quality. However, it is reasonable to expect that thematic map confidence decreases with decreasing input data abundance, resolution, and reference control.

Confidence Level	Definition	Rationale/Criteria	Examples
Higher (3)	Lowest chance of omission (missing a habitat patch) and comission (mis-identifying a habitat patch) errors.	Automated or interpretive classifications made from high resolution acoustic imagery with support from groundtruth observations used as reference during mapping process.	OCNMS Habitat Maps, CA (USGS) and OR (OSU) State Waters maps, USGS and Center for Habitat Studies Puget Sound/Salish Sea maps
Medium (2)	Moderate chance of omission and comission errors.	Automated or interpretive classification of high resolution acoustic imagery without groundtruth reference.	CA Territorial Sea "predictive" maps of Smooth and Rough bottom, Oregon Predicted Rock Outcrop, OR and WA Smooth Sheet Maps, and some areas of the Version 1 -> 3.6.1 SGH Maps for WA and OR.
Lower (1)	Highest chance of omission and comission errors.	Interpretive maps, generally of regional scale, made from sparse or extrapolated data. Mapping generally applies localized knowledge over broad regions.	Version 1 -> 3.6 SGH Maps for WA, OR, and CA

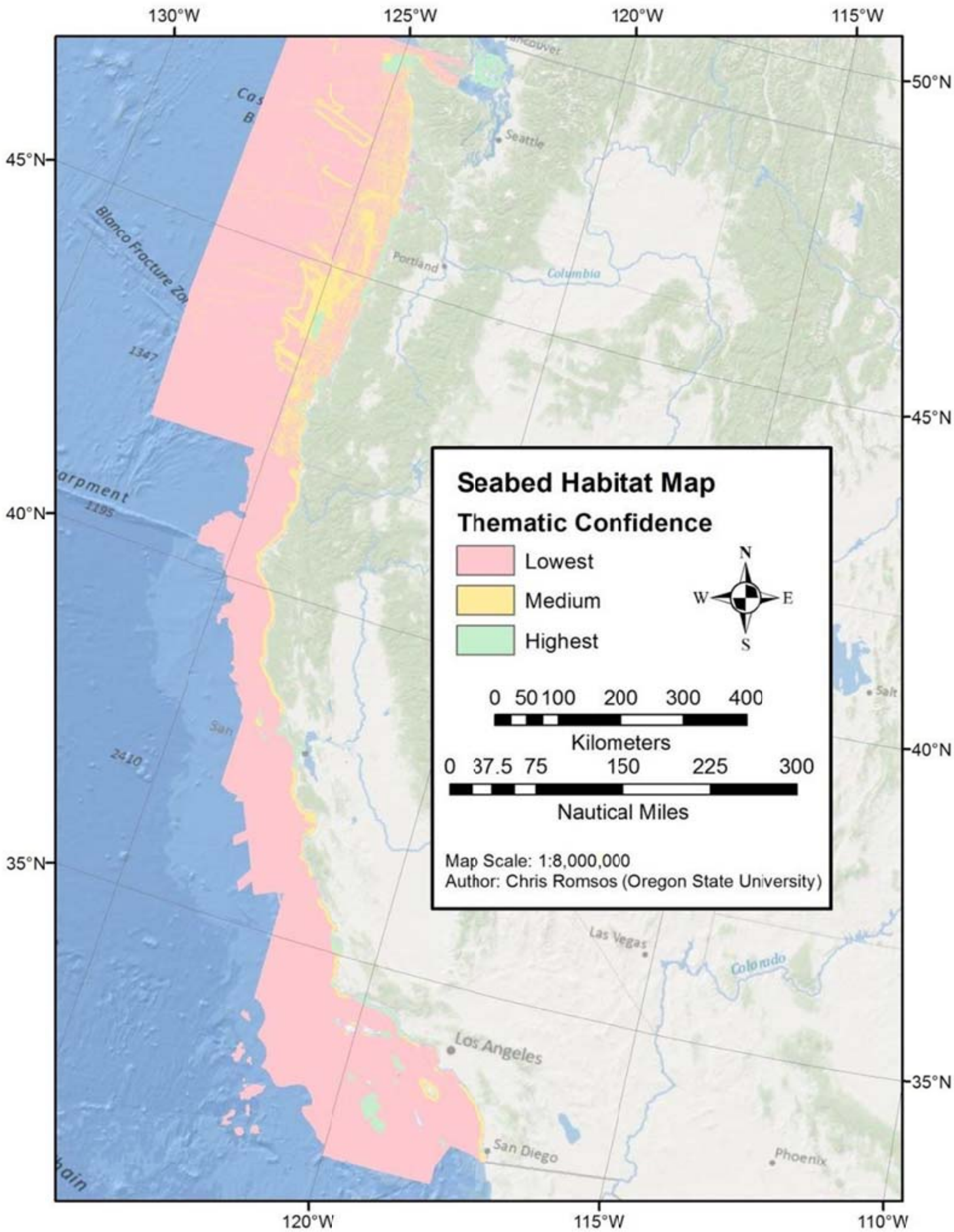


Figure A1.1.3**.** Thematic confidence for the integrated seabed habitat map. Individual habitat map raster data layers from the integration phase were reclassified and assigned a thematic confidence score according to the outlined framework. Scored data layers were mosaicked in the same order as the integrated habitat map processing where modern data (or highest quality) took precedence.

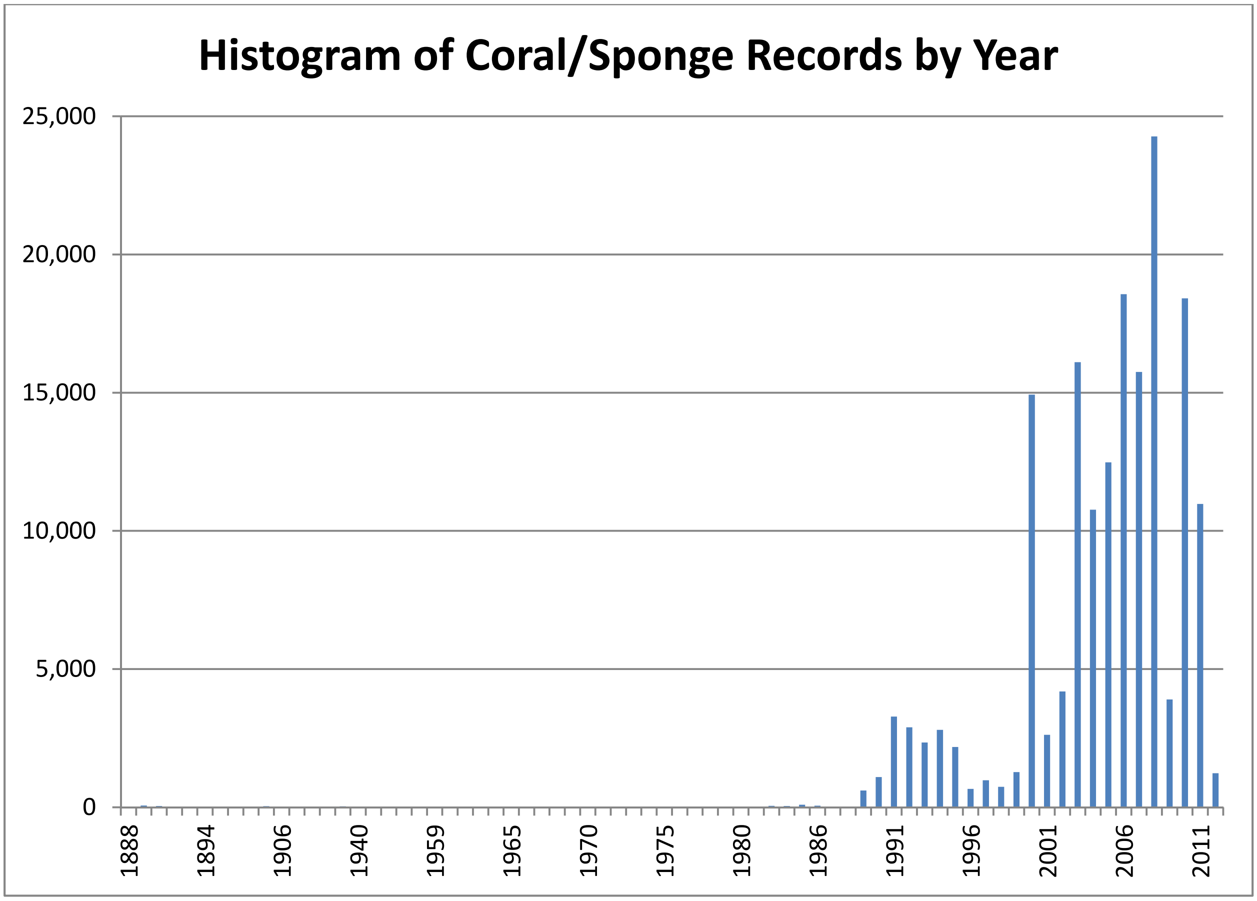


Figure A1.2.1. Distribution of coral and sponge records by year for observations collected from areas within the U.S. exclusive economic zone off the U.S. West Coast. Data source: NOAA's Deep Sea Coral Research and Technology Program (see Table A1.2).

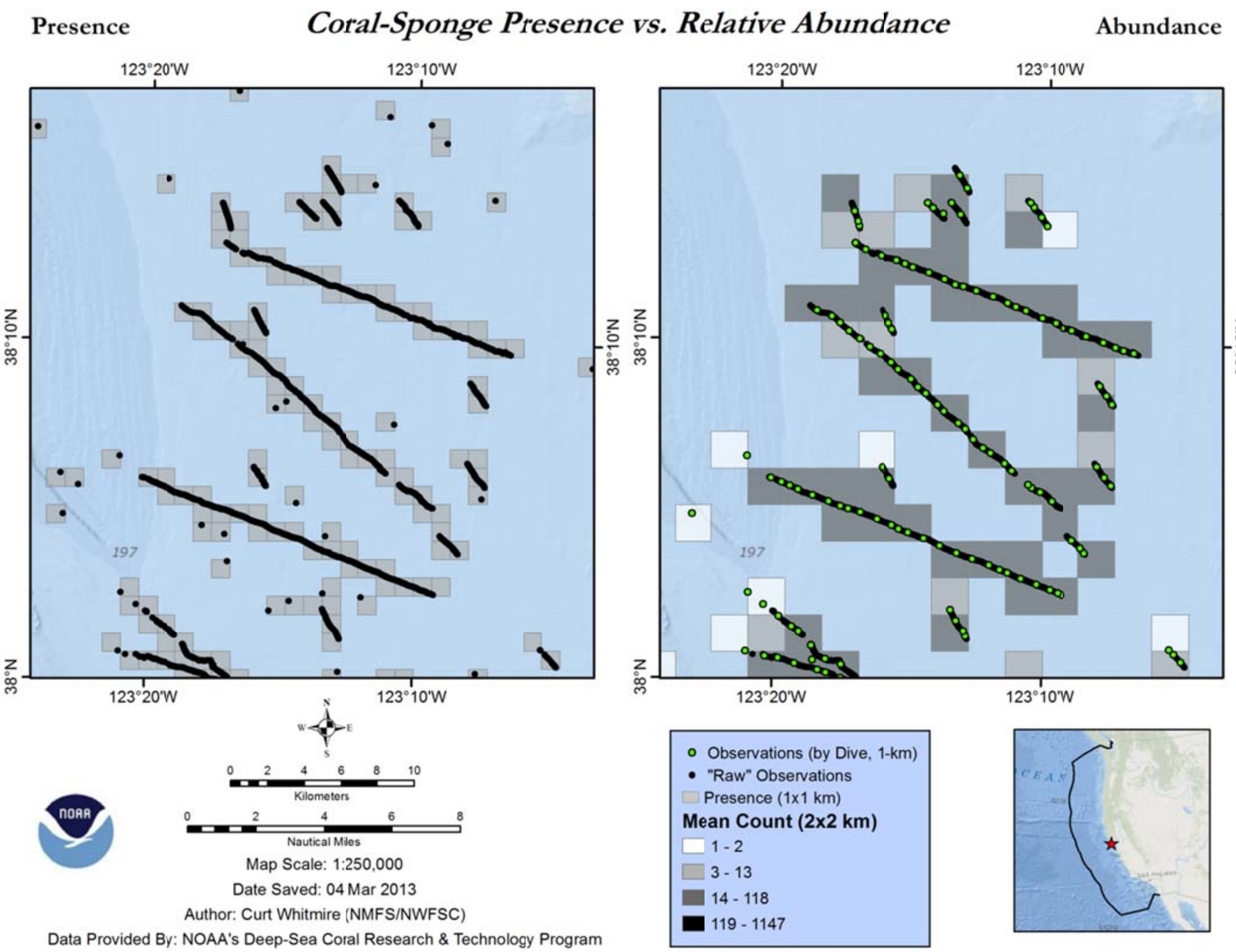


Figure A1.2.2. Map showing spatial summarization of presence (left) and relative observed abundance (right) of coral and sponge. Presence was summarized within 1x1 km cells, while relative observed abundance (i.e., mean count per dive or transect) was summarized within 2x2 km cells.

Table A1.2. Sources of data of direct observations* of corals and sponges recorded off the U.S. West Coast between 1989 and 2012. Source information includes the organization, point of contact for the data source and any relevant citation. Main data source: NOAA's Deep Sea Coral Research and Technology Program.

DATA SOURCE: (Organization\Contact\Citation)	# Records
Center for Coastal Environmental Health and Biomolecular Research, NOAA	**3,973**
Peter Etnoyer	**3,973**
Etnoyer et al. In prep.	3,785
Stierhoff et al 2011, NOAA Tech Memo NOS NCCOS 138	188
Channel Islands National Marine Sanctuary, NOAA	**55**
Danielle Lipski	**55**
Various	55
Cordell Bank National Marine Sanctuary, NOAA	**4,896**
Kaitlin Graiff	**4,896**
Etherington, L., P. van der Leeden, K. Graiff, B. Nickel. 2011. Deep-sea coral patterns and habitat modeling results from Cordell Bank, CA. Report to NOAA Deep-Sea Coral Research and Technology Program, pp. 24.	1,115
Graiff, K., D. Roberts, D. Howard, P. Etnoyer, G. Cochrane, J. Hyland and J. Roletto. 2011. A characterization of deep-sea coral and sponge communities on the continental slope west of Cordell Bank, using a remotely operated vehicle. Report to NOAA Deep-Sea Coral Research and Technology Program, pp. 24.	195
Various	3,586
Gulf of the Farallones National Marine Sanctuary, NOAA	**1,223**
Jan Roletto	**1,223**
NOAA. 2013. Deep-sea Coral Cruise within the Gulf of the Farallones National Marine Sanctuary, Preliminary Data, 1-12 October 2012. Prepared for National Oceanic and Atmospheric Administration, San Francisco, CA.	1,223
Monterey Bay Aquarium Research Institute	**120,478**
Lonny Lundsten	**120,478**
Various	120,478
Northwest Fisheries Science Center, NOAA	**9,307**
Elizabeth Clarke	**9,307**
Various	9,307
Oceana	**176**
Ben Enticknap	**80**

DATA SOURCE: (Organization\Contact\Citation)	# Records
Enticknap, B., G. Shester, M. Gorny, and M. Kelley. 2012. Important Ecological Areas off the Southern Oregon Coast: Fish and Seafloor Habitat Characterization Using a Remotely Operated Vehicle. Oceana.	80
Geoff Shester	**96**
Shester G., Donlou N., and Gorny M. 2012. Important Ecological Areas: Seafloor Habitat Expedition, Monterey Bay, California. 95 pp.	96
Olympic Coast National Marine Sanctuary, NOAA	**22,477**
Ed Bowlby	**22,477**
Various	22,477
Oregon State University	**54**
Chris Goldfinger	**54**
Strom, N.A. 2006. Structure-forming benthic invertebrates: habitat distributions on the continental margin of Oregon and Washington. MS Thesis, Oregon State University, Corvallis, OR.	54
Southwest Fisheries Science Center, NOAA	**2,731**
Mary Yoklavich	**2,731**
Various	2,731
Washington State University	**239**
Brian Tissot	**239**
Bianchi, C. 2011. Abundance and distribution of megafaunal invertebrates in NE Pacific submarine canyons and their ecological association with fishes. M.S., thesis. Washington State Univ., Washington State University. Vancouver, WA	108
Bright, J.L. 2007. Abundance and distribution of structure-forming invertebrates and their association with fishes at the Channel Islands ôFootprintö Off the Southern Coast of California. M.S., thesis. Washington State Univ., Vancouver, WA.	80
Pirtle, J.L. 2005. Habitat-based assessment of structure-forming megafaunal invertebrates and fishes on Cordell Bank, California. M.S., thesis. Washington State Univ., Vancouver, WA.	51
TOTAL	**165,609**

* Additional records of corals and sponges include 8,227 records of specimens collected either by submersible, remotely-operated vehicle, trawl, dredge or grab. Most (99%) of these specimens (trawl, dredge, grab) were not observed in situ.

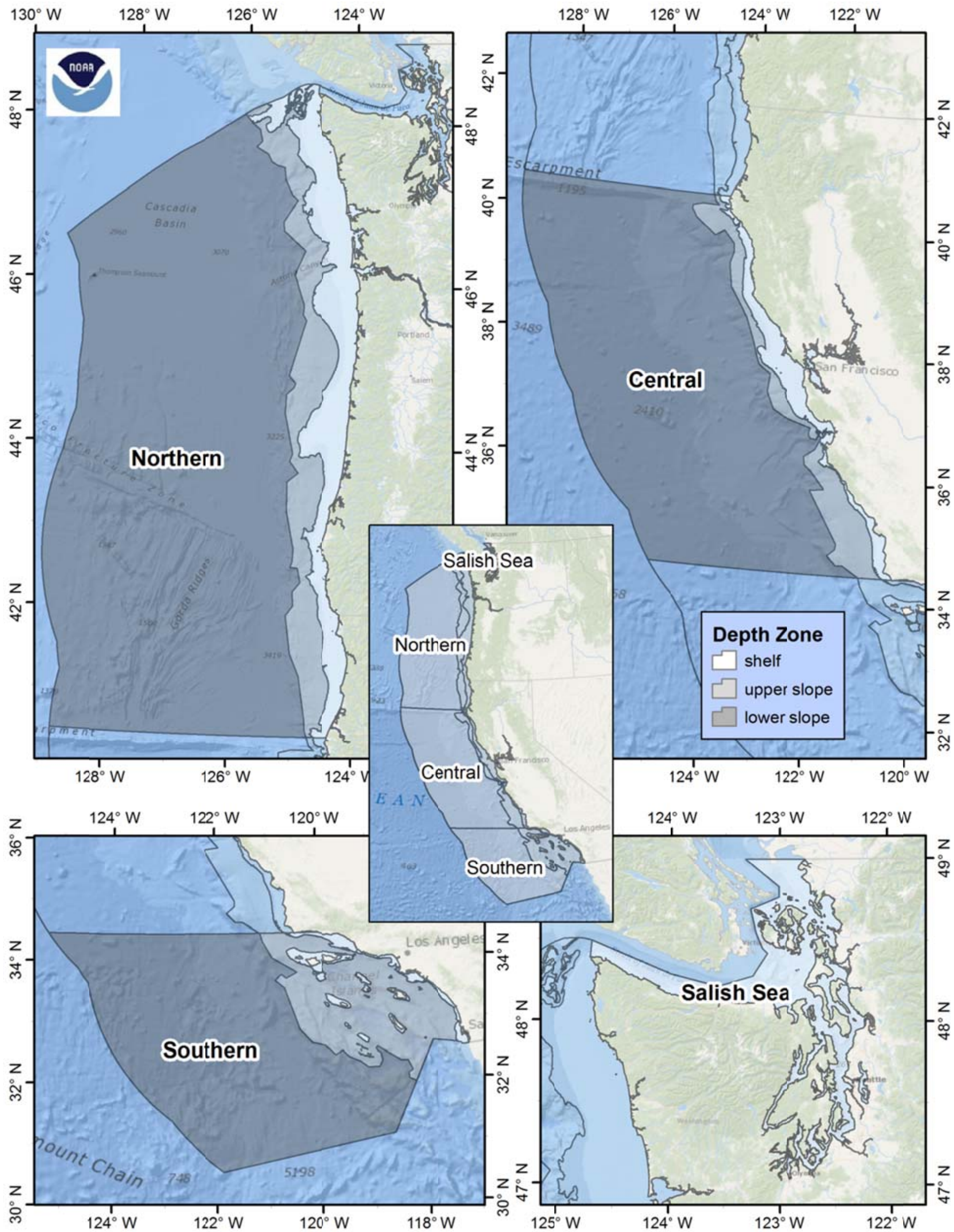


Figure A1.3.1. Map showing the spatial stratification, including four biogeographic sub-regions and three depth zones.

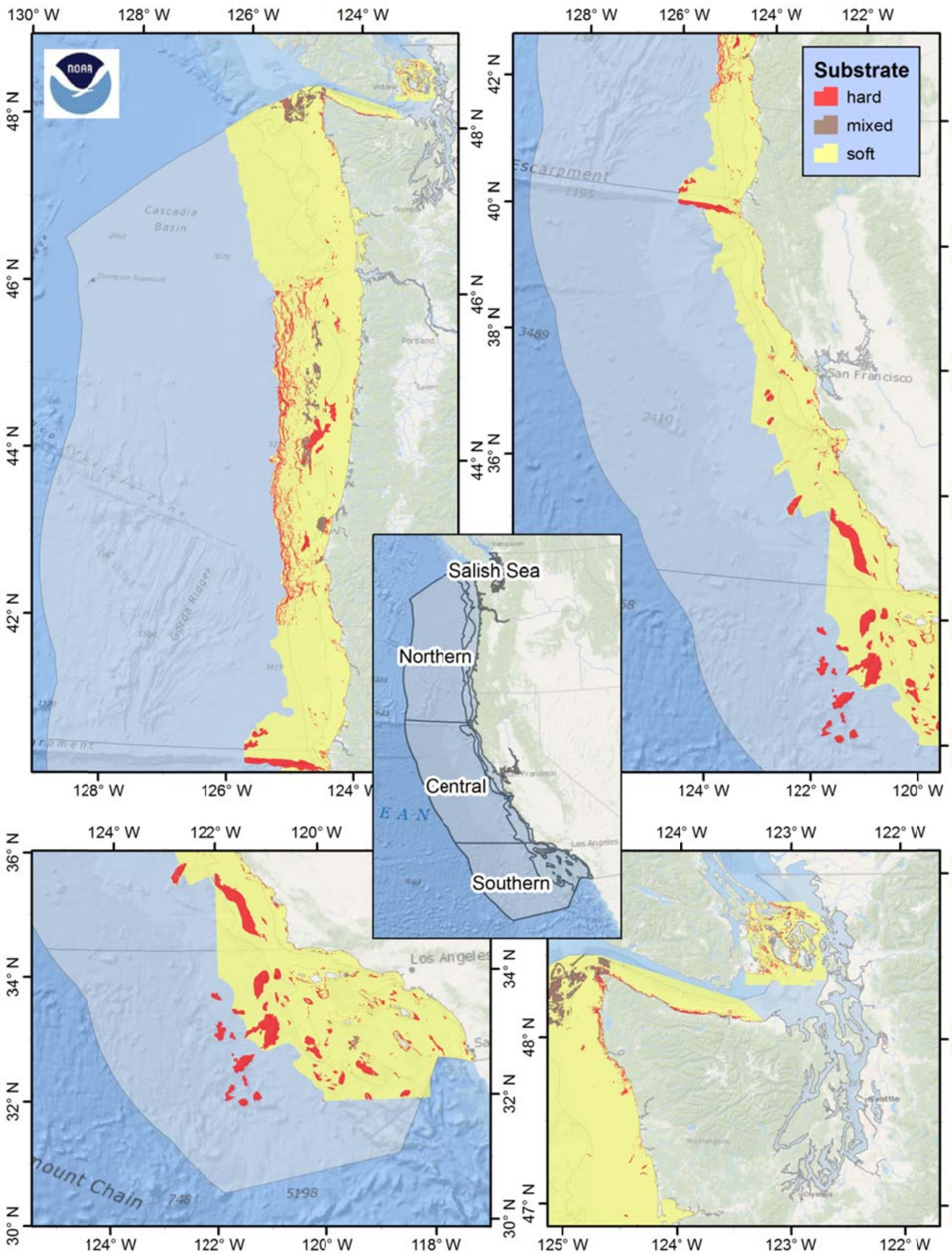


Figure A1.3.2. Map showing the spatial distribution of three major seabed habitat types: hard, mixed and soft. Much of the lower slope has not been classified in terms of substrate type.

Table A1.3.1. Distribution of seabed habitat types by depth zones both coastwide and in four biogeographic sub-regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Percentage values represent relative contribution to the sub-region. The "Salish Sea" only encompasses the shallowest ("shelf") depth zone. Last row shows relative contribution to the sub-region.

		BIOGEOGRAPHIC SUB-REGION								COASTWIDE	
		Northern		Central		Southern		Salish Sea		Combined	
Depth Zone	*Substrate*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Shelf[1]	Total	3,404,867	11.1%	1,715,270	5.8%	775,396	3.6%	739,957	100.0%	6,635,491	8.0%
	hard	170,661	0.6%	104,228	0.4%	52,064	0.2%	15,701	2.1%	342,655	0.4%
	mixed	94,430	0.3%	5,277	0.0%	15,054	0.1%	7,469	1.0%	122,230	0.1%
	soft	3,049,609	9.9%	1,469,779	5.0%	691,704	3.2%	213,668	28.9%	5,424,760	6.6%
	undefined	90,167	0.3%	135,986	0.5%	16,574	0.1%	503,119	68.0%	745,846	0.9%
Upper Slope[2]	Total	3,021,125	9.8%	2,389,292	8.1%	4,669,633	21.6%	0	0.0%	10,080,050	12.2%
	hard	103,766	0.3%	267,468	0.9%	242,023	1.1%	0	0.0%	613,257	0.7%
	mixed	105,496	0.3%	3,175	0.0%	18,555	0.1%	0	0.0%	127,226	0.2%
	soft	2,811,725	9.1%	2,107,156	7.1%	4,400,561	20.3%	0	0.0%	9,319,442	11.3%
	undefined	138	0.0%	11,493	0.0%	8,495	0.0%	0	0.0%	20,125	0.0%
Lower Slope[3]	Total	24,311,081	79.1%	25,381,145	86.1%	16,184,376	74.8%	0	0.0%	65,876,603	79.8%
	hard	324,537	1.1%	143,068	0.5%	578,992	2.7%	0	0.0%	1,046,598	1.3%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	2,525,125	8.2%	2,681,556	9.1%	2,119,680	9.8%	0	0.0%	7,326,361	8.9%
	undefined	21,461,420	69.8%	22,556,521	76.5%	13,485,704	62.3%	0	0.0%	57,503,645	69.6%
Column Total		30,737,074	100.0%	29,485,708	100.0%	21,629,405	100.0%	739,957	100.0%	82,592,144	100.0%
Sub-Region		30,737,074	37.2%	29,485,708	35.7%	21,629,405	26.2%	739,957	0.9%	82,592,144	100.0%

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

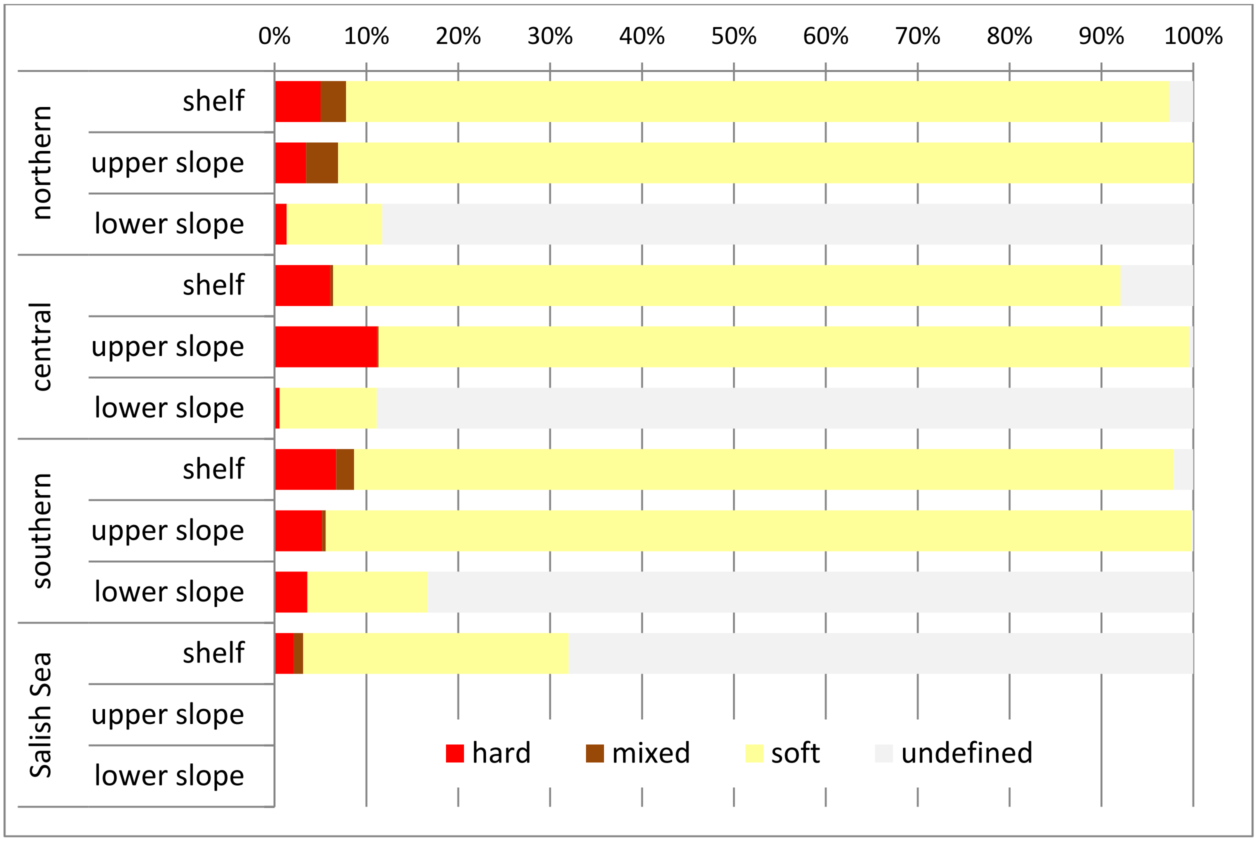


Figure A1.3.3. Relative distribution of seabed habitat types by depth zones in four biogeographic sub-regions. The "Salish Sea" only encompasses the shallowest ("shelf") depth zone.

Table A1.3.2a. Distribution of seabed habitat types and EFH-specific gear prohibitions by depth zones in the "northern" biogeographic sub-region: Cape Flattery, WA to Cape Mendocino, CA. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the sub-region.

NORTHERN BIOGEOGRAPHIC SUB-REGION											
		Total		Bottom Contact Prohibited		Bottom Contact Prohibited (or other gear deployed deeper than 500 ftm)		Bottom Trawl Prohibited		Bottom Trawl Prohibited (except demersal seine)	
Depth Zone	Substrate	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Shelf[1]	**Total**	**3,404,867**	**11.1%**	**0**	**0.0%**	**0**	**0.0%**	**113,964**	**0.5%**	**921**	**1.3%**
	hard	170,661	0.6%	0	0.0%	0	0.0%	48,453	0.2%	168	0.2%
	mixed	94,430	0.3%	0	0.0%	0	0.0%	28,440	0.1%	0	0.0%
	soft	3,049,609	9.9%	0	0.0%	0	0.0%	37,071	0.2%	754	1.0%
	undefined	90,167	0.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Upper Slope[2]	**Total**	**3,021,125**	**9.8%**	**0**	**0.0%**	**0**	**0.0%**	**211,092**	**0.9%**	**15,119**	**20.8%**
	hard	103,766	0.3%	0	0.0%	0	0.0%	10,375	0.0%	0	0.0%
	mixed	105,496	0.3%	0	0.0%	0	0.0%	18,063	0.1%	0	0.0%
	soft	2,811,725	9.1%	0	0.0%	0	0.0%	182,654	0.7%	15,119	20.8%
	undefined	138	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Lower Slope[3]	**Total**	**24,311,081**	**79.1%**	**142,405**	**100.0%**	**0**	**0.0%**	**24,251,201**	**98.7%**	**56,661**	**77.9%**
	hard	324,537	1.1%	0	0.0%	0	0.0%	324,537	1.3%	0	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	2,525,125	8.2%	0	0.0%	0	0.0%	2,524,792	10.3%	56,661	77.9%
	undefined	21,461,420	69.8%	142,405	100.0%	0	0.0%	21,401,872	87.1%	0	0.0%
Column Total		**30,737,074**	**100.0%**	**142,405**	**100.0%**	**0**	**0.0%**	**24,576,257**	**100.0%**	**72,702**	**100.0%**
Sub-Region		**30,737,074**	**100.0%**	**142,405**	**0.5%**	**0**	**0.0%**	**24,576,257**	**80.0%**	**72,702**	**0.2%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

Table A1.3.2b. Distribution of seabed habitat types and EFH-specific gear prohibitions by depth zones in the "central" biogeographic sub-region: Cape Mendocino, CA to Point Conception, CA. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the sub-region.

CENTRAL BIOGEOGRAPHIC SUB-REGION											
		Total		**Bottom Contact Prohibited**		**Bottom Contact Prohibited (or other gear deployed deeper than 500 ftm)**		**Bottom Trawl Prohibited**		**Bottom Trawl Prohibited (except demersal seine)**	
Depth Zone	***Substrate***	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Shelf[1]	**Total**	**1,715,270**	**5.8%**	**6,836**	**100.0%**	**0**	**0.0%**	**0**	**0.0%**	**157,979**	**9.4%**
	hard	104,228	0.4%	3,102	45.4%	0	0.0%	0	0.0%	33,255	2.0%
	mixed	5,277	0.0%	171	2.5%	0	0.0%	0	0.0%	1,224	0.1%
	soft	1,469,779	5.0%	3,564	52.1%	0	0.0%	0	0.0%	122,850	7.3%
	undefined	135,986	0.5%	0	0.0%	0	0.0%	0	0.0%	650	0.0%
Upper Slope[2]	**Total**	**2,389,292**	**8.1%**	**0**	**0.0%**	**0**	**0.0%**	**1**	**0.0%**	**599,655**	**35.7%**
	hard	267,468	0.9%	0	0.0%	0	0.0%	0	0.0%	137,969	8.2%
	mixed	3,175	0.0%	0	0.0%	0	0.0%	0	0.0%	81	0.0%
	soft	2,107,156	7.1%	0	0.0%	0	0.0%	1	0.0%	452,429	26.9%
	undefined	11,493	0.0%	0	0.0%	0	0.0%	0	0.0%	9,176	0.5%
Lower Slope[3]	**Total**	**25,381,145**	**86.1%**	**0**	**0.0%**	**200,899**	**100.0%**	**5,893,967**	**100.0%**	**923,502**	**54.9%**
	hard	143,068	0.5%	0	0.0%	45,695	22.7%	143,068	2.4%	64,575	3.8%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	2,681,556	9.1%	0	0.0%	56,901	28.3%	2,616,542	44.4%	684,916	40.7%
	undefined	22,556,521	76.5%	0	0.0%	98,304	48.9%	3,134,357	53.2%	174,011	10.4%
Column Total		**29,485,708**	**100.0%**	**6,836**	**100.0%**	**200,899**	**100.0%**	**5,893,968**	**100.0%**	**1,681,136**	**100.0%**
Sub-Region		**29,485,708**	**100.0%**	**6,836**	**0.0%**	**200,899**	**0.7%**	**5,893,968**	**20.0%**	**1,681,136**	**5.7%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.

[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.

[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

Table A1.3.2c. Distribution of seabed habitat types and EFH-specific gear prohibitions by depth zones in the "southern" biogeographic sub-region: Point Conception, CA to U.S.-Mexico maritime border. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the sub-region.

		SOUTHERN BIOGEOGRAPHIC SUB-REGION									
		Total		**Bottom Contact Prohibited**		**Bottom Contact Prohibited (or other gear deployed deeper than 500 ftm)**		**Bottom Trawl Prohibited**		**Bottom Trawl Prohibited (except demersal seine)**	
Depth Zone	***Substrate***	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Shelf[1]	**Total**	**775,396**	**3.6%**	**41,786**	**50.4%**	**0**	**0.0%**	**0**	**0.0%**	**57,176**	**9.8%**
	hard	52,064	0.2%	2,633	3.2%	0	0.0%	0	0.0%	5,744	1.0%
	mixed	15,054	0.1%	302	0.4%	0	0.0%	0	0.0%	2,061	0.4%
	soft	691,704	3.2%	38,667	46.6%	0	0.0%	0	0.0%	49,171	8.5%
	undefined	16,574	0.1%	183	0.2%	0	0.0%	0	0.0%	201	0.0%
Upper Slope[2]	**Total**	**4,669,633**	**21.6%**	**41,195**	**49.6%**	**0**	**0.0%**	**0**	**0.0%**	**407,036**	**70.0%**
	hard	242,023	1.1%	673	0.8%	0	0.0%	0	0.0%	19,264	3.3%
	mixed	18,555	0.1%	55	0.1%	0	0.0%	0	0.0%	12,141	2.1%
	soft	4,400,561	20.3%	40,467	48.8%	0	0.0%	0	0.0%	375,398	64.6%
	undefined	8,495	0.0%	0	0.0%	0	0.0%	0	0.0%	235	0.0%
Lower Slope[3]	**Total**	**16,184,376**	**74.8%**	**0**	**0.0%**	**0**	**0.0%**	**3,651,408**	**100.0%**	**117,020**	**20.1%**
	hard	578,992	2.7%	0	0.0%	0	0.0%	578,992	15.9%	32,808	5.6%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	2,119,680	9.8%	0	0.0%	0	0.0%	1,703,013	46.6%	84,211	14.5%
	undefined	13,485,704	62.3%	0	0.0%	0	0.0%	1,369,403	37.5%	0	0.0%
Column Total		**21,629,405**	**100.0%**	**82,981**	**100.0%**	**0**	**0.0%**	**3,651,408**	**100.0%**	**581,232**	**100.0%**
Sub-Region		**21,629,405**	**100.0%**	**82,981**	**0.4%**	**0**	**0.0%**	**3,651,408**	**16.9%**	**581,232**	**2.7%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

Table A1.3.2d. Distribution of seabed habitat types and EFH-specific gear prohibitions by depth zones in the Salish Sea: Puget Sound and Straits of Georgia and Juan de Fuca. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the sub-region. No EFH Conservation Areas are located in the "Salish Sea."

SALISH SEA											
		Total		Bottom Contact Prohibited		Bottom Contact Prohibited (or other gear deployed deeper than 500 ftm)		Bottom Trawl Prohibited		Bottom Trawl Prohibited (except demersal seine)	
Depth Zone	***Substrate***	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Shelf[1]	**Total**	**739,957**	**100.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
	hard	15,701	2.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	mixed	7,469	1.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	213,668	28.9%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	undefined	503,119	68.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Upper Slope[2]	**Total**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
	hard	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	undefined	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Lower Slope[3]	**Total**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
	hard	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	undefined	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Column Total		**739,957**	**100.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
Sub-Region		**739,957**	**100.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

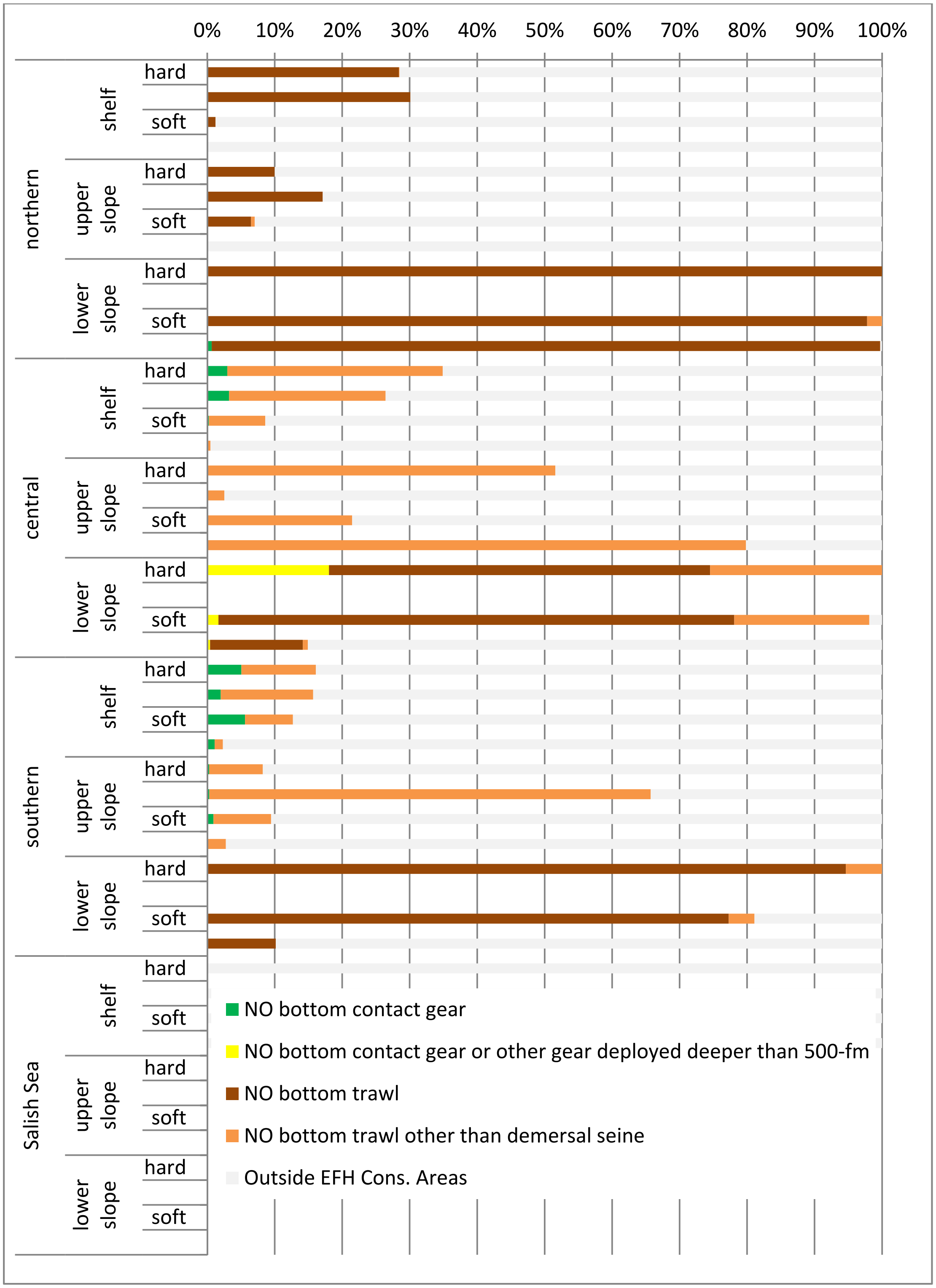


Figure A1.3.4. Percentages of seabed habitat areas by depth zone and biogeographic sub-regions where EFH-specific gear prohibitions apply. No EFH Conservation Areas are located in the “Salish Sea” and no “mixed” substrate types are known to occur with the lower slope of any biogeographic sub-region.

Table A1.3.3a. Distribution of seabed habitat types and commercial gear prohibitions by depth zones in the “northern” biogeographic sub-region: Cape Flattery, WA to Cape Mendocino, CA. Percentage values represent relative contribution to the sub-region. Last row shows relative contribution to the sub-region.

NORTHERN BIOGEOGRAPHIC SUB-REGION									
		Total		**Bottom Trawl Prohibited**		**Midwater Trawl Prohibited**		**Fixed Gear Prohibited**	
Depth Zone	***Substrate***	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Shelf[1]	**Total**	**3,404,867**	**11.1%**	**621,648**	**2.5%**	**183**	**100.0%**	**183**	**0.1%**
	hard	170,661	0.6%	67,292	0.3%	2	0.9%	2	0.0%
	mixed	94,430	0.3%	35,513	0.1%	0	0.0%	0	0.0%
	soft	3,049,609	9.9%	506,031	2.0%	181	98.9%	181	0.1%
	undefined	90,167	0.3%	12,812	0.1%	0	0.2%	0	0.0%
Upper Slope[2]	**Total**	**3,021,125**	**9.8%**	**448,596**	**1.8%**	**0**	**0.0%**	**0**	**0.0%**
	hard	103,766	0.3%	14,221	0.1%	0	0.0%	0	0.0%
	mixed	105,496	0.3%	26,438	0.1%	0	0.0%	0	0.0%
	soft	2,811,725	9.1%	407,935	1.6%	0	0.0%	0	0.0%
	undefined	138	0.0%	2	0.0%	0	0.0%	0	0.0%
Lower Slope[3]	**Total**	**24,311,081**	**79.1%**	**24,251,201**	**95.8%**	**0**	**0.0%**	**142,405**	**99.9%**
	hard	324,537	1.1%	324,537	1.3%	0	0.0%	0	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	2,525,125	8.2%	2,524,792	10.0%	0	0.0%	0	0.0%
	undefined	21,461,420	69.8%	21,401,872	84.5%	0	0.0%	142,405	99.9%
Column Total		**30,737,074**	**100.0%**	**25,321,445**	**100.0%**	**183**	**100.0%**	**142,588**	**100.0%**
Sub-Region		**30,737,074**	**100.0%**	**25,321,445**	**82.4%**	**183**	**0.0%**	**142,588**	**0.5%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

Table A1.3.3b. Distribution of seabed habitat types and commercial gear prohibitions by depth zones in the "central" biogeographic sub-region: Cape Mendocino, CA to Point Conception, CA. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the sub-region.

		CENTRAL BIOGEOGRAPHIC SUB-REGION							
		Total		**Bottom Trawl Prohibited**		**Midwater Trawl Prohibited**		**Fixed Gear Prohibited**	
Depth Zone	***Substrate***	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Shelf[1]	**Total**	**1,715,270**	**5.8%**	**868,685**	**11.6%**	**45,730**	**95.5%**	**52,567**	**20.6%**
	hard	104,228	0.4%	94,048	1.3%	8,777	18.3%	11,879	4.6%
	mixed	5,277	0.0%	5,056	0.1%	338	0.7%	509	0.2%
	soft	1,469,779	5.0%	633,595	8.5%	34,987	73.1%	38,551	15.1%
	undefined	135,986	0.5%	135,986	1.8%	1,628	3.4%	1,628	0.6%
Upper Slope[2]	**Total**	**2,389,292**	**8.1%**	**726,199**	**9.7%**	**2,140**	**4.5%**	**2,140**	**0.8%**
	hard	267,468	0.9%	139,669	1.9%	3	0.0%	3	0.0%
	mixed	3,175	0.0%	1,485	0.0%	0	0.0%	0	0.0%
	soft	2,107,156	7.1%	575,869	7.7%	2,137	4.5%	2,137	0.8%
	undefined	11,493	0.0%	9,176	0.1%	0	0.0%	0	0.0%
Lower Slope[3]	**Total**	**25,381,145**	**86.1%**	**5,893,967**	**78.7%**	**0**	**0.0%**	**200,899**	**78.6%**
	hard	143,068	0.5%	143,068	1.9%	0	0.0%	45,695	17.9%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	2,681,556	9.1%	2,616,542	34.9%	0	0.0%	56,901	22.3%
	undefined	22,556,521	76.5%	3,134,357	41.9%	0	0.0%	98,304	38.5%
Column Total		**29,485,708**	**100.0%**	**7,488,851**	**100.0%**	**47,870**	**100.0%**	**255,605**	**100.0%**
Sub-Region		**29,485,708**	**100.0%**	**7,488,851**	**25.4%**	**47,870**	**0.2%**	**255,605**	**0.9%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

Table A1.3.3c. Distribution of seabed habitat types and commercial gear prohibitions by depth zones in the "southern" biogeographic sub-region: Point Conception, CA to U.S.-Mexico maritime border. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the sub-region.

		SOUTHERN BIOGEOGRAPHIC SUB-REGION							
		Total		Bottom Trawl Prohibited		Midwater Trawl Prohibited		Fixed Gear Prohibited	
Depth Zone	*Substrate*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Shelf[1]	**Total**	**775,396**	**3.6%**	**587,332**	**12.0%**	**58,801**	**77.8%**	**68,534**	**58.4%**
	hard	52,064	0.2%	41,382	0.8%	5,150	6.8%	5,339	4.5%
	mixed	15,054	0.1%	10,769	0.2%	487	0.6%	629	0.5%
	soft	691,704	3.2%	519,144	10.6%	52,477	69.5%	61,859	52.7%
	undefined	16,574	0.1%	16,037	0.3%	687	0.9%	707	0.6%
Upper Slope[2]	**Total**	**4,669,633**	**21.6%**	**650,456**	**13.3%**	**16,737**	**22.2%**	**48,918**	**41.6%**
	hard	242,023	1.1%	43,463	0.9%	436	0.6%	906	0.8%
	mixed	18,555	0.1%	12,293	0.3%	0	0.0%	55	0.0%
	soft	4,400,561	20.3%	594,203	12.2%	16,301	21.6%	47,957	40.8%
	undefined	8,495	0.0%	497	0.0%	0	0.0%	0	0.0%
Lower Slope[3]	**Total**	**16,184,376**	**74.8%**	**3,651,408**	**74.7%**	**0**	**0.0%**	**0**	**0.0%**
	hard	578,992	2.7%	578,992	11.8%	0	0.0%	0	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	2,119,680	9.8%	1,703,013	34.8%	0	0.0%	0	0.0%
	undefined	13,485,704	62.3%	1,369,403	28.0%	0	0.0%	0	0.0%
Column Total		**21,629,405**	**100.0%**	**4,889,195**	**100.0%**	**75,539**	**100.0%**	**117,452**	**100.0%**
Sub-Region		**21,629,405**	**100.0%**	**4,889,195**	**22.6%**	**75,539**	**0.3%**	**117,452**	**0.5%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

Table A1.3.3d. Distribution of seabed habitat types and commercial gear prohibitions by depth zones in the Salish Sea: Puget Sound and Straits of Georgia and Juan de Fuca. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the sub-region. The "Salish Sea" only encompasses the shallowest ("shelf") depth zone.

		SALISH SEA							
		Total		Bottom Trawl Prohibited		Midwater Trawl Prohibited		Fixed Gear Prohibited	
Depth Zone	***Substrate***	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Shelf[1]	**Total**	**739,957**	**100.0%**	**739,957**	**100.0%**	**230**	**100.0%**	**230**	**100.0%**
	hard	15,701	2.1%	15,701	2.1%	0	0.0%	0	0.0%
	mixed	7,469	1.0%	7,469	1.0%	0	0.0%	0	0.0%
	soft	213,668	28.9%	213,668	28.9%	0	0.0%	0	0.0%
	undefined	503,119	68.0%	503,119	68.0%	230	100.0%	230	100.0%
Upper Slope[2]	**Total**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
	hard	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	undefined	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Lower Slope[3]	**Total**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
	hard	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	undefined	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Column Total		**739,957**	**100.0%**	**739,957**	**100.0%**	**230**	**100.0%**	**230**	**100.0%**
Sub-Region		**739,957**	**100.0%**	**739,957**	**100.0%**	**230**	**0.0%**	**230**	**0.0%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

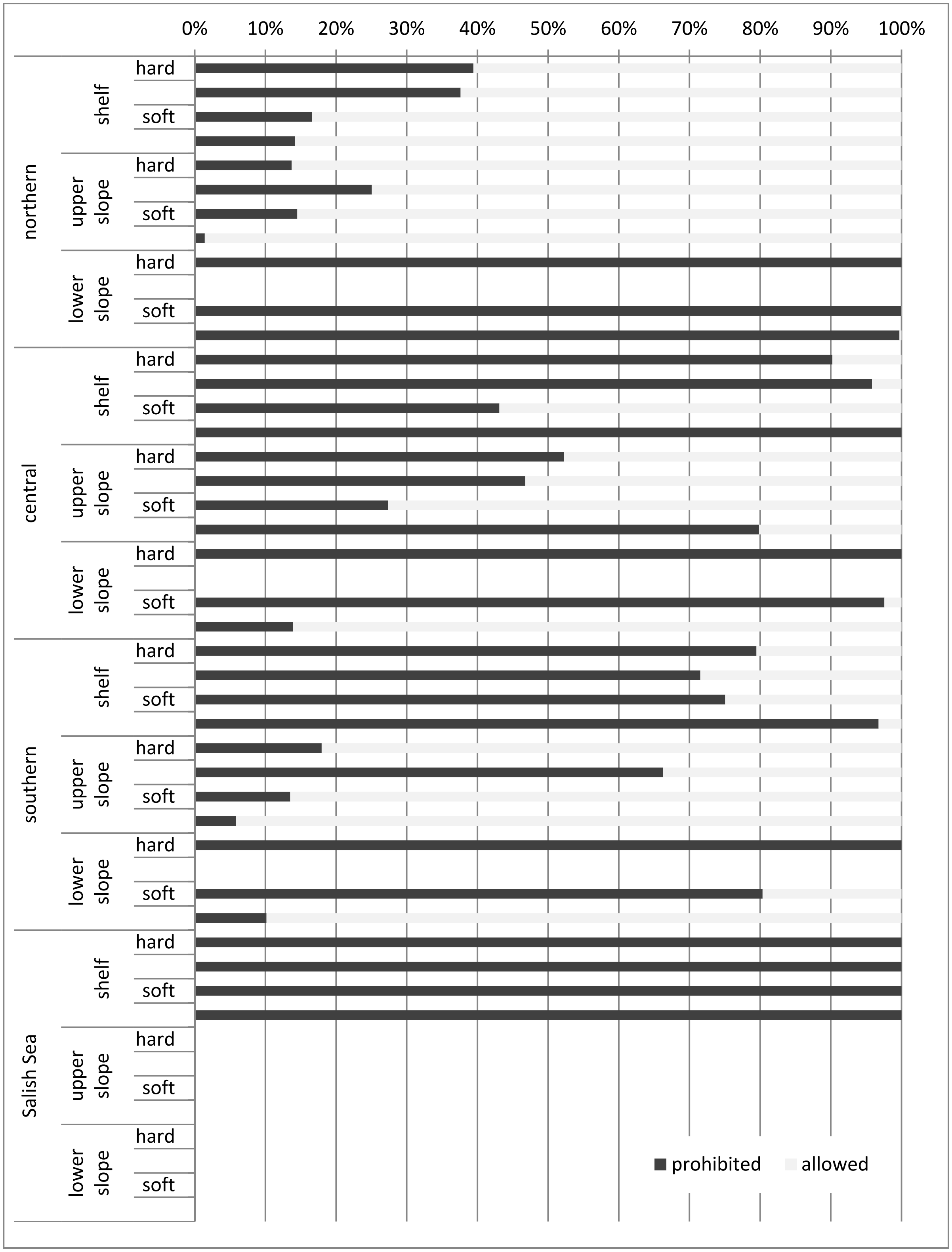


Figure A1.3.5. Percentages of seabed habitat areas by depth zone and biogeographic sub-regions where bottom trawling is “prohibited” and “allowed”. The “Salish Sea” only encompasses the shallowest (“shelf”) depth zone.

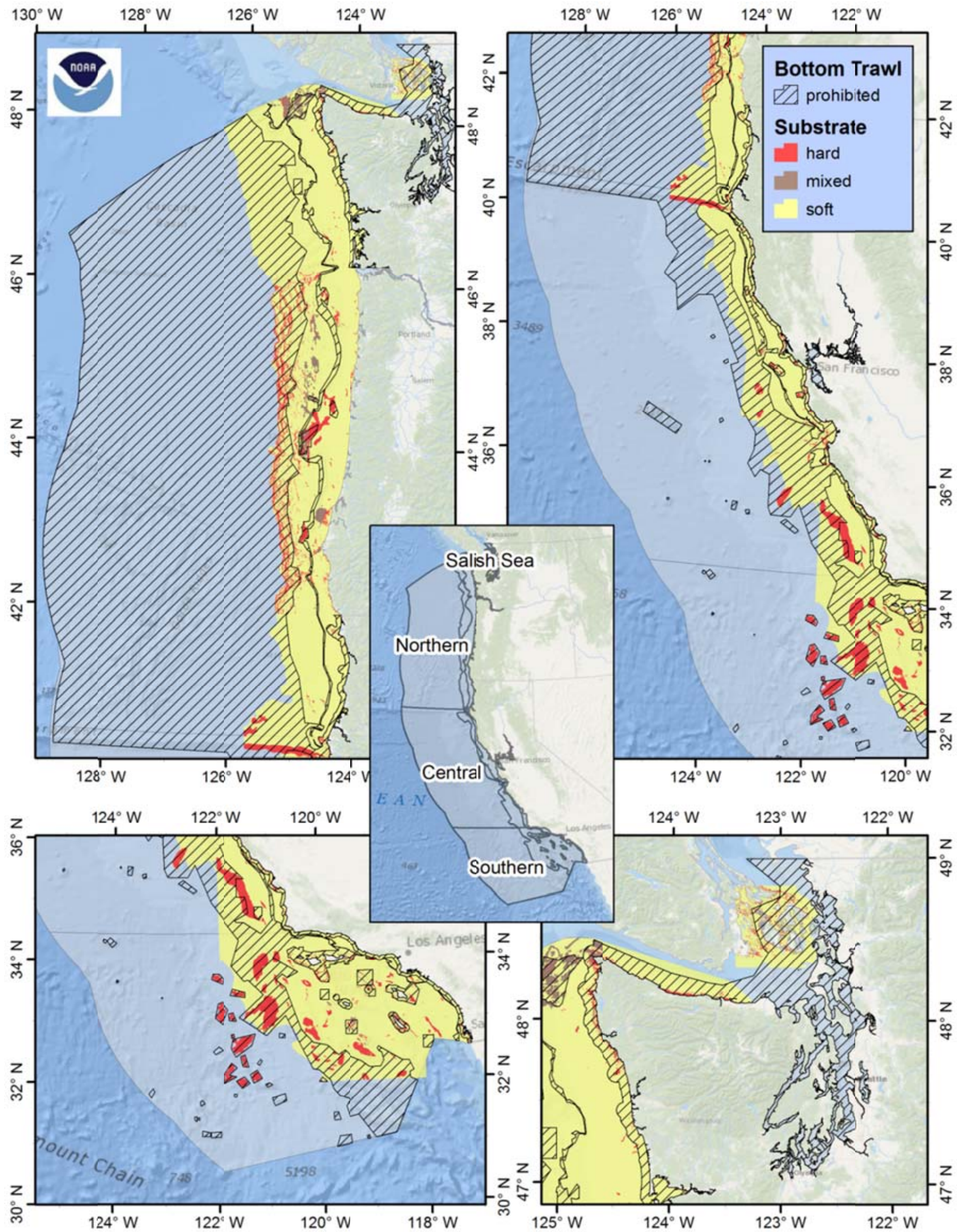


Figure A1.3.6. Map showing the composite area closed to bottom trawling overlain on three major seabed habitat types: hard, mixed and soft. Bottom trawl gear is prohibited in all 51 EFH conservation areas, any state or federal (e.g., Channel Island NMS) "no-take" marine reserve, the state territorial sea of WA and most of CA, and the area of the trawl RCA that has been permanently closed since inception of the RCA.

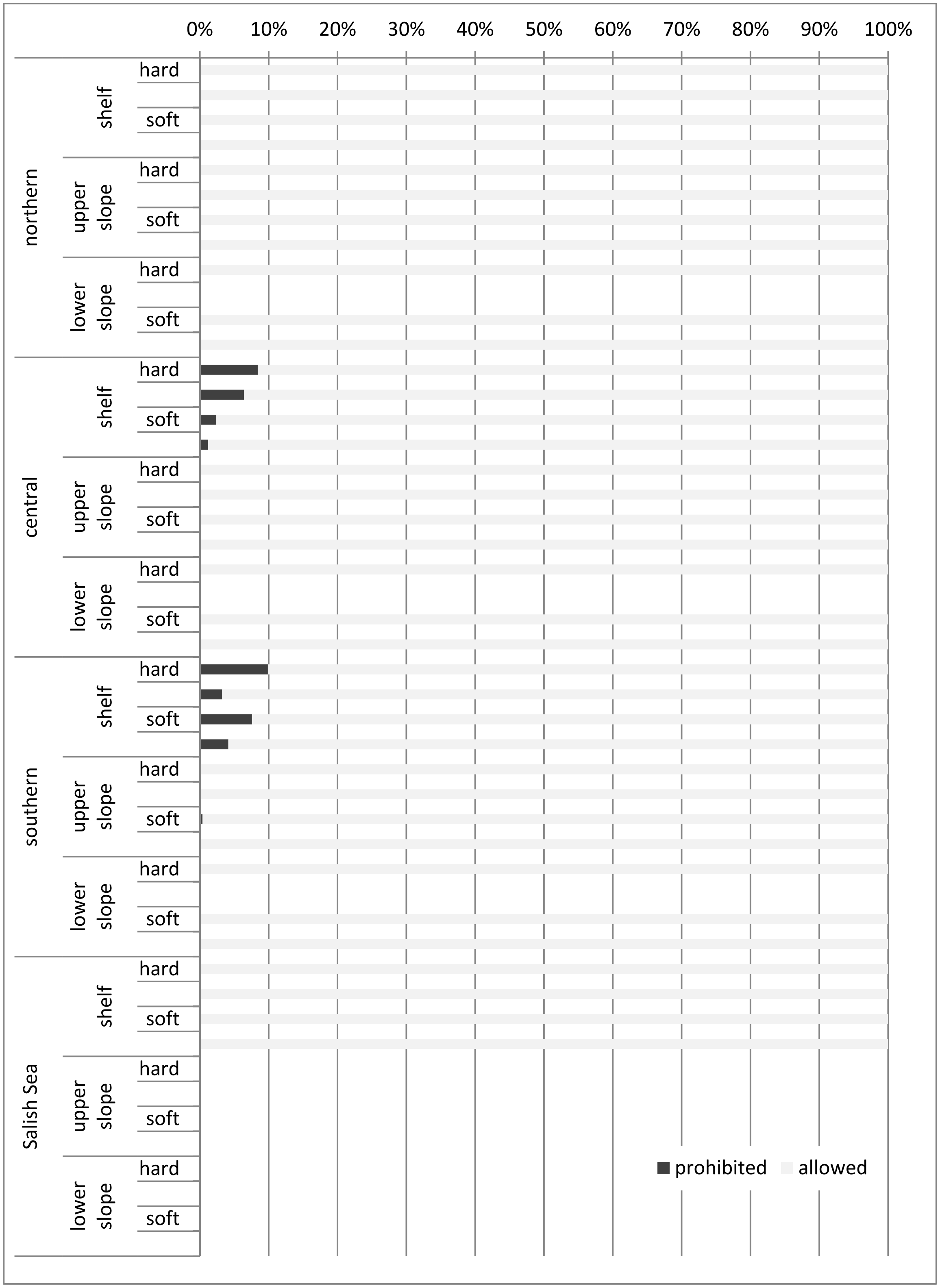


Figure A1.3.7a. Percentages of seabed habitat areas by depth zone and biogeographic sub-regions where midwater trawling is “prohibited” and “allowed”. The “Salish Sea” only encompasses the shallowest (“shelf”) depth zone.

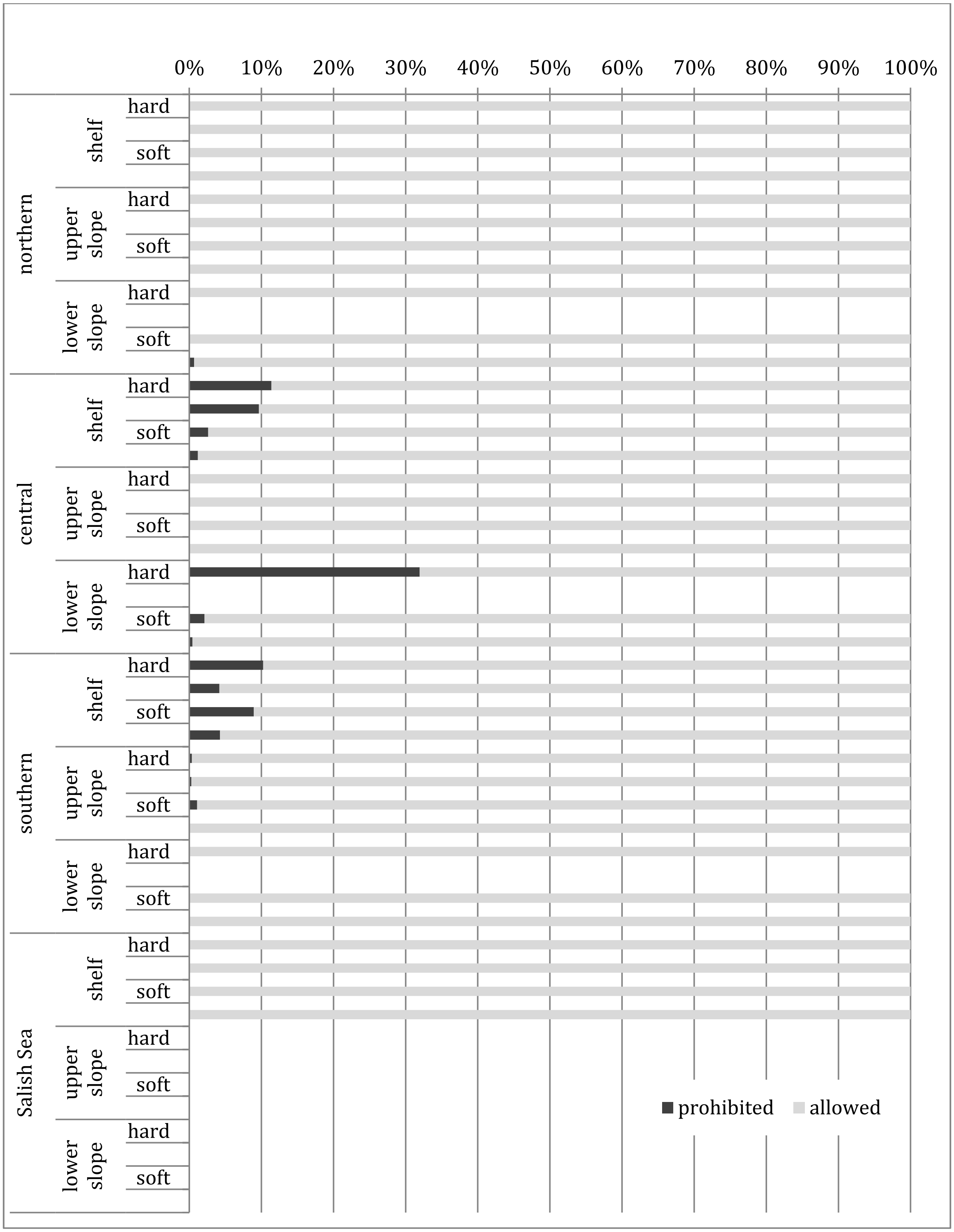


Figure A1.3.7b. Percentages of seabed habitat areas by depth zone and biogeographic sub-regions where fixed gears are “prohibited” and “allowed”. The “Salish Sea” only encompasses the shallowest (“shelf”) depth zone.

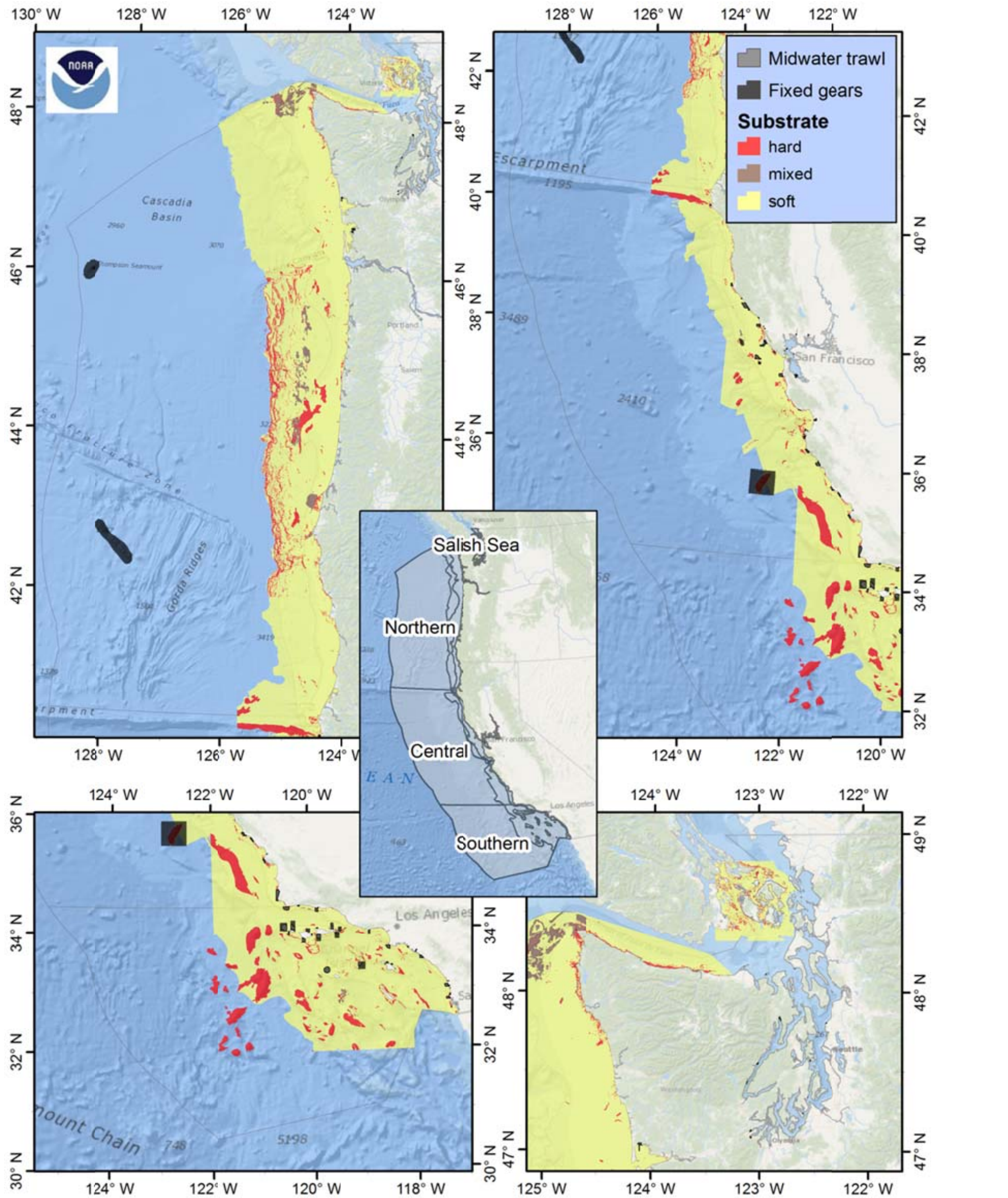


Figure A1.3.8. Map showing the composite area closed to midwater trawling and fixed gears overlain on three major seabed habitat types: hard, mixed and soft. Areas closed to these gear types encompass a relatively small total area compared to those closed to bottom trawling. Fixed gears, since they contact the bottom, or prohibited in 16 of 51 EFH conservation areas, while midwater trawls are only prohibited in state and federal (e.g., Channel Island NMS) “no-take” marine reserves.

Table A1.3.4a. Distribution of seabed habitat types and fishing restrictions by depth zones in the "northern" biogeographic sub-region: Cape Flattery, WA to Cape Mendocino, CA. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the sub-region.

NORTHERN BIOGEOGRAPHIC SUB-REGION									
		Total		Commercial Prohibited		Commercial Restricted		NO Commercial Restrictions	
Depth Zone	***Substrate***	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Shelf[1]	**Total**	**3,404,867**	**11.1%**	**183**	**100.0%**	**1,196,295**	**4.6%**	**2,208,561**	**46.3%**
	hard	170,661	0.6%	2	0.9%	73,023	0.3%	97,637	2.0%
	mixed	94,430	0.3%	0	0.0%	62,884	0.2%	31,545	0.7%
	soft	3,049,609	9.9%	181	98.9%	1,046,499	4.0%	2,003,101	42.0%
	undefined	90,167	0.3%	0	0.2%	13,889	0.1%	76,278	1.6%
Upper Slope[2]	**Total**	**3,021,125**	**9.8%**	**0**	**0.0%**	**521,774**	**2.0%**	**2,499,351**	**52.4%**
	hard	103,766	0.3%	0	0.0%	14,877	0.1%	88,889	1.9%
	mixed	105,496	0.3%	0	0.0%	35,855	0.1%	69,641	1.5%
	soft	2,811,725	9.1%	0	0.0%	470,962	1.8%	2,340,764	49.1%
	undefined	138	0.0%	0	0.0%	80	0.0%	57	0.0%
Lower Slope[3]	**Total**	**24,311,081**	**79.1%**	**0**	**0.0%**	**24,251,201**	**93.4%**	**59,880**	**1.3%**
	hard	324,537	1.1%	0	0.0%	324,537	1.2%	0	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	2,525,125	8.2%	0	0.0%	2,524,792	9.7%	333	0.0%
	undefined	21,461,420	69.8%	0	0.0%	21,401,872	82.4%	59,548	1.2%
Column Total		**30,737,074**	**100.0%**	**183**	**100.0%**	**25,969,269**	**100.0%**	**4,767,793**	**100.0%**
Sub-Region		**30,737,074**	**100.0%**	**183**	**0.0%**	**25,969,269**	**84.5%**	**4,767,793**	**15.5%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

Table A1.3.4b. Distribution of seabed habitat types and fishing restrictions by depth zones in the "central" biogeographic sub-region: Cape Mendocino, CA to Point Conception, CA. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the sub-region.

		CENTRAL BIOGEOGRAPHIC SUB-REGION							
		Total		**Commercial Prohibited**		**Commercial Restricted**		**NO Commercial Restrictions**	
Depth Zone	***Substrate***	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Shelf[1]	**Total**	**1,715,270**	**5.8%**	**45,730**	**95.5%**	**868,546**	**11.6%**	**846,585**	**3.8%**
	hard	104,228	0.4%	8,777	18.3%	94,048	1.3%	10,180	0.0%
	mixed	5,277	0.0%	338	0.7%	5,056	0.1%	221	0.0%
	soft	1,469,779	5.0%	34,987	73.1%	633,456	8.5%	836,184	3.8%
	undefined	135,986	0.5%	1,628	3.4%	135,986	1.8%	0	0.0%
Upper Slope[2]	**Total**	**2,389,292**	**8.1%**	**2,140**	**4.5%**	**726,199**	**9.7%**	**1,663,093**	**7.6%**
	hard	267,468	0.9%	3	0.0%	139,669	1.9%	127,799	0.6%
	mixed	3,175	0.0%	0	0.0%	1,485	0.0%	1,691	0.0%
	soft	2,107,156	7.1%	2,137	4.5%	575,869	7.7%	1,531,287	7.0%
	undefined	11,493	0.0%	0	0.0%	9,176	0.1%	2,317	0.0%
Lower Slope[3]	**Total**	**25,381,145**	**86.1%**	**0**	**0.0%**	**5,893,967**	**78.7%**	**19,487,179**	**88.6%**
	hard	143,068	0.5%	0	0.0%	143,068	1.9%	0	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	2,681,556	9.1%	0	0.0%	2,616,542	34.9%	65,014	0.3%
	undefined	22,556,521	76.5%	0	0.0%	3,134,357	41.9%	19,422,165	88.3%
Column Total		**29,485,708**	**100.0%**	**47,870**	**100.0%**	**7,488,712**	**100.0%**	**21,996,857**	**100.0%**
Sub-Region		**29,485,708**	**100.0%**	**47,870**	**0.2%**	**7,488,712**	**25.4%**	**21,996,857**	**74.6%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

Table A1.3.4c. Distribution of seabed habitat types and fishing restrictions by depth zones in the "southern" biogeographic sub-region: Point Conception, CA to U.S.-Mexico maritime border. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the sub-region.

SOUTHERN BIOGEOGRAPHIC SUB-REGION									
		Total		**Commercial Prohibited**		**Commercial Restricted**		**NO Commercial Restrictions**	
Depth Zone	***Substrate***	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Shelf[1]	**Total**	**775,396**	**3.6%**	**58,801**	**77.8%**	**635,159**	**10.5%**	**140,186**	**0.9%**
	hard	52,064	0.2%	5,150	6.8%	46,240	0.8%	5,824	0.0%
	mixed	15,054	0.1%	487	0.6%	14,408	0.2%	646	0.0%
	soft	691,704	3.2%	52,477	69.5%	558,466	9.3%	133,187	0.9%
	undefined	16,574	0.1%	687	0.9%	16,045	0.3%	530	0.0%
Upper Slope[2]	**Total**	**4,669,633**	**21.6%**	**16,737**	**22.2%**	**1,745,921**	**28.9%**	**2,923,637**	**18.7%**
	hard	242,023	1.1%	436	0.6%	103,330	1.7%	138,693	0.9%
	mixed	18,555	0.1%	0	0.0%	18,555	0.3%	0	0.0%
	soft	4,400,561	20.3%	16,301	21.6%	1,623,539	26.9%	2,776,947	17.8%
	undefined	8,495	0.0%	0	0.0%	497	0.0%	7,998	0.1%
Lower Slope[3]	**Total**	**16,184,376**	**74.8%**	**0**	**0.0%**	**3,651,408**	**60.5%**	**12,532,968**	**80.4%**
	hard	578,992	2.7%	0	0.0%	578,992	9.6%	0	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	2,119,680	9.8%	0	0.0%	1,703,013	28.2%	416,668	2.7%
	undefined	13,485,704	62.3%	0	0.0%	1,369,403	22.7%	12,116,301	77.7%
Column Total		**21,629,405**	**100.0%**	**75,539**	**100.0%**	**6,032,488**	**100.0%**	**15,596,792**	**100.0%**
Sub-Region		**21,629,405**	**100.0%**	**75,539**	**0.3%**	**6,032,488**	**27.9%**	**15,596,792**	**72.1%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

Table A1.3.4d. Distribution of seabed habitat types and fishing restrictions by depth zones in the Salish Sea: Puget Sound and Straits of Georgia and Juan de Fuca. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the sub-region. The "Salish Sea" only encompasses the shallowest ("shelf") depth zone.

		SALISH SEA							
		Total		**Commercial Prohibited**		**Commercial Restricted**		**NO Commercial Restrictions**	
Depth Zone	***Substrate***	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Shelf[1]	**Total**	**739,957**	**100.0%**	**230**	**100.0%**	**739,957**	**100.0%**	**0**	**0.0%**
	hard	15,701	2.1%	0	0.0%	15,701	2.1%	0	0.0%
	mixed	7,469	1.0%	0	0.0%	7,469	1.0%	0	0.0%
	soft	213,668	28.9%	0	0.0%	213,668	28.9%	0	0.0%
	undefined	503,119	68.0%	230	100.0%	503,119	68.0%	0	0.0%
Upper Slope[2]	**Total**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
	hard	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	undefined	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Lower Slope[3]	**Total**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
	hard	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	undefined	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Column Total		**739,957**	**100.0%**	**230**	**100.0%**	**739,957**	**100.0%**	**0**	**0.0%**
Sub-Region		**739,957**	**100.0%**	**230**	**0.0%**	**739,957**	**100.0%**	**0**	**0.0%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

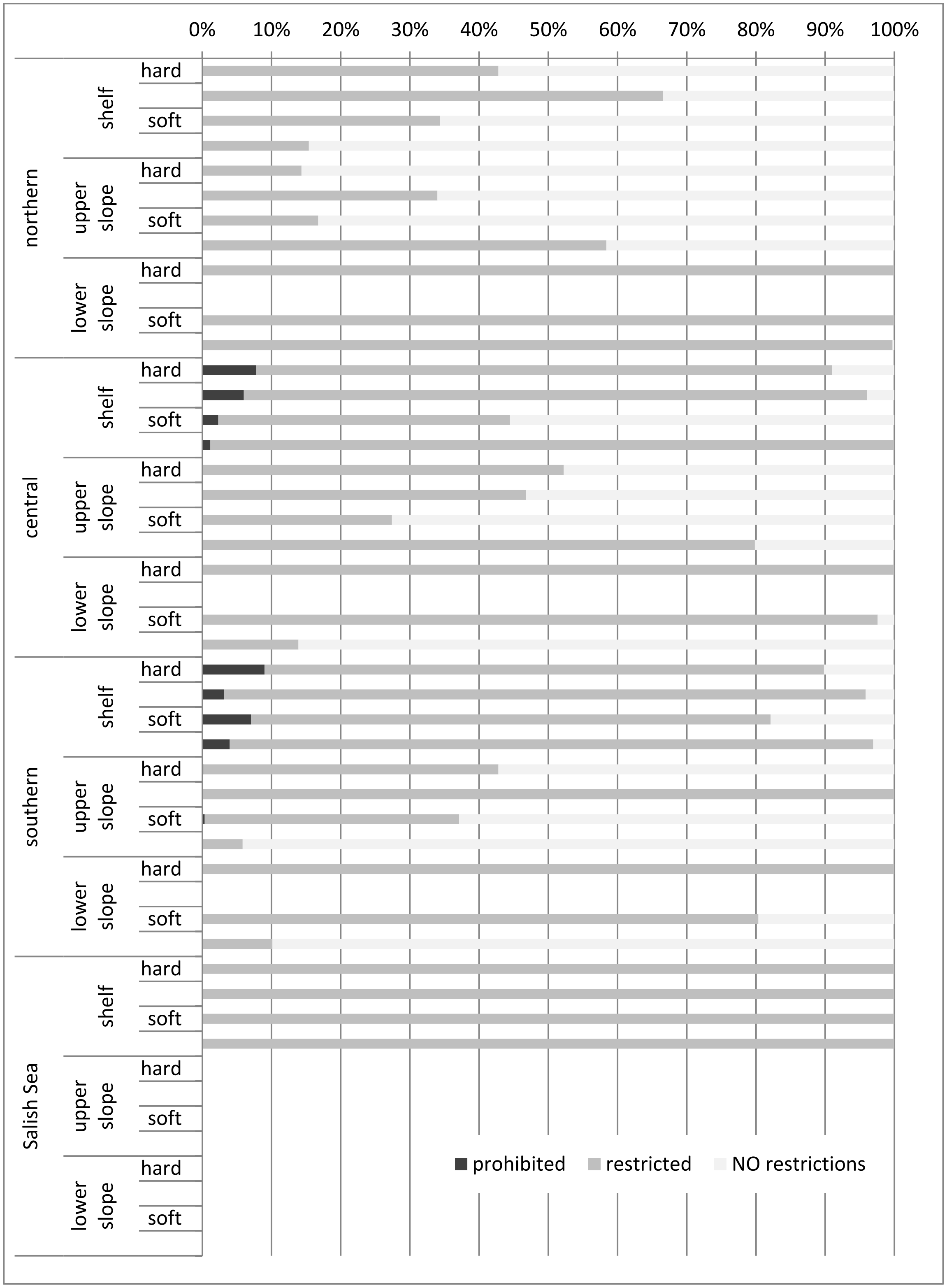


Figure A1.3.9. Percentages of seabed habitat areas by depth zone and biogeographic sub-regions where commercial fishing is “prohibited” (to all gear types), “restricted” (to certain gear types) and allowed (“NO restrictions”). The “Salish Sea” only encompasses the shallowest (“shelf”) depth zone.

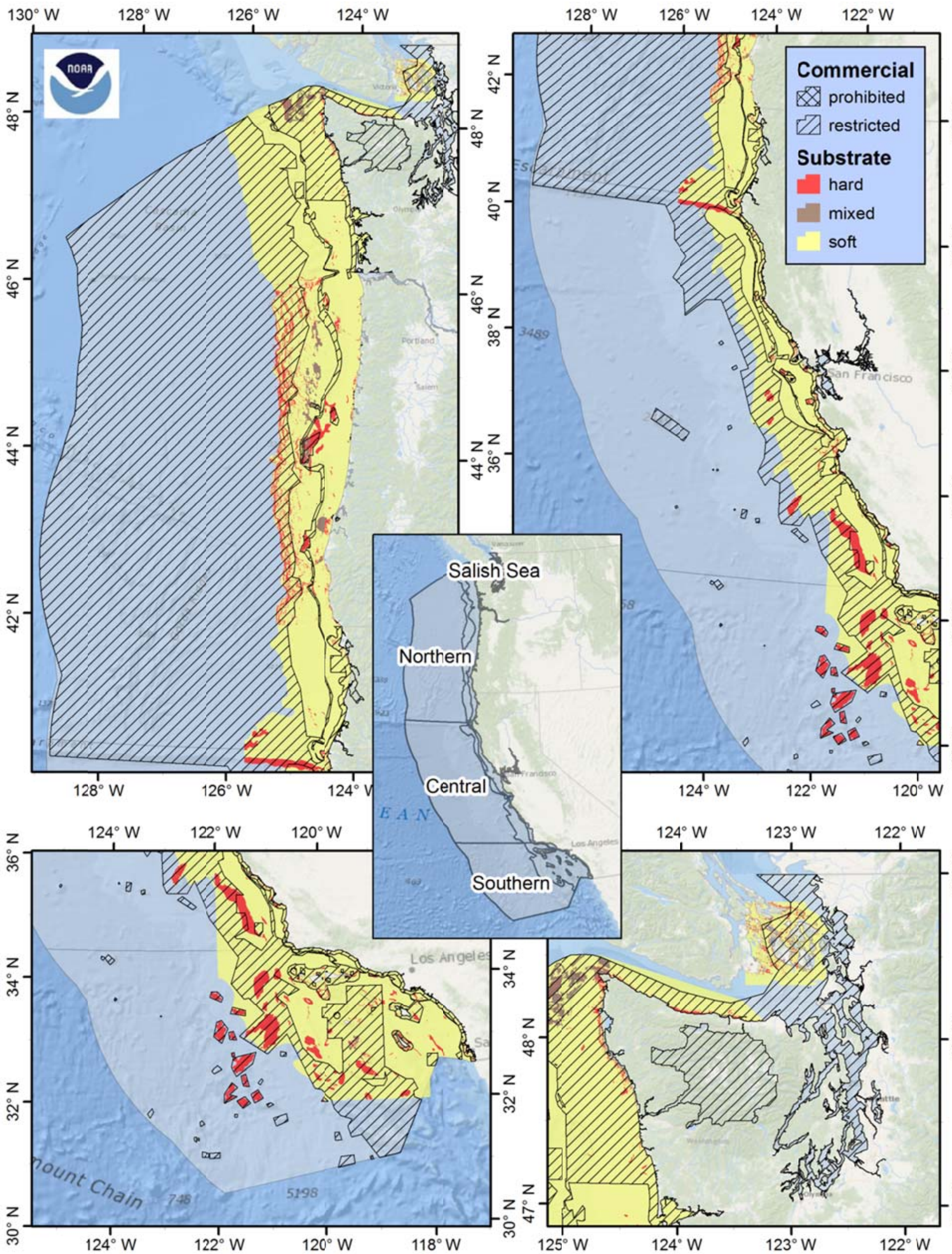


Figure A1.3.10. Map showing the composite area where commercial fishing is either “restricted” or completely “prohibited” overlain on three major seabed habitat types: hard, mixed and soft.

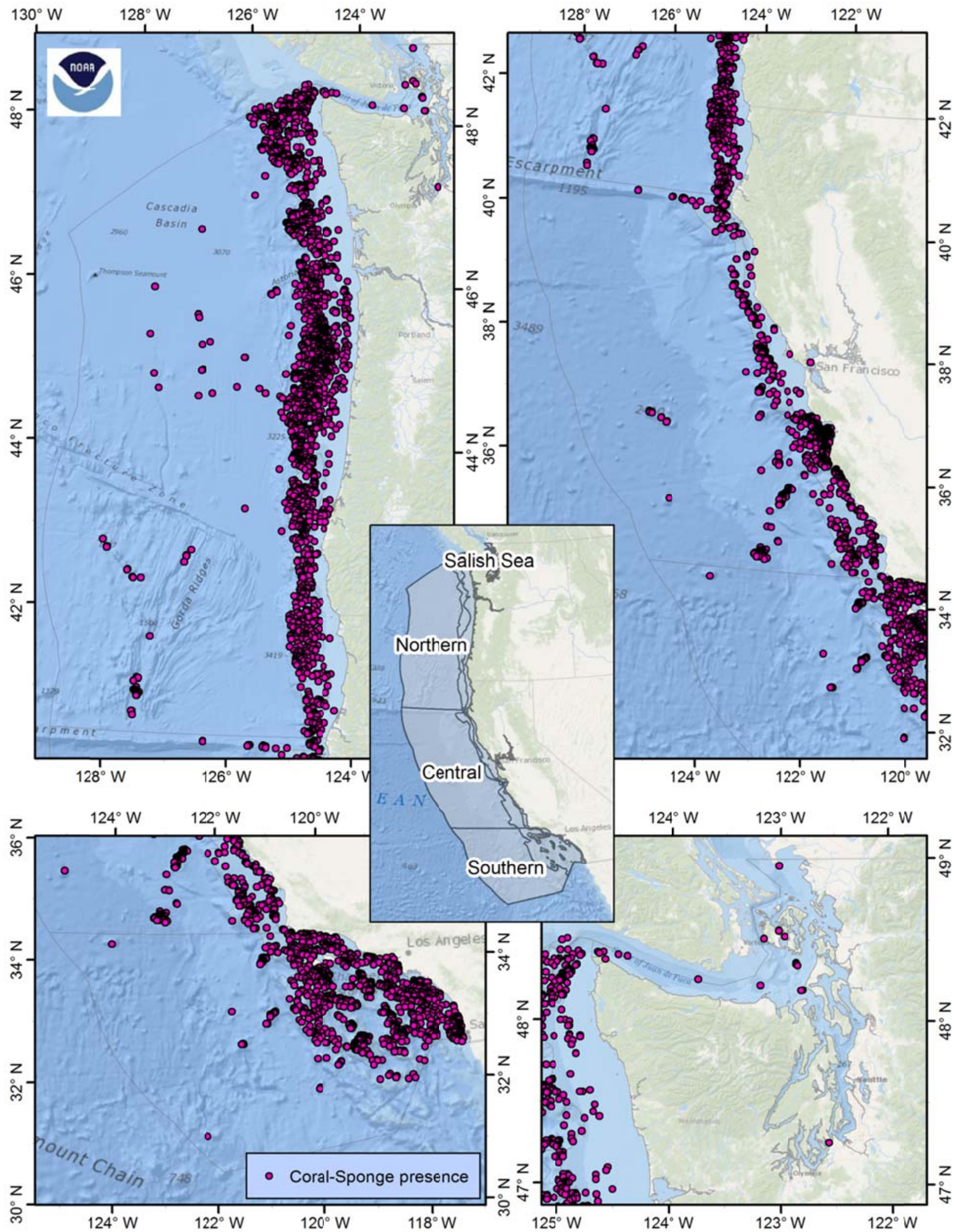


Figure A1.3.11a. Map showing the spatial distribution of coral (excluding pennatulids) and sponge presence, summarized by 1x1 km cells.

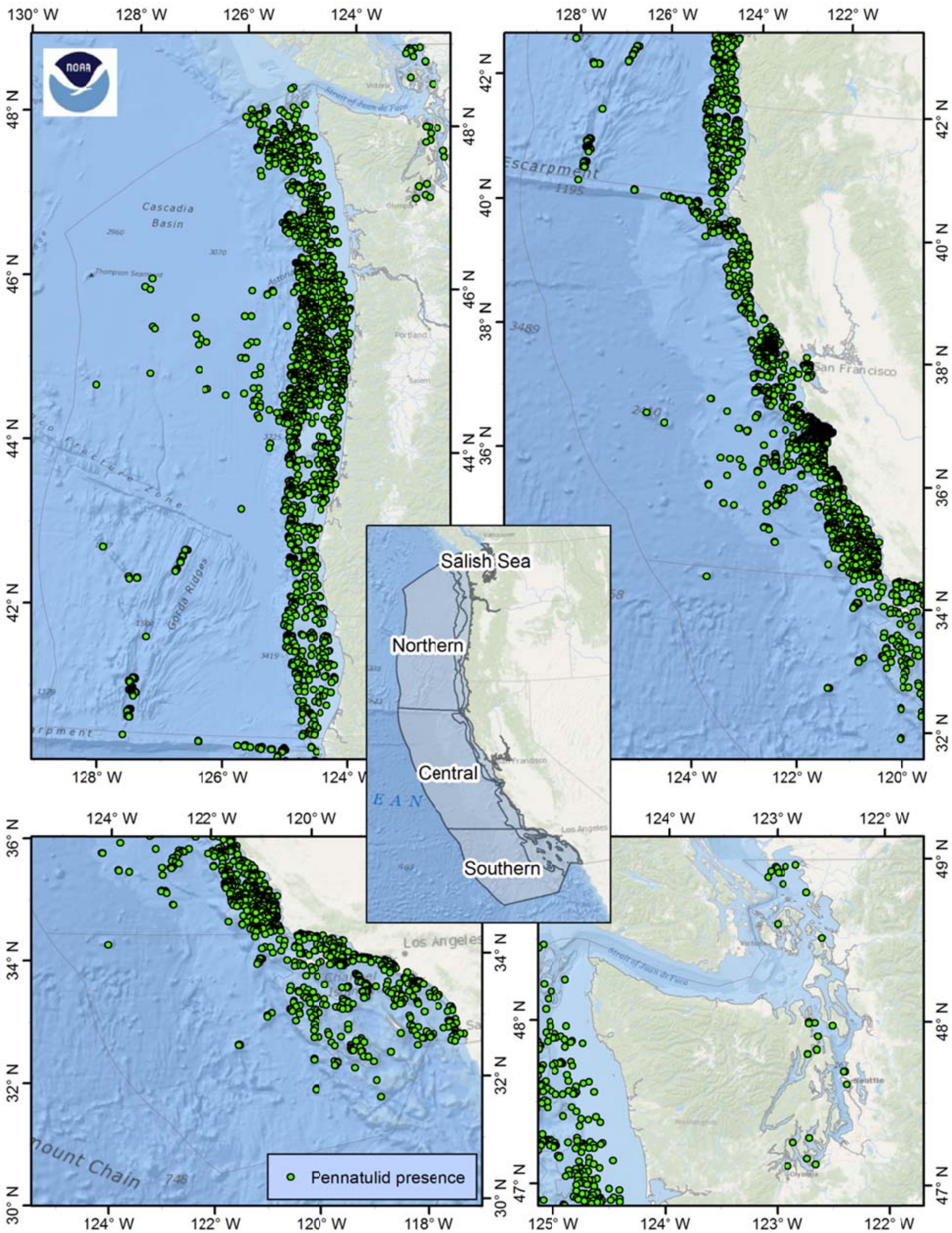
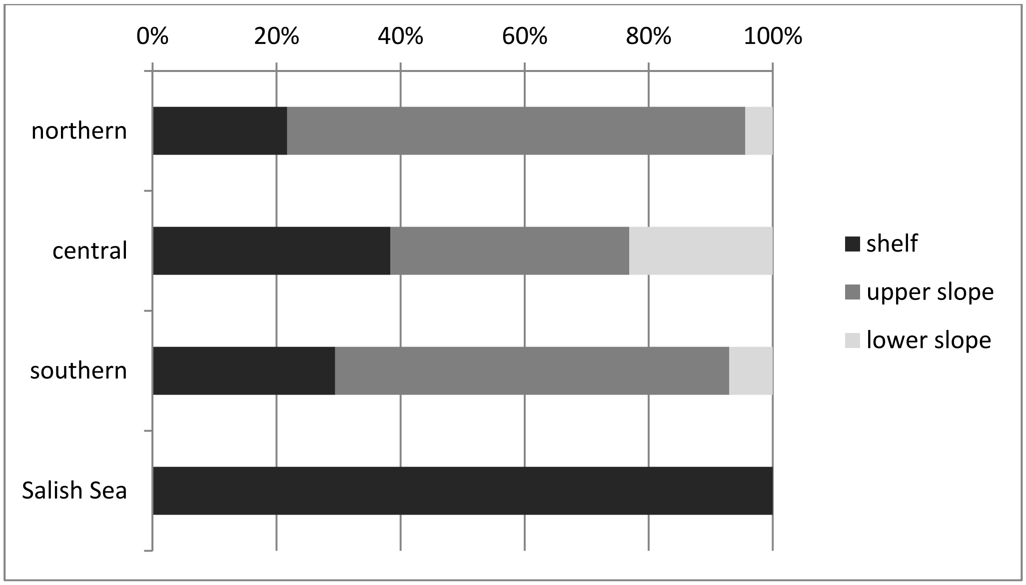


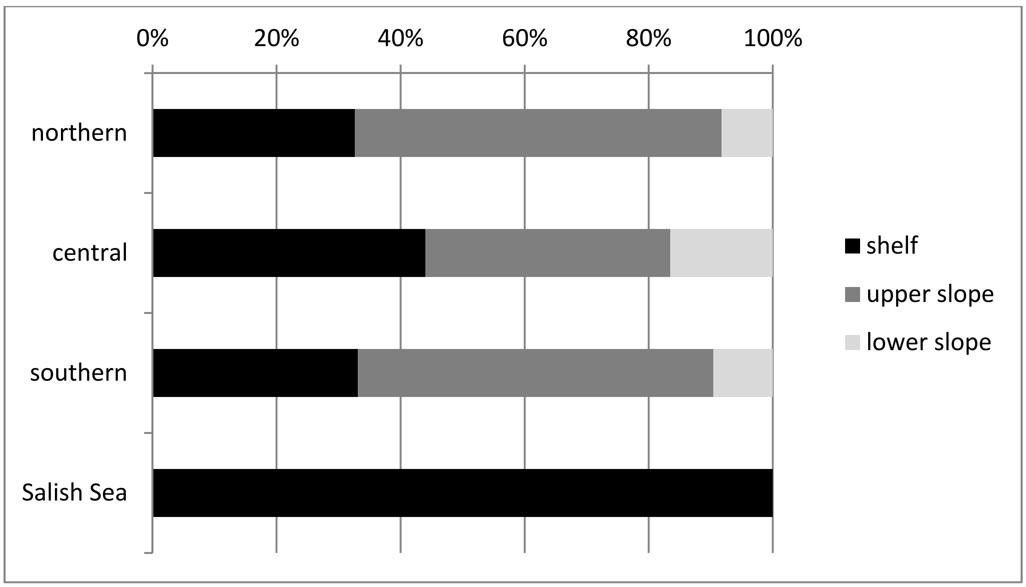
Figure A1.3.11b. Map showing the spatial distribution of pennatulid presence, summarized by 1x1 km cells.

Table A1.3.5. Distribution of presence of two groups of biogenic taxa [coral (excluding pennatulids) and sponge (top); pennatulid (bottom)]by depth zones both coast-wide and in four biogeographic sub-regions: “Northern” (i.e., Cape Flattery, WA to Cape Mendocino, CA), “Central” (i.e., Cape Mendocino, CA to Point Conception, CA), “Southern” (i.e., Point Conception, CA to U.S.-Mexico maritime border) and “Salish Sea” (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). The “Salish Sea” only encompasses the shallowest (“shelf”) depth zone. Percentage values represent relative contribution to the sub-region. Counts represent the number of 1x1 km grid cells where coral and/or sponge were present.

	BIOGEOGRAPHIC SUB-REGION								COAST-WIDE	
	Northern		Central		Southern		Salish Sea		Combined	
Depth Zone	*Count*	*%*	*Count*	*%*	*Count*	*%*	*Count*	*%*	*Count*	*%*
Shelf[1]	426	21.7%	395	38.4%	323	29.4%	16	100.0%	1,160	28.3%
Upper Slope[2]	1,448	73.8%	396	38.5%	697	63.5%	0	0.0%	2,541	61.9%
Lower Slope[3]	87	4.4%	238	23.1%	77	7.0%	0	0.0%	402	9.8%
Total	**1,961**	**47.8%**	**1,029**	**25.1%**	**1,097**	**26.7%**	**16**	**0.4%**	**4,103**	**100.0%**
	Coral (excluding pennatulids) and Sponge Presence [above] | Pennatulid Presence [below]									
Shelf[1]	586	32.7%	736	44.0%	149	33.1%	27	100.0%	1,498	38.0%
Upper Slope[2]	1,060	59.1%	660	39.5%	258	57.3%	0	0.0%	1,978	50.2%
Lower Slope[3]	148	8.2%	276	16.5%	43	9.6%	0	0.0%	467	11.8%
Total	**1,794**	**45.5%**	**1,672**	**42.4%**	**450**	**11.4%**	**27**	**0.7%**	**3,943**	**100.0%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).[3]





1.3.12a and b. Relative distribution of [a] coral (excluding pennatulids) and sponge presence [top], and [b] pennatulid presence [bottom] by depth zones in four biogeographic sub-regions. The "Salish Sea" only encompasses the shallowest ("shelf") depth zone.

Table A1.3.6a. Distribution of coral (excluding pennatulids) and sponge presence within areas of various fishing gear restrictions, summarized by depth zones in four biogeographic sub-regions: northern, central, southern and Salish Sea. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the entire FMP area. Counts represent the number of 1x1 km grid cells where coral and/or sponge were present.

CORAL (EXCLUDING PENNATULIDS) AND SPONGE PRESENCE											
		Bottom Contact Prohibited		**Bottom Contact Prohibited (or other gear deployed deeper than 500 ftm)**		**Bottom Trawl Prohibited**		**Bottom Trawl Prohibited (except demersal seine)**		**Outside EFH Cons. Areas**	
SUB-REGION	***Depth Zone***	*Count*	*%*	*Count*	*%*	*Count*	*%*	*Count*	*%*	*Count*	*%*
Northern	**Total**	**8**	**9.1%**	**0**	**0.0%**	**311**	**53.9%**	**2**	**0.4%**	**1,649**	**54.4%**
	shelf[1]	0	0.0%	0	0.0%	55	9.5%	0	0.0%	371	12.2%
	upper slope[2]	0	0.0%	0	0.0%	169	29.3%	1	0.2%	1,278	42.2%
	lower slope[3]	8	9.1%	0	0.0%	87	15.1%	1	0.2%	0	0.0%
Central	**Total**	**31**	**35.2%**	**73**	**100.0%**	**195**	**33.8%**	**360**	**70.9%**	**506**	**16.7%**
	shelf[1]	31	35.2%	0	0.0%	0	0.0%	187	36.8%	177	5.8%
	upper slope[2]	0	0.0%	0	0.0%	0	0.0%	110	21.7%	286	9.4%
	lower slope[3]	0	0.0%	73	100.0%	195	33.8%	63	12.4%	43	1.4%
Southern	**Total**	**49**	**55.7%**	**0**	**0.0%**	**71**	**12.3%**	**146**	**28.7%**	**858**	**28.3%**
	shelf[1]	12	13.6%	0	0.0%	0	0.0%	59	11.6%	252	8.3%
	upper slope[2]	37	42.0%	0	0.0%	0	0.0%	60	11.8%	600	19.8%
	lower slope[3]	0	0.0%	0	0.0%	71	12.3%	27	5.3%	6	0.2%
Salish Sea	**Total**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**16**	**0.5%**
	shelf[1]	0	0.0%	0	0.0%	0	0.0%	0	0.0%	16	0.5%
	upper slope[2]	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	lower slope[3]	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Column Total		**88**	**100.0%**	**73**	**100.0%**	**577**	**100.0%**	**508**	**100.0%**	**3,029**	**100.0%**
Coastwide		**88**	**2.1%**	**73**	**1.7%**	**577**	**13.5%**	**508**	**11.9%**	**3,029**	**70.9%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

Table A1.3.6b. Distribution of pennatulid presence within areas of various fishing gear restrictions, summarized by depth zones in four biogeographic sub-regions: northern, central, southern and Salish Sea. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the entire FMP area. Counts represent the number of 1x1 km grid cells where coral and/or sponge were present.

PENNATULID PRESENCE		Bottom Contact Prohibited		Bottom Contact Prohibited (or other gear deployed deeper than 500 ftm)		Bottom Trawl Prohibited		Bottom Trawl Prohibited (except demersal seine)		Outside EFH Cons. Areas	
SUB-REGION	***Depth Zone***	*Count*	*%*	*Count*	*%*	*Count*	*%*	*Count*	*%*	*Count*	*%*
Northern	**Total**	**3**	**8.3%**	**0**	**0.0%**	**240**	**46.4%**	**2**	**0.4%**	**1,553**	**52.0%**
	shelf[1]	0	0.0%	0	0.0%	6	1.2%	1	0.2%	579	19.4%
	upper slope[2]	0	0.0%	0	0.0%	86	16.6%	0	0.0%	974	32.6%
	lower slope[3]	3	8.3%	0	0.0%	148	28.6%	1	0.2%	0	0.0%
Central	**Total**	**5**	**13.9%**	**24**	**100.0%**	**239**	**46.2%**	**483**	**88.8%**	**1,067**	**35.7%**
	shelf[1]	5	13.9%	0	0.0%	0	0.0%	196	36.0%	535	17.9%
	upper slope[2]	0	0.0%	0	0.0%	0	0.0%	165	30.3%	495	16.6%
	lower slope[3]	0	0.0%	24	100.0%	239	46.2%	122	22.4%	37	1.2%
Southern	**Total**	**28**	**77.8%**	**0**	**0.0%**	**38**	**7.4%**	**59**	**10.8%**	**339**	**11.4%**
	shelf[1]	4	11.1%	0	0.0%	0	0.0%	28	5.1%	117	3.9%
	upper slope[2]	24	66.7%	0	0.0%	0	0.0%	17	3.1%	217	7.3%
	lower slope[3]	0	0.0%	0	0.0%	38	7.4%	14	2.6%	5	0.2%
Salish Sea	**Total**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**27**	**0.9%**
	shelf[1]	0	0.0%	0	0.0%	0	0.0%	0	0.0%	27	0.9%
	upper slope[2]	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	lower slope[3]	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Column Total		**36**	**100.0%**	**24**	**100.0%**	**517**	**100.0%**	**544**	**100.0%**	**2,986**	**100.0%**
Coastwide		**36**	**0.9%**	**24**	**0.6%**	**517**	**12.6%**	**544**	**13.2%**	**2,986**	**72.7%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

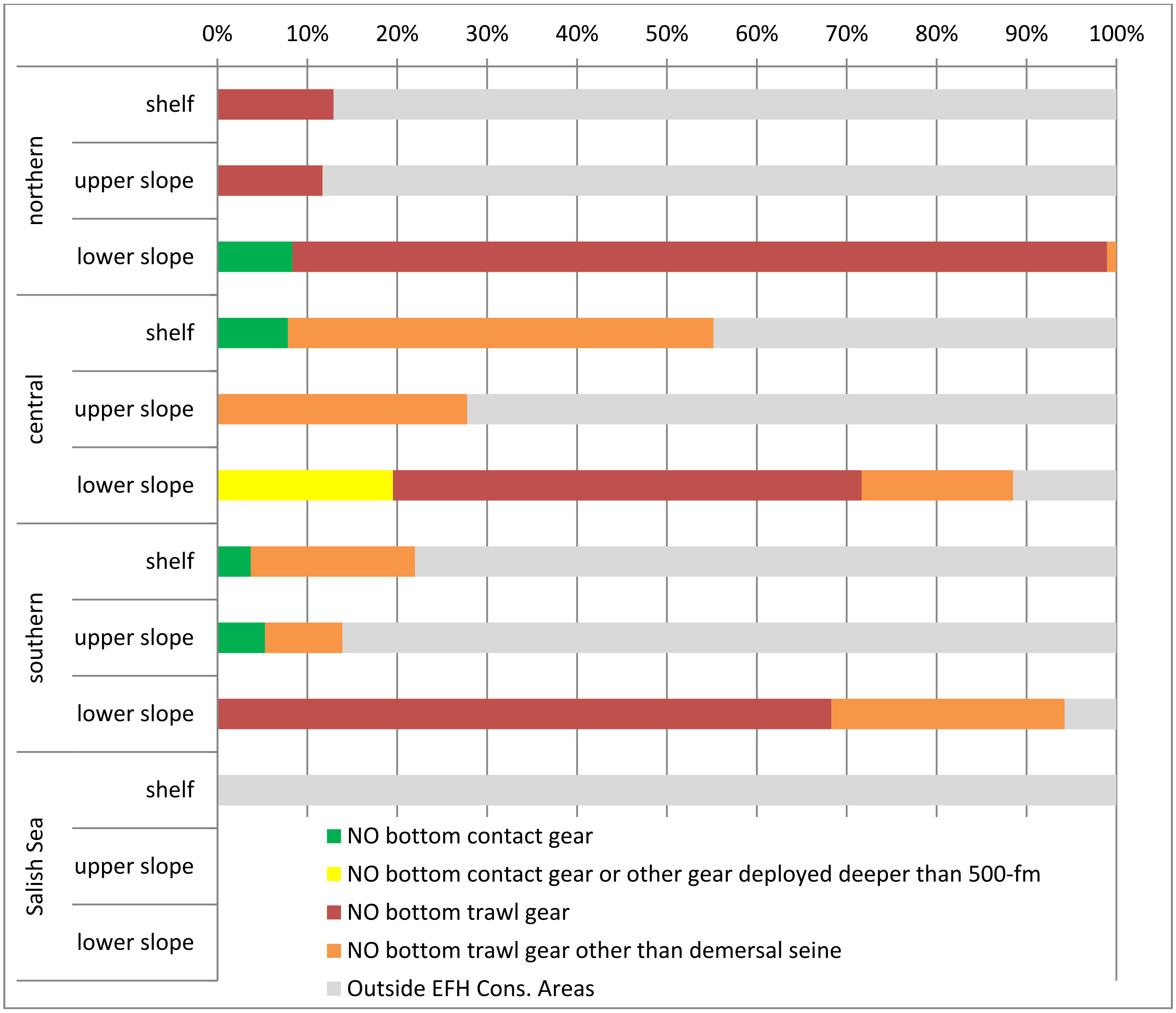


Figure A1.3.13a. Percentages of coral (excluding pennatulids) and sponge presence by depth zone and biogeographic sub-regions where EFH-specific gear prohibitions apply. No EFH Conservation Areas are located in the "Salish Sea".

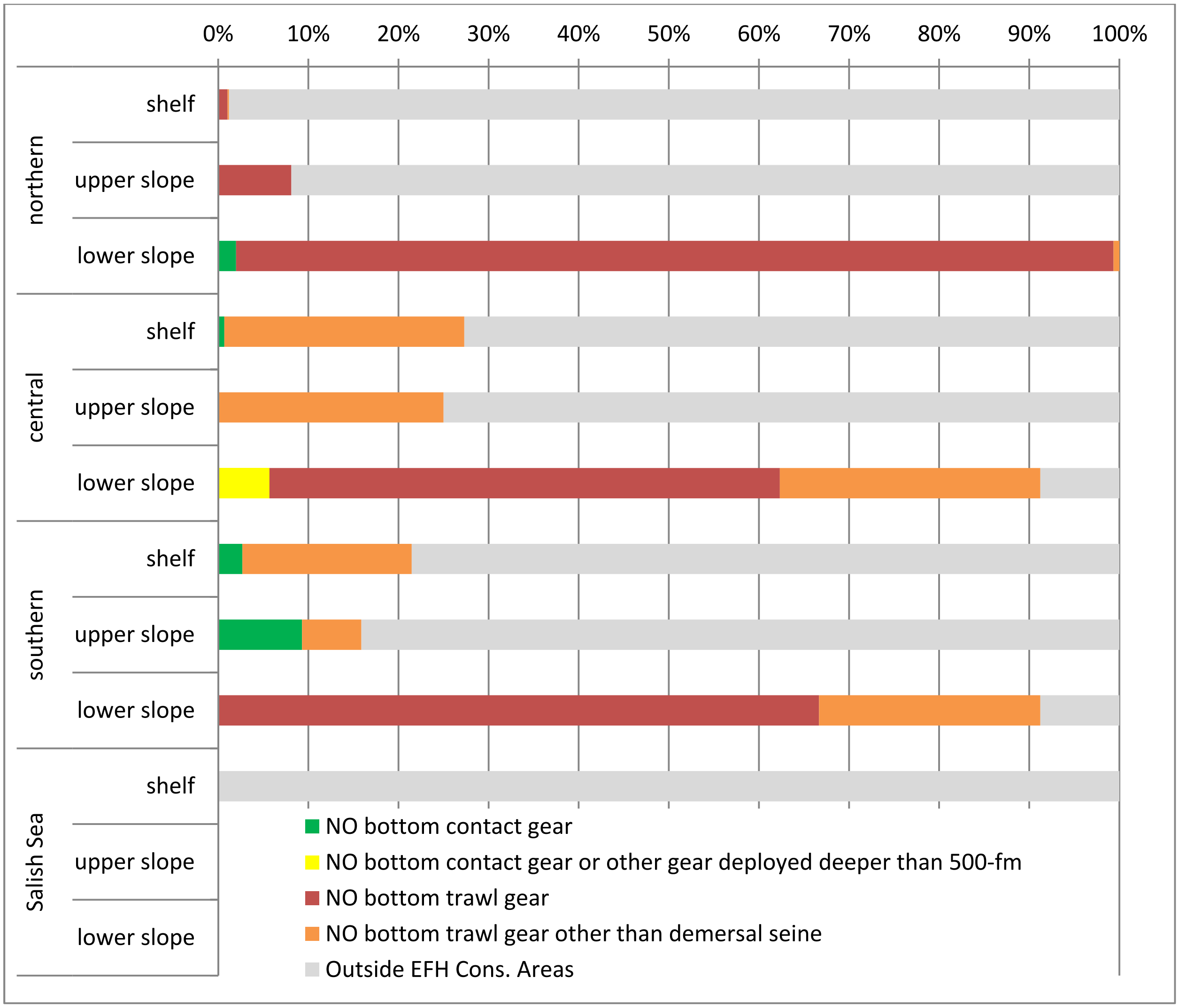


Figure A1.3.13b. Percentages of pennatulid presence by depth zone and biogeographic sub-regions where EFH-specific gear prohibitions apply. No EFH Conservation Areas are located in the “Salish Sea”.

Table A1.3.7a. Distribution of coral (excluding pennatulids) and sponge presence within areas of various fishing gear restrictions, summarized by depth zones in four biogeographic sub-regions: northern, central, southern and Salish Sea. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the entire FMP area. Counts represent the number of 1x1 km grid cells where coral and/or sponge were present.

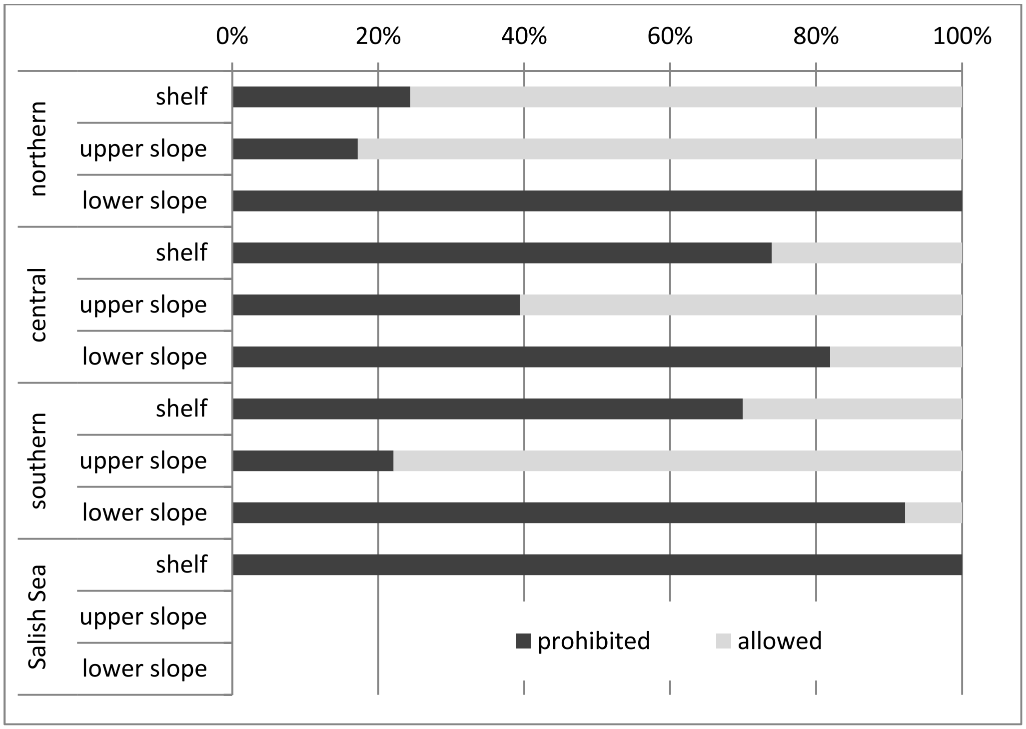
CORAL (EXCLUDING PENNATULIDS) AND SPONGE PRESENCE									
		Bottom Trawl Prohibited		Midwater Trawl Prohibited		Fixed Gear Prohibited		NO Gear Prohibitions	
SUB-REGION	***Depth Zone***	*Count*	*%*	*Count*	*%*	*Count*	*%*	*Count*	*%*
Northern	**Total**	**440**	**28.4%**	**0**	**0.0%**	**8**	**4.1%**	**1,521**	**59.6%**
	shelf[1]	104	6.7%	0	0.0%	0	0.0%	322	12.6%
	upper slope[2]	249	16.1%	0	0.0%	0	0.0%	1,199	47.0%
	lower slope[3]	87	5.6%	0	0.0%	8	4.1%	0	0.0%
Central	**Total**	**643**	**41.5%**	**25**	**48.1%**	**129**	**65.5%**	**386**	**15.1%**
	shelf[1]	292	18.8%	22	42.3%	53	26.9%	103	4.0%
	upper slope[2]	156	10.1%	3	5.8%	3	1.5%	240	9.4%
	lower slope[3]	195	12.6%	0	0.0%	73	37.1%	43	1.7%
Southern	**Total**	**451**	**29.1%**	**27**	**51.9%**	**60**	**30.5%**	**646**	**25.3%**
	shelf[1]	226	14.6%	21	40.4%	21	10.7%	97	3.8%
	upper slope[2]	154	9.9%	6	11.5%	39	19.8%	543	21.3%
	lower slope[3]	71	4.6%	0	0.0%	0	0.0%	6	0.2%
Salish Sea	**Total**	**16**	**1.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
	shelf[1]	16	1.0%	0	0.0%	0	0.0%	0	0.0%
	upper slope[2]	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	lower slope[3]	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Column Total		**1,550**	**100.0%**	**52**	**100.0%**	**197**	**100.0%**	**2,553**	**100.0%**
Coastwide		**1,550**	**37.8%**	**52**	**1.3%**	**197**	**4.8%**	**2,553**	**62.2%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

Table A1.3.7b. Distribution pennatulid presence within areas of various fishing gear restrictions, summarized by depth zones in four biogeographic sub-regions: northern, central, southern and Salish Sea. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the entire FMP area. Counts represent the number of 1x1 km grid cells where coral and/or sponge were present.

PENNATULID PRESENCE									
		Bottom Trawl Prohibited		Midwater Trawl Prohibited		Fixed Gear Prohibited		NO Gear Prohibitions	
SUB-REGION	*Depth Zone*	*Count*	*%*	*Count*	*%*	*Count*	*%*	*Count*	*%*
Northern	**Total**	**305**	**22.0%**	**0**	**0.0%**	**3**	**3.8%**	**1,489**	**58.2%**
	shelf[1]	35	2.5%	0	0.0%	0	0.0%	551	21.5%
	upper slope[2]	122	8.8%	0	0.0%	0	0.0%	938	36.7%
	lower slope[3]	148	10.7%	0	0.0%	3	3.8%	0	0.0%
Central	**Total**	**847**	**61.2%**	**18**	**75.0%**	**47**	**58.8%**	**825**	**32.3%**
	shelf[1]	389	28.1%	13	54.2%	18	22.5%	347	13.6%
	upper slope[2]	219	15.8%	5	20.8%	5	6.3%	441	17.2%
	lower slope[3]	239	17.3%	0	0.0%	24	30.0%	37	1.4%
Southern	**Total**	**206**	**14.9%**	**6**	**25.0%**	**30**	**37.5%**	**244**	**9.5%**
	shelf[1]	100	7.2%	3	12.5%	4	5.0%	49	1.9%
	upper slope[2]	68	4.9%	3	12.5%	26	32.5%	190	7.4%
	lower slope[3]	38	2.7%	0	0.0%	0	0.0%	5	0.2%
Salish Sea	**Total**	**27**	**1.9%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
	shelf[1]	27	1.9%	0	0.0%	0	0.0%	0	0.0%
	upper slope[2]	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	lower slope[3]	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Column Total		**1,385**	**100.0%**	**24**	**100.0%**	**80**	**100.0%**	**2,558**	**100.0%**
Coastwide		**1,385**	**35.1%**	**24**	**0.6%**	**80**	**2.0%**	**2,558**	**64.9%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).



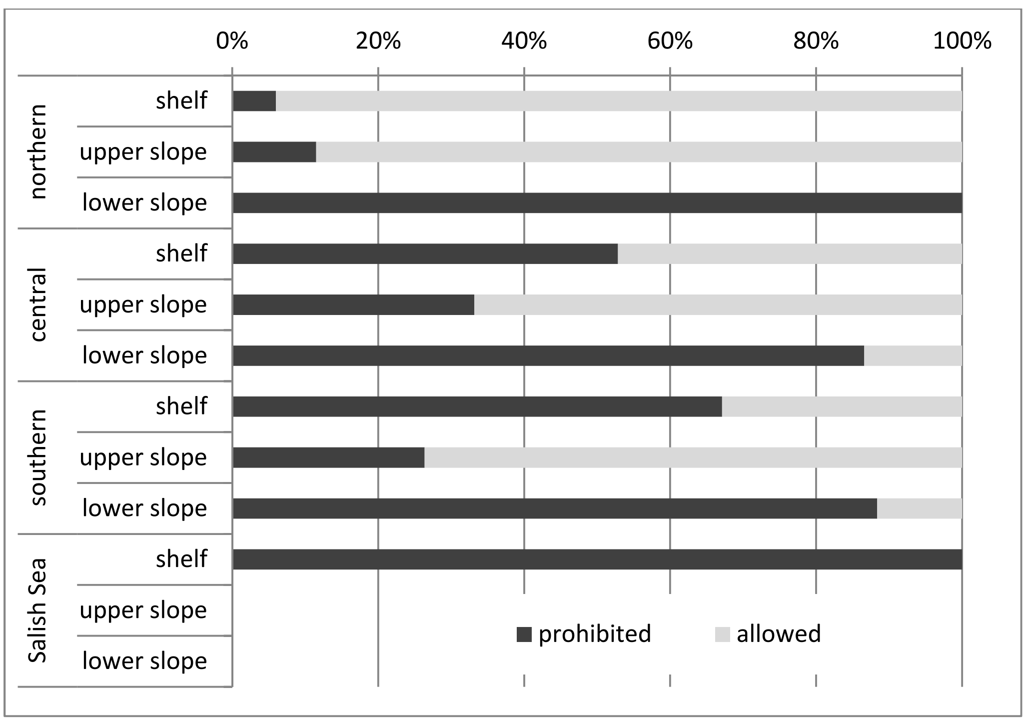
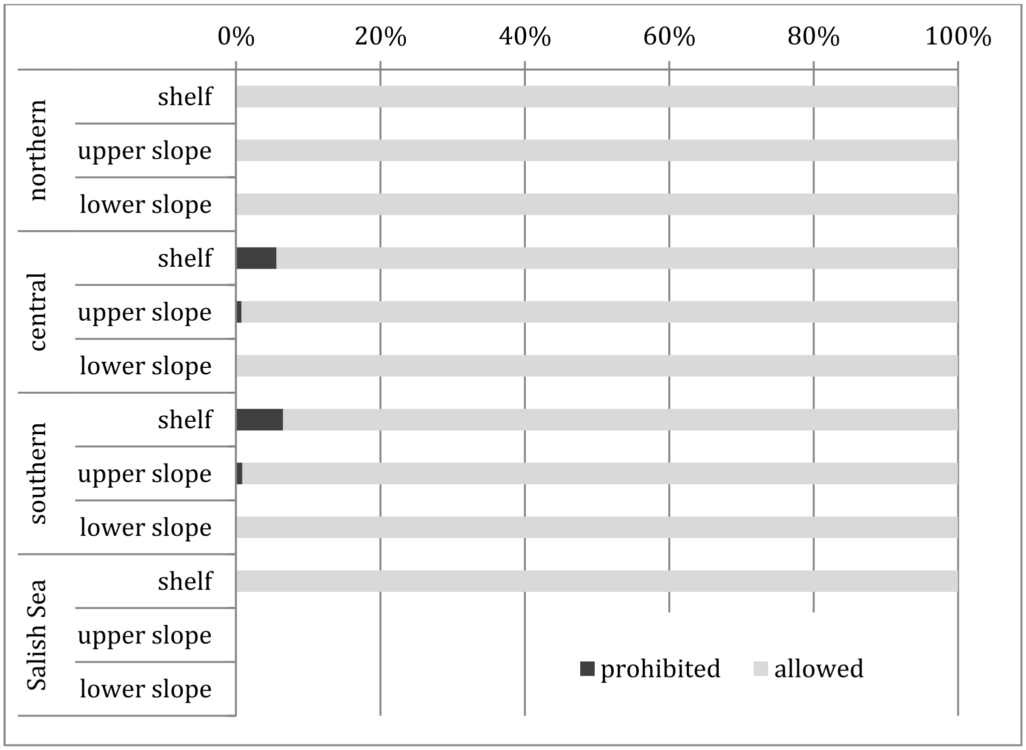


Figure A1.3.14a and b. Percentages of [a] coral (excluding pennatulids) and sponge presence [top], and [b] pennatulid presence [bottom] by depth zone and biogeographic sub-regions where bottom trawling is “prohibited” and “allowed”. Presence was summarized within 1x1 km grid cells. The “Salish Sea” only encompasses the shallowest (“shelf”) depth zone.



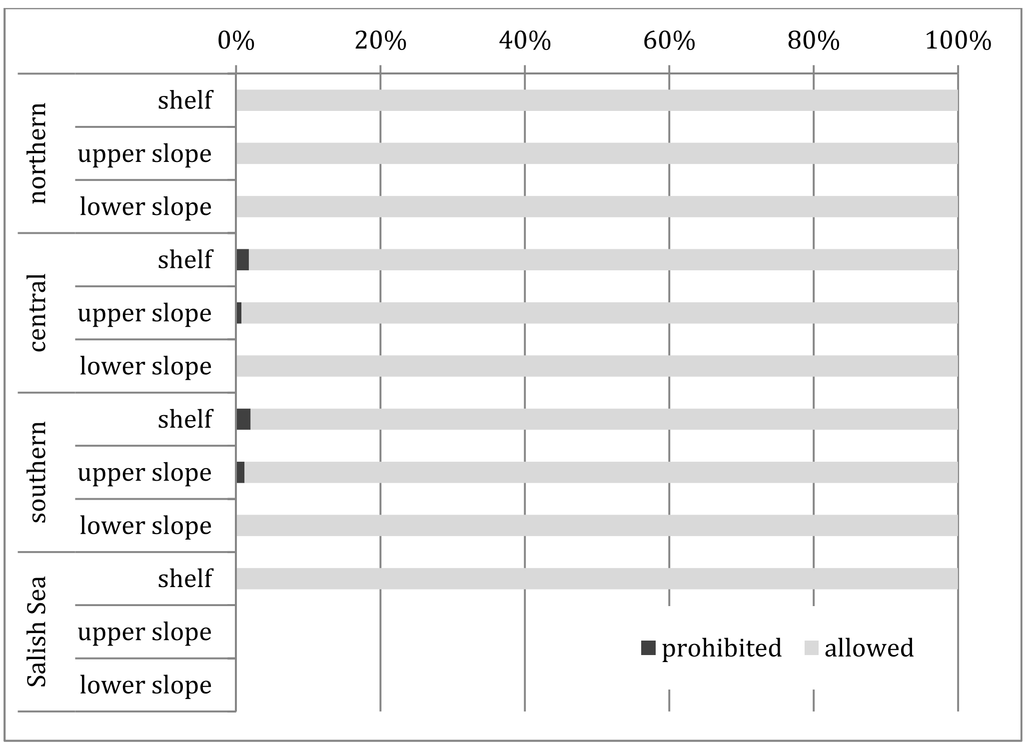
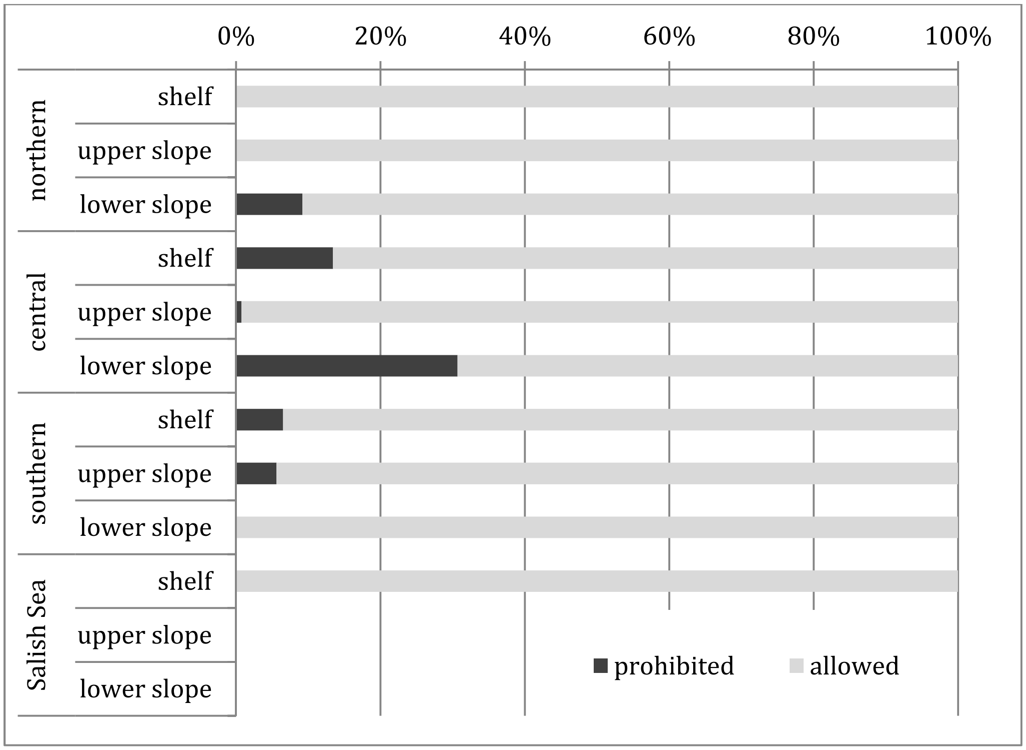


Figure A1.3.15a and b. Percentages of [a] coral (excluding pennatulids) and sponge presence [top], and [b] pennatulid presence [bottom] by depth zone and biogeographic sub-regions where midwater trawling and fixed gears are "prohibited" and "allowed". Presence was summarized within 1x1 km grid cells. The "Salish Sea" only encompasses the shallowest ("shelf") depth zone.



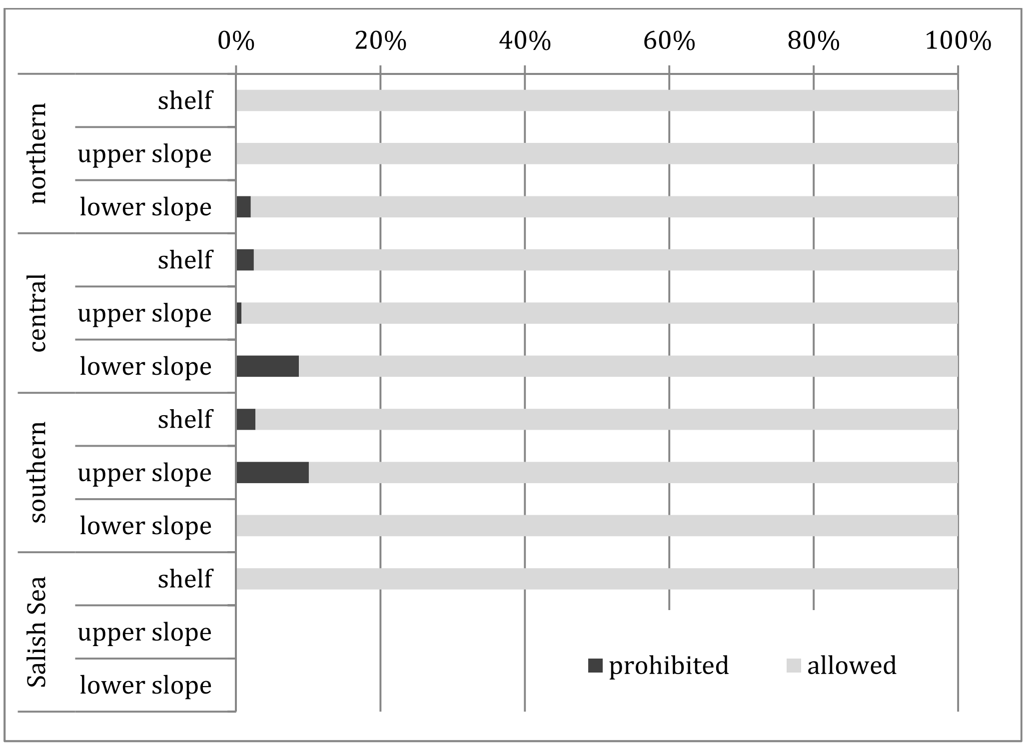


Figure A1.3.15c and d. Percentages of [c] coral (excluding pennatulids) and sponge presence [top], and [d] pennatulid presence [bottom] by depth zone and biogeographic sub-regions where fixed gears are "prohibited" and "allowed". Presence was summarized within 1x1 km grid cells. The "Salish Sea" only encompasses the shallowest ("shelf") depth zone.

Table A1.3.8a. Distribution of coral (excluding pennatulids) and sponge presence within areas of various fishing restrictions, summarized by depth zones in four biogeographic sub-regions: northern, central, southern and Salish Sea. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the entire FMP area. Counts represent the number of 1x1 km grid cells where coral and/or sponge were present.

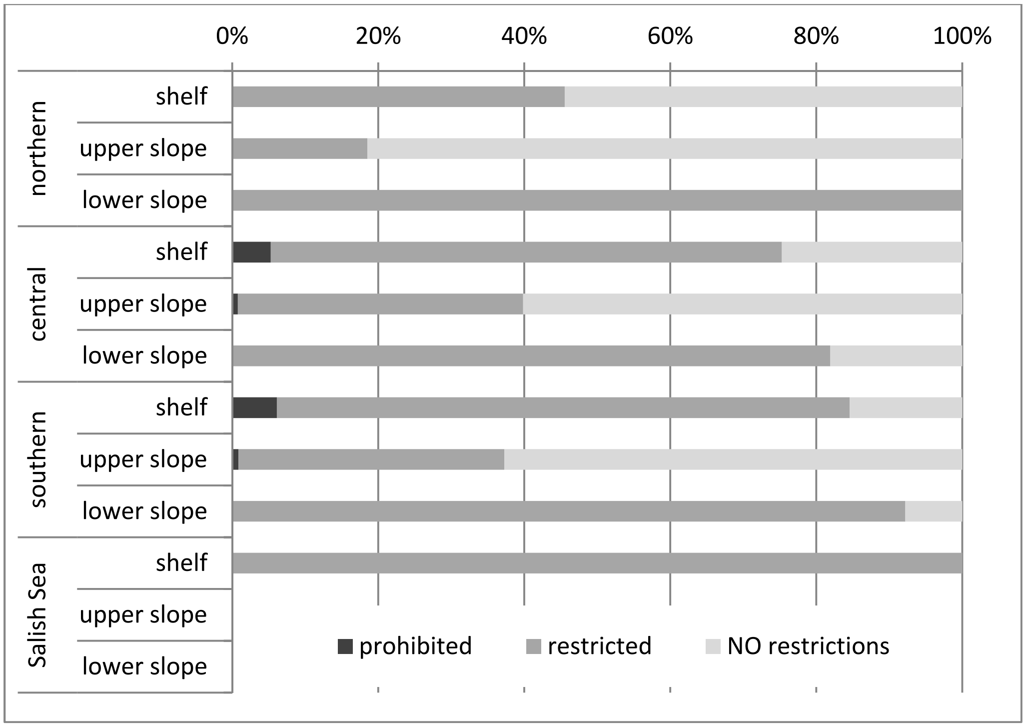
		CORAL (EXCLUDING PENNATULIDS) AND SPONGE PRESENCE					
		Commercial Prohibited		**Commercial Restricted**		**NO Commercial Restrictions**	
SUB-REGION	***Depth Zone***	*Count*	*%*	*Count*	*%*	*Count*	*%*
Northern	**Total**	**0**	**0.0%**	**549**	**30.4%**	**1,412**	**61.4%**
	shelf[1]	0	0.0%	194	10.7%	232	10.1%
	upper slope[2]	0	0.0%	268	14.8%	1,180	51.3%
	lower slope[3]	0	0.0%	87	4.8%	0	0.0%
Central	**Total**	**25**	**48.1%**	**643**	**35.6%**	**386**	**16.8%**
	shelf[1]	22	42.3%	292	16.2%	103	4.5%
	upper slope[2]	3	5.8%	156	8.6%	240	10.4%
	lower slope[3]	0	0.0%	195	10.8%	43	1.9%
Southern	**Total**	**27**	**51.9%**	**597**	**33.1%**	**500**	**21.8%**
	shelf[1]	21	40.4%	270	15.0%	53	2.3%
	upper slope[2]	6	11.5%	256	14.2%	441	19.2%
	lower slope[3]	0	0.0%	71	3.9%	6	0.3%
Salish Sea	**Total**	**0**	**0.0%**	**16**	**0.9%**	**0**	**0.0%**
	shelf[1]	0	0.0%	16	0.9%	0	0.0%
	upper slope[2]	0	0.0%	0	0.0%	0	0.0%
	lower slope[3]	0	0.0%	0	0.0%	0	0.0%
Column Total		**52**	**100.0%**	**1,805**	**100.0%**	**2,298**	**100.0%**
Coastwide		**52**	**1.3%**	**1,805**	**43.4%**	**2,298**	**55.3%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

Table A1.3.8b. Distribution pennatulid presence within areas of various fishing restrictions, summarized by depth zones in four biogeographic sub-regions: northern, central, southern and Salish Sea. Percentage values represent relative contribution to the category of fishing restriction. Last row shows relative contribution to the entire FMP area. Counts represent the number of 1x1 km grid cells where coral and/or sponge were present.

		PENNATULID PRESENCE					
		Commercial Prohibited		Commercial Restricted		NO Commercial Restrictions	
SUB-REGION	***Depth Zone***	*Count*	*%*	*Count*	*%*	*Count*	*%*
Northern	**Total**	**0**	**0.0%**	**392**	**25.9%**	**1,402**	**57.6%**
	shelf[1]	0	0.0%	108	7.1%	478	19.7%
	upper slope[2]	0	0.0%	136	9.0%	924	38.0%
	lower slope[3]	0	0.0%	148	9.8%	0	0.0%
Central	**Total**	**18**	**75.0%**	**847**	**56.1%**	**825**	**33.9%**
	shelf[1]	13	54.2%	389	25.7%	347	14.3%
	upper slope[2]	5	20.8%	219	14.5%	441	18.1%
	lower slope[3]	0	0.0%	239	15.8%	37	1.5%
Southern	**Total**	**6**	**25.0%**	**245**	**16.2%**	**205**	**8.4%**
	shelf[1]	3	12.5%	104	6.9%	45	1.9%
	upper slope[2]	3	12.5%	103	6.8%	155	6.4%
	lower slope[3]	0	0.0%	38	2.5%	5	0.2%
Salish Sea	**Total**	**0**	**0.0%**	**27**	**1.8%**	**0**	**0.0%**
	shelf[1]	0	0.0%	27	1.8%	0	0.0%
	upper slope[2]	0	0.0%	0	0.0%	0	0.0%
	lower slope[3]	0	0.0%	0	0.0%	0	0.0%
Column Total		**24**	**100.0%**	**1,511**	**100.0%**	**2,432**	**100.0%**
Coastwide		**24**	**0.6%**	**1,511**	**38.1%**	**2,432**	**61.3%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).



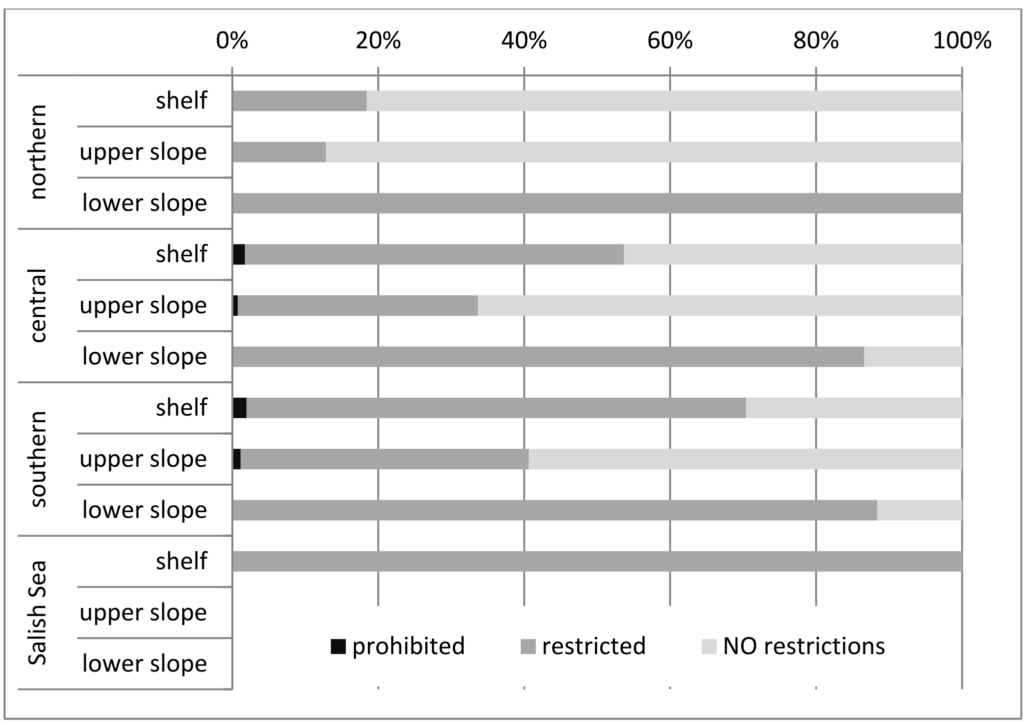
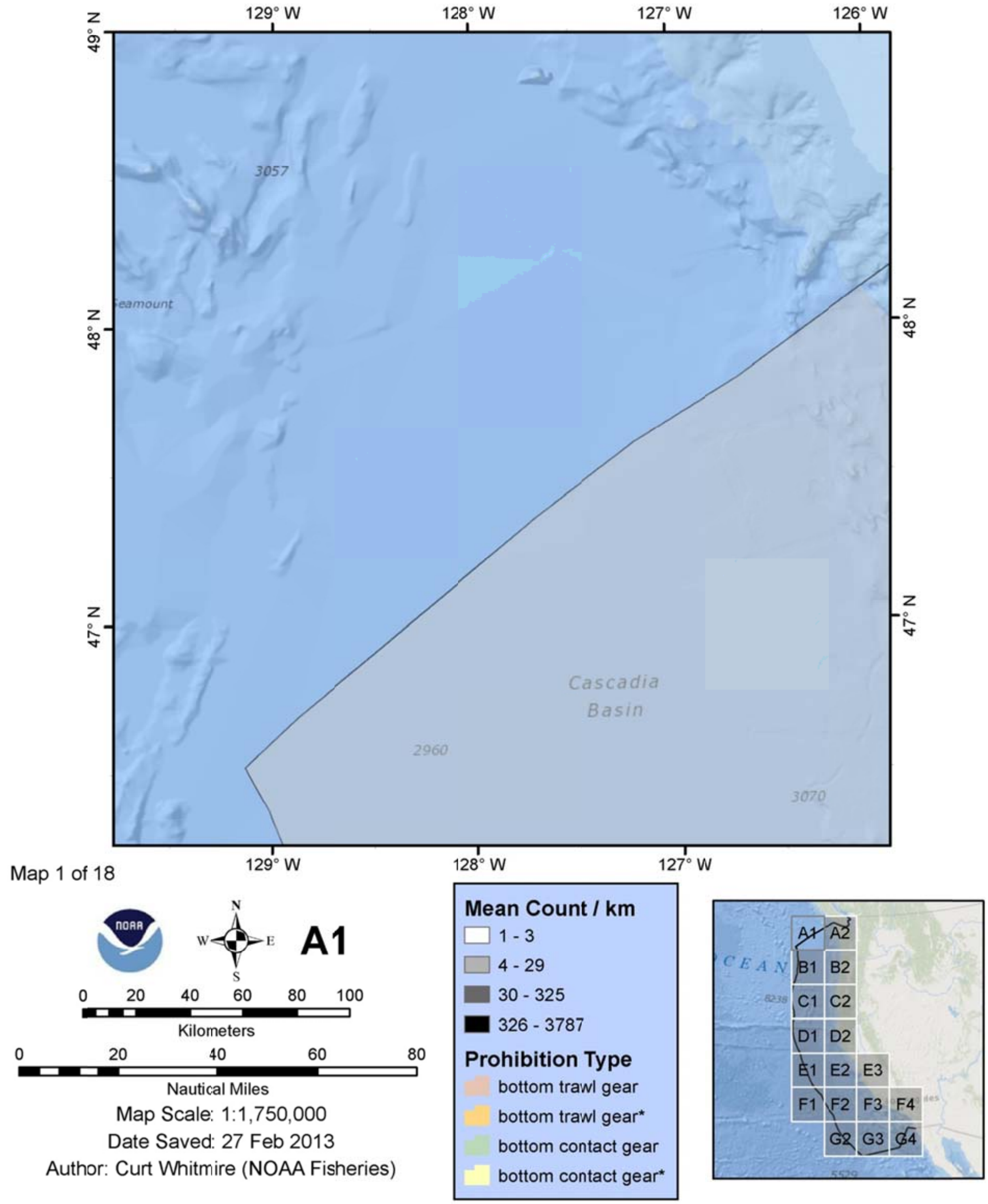


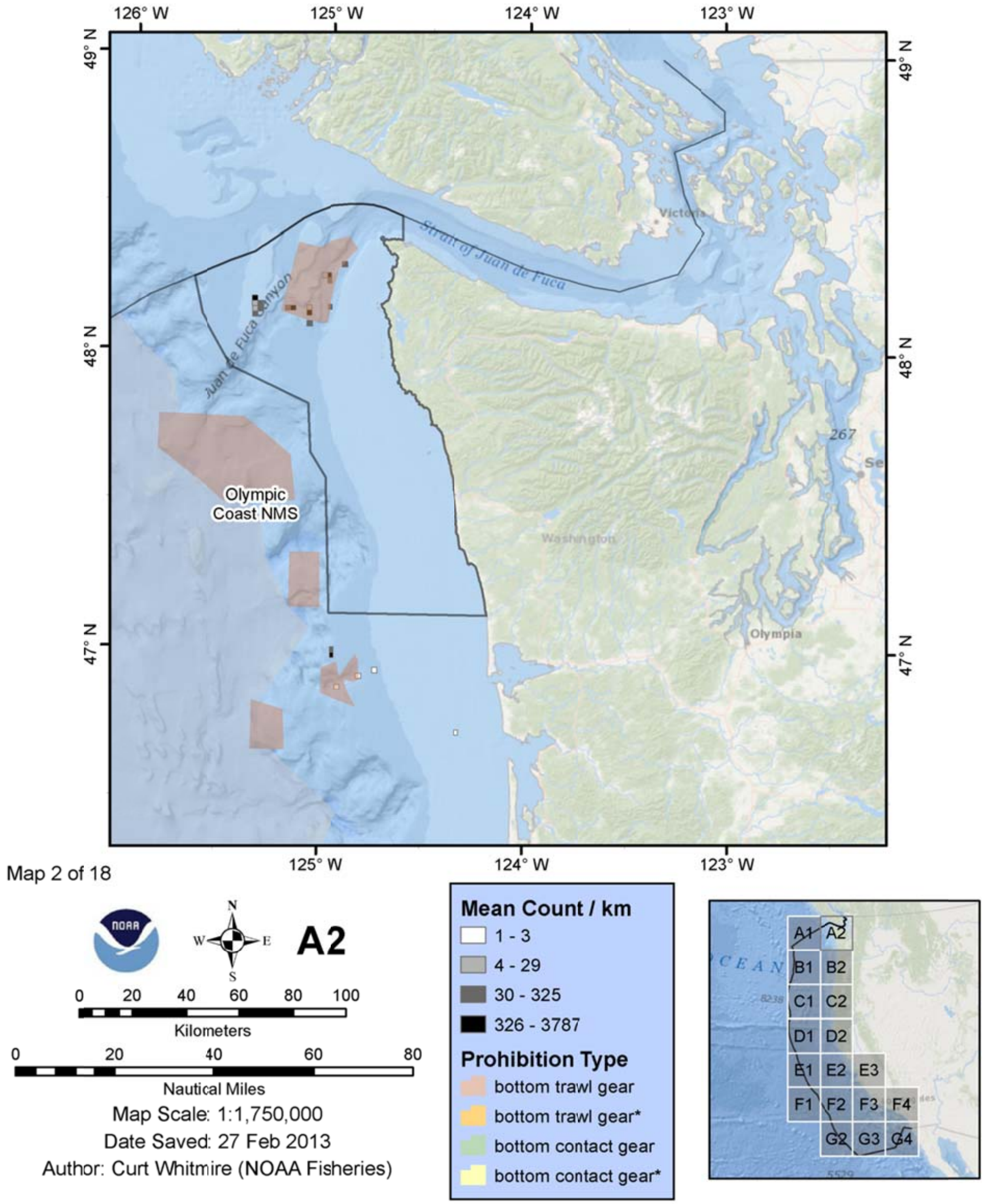
Figure A1.3.16a and b. Percentages of [a] coral (excluding pennatulids) and sponge presence [top], and [b] pennatulid presence [bottom] by depth zone and biogeographic sub-regions where commercial fishing is “prohibited” (to all gear types), “restricted” (to certain gear types) and allowed (“NO restrictions”). Presence was summarized within 1x1 km grid cells. The “Salish Sea” only encompasses the shallowest (“shelf”) depth zone.

Figure A1.3.17a, Maps A1-G4. Map views showing distribution of coral (excluding pennatulids) and sponge in situ observations, summarized as mean counts of observations by km of transect within 2x2 km grid cells. Mean counts per km are symbolized on a gradient of colors from lightest (lowest) to darkest (highest). EFH Conservation Areas are symbolized by gear prohibition, including bottom trawl (light brown), bottom trawl other than demersal seine (orange), bottom contact (green), and bottom contact and other gear deployed deeper than 500 m (yellow). The “Seaward of the 700-fm contour” conservation area is shown in transparent gray. Boundaries of each of the five west coast national marine sanctuaries (NMS) are also shown.

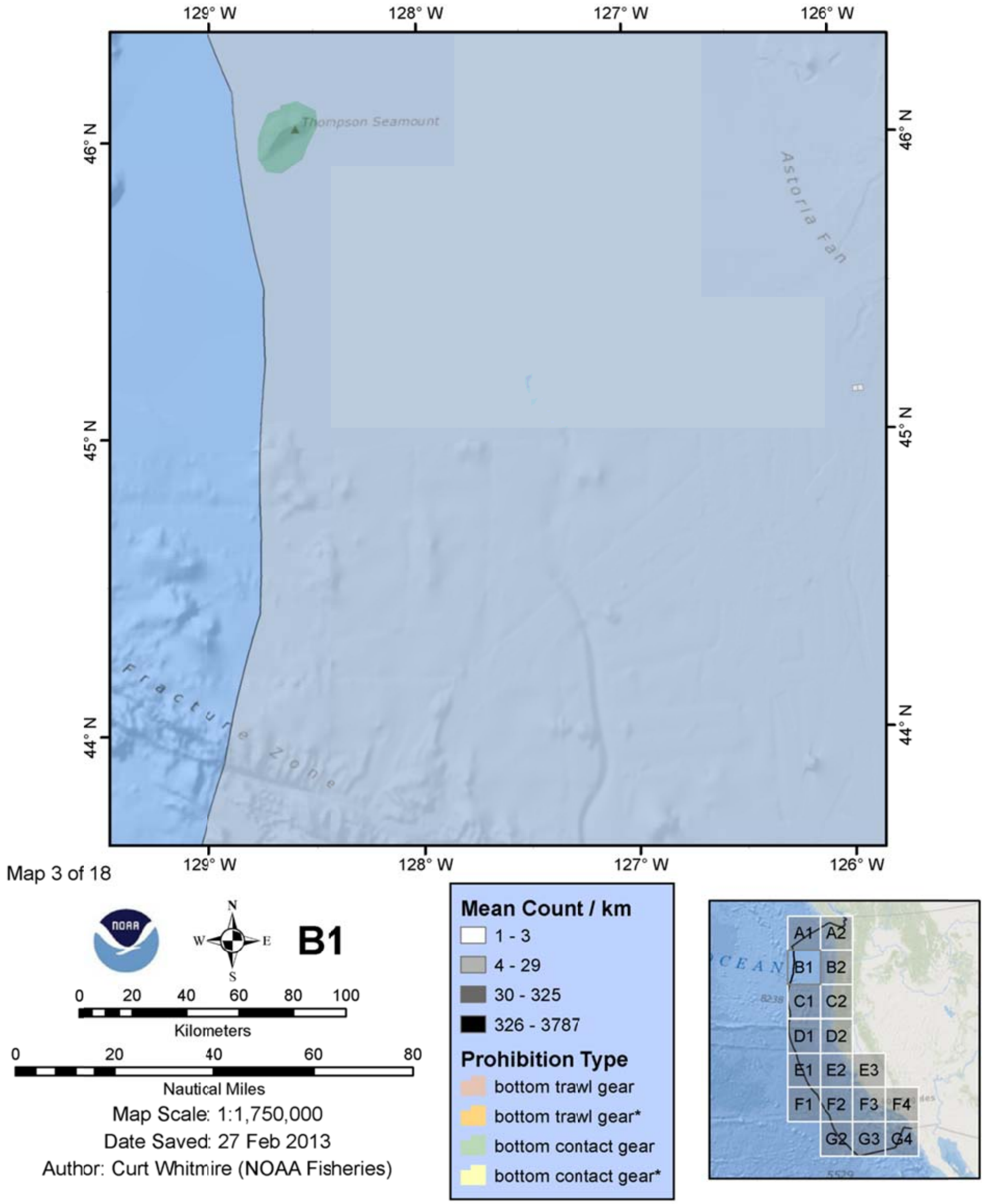
Coral (excluding Pennatulid) and Sponge Observations



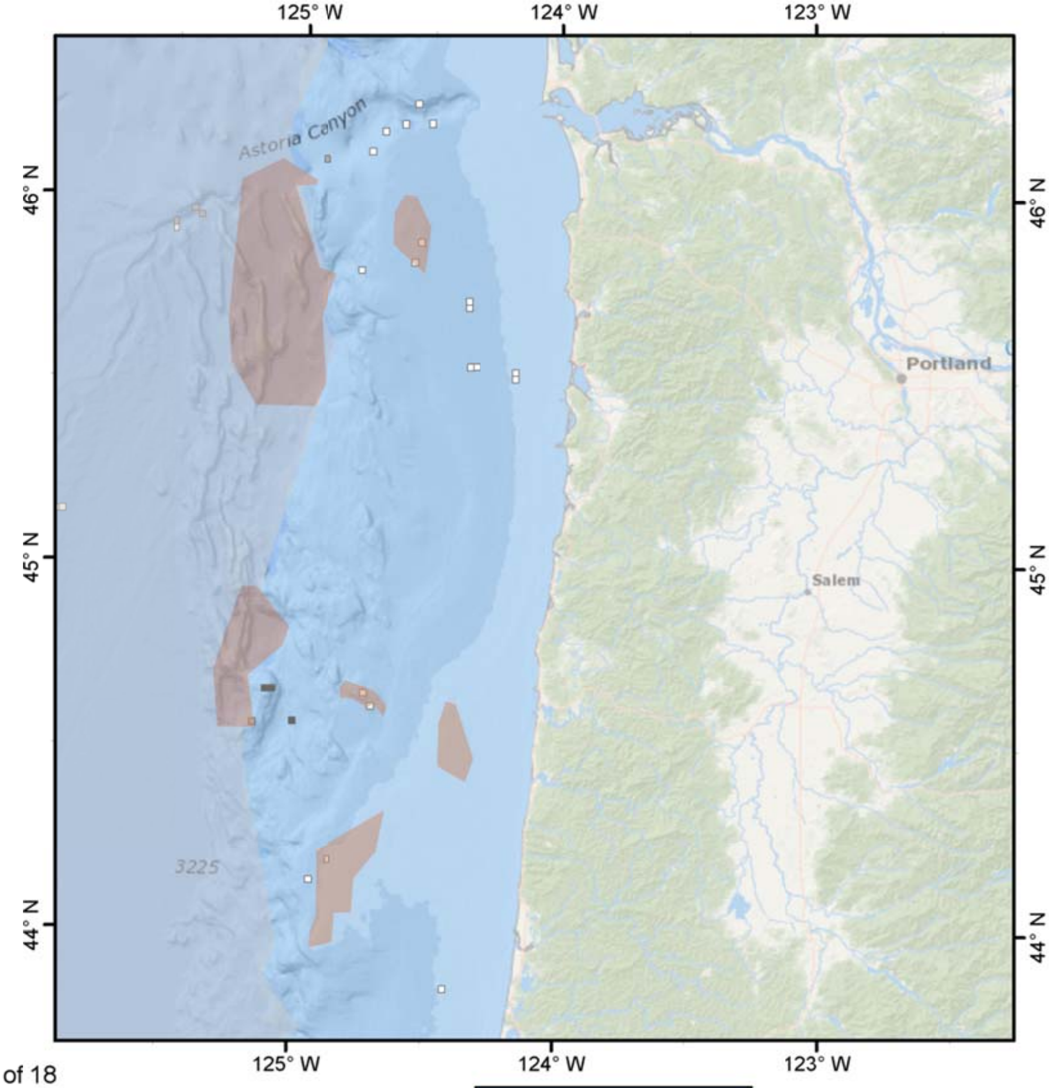
Coral (excluding Pennatulid) and Sponge Observations



Coral (excluding Pennatulid) and Sponge Observations



Coral (excluding Pennatulid) and Sponge Observations



Map 4 of 18

B2

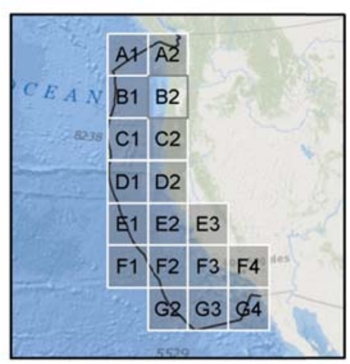
0 20 40 60 80 100
Kilometers

0 20 40 60 80
Nautical Miles

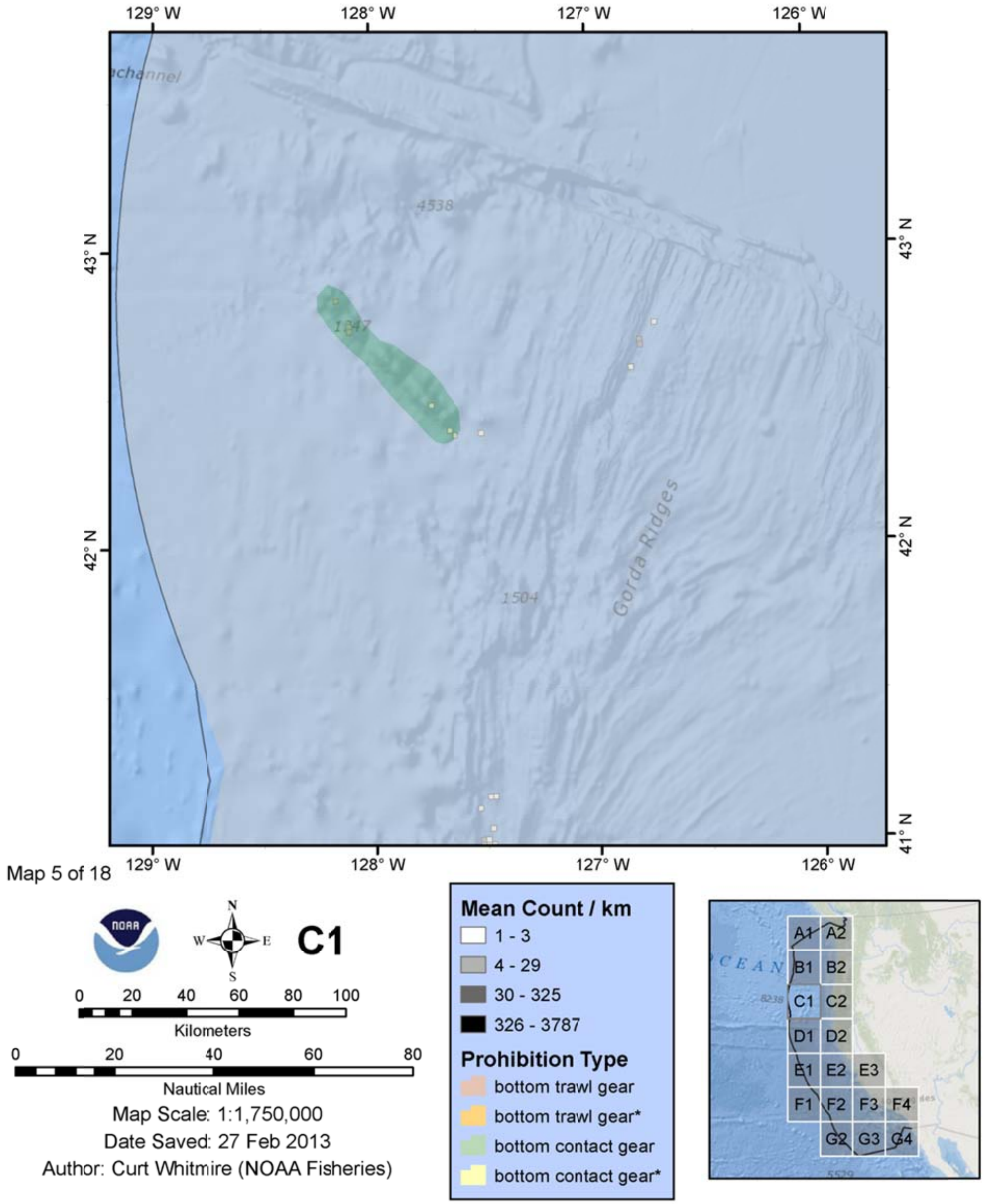
Map Scale: 1:1,750,000
Date Saved: 27 Feb 2013
Author: Curt Whitmire (NOAA Fisheries)

Mean Count / km
- 1 - 3
- 4 - 29
- 30 - 325
- 326 - 3787

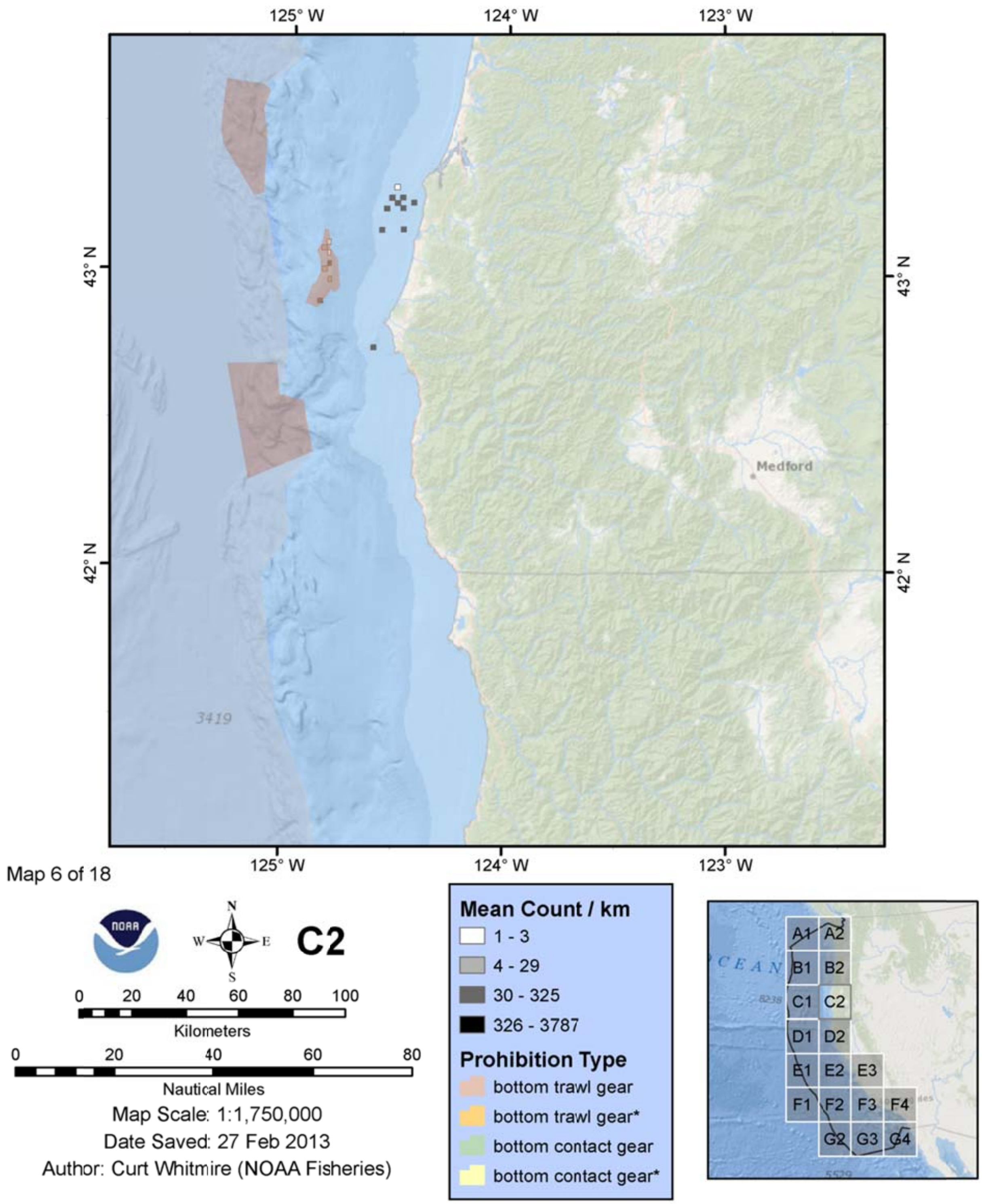
Prohibition Type
- bottom trawl gear
- bottom trawl gear*
- bottom contact gear
- bottom contact gear*



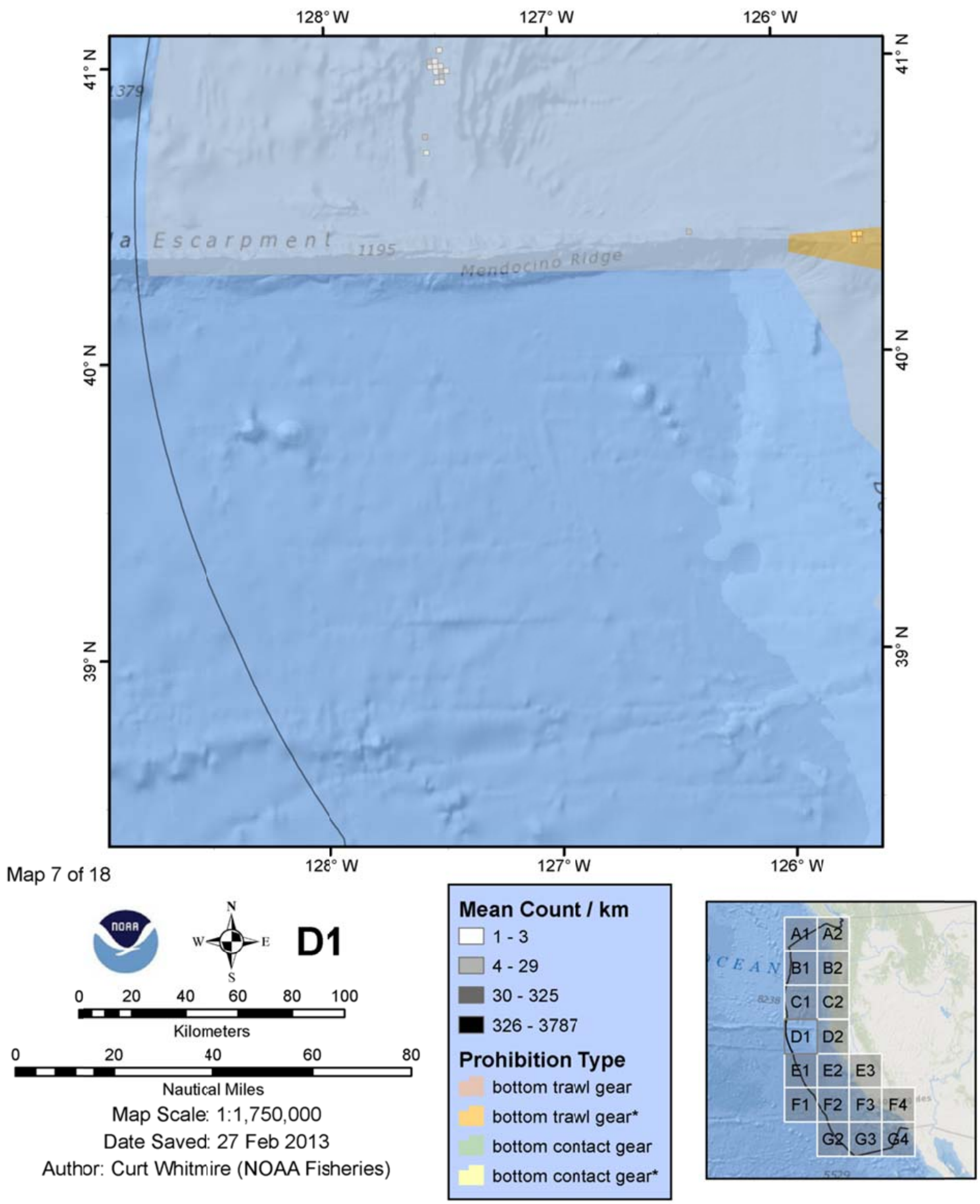
Coral (excluding Pennatulid) and Sponge Observations



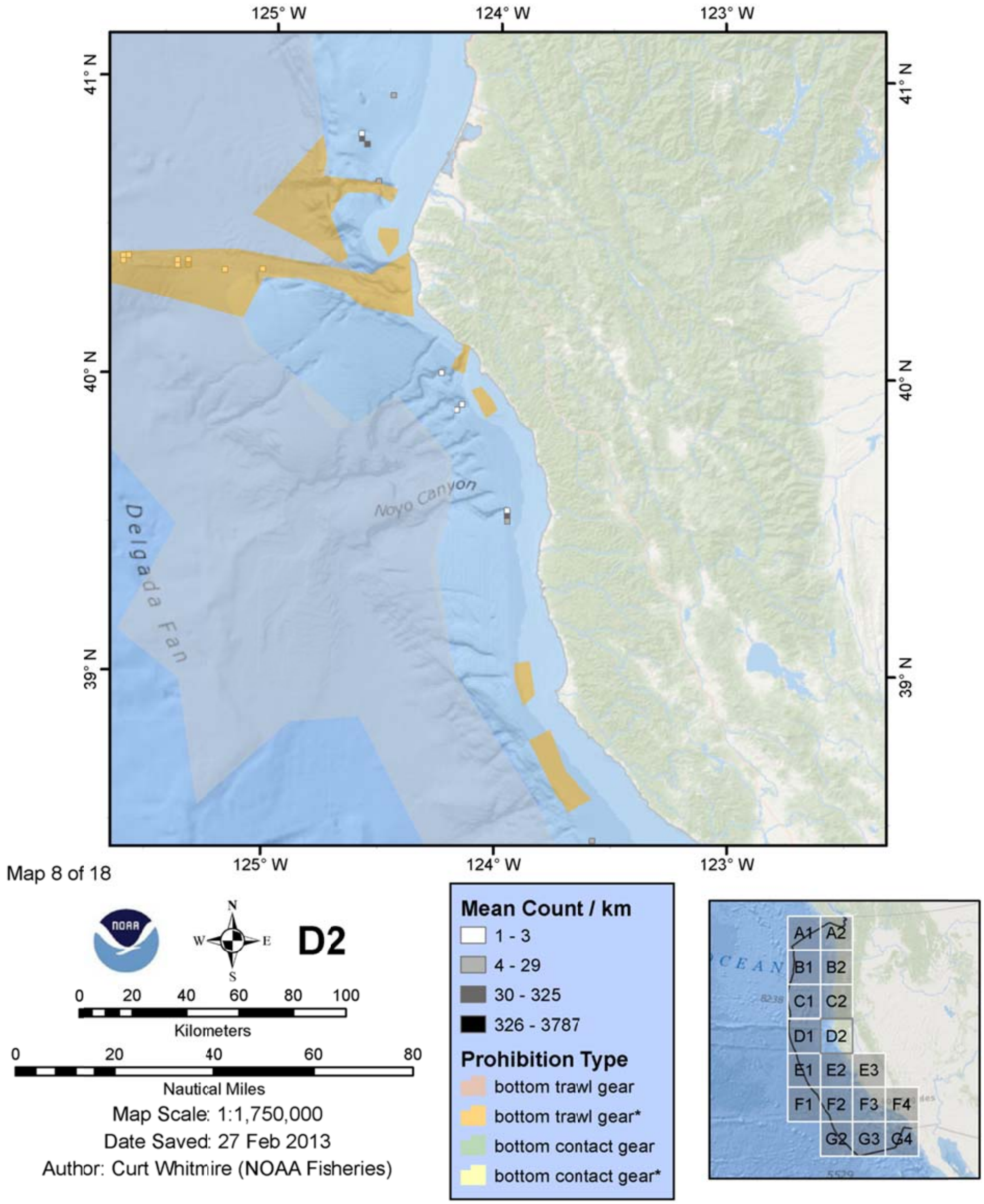
Coral (excluding Pennatulid) and Sponge Observations



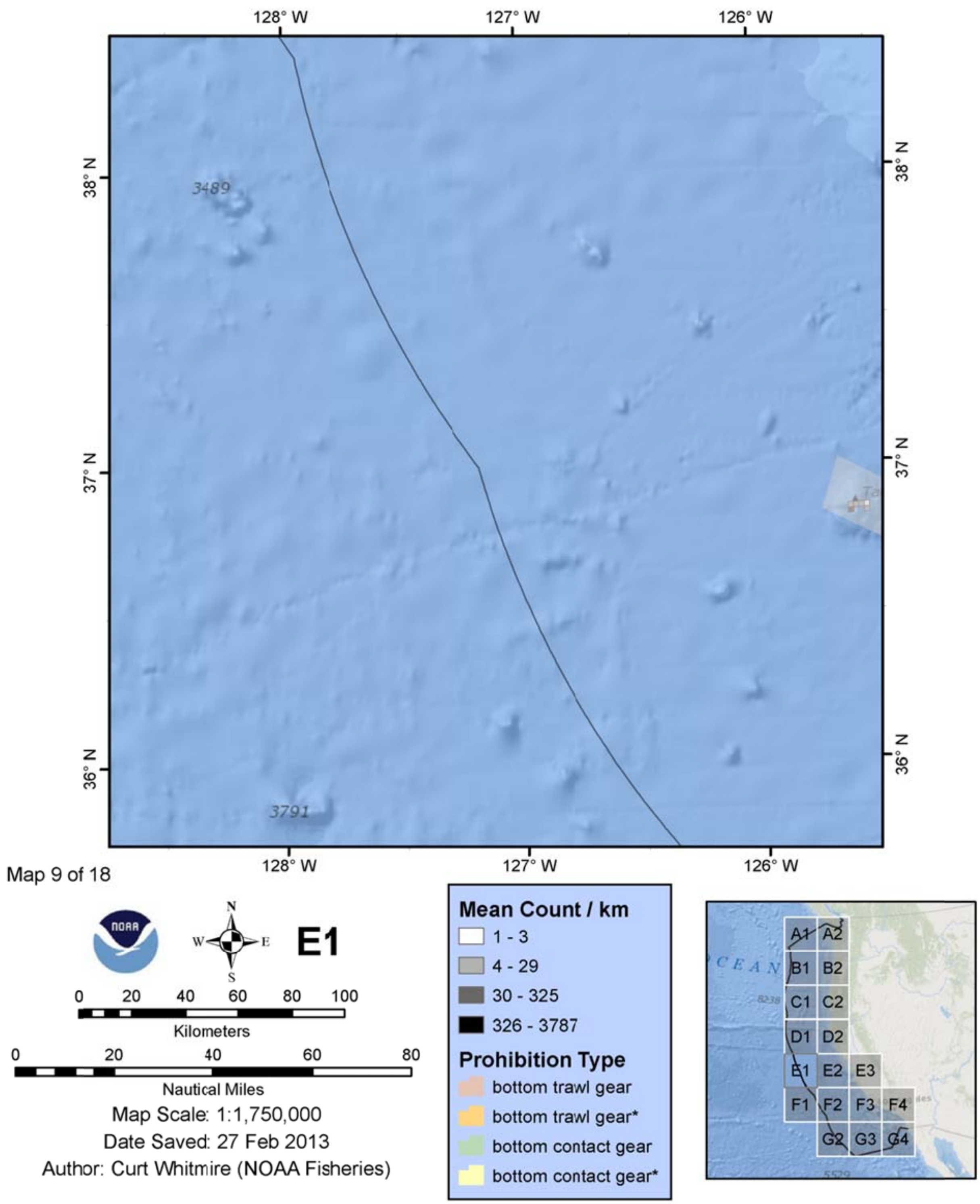
Coral (excluding Pennatulid) and Sponge Observations



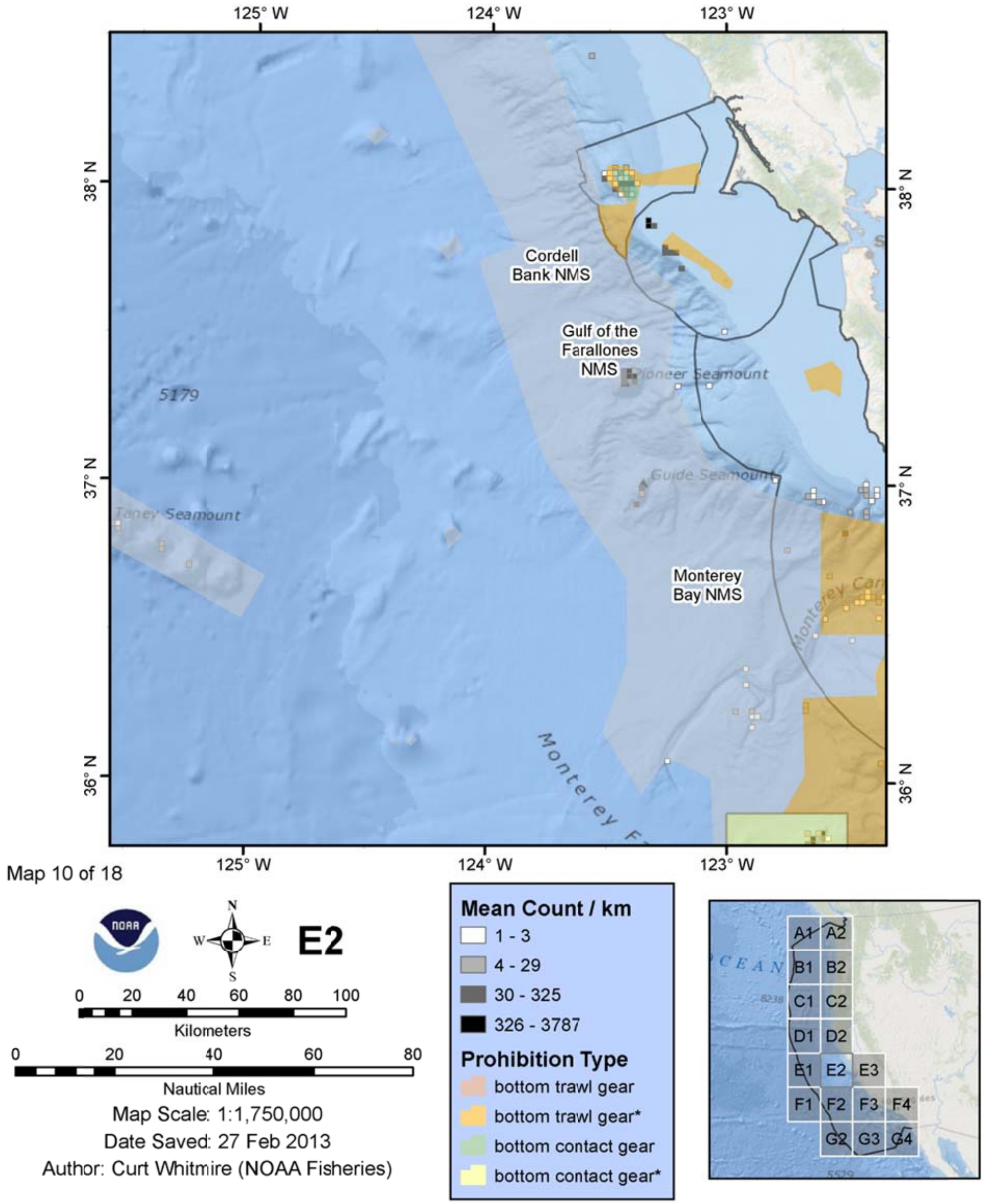
Coral (excluding Pennatulid) and Sponge Observations



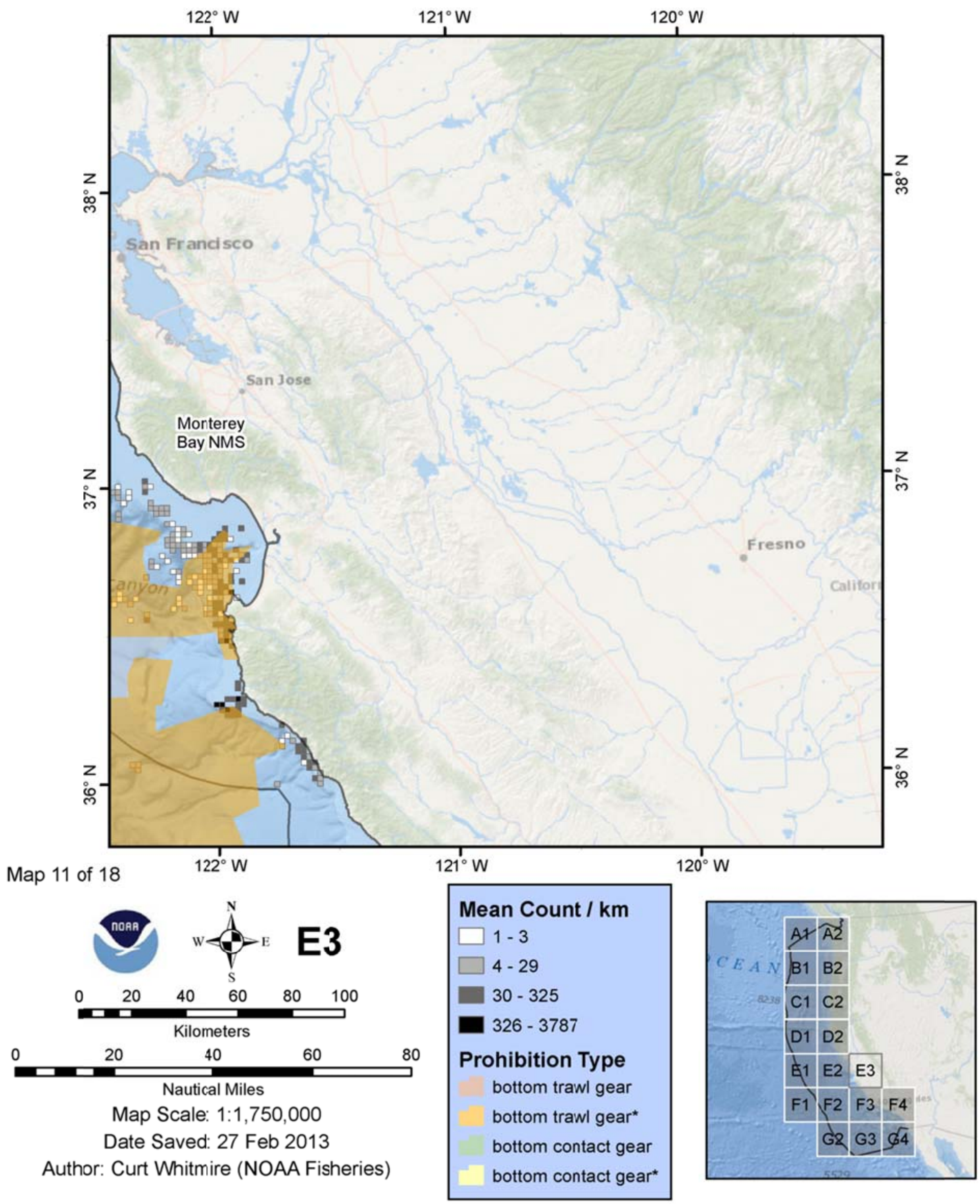
Coral (excluding Pennatulid) and Sponge Observations



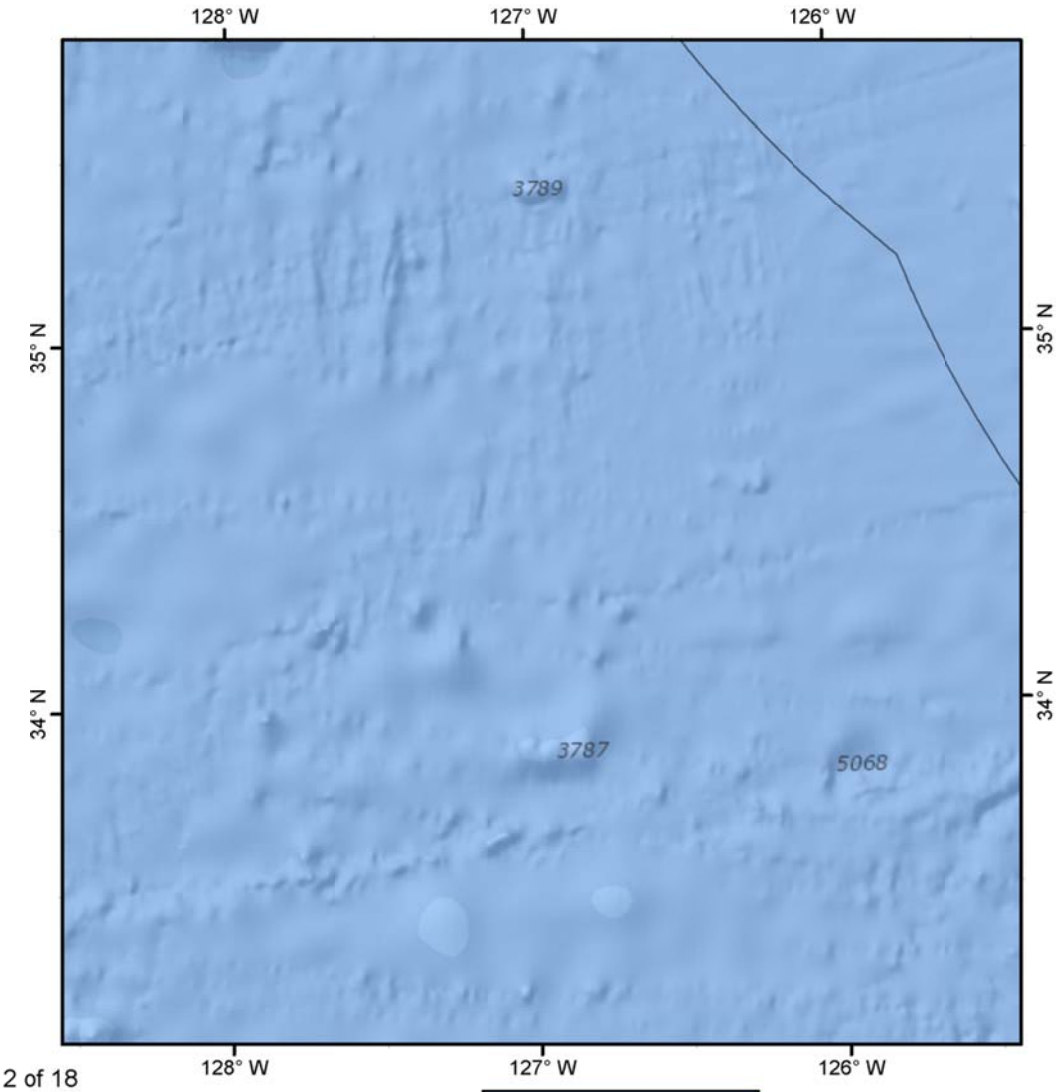
Coral (excluding Pennatulid) and Sponge Observations



Coral (excluding Pennatulid) and Sponge Observations



Coral (excluding Pennatulid) and Sponge Observations



Map 12 of 18

F1

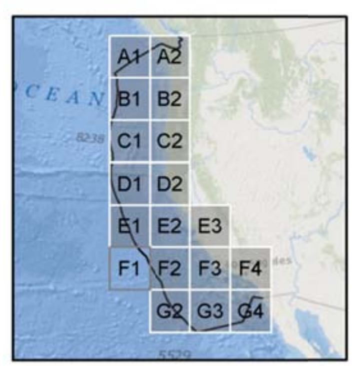
Kilometers: 0 20 40 60 80 100

Nautical Miles: 0 20 40 60 80

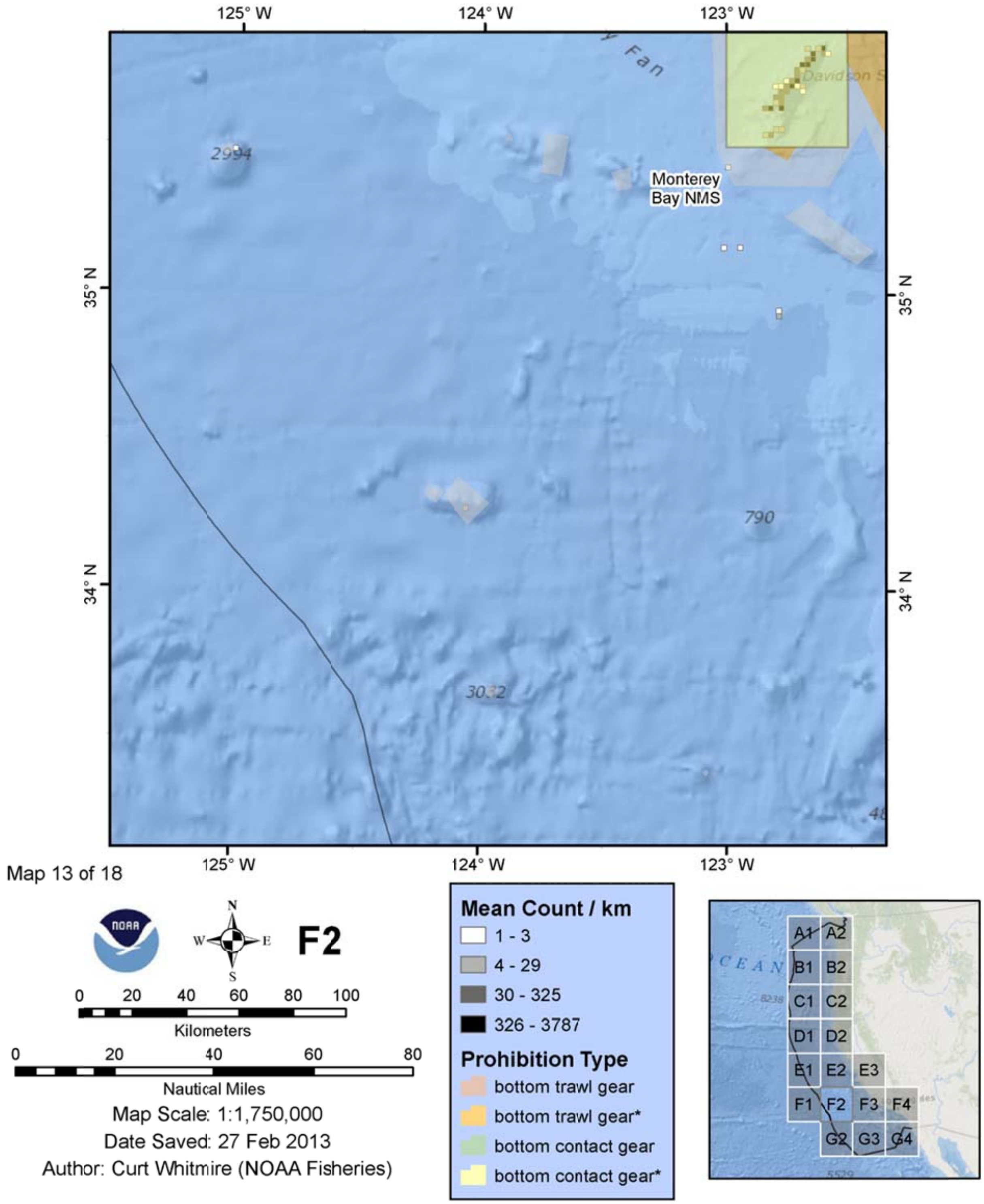
Map Scale: 1:1,750,000
Date Saved: 27 Feb 2013
Author: Curt Whitmire (NOAA Fisheries)

Mean Count / km
- 1 - 3
- 4 - 29
- 30 - 325
- 326 - 3787

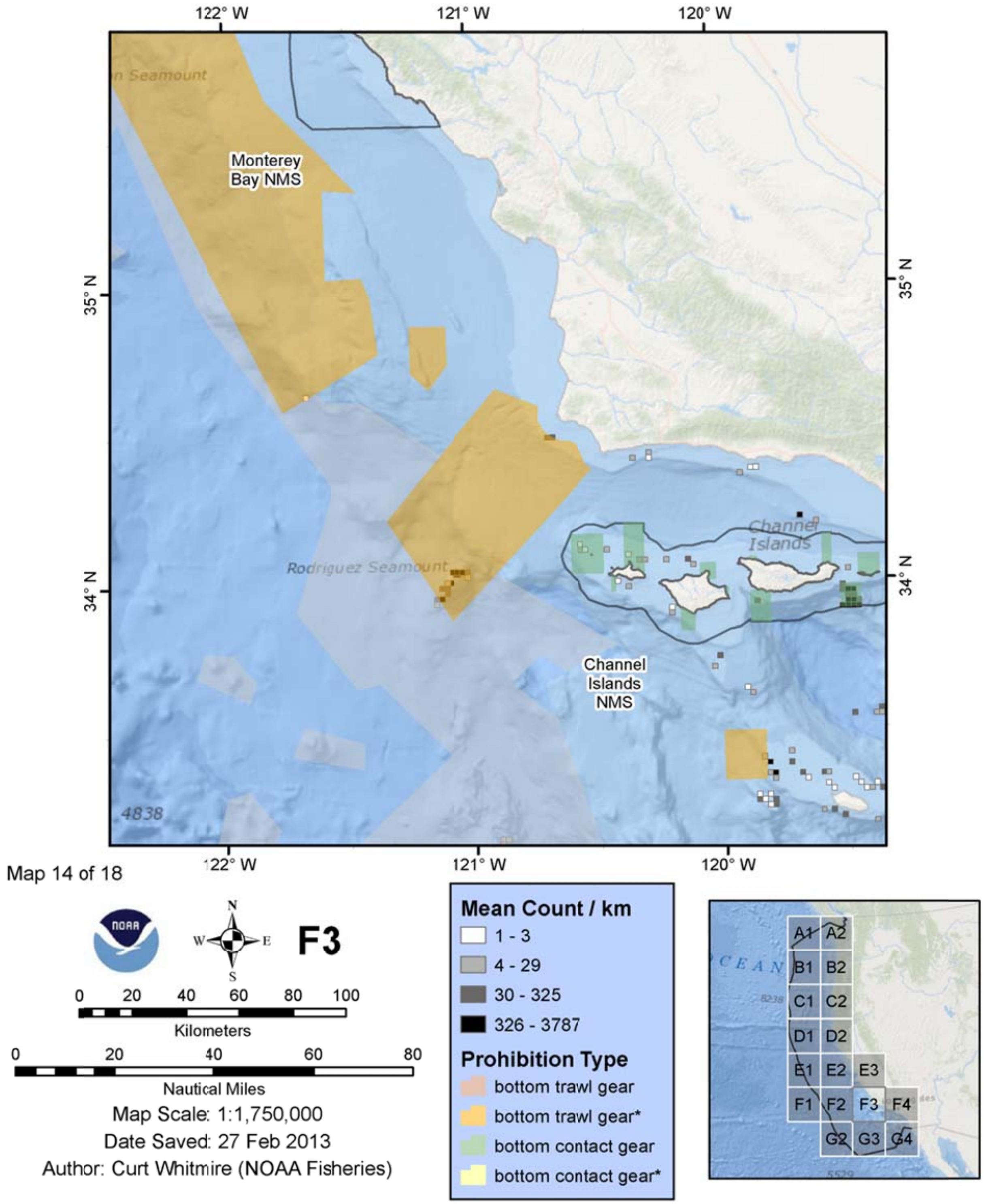
Prohibition Type
- bottom trawl gear
- bottom trawl gear*
- bottom contact gear
- bottom contact gear*



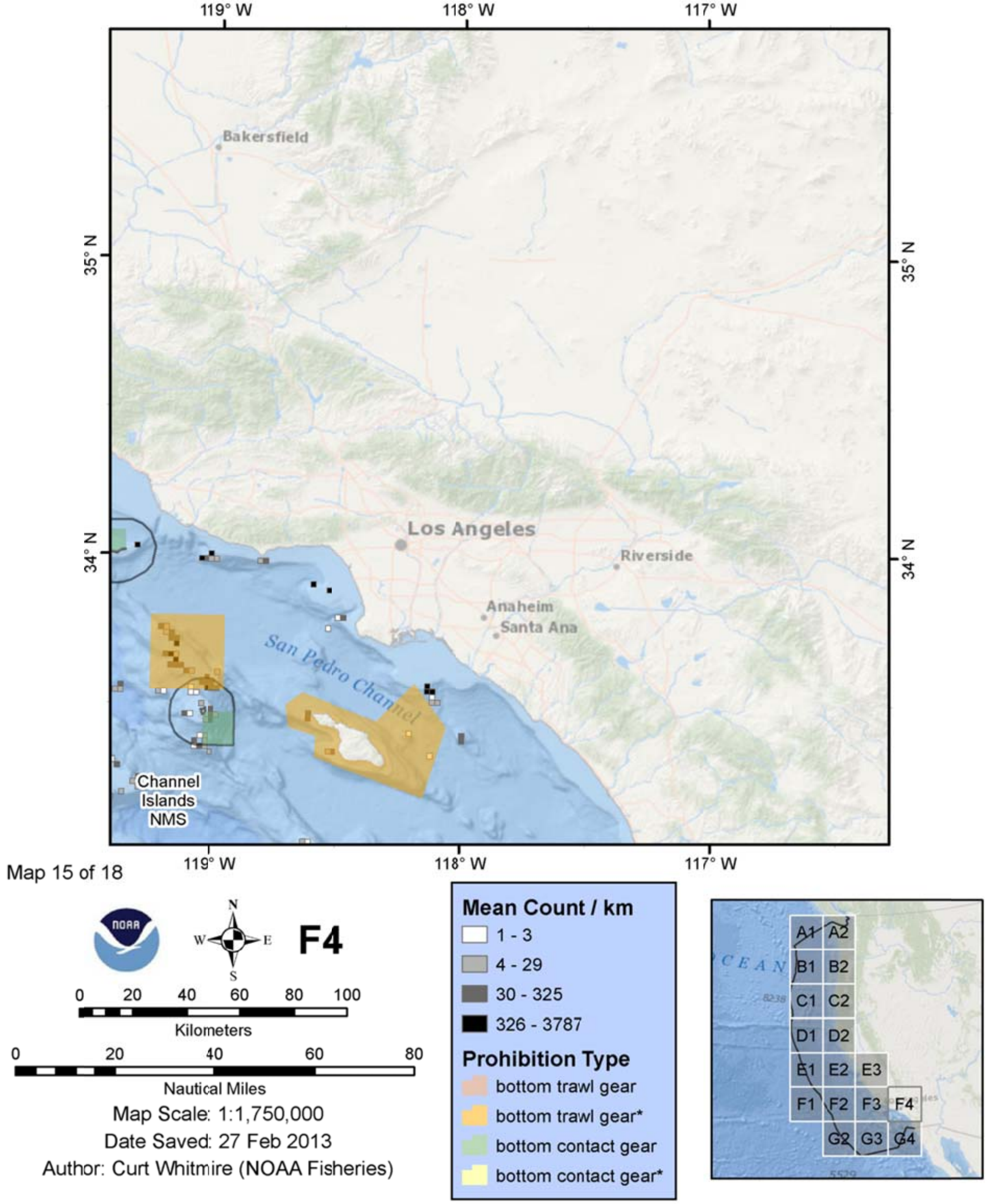
Coral (excluding Pennatulid) and Sponge Observations



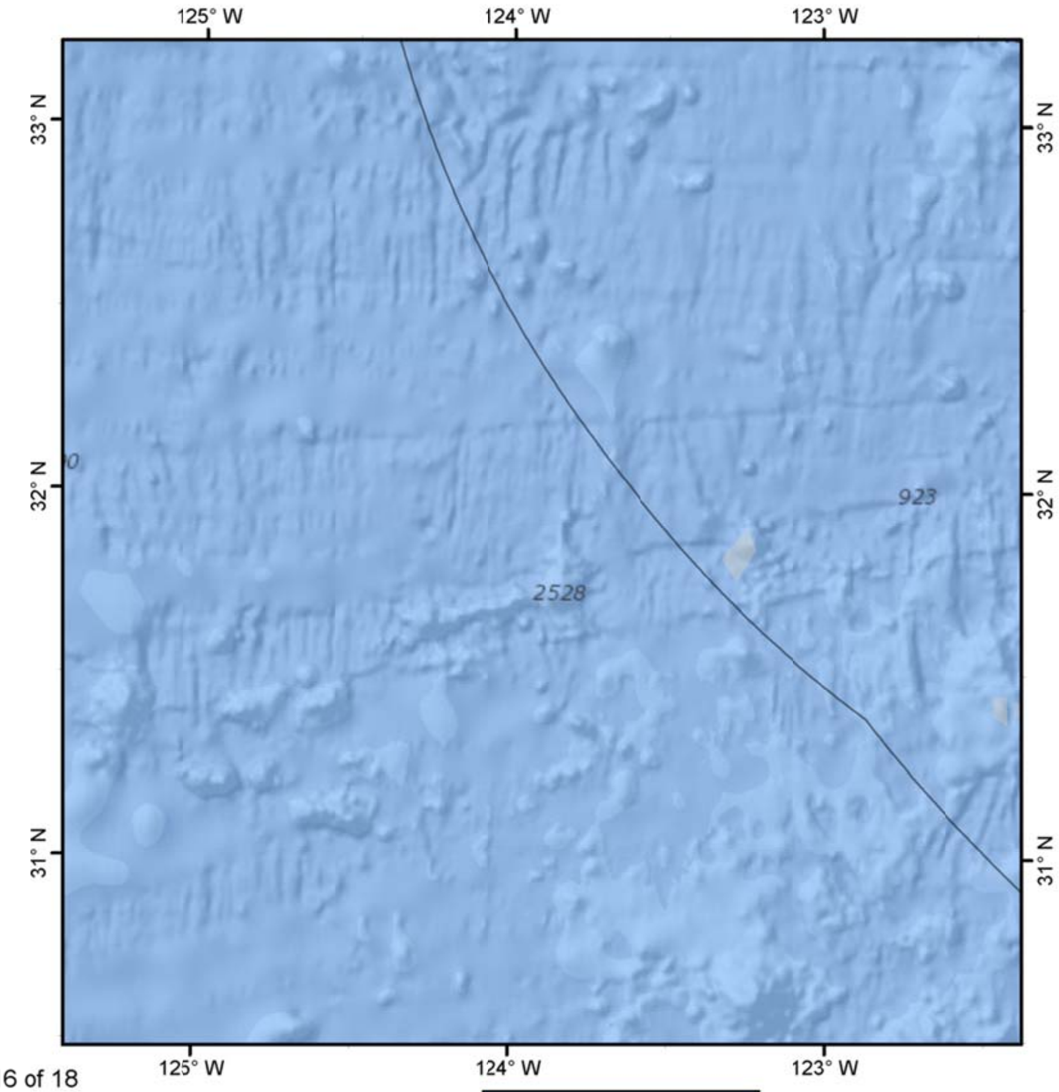
Coral (excluding Pennatulid) and Sponge Observations



Coral (excluding Pennatulid) and Sponge Observations



Coral (excluding Pennatulid) and Sponge Observations



Map 16 of 18

G2

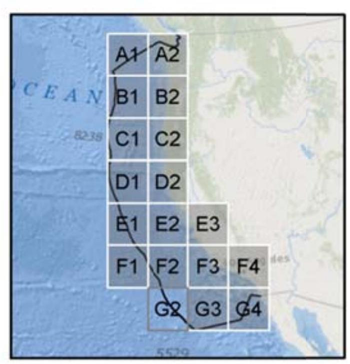
0 20 40 60 80 100
Kilometers

0 20 40 60 80
Nautical Miles

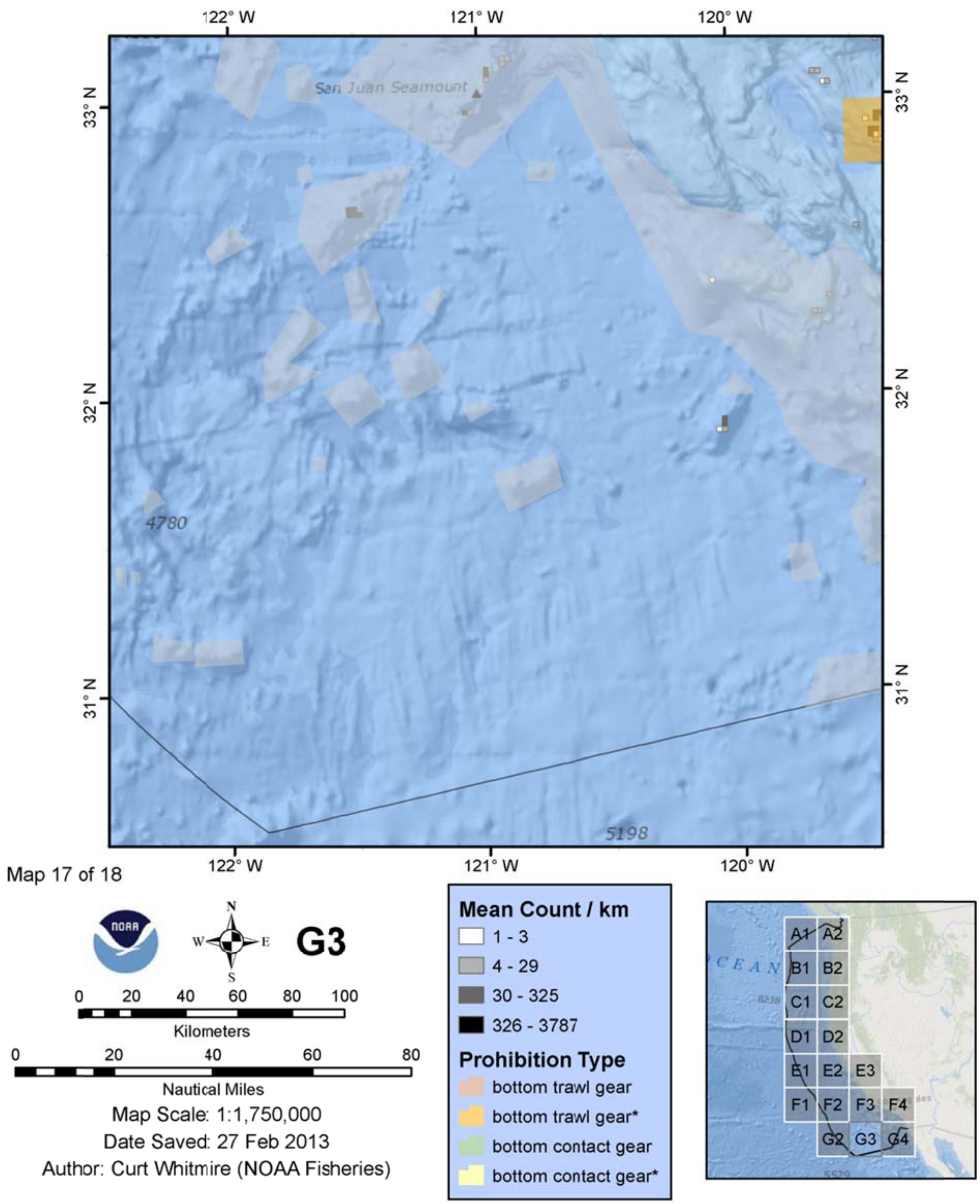
Map Scale: 1:1,750,000
Date Saved: 27 Feb 2013
Author: Curt Whitmire (NOAA Fisheries)

Mean Count / km
- 1 - 3
- 4 - 29
- 30 - 325
- 326 - 3787

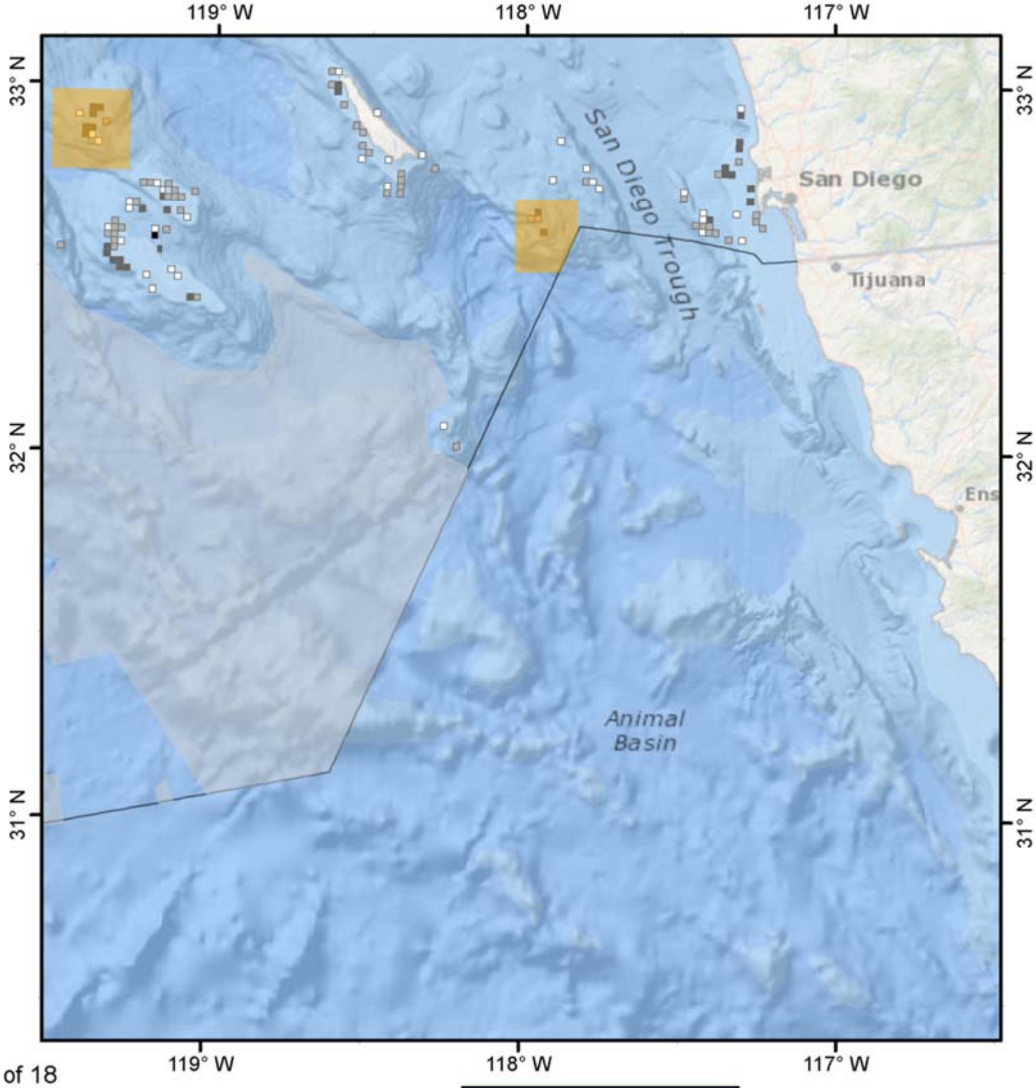
Prohibition Type
- bottom trawl gear
- bottom trawl gear*
- bottom contact gear
- bottom contact gear*



Coral (excluding Pennatulid) and Sponge Observations



Coral (excluding Pennatulid) and Sponge Observations



Map 18 of 18

G4

0 20 40 60 80 100
Kilometers

0 20 40 60 80
Nautical Miles

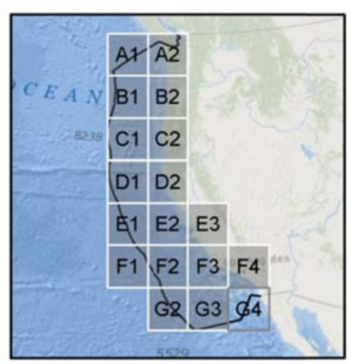
Map Scale: 1:1,750,000

Date Saved: 27 Feb 2013

Author: Curt Whitmire (NOAA Fisheries)

Mean Count / km
- 1 - 3
- 4 - 29
- 30 - 325
- 326 - 3787

Prohibition Type
- bottom trawl gear
- bottom trawl gear*
- bottom contact gear
- bottom contact gear*



2.0 METHODS FOR MODELING SPECIES-HABITAT RELATIONSHIPS

2.1 DESCRIBE BAYESIAN MODELING FRAMEWORK FOR DETERMINING ASSOCIATIONS BETWEEN GROUNDFISH SPECIES AND HABITAT COVARIATES

2.1.1 Figure and Table labeling conventions:

Here we outline the statistical modeling methods used for estimating species-habitat relationships. We detail the Northwest Fisheries Science Center model (NWFSC model; Section A2.1) and the National Centers for Coastal Ocean Science model (NCCOS model; Section A2.2). Both model descriptions include a discussion of the habitat variables included in the model, model structure, computational issues, and model selection algorithms employed. Both models were applied to the six focal species described in the synthesis section of the document. The NCCOS model was also developed for an additional five species. The primary data source for both models is the west coast NOAA trawl survey. Both models provide estimates for the expected catch at particular locations and the uncertainty associated with the expected catch at each location. For brevity, we present only the point estimates of expected catch in the figures.

Figs. 2.1 to 2.18 are identical to the figures in Section 3 of the main report and display the results for the NWFSC and NCCOS models for the six focal species. Figs. 2.19 to 2.23 show the results for the 5 species modeled by NCCOS but not NWFSC. Figs. 2.24 and 2.25 illustrate the construction of the NWFSC model and Figure 2.26 shows the location of survey trawl locations for 2003-2011.

2.1.2 Shared Data Sources for the NWFSC and NCCOS models

Groundfishes were modeled using species, relative abundance and effort observations collected as part of the annual fishery-independent West Coast Groundfish Bottom Trawl Survey (Slope and Slope/Shelf combined time series). The data was provided by the NWFSC - Fishery Resource Analysis and Monitoring (FRAM) Division (Figure 2.26). The West Coast Groundfish Bottom Trawl Survey was designed specifically to provide a fishery-independent data basis for the statistical assessments required by the fisheries management process, and its unbiased statistical design lends itself to assessing habitats within areas well-sampled by the survey.

The sampling design and gear used by the NWFSC has been explained by Keller et al. (2008 and 2012) and Bradburn et al. (2011). Briefly, the NWFSC has been conducting annual bottom trawl surveys off the U.S. West Coast since 1998. We use only data collected after 2003, which is when the sampling design was changed to expand the depth coverage and measure additional fishes. After 2003, tows were collected on the shelf and slope in depths from 55-1280 meters in the U.S. exclusive economic zone. On average 700 randomly positioned tows were collected each year using a sampling design stratified by geographic region and depth. Tows were taken targeting a fishing time of 15 minutes and a speed of 2.2 knots. Vessels were equipped with customized Aberdeen style nets with a small mesh (3.8 cm stretched measure) liner in the codend, a 25.9-m headrope, and a 31.7-m foot rope and a differential geographic positioning system (DGPS). DGPS data were used to estimate tow position and distance fished. Area swept was provided in the received dataset and was the product of the mean net width and the distance fished. All fish and invertebrates were sorted to species (or the lowest possible taxon), and then weighed. For more information on the West Coast Groundfish Bottom Trawl Survey contact the NWFSC's FRAM division or visit their website at: http://www.nwfsc.noaa.gov/research/divisions/fram/index.cfm.

2.1.3 NWFSC model

2.1.3.1 Data Sources

The NWFSC model primarily used data from the trawl survey (described above; years 2003-2011) but also supplemented trawl data with visual survey data from submersibles. While the trawl survey is a rich data set, it provides a fundamentally biased sampling of benthic habitats (e.g. Jagielo et al 2003). Because bottom trawl gear does not function well in areas with steep, rocky seafloor, these habitats are largely unsampled during the survey. As a result, any species that is strongly affiliated with rocky habitats is poorly sampled during the trawl survey. While this fact has a number of broader implications - it makes it difficult to account for unsampled areas in stock assessments - in the context of EFH it affects the ability to estimate species-habitat associations by limiting the range of bottom-type habitats sampled. For example, it is impossible to determine if a species prefers sandy or boulder substrate if we only sample sandy substrates. Fortunately, the habitats that are impossible to sample with trawl gear have been investigated using other sampling techniques. The rocky outcrops have been studied with underwater submersibles and visual surveys (Yoklavich et al. 2000, Jagielo et al. 2003, Tissot et al. 2007; Table A2.1.1). In general, visual surveys provide much more detailed information about small-scale habitat associations (on the 10s to 100s m^2 scales) than trawls which integrate abundance information on the 10,000m^2 scale.

Due to time limitations, we were only able to include a subset of the available submersible survey information for the west coast (see Table A2.1.1). We hope to gradually incorporate more submersible survey information in the coming years.

While the visual surveys potentially provide information on the probability of occurrence and abundance aspects of the model, in our analysis we only used submersible surveys to inform the probability of occurrence portion of δ-GLM. We did this primarily because virtually all submersible surveys occurred before 2003 (some occurred in the 1980s). We felt comfortable modeling all of the submersible surveys as if they occurred in 2003 for the probability of occurrence because we viewed it as vital to include the observations from these poorly sampled habitats, even if it resulted in confusing temporal and spatial processes. All visual surveys occurring before 2003 were modeled as if they occurred in 2003. Because of the much larger variability in the abundance data and the fact that the submersible surveys reported counts for each species not biomass, we elected to rely exclusively on the trawl data to inform the abundance model.

In some cases we were able to compile transect by transect data from the submersible surveys. In such cases, we tallied whether the species was observed during the transect and used the transect midpoint to extract the relevant habitat values from those locations. We used the area visually searched by the submersible as the area offset. Generally, the area searched by submersibles was substantially lower than the area swept during the trawl survey. This means we assume that the detectability of fish in the trawl survey is equivalent to the visual surveys. While this assumption is likely violated in practice, we have no information about the selectivity of trawl surveys relative to visual surveys and so cannot directly account for any potential detectability variation between survey methods. In some cases we extracted information from published literature that did not have the individual tows. We also developed methods for incorporating these aggregated survey data in a small number of instances (<10 observation; see *Parameter models* below).

2.1.3.2 NWFSC Model Description (Non-technical)

The statistical model is designed to identify the relationship between habitat and fish abundance in the California current ecosystem. The habitat data included are described elsewhere in this document (see Section 2.1 and Appendix 1). We rely primarily on the NOAA west coast bottom trawl survey as for data on fish abundance.

The statistical model is divided into two components. The first component models the probability of occurrence for each species and the second component models the abundance of fish. Each component is subsequently comprised of two additive parts. Because both the probability of occurrence model and abundance models have the same basic model structure, we will only describe the probability of occurrence model here.

Taking the probability of occurrence portion of model, we can describe generic probability of occurrence model for species "*A*" as: the probability of occurrence of species *A* at point *s* is proportional to the effect of habitat plus the effect of space. Here "effect of habitat" is the contribution of habitat variables at location *s* to the probability observing at least one individual of species *A.* In our modeling we considered four habitat variables: water depth, bottom temperature, seafloor sediment grain size (ranging from rock to silt), and the distance from the observation to the nearest rock outcrop. The overall effect of habitat on probability of occurrence is a linear combination of habitat variables. For example, one potential model is: effect of habitat = effect of depth + effect of bottom temperature + effect of distance to rock. The model estimates how well each habitat variable explains the observed occurrence of species in the trawl survey.

The contribution of each habitat variable to the probability of occurrence is relatively intuitive. However, no matter how well we choose our habitat variables, we will likely not have included all of the important aspects that drive a species occurrence and abundance. There are other variables that are important determinant of the distribution of species that are not included. Some of these variables may be habitat related (e.g. the presence of corals or other biogenic habitats) while others may be biological or physical (e.g. a species is unable to disperse to a particular location). Furthermore, there will be some component of randomness that introduces variation into the observed fish abundance in a trawl. Overall, these unobserved and random components mean that some locations will have higher probability of occurrence than we expect based on their habitat alone while other locations will have lower probability of occurrence. Furthermore, we expect areas that are close together in space tend to be similar in their deviation from the habitat effect. The “effect of space” term above takes the spatial clustering of unusually high or low predictions by the habitat variables and estimates a smooth surface that tries to account for the variation not explained by the habitat variables.

Using this basic model structure, we estimated a series of models using our four habitat variables. We use Bayesian statistical methods to estimate the model parameters. Bayesian models are particularly useful because they allow for the incorporation of prior information about parameters. We then use model selection techniques to identify which habitat covariates should be retained and included in the final model. Finally, we use the preferred model to create a predictive map of the probability of occurrence and abundance for each species and contrast our results with the NCCOS model.

2.1.3.3 NWFSC Model Description (Technical)

We develop a hierarchical generalized linear model to describe species-habitat associations (see Cressie and Wikle 2011, Wikle 2010). The model focuses on the NOAA trawl survey data because this is the largest single source of available data for west coast groundfish. However, other types of information can be incorporated into the same modeling framework as shown below. We use Bayesian statistical framework because of its flexibility and ability to incorporate prior information. Additionally, the Bayesian framework allows for explicit incorporation of uncertainty in the spatial component of the model. In general, the models we employ are known in the fisheries literature as δ-GLM models (Stefánsson 1996, Maunder and Punt 2004) and in the spatial statistics literature as hurdle models (Ver Hoef and Jansen 2007).

We model the trawl and submersible data as a point process. We treat the fish collected during each trawl or transect as if it were collected at the midpoint of the trawl or visual transect. We acknowledge that the trawl and submersible surveys are not actually point observations but rather an aggregation of fish collected (or visually counted) over a larger area. However, the sampled transect is small relatively to the distance between samples and so we view treating the data as point observations as a reasonable approximation that provides flexibility in modeling the spatial structure (Royle and Wikle 2005, Latimer et al. 2009).

In the following sections, we begin by outline the statistical model. The model consists of three main components: 1) a data model that describes the process of observing fish, 2) a process model that describes the variation in the fish abundance as a result of habitat variables, and 3) a parameter model which describes our prior assumptions about model parameters. After describing the model structure, we describe the selection of habitat covariates to include in the habitat model. Finally, we discuss the model implementation, model diagnostics, model selection, and other technical details.

Notation

Throughout our mathematical description of the model, capital letters indicate random variables, lowercase Greek letters indicate scalar parameters and latent variables, bold lowercase symbols indicate vectors, and bold uppercase denote matrices. We always use base *e ("natural")* logarithms.

Data Model

We start by writing a model for the catch of a single species at position s_{iy} during the NMFS trawl survey, $Z(s_{iy})$, where i indexes the observation and y indexes year. For notational simplicity and clarity, in the following description we consider observations that occur within a single year and omit the y index. Generally, $Z(s_i)$ is reported in biomass but poorly described by a single continuous distribution; $Z(s_i)$ cannot be negative and but can have a large number of 0 observations. This fact motives the use of mixture distributions that can break the observed catches into two components, a probability of occurrence component to account for observed 0 catches and a positive component that describes the distribution of catches conditioned on the presence of fish (Stefánsson 1996, Maunder and Punt 2004). In recent years, this modeling approach has gained favor for modeling trawl catches because it can accommodate the abundance of zero-observations in trawl data. We follow this trend and write the random variable $Z(s_i)$ as a mixture distribution conditioned on model parameters,

$$Z(s_i)|\phi(s_i), \mu(s_i), \psi \sim Bernoulli(\phi(s_i))Gamma(\mu(s_i), \psi) \qquad \text{(A2.1.1)}$$

Here $\phi(s_i)$ is the probability of catching at least one fish; therefore, the probability of catching zero fish is 1- $\phi(s_i)$. Then $Gamma(\mu(s_i),\psi)$ determines the distribution of catches for the non-zero tows. We parameterize the gamma distribution in terms of its mean, μ, and coefficient of variation, ψ[1]. We assume that the CV of observed catches scales with the mean catch in a consistent manner across all sites (i.e. ψ does not have a spatial or temporal component). The gamma distribution is only one of several possible alternative models for the probability density function of positive observations. Other authors have used a range of other positive distributions to model observed catches (Maunder and Punt 2004). These alternate distributions can easily be used in place of the gamma distribution. Throughout our model description and results, we refer to the Bernoulli component of the mixture as the "probability of occurrence" part of the model and the gamma component as the "abundance" or "positive" part of the model. It is possible to allow the two components of eqn A2.1.1 to be correlated such that the probability of occurrence component informs the abundance component (Thorsen and Ward *In review*). It is computationally and conceptually easier to treat the two processes as independent. We treat them independently here.

In the results, we show two plots for each species. The first is a result for the Bernoullli component, titled "probability of occurrence" maps (see Figs 2.1 to 2.18) which show the expected value of $\phi(s_i)$, $E[\phi(s_i)]$. We also show results for the full abundance model that includes both the Bernoulli and gamma components of the model, which the product of the expectations for the two components: $E[\phi(s_i)]E[\mu(s_i)]$.

Process Model

Thus far we have specified a data model which describes how the random variable $\boldsymbol{Z}$ is a mixture distribution. We join the parameters of the mixture distribution to measurable attributes of the environment using a generalized linear model. We write the mean for the two components of our model as a linear combination of explanatory variables, $\boldsymbol{X}$, fixed regression parameters, $\boldsymbol{\beta}$, and spatial effects, $\boldsymbol{w}$. We also need to account for variation in the amount of effort expended in catching the observed fish. Let Y be the effort offset. We use a logit-link function for the probability of occurrence and a log-link for the abundance component,

---

[1] So, $f(x;\mu,\psi) = Gamma(\mu,\psi) = \frac{(\mu\psi^2)^{-\psi^{-2}}}{\Gamma(\psi^{-2})}x^{\psi^{-2}-1}e^{-(\mu\psi^2)^{-1}x}$ where Γ is the Gamma function. The expected value of this parameterization is $E[x] = \mu$ and coefficient of variation, $CV[x] = \psi$. This Gamma density can be connected to the more familiar $Gamma(\alpha,\beta)$ parameterization by substituting $\alpha = \psi^{-2}$ and $\beta = (\mu\psi^2)^{-1}$.

$$\text{logit}(\phi(\boldsymbol{s})) = \boldsymbol{X_1}(\boldsymbol{s})\boldsymbol{\beta_1} + \gamma_1 Y_1 + \boldsymbol{w_1}(\boldsymbol{s})$$
$$\log(\mu(\boldsymbol{s})) = \boldsymbol{X_2}(\boldsymbol{s})\boldsymbol{\beta_2} + \gamma_2 Y_2 + \boldsymbol{w_2}(\boldsymbol{s}) \qquad \text{(A2.1.2)}$$

We introduce the subscripts 1 and 2 to emphasize that the explanatory variables and spatial effects need not be identical between the two models. The matrices ***X(s)*** contains measured habitat covariates at each point. In our model we considered a suite of available habitat covariates including depth, bottom temperature, sediment characteristics, and distance from rocky substrate (see below for details). We also include categorical offsets for the area of bottom swept by each trawl and a fixed effect for each year that is intended to account for temporal variation in abundance. For the positive model component, we use *log(Area swept)* as our offset, Y_2 = *log(area swept),* and assume catch is proportional to effort, $\gamma_2 = 1$. For the probability of occurrence model, we use Y_1 = *area swept,* and again assume $\gamma_1 = 1$. In other cases, it may be advantageous to assume $\gamma_1 = 0$ (Thorson et al. 2011).

Note that eqn A2.1.2 does not have a non-spatial error term (ie. a "nugget" effect in spatial statistics). Because the trawl survey is unreplicated – no point is sampled multiple times – a non-spatial error term is likely to be statistically unidentifiable. Preliminary efforts to estimate the nugget effect confirmed this difficulty and we did not attempt to estimate a non-spatial error term in any of our models.

We also estimated models using the non-spatial version of eqn A2.1.2 in which $w_1(\boldsymbol{s})$ and $w_2(\boldsymbol{s})$ are set equal to 0. In the non-spatial model, trawl observations are then assumed to be independent. In the following we will refer to $\phi(s_i)$ and $\mu(s_i)$ as "latent variables" and treat them as quantities to be estimated. This has computational benefits that speed model estimation.

Eqns A2.1.1 and A2.1.2 produce a model that parallels the δ-GLM models used in west coast stock assessment (e.g. Stewart et al. 2010, Thorsen et al. 2011, Thorson and Ward *In review*). However, the spatial component of the model above is not currently incorporated into stock assessments. While there are a number of subtle differences between the spatial and non-spatial formulations, the important distinction is that in the non-spatial model the expected mean abundance is identical for each observation within a strata (for example, theoretical strata might be: shallow waters north of Cape Mendicino in a given year), whereas for the spatial model each observed point will have a distinct expected mean that depends on the habitat covariates observed at each location and the observations of abundance near that point.

We make the standard assumption that the spatial effects are multivariate normal distributed random variables (Cressie 1993, Cressie and Wikle 2011) so $\boldsymbol{w_1} \sim MVN(0, \boldsymbol{\Sigma_{w1}}(d,\theta_1))$ and $\boldsymbol{w_2} \sim MVN(0, \boldsymbol{\Sigma_{w2}}(d,\theta_2))$, where $\boldsymbol{\Sigma_w}(d,\theta)$ is a covariance matrix with scale parameter θ that controls the correlation between points as a function of distance, d.

Because we used 9 years of the annual trawl survey data (2003 – 2011), the data contains information about both the spatial and temporal patterns of abundance. To avoid confusing temporal trends in abundance with spatial variation, we constructed a covariance matrix that only allowed samples collected within a given year to have spatial covariance. Therefore we made the spatial covariance matrix, $\boldsymbol{\Sigma_w}$, block-diagonal with diagonal elements comprised of year-specific spatial covariance matrices,

$$\boldsymbol{\Sigma_w} = \begin{bmatrix} \boldsymbol{\Sigma_{2003}} & 0 & \cdots & 0 \\ 0 & \boldsymbol{\Sigma_{2004}} & \cdots & 0 \\ \vdots & \vdots & \ddots & 0 \\ 0 & 0 & 0 & \boldsymbol{\Sigma_{2011}} \end{bmatrix} \tag{A2.1.3}$$

where $\boldsymbol{\Sigma_{2003}}$ is the covariance matrix for observations in 2003, for example. This general structure allows between year spatial covariances to be independent and allows for the fish to move between years and cluster in different locations between years. This is a simple formulation of a broad, general class of spatio-temporal models (Cressie and Wikle 2011). More complicated spatio-temporal model structures that allow some covariation between years are certainly possible and reasonable. We hope to develop more sophisticated models in future efforts. Our current method this provides a method for identification of locations that are persistently of higher abundance across year and can aid in the identification of "hot spots" for particular species (see Figs. A2.1.24, A2.1.25).

We assume the spatial variance is homogeneous within a year and the covariance function between any two locations (e.g. s and s') is only a function of the distance, d, between them (ie. it is isotropic) so

$$\text{cov}(s, s') = \sigma_y^2 r(d, \theta) \tag{A2.1.4}$$

where $r_\eta(d,\theta)$ is the correlation function, and σ_y^2 is the spatial variance. In all of the models considered here we assume $r_\eta(d,\theta)$ is an exponential correlation function, $r_\eta(d,\theta) = exp(-d/\theta)$. The parameter θ controls the spatial scale of correlation among observations with larger values of θ corresponding to increased correlation with distance. For the exponential correlation function the effective range is 3θ (effective range is the distance between observations at which correlation falls to 0.05; Cressie 1993). We considered model structures in which σ_y^2 was allowed to vary among years as well as models in which it was constant among years (ie. $\sigma_y^2 = \sigma^2$). While we initially attempted to estimate a θ for each year, we found the model unmanageable and so estimated a single shared θ for all years in the final model runs. This model assumption forces the scale of spatial aggregation to be similar in all years, but allows the location and amplitude of spatial aggregation to vary.

Parameter models

A key component of Bayesian models is the specification of prior distributions for the parameters. By tradition, non-informative priors have been used in most ecological and fisheries applications. In our case, however, there are clearly sources of information apart from the measured covariates that should be allowed to inform our model inference. We discuss two potential ways to incorporate prior information in the model structure. First, priors can be placed on the regression parameters, $\boldsymbol{\beta}$, that specify the relationship between habitat characteristics and abundance. We did not have enough information to generate reasonable priors for $\boldsymbol{\beta}$, so we do not utilize prior information on $\boldsymbol{\beta}$ in any of the models.

Second, in a spatial context, priors can be placed on the latent variable components of the δ-GLM model described above. For example, we might have prior information on the probability of occurrence for a particular location that is not observed during the trawl survey. If this were true, we could place a prior on probability of occurrence for that location (ie. $\phi(s_i)$). Such prior information could come from unpublished data or expert opinion. These locations do not necessarily correspond to trawl survey locations. Such priors must be constructed carefully to ensure they are on the appropriate measurement scale and ensure they are comparable to the observed trawl data. We collected data from non-trawl sources and included some of it in the analysis via prior information on $\phi(s)$. We used priors for $\phi(s)$ in cases where we did not have individual transect level information from the visual surveys. We aggregated observations from clusters of transects to produce a prior distribution at the center of the cluster. For more detailed information, contact the authors.

Table A2.1.2 summarizes the prior distributions for the parameters. We used diffuse multivariate prior distributions for the regression parameters, conjugate inverse-gamma distributions for σ_y^2, and uniform distributions for θ and ψ. We constrained the scale parameter θ to the range {20,1000} for all species in the probability of occurrence model based on visual inspection of the spacing of trawl survey locations with the intention of precluding the possibility of estimating spatial structure that is at a finer scale than the survey data. Because the abundance part of the model only includes non-zero observations and thus comprises a smaller subset of the data, the density of observations decreased and distance between observations increased. Therefore, we used $\theta \sim Unif(50,1000)$ for less frequently observed species (darkblotched and greenstriped rockfishes) while maintaining for $\theta \sim Unif(20,1000)$ for sablefish, longspine thornyhead, and petrale sole. We did not have enough positive observations to feel confident in the quality of an abundance model for yelloweye rockfish.

Table A2.1.2: Prior distributions used in the NWFSC statistical model. (**I** is the identity matrix)

	Probability of Occurrence	**Abundance**
Parameter		
$\boldsymbol{\beta}$	Multivariate Normal(0, $100^2\boldsymbol{I}$)	Multivariate Normal(0, $100^2\boldsymbol{I}$)
σ_y^2	Inverse-Gamma (3,1)	Inverse-Gamma (0.75,0.5)
ϑ	Uniform (20,1000)	Uniform (20,1000); Uniform (50,1000)
ψ	NA	Uniform (0.1,5)

Covariate Selection

We used only data sources for covariates that were available for the entire spatial domain of the trawl survey. After perusing the available data layers used in EFH Phase 1 report (PFMC 2012), we decided to use depth, bottom temperature, and sediment characteristics as continuous habitat covariates in our model (Table A2.1.3). Descriptions of these data layers can be found elsewhere in this report (Section 1, Appendix 1). We added a fourth continuous covariate, distance to nearest rocky habitat, which represented proximity to habitat features deemed important to demersal fishes. We used the "Nearest Features" tool (Jenness Enterprises, v. 3.8b) in ESRI ArcView (v. 3.2a) to calculate the distance from each of the trawl survey sites to the nearest rock habitat patch. Rock was defined as any grid cell in the substrate type datalayer with a value of 1 or 4. We only used rocky patches greater than 1 ha in area. All habitat covariates were centered before model estimation. While we expect many of the habitat attributes of the trawl locations, such as depth and bottom type to be constant across the entire trawl time-series, we know that other factors that we could not include are also affecting fish populations. For example, the total abundance of a particular species may be changing over time — declining due to fishing pressure or poor recruitment or increasing due to fishing restrictions or favorable oceanographic conditions. Therefore, we also included the option of estimating a fixed categorical value for each year. Adding such a year effect allows for the probability of occurrence and overall abundance to vary across the time-series. We do not allow for interactions between the categorical year effects and thus we assumed a constant effect of habitat variables across years and only allowed for a discrete shift up or down between years. Recall, however, that the spatial effect allows for the deviation from this overall habitat mean to vary spatially among years.

While we allow for temporal trends in both the probability of occurrence and abundance component of the models to account for temporal patterns, developing methods to directly include known pressures (e.g. local fishing effort) would be an important model improvement and next step.

We initially considered including information about biogenic habitats, our initial survey of available data for biogenic habitats concluded that the data were too limited in quality and their spatial extent to be included in our coast-wide model (Section 1.1, Appendix 1). Future work should emphasize developing broad scale information about biogenic habitat that can be incorporated fully into species-habitat models.

We do not include any region-specific categorical variables in our model because we did not have good *a priori* ideas for locations at which habitat-area relationships might change. We wished to avoid arbitrarily imposing a spatial structure for species-habitat relationships. We hoped that the spatial component of the model would provide the needed flexibility to account for spatial variation in the species-habitat relationship.

We only considered models using the main effects of the habitat covariates and did not consider any interactions among the covariates. Thus our model included at most 16 parameters. This small number of parameter ensures that the parameters maintain biological interpretability. The small model dimension also reduces the likelihood of model over-fitting and reduces the importance of performing extensive cross-validation testing to avoid overfitting.

After some exploratory analysis, we elected to transform depth and distance to rock outcrop before their inclusion in the models. We $\log_e$-transformed depth and square-root transformed the distance to nearest rock outcrop. The transformation of depth improved the explanatory value of depth in all species examined and the square-root transformation was effective at increasing the contrast between locations that are in close proximity to rocky outcrop and reducing the statistical leverage of points at great distances from any rock outcrop.

Finally, we used a habitat confidence layer to incorporate uncertainty in sediment grain size data (see Appendix 1). Given that the grain size map covers areas derived from surveys of varying quality – ranging from detailed side-scan sonar surveys conducted in the last decade to grab sample surveys completed nearly a century ago – it is reasonable to assume that our certainty about sediment grain size will vary along the coast (PFMC 2012). Therefore we elected to add uncertainty to each sediment grain size by making the sediment grain size a normal random variable. For location i, $X_{i,grain.size} \sim N(\kappa_i, \tau_i^2)$, where κ_i is the value from the grain size map. For hard habitats, we used $\kappa_i = -8.5$ and $\tau_i = 0.25, 0.5,$ and 0.75 for high, medium, and low substrate certainty, respectively. For mixed substrate, we used $\kappa = -4$ and $\tau_i = 2, 3,$ and 4 for high, medium, and low substrate certainty, respectively. For soft substrates, we let κ_i be the predicted value derived from the sediment map, and set and $\tau = 1, 2,$ and 3 for high, medium, and low certainty locations. These values were developed after extensive discussion amongst the NOAA scientific staff, but other values of τ may be reasonable.

Model fitting involved standard Markov chain Monte Carlo (MCMC, see below) techniques. For each iteration of the MCMC estimation process we drew a new value for each location from $X_{i,grain.size}$. This approach ensured that our parameter estimates integrated over the uncertainty in sediment characteristics. We acknowledge that this is a somewhat inelegant statistical method for incorporating uncertainty in sediment size, but it is an important first step toward including spatially variable quality of information into species-habitat associations.

Table A2.1.3. A list of the habitat covariates included in the NWFSC statistical model.

Habitat Covariates	**Forms included in the model**
Depth (m)	Log(depth) Log(depth)2
Bottom temperature (C)	Bottom Temperature (Bottom Temperature)2
Sediment grain size (Φ Scale; Krumbein and Sloss 1963)	Grain Size (Grain Size)2
Distance to nearest rocky outcrop (km)	(km)0.5

2.1.3.4 Model Estimation

General Procedure

Within the general model form outlined in the preceding section, there is a great amount of flexibility with regards to which habitat covariates are included into the model. There are also options for the specific form the spatial components of the model component. We followed a three-part model estimation procedure. We first estimated a series of non-spatial models using all combinations of habitat covariates using standard Markov chain Monte Carlo (MCMC) techniques (see *MCMC details* below). For the non-spatial models we identified between four and ten models using two model selection criteria: a formal scoring metric based on the posterior predictive distribution known as the log-score (Gelfand and Day 1994, Gelfand and Ghosh 1998, Draper and Krnjajić 2010; see *Model Selection* below), and an qualitative inspection of model fit which included inspection of MCMC chains and plots of the marginal posterior distributions of regression parameters.

After the set of preferred models was identified, we estimated parameters for the full spatial model using the identified habitat covariates. We used posterior parameter estimates from the non-spatial model to initiate the MCMC chains in the spatial model to reduce the burn-in and computing time. We again used log-score and qualitative model inspection to identify a preferred spatial model and for comparing spatial and non-spatial models.

For the preferred model, we then constructed a series of predictive maps for the probability of occurrence and abundance on a 2 x 2 km grid of the west coast (see below).

Computational Issues for Spatial Models

Spatial data present a series of computational problems. In particular, when the number of observations gets large (say > 2000 observations), standard procedures to estimate parameters in a point process model become computationally difficult and intolerably slow (Banerjee et al. 2008). The computational issues are entirely driven by estimation of the spatially term, $\boldsymbol{w}$. Problems arise because the covariance matrix $\boldsymbol{\Sigma_w}$ is large and not diagonal. Because estimation involves calculating the matrix inverse of $\boldsymbol{\Sigma_w}$, compuation can be exceedingly slow. This is known as the "large N" problem in spatial statistics (Banerjee et al. 2004, Banerjee et al 2008, Cressie and Wikle 2011) and remains a difficult problem even when explicit matrix inversion is replaced with fast linear solvers.

A number of approaches based on approximating the covariance matrix have been proposed to speed the computation of spatial models (see e.g. Royle and Wikle 2005, Latimer et al 2009). We employ the predictive process modeling approach to improve model computation speed. A thorough discussion of predictive process approach can be found elsewhere (Banerjee et al. 2008, Finley et al. 2009, Latimer et al. 2009), so we only outline the methods here. Briefly, the predictive process approach develops an approximation of the full covariance matrix $\boldsymbol{\Sigma_w}$ using a much smaller covariance matrix. To do this, we establish new set of points that are interspersed with the observed locations. These locations are known as "knots" and the number of knots is much smaller than the number of observations. For the statistical model, we have to estimate a spatial component for each knot location, $\boldsymbol{w^*}$, instead of a spatial component for each observation, $\boldsymbol{w}$. We estimate a spatial covariance matrix among the knots and predict the value of spatial effects at the observed points from the knots. The key advantage of introducing the knots is that we only have to calculate the inverse of the covariance matrix of the knots and because the length of $\boldsymbol{w^*}$ is much less than the length of $\boldsymbol{w}$ the computational savings are substantial. We employ the "modified" predictive process model described by Finley et al. (2009). This "modified" model contains an adjustment parameter estimates to avoid bias in the estimation the spatial parameters. Bayesian estimation of $\boldsymbol{w}$ also allows for uncertainty in estimates of the spatial scale parameter θ.

The use of predictive process models requires the consideration of two additional model aspects. The number of knots needs to be specified and the location knots needs to be determined. Using a smaller number of knots will speed computation time but result in a smoother, less rugose spatial surface compared to a model that uses the raw data. Following some preliminary exploration, we used 150 knots for the probability of occurrence models. For the abundance component, we used the minimum number of observations in a single year for each species except for sablefish, where we used 300 knots (Table A2.1.4). To determine the knot locations we selected a single set of knot locations using a k-means clustering algorithm on all years of observations simultaneously (via the "kmeans" function in R; Hartigan and Wong 1979). We then used this single set of knot locations for each year in the model estimation.

Table A2.1.4: N is total number of observations across all years for the probability of occurrence and the number of observations with > 0 kg observed for the abundance component of the model. Number in parentheses is the number of observations used from submersible surveys. We do not include non-trawl information for petrale sole because they are difficult to identify in submersible surveys. Longspine thornyhead were never reported in any of the submersible surveys.

Species	**Probably of Occurrence**		**Abundance**	
	N	knots	N	knots
Darkblotched rockfish	5808 (77)	150	1026	91
Greenstriped rockfish	5808 (77)	150	1482	132
Yelloweye rockfish	5812 (81)	150	-	-
Petrale sole	5731 (0)	150	2376	198
Sablefish	5731 (0)	150	3767	300
Longspine thornyhead	5731 (0)	150	2096	196

MCMC details

We are interested in calculating the posterior density for the parameters and latent states given the observed data. Let $z_1(\boldsymbol{s})$ represent the observed presence-absence data of the model, then the full posterior for the presence-absence component can be written,

$$\begin{aligned} p(\phi(\boldsymbol{s}), \boldsymbol{w}^*, \theta, \boldsymbol{\sigma}^2 | z_1(\boldsymbol{s})) \propto \quad & p(z_1(\boldsymbol{s})|\phi(\boldsymbol{s})) \\ & p(\phi(\boldsymbol{s})|\boldsymbol{w}^*, \boldsymbol{\beta}, \theta, \boldsymbol{\sigma}^2) \\ & p(\boldsymbol{w}^*|\theta, \boldsymbol{\sigma}^2) \\ & p(\boldsymbol{\beta}, \theta, \boldsymbol{\sigma}^2) \qquad \text{(A2.1.5)} \end{aligned}$$

with the right hand side showing how the posterior can be factored into four components. We can write a similar model for the abundance model. Non-spatial models are simpler because they do not involve estimating $\boldsymbol{w}^*$, θ, or $\boldsymbol{\sigma}^2$. For both non-spatial and spatial model we use using a mix of Gibbs and Metropolis-Hastings sampling steps to estimate parameters (Gelman et al. 2004). To both of the non-spatial models we added a small, fixed amount of pure error to the model to ease MCMC sampling: e.g. the non-spatial model for the probability of occurrence is then $logit(\phi(s_i)) = \boldsymbol{X}(\boldsymbol{s_i})\boldsymbol{\beta} + \varepsilon_i$, where ε_i are independent and $\varepsilon \sim N(0,\tau^2)$. Abundance models had an analogous form. For the probability of occurrence and abundance models, we set $\tau^2 = 0.01$.

Due to a large number of models we considered we initially ran a single MCMC chain for each model. For the models that appeared to best match the data, we ran subsequent MCMC chains from dispersed starting point to verify convergence to a single stationary distribution. For probability of occurrence models, visual inspection of chains suggested non-spatial models converged relatively slowly but had decent mixing properties. Thus we ran a very long burn-in chain of 100,000 iterations and a monitoring chain of 50,000 iterations. While both of these chain lengths were excessive, the chain length removed any questions about model convergence. We then used the ending values from the non-spatial model to initiate the spatial models. Because spatial models ran much more slowly and the parameter values were already near their stationary distribution, we ran a 10,000 iteration burn-in and a 25,000 iteration monitoring run. In most cases, the MCMC chains for the spatial model converged but mixed relatively slowly (ie. MCMC draws from the stationary distribution were highly autocorrelated).

The positive model had better MCMC characteristics overall. We used a burn-in of 30,000 and a monitored MCMC of 50,000 iterations for the non-spatial model and a burn-in of 5,000 and monitored MCMC of 10,000 iterations. The mixing properties of both abundance models were improved greatly over the probability of occurrence model.

Model Selection

An important component of devising and applying new statistical models is comparing the relative effectiveness of various models at describing available data. In this section, we discuss how we compare among the possible spatial models using posterior predictive scoring rules. Generally, we are interested in identifying models that make good predictions. A way of formalizing this desire for good predictions is to say that we want to maximize the predicted probability of observing the value of a new data point, z_{new}, given our previously observed data and our estimated parameters. For notational simplicity, let $\boldsymbol{\Theta}$ be the estimated parameters and latent variables in the model. Thus, a good model would be one that provides a large value of $p(z_{new}|\mathbf{z},\boldsymbol{\Theta})$. Proper rules for comparing a data value z_{new} with its predictive distribution involve the logarithm of the height of $p(z_{new}\,|\mathbf{z},\boldsymbol{\Theta})$, or $log(p(z_{new}\,|\mathbf{z},\boldsymbol{\Theta}))$ (Gneiting and Raftery 2007, Draper and Krnjajić 2010). This metric of predictive quality is known as the log-score (*LS*).

Ideally, we would estimate log($p(z_{new}\,|\mathbf{z},\boldsymbol{\Theta}))$ via cross-validation; we would exclude some set of our observations from our model estimation procedure and predict those excluded values. This suggests we would need to run a number of MCMC models for each covariate and each run would have a different set of data points excluded from model estimation (e.g. Draper and Krnjajić 2010, Shelton et al. 2012). In practice, this is impractical due to the long computing times for models estimated with MCMC. Fortunately, with reasonably large sample sizes, we can use what is known as the “full sample” log-score that will approximate the cross-validation derived log-score (Draper and Krnjajić 2010). For each draw of the MCMC, g, we calculate the predicted probability of each observed data point, i, then

$$LS = \frac{1}{G}\sum_{g=1}^{G}\sum_{i=1}^{n}\log\left[p(z_i|\boldsymbol{z}, \boldsymbol{\Theta^g})\right] \qquad \text{(A2.1.6)}$$

where n is the number of observations and G is the number of MCMC iterations. Larger log-scales indicate a higher overall match between prediction and observations. An alternative scoring criterion would be to divide the right side of eqn A2.1.6 by n to provide log-scores on a per observation basis.

Constructing Prediction Maps

After producing posterior distributions for model parameters and the spatial latent variables at the knot locations, we used draws from the joint posterior distribution to generate predictive map for probability of occurrence and for abundance. These two surfaces correspond to a surface for $\boldsymbol{\phi}$ and a surface for $\boldsymbol{\mu}$ in eqn A2.1.1, respectively. These two surfaces can be combined to provide a surface for the expected value of catch, ***E[Z]***.

We first generated a gridded (2x2 km) coast-wide map of the model spatial domain. The north/south extents of the domain approximated the U.S. border, while the shoreline and seaward boundaries were defined by a vector shoreline geospatial datalayer (NOAA 2001), and the 1,600 m isobath (3-arcsecond grain, [~86 m] NOAA 2003), respectively. We created the 2x2 km gridded polygon datalayer using “Generate Regular Points in ArcMap”, which is a Hawth’s Tools ArcGIS tool that runs in ArcMap (v. 9.3.1). We overlaid this gridded domain with the four habitat covariate datalayers and calculated the corresponding values for each of the grid cells. Since the covariates were continuous variables, each was expressed as an area weighted mean (AWM) for each of the grid cells.

We use $\boldsymbol{s_0}$ to denote the predicted grid centers along the coast. For depth, sediment grain size, and distance to rock outcrop the covariate values at each location were consistent across years.

For bottom temperature, we did not have a direct measure for each of the 2 X 2 km grid cells, so we used the trawl survey site bottom temperature data to interpolate a gridded surface of bottom temperature for each year (2003 – 2011). We used the “kriging” command ESRI ARC/INFO grid (v. 9.2) to interpolate bottom temperature. We interpolated bottom temperature on a 1 X 1 km grid for each year of the trawl survey data using the following kriging parameters: model domain polygon used as “barrier cover”; SPHERICAL semi-variogram model for kriging method; maximum of 12 neighboring input sample points; and, 100 km search radius to select neighboring points. We also used these interpolated bottom temperature datalayers to fill in missing bottom temperature in 272 of the bottom trawl survey sites.

We used a slightly different approach for calculating distance to nearest rocky habitat patch for the 2 X 2 km gridded datalayer. Calculating the distance from the centroids of each of the ~43k, 2 X 2 km grid cells to the nearest edge of each of the rocky habitat patches exceeded the capabilities of the "Nearest Features" tool that we used in generating the covariates for each of the bottom trawl survey sites, so we used the "NEAR" command in ESRI ARC/INFO (v. 9.2), which is a more robust software package.

Depending on the model used, each year modeled could also have a distinct offset (intercept) corresponding to a coastwide change in the probability of occurrence or abundance. Given these maps, we can generate predicted values for $\boldsymbol{s_0}$. For the probability of occurrence model, we generate predicted values at $\boldsymbol{s_0}$ for the g^{th} draw from the posterior,

$$\text{logit}(\boldsymbol{\phi^g}(\boldsymbol{s_0})) = \boldsymbol{X_1}(\boldsymbol{s_0})\boldsymbol{\beta_1^g} + Y_1 + \boldsymbol{c^T}(\boldsymbol{s_0},\theta^g)\boldsymbol{C^{*-1}}(\theta^g)\boldsymbol{\eta_1^{*g}} \qquad \text{(A2.1.7)}$$

where the first term on the right side is the predicted value from the fixed habitat covariates, the second is the effort offset, and the third term is the linear interpolation of the spatial effect at each predicted point from the sampled knot locations (ie. the standard kriging projection). Here $\boldsymbol{C^*}$ is the covariance matrix for knot locations and $\boldsymbol{c}$ is a matrix describing the covariance between the prediction points and the knot locations (ie. $\boldsymbol{c}(\boldsymbol{s_0},\theta^g) = [\boldsymbol{C}(\boldsymbol{s_0}, \boldsymbol{s_j^{*g}},\theta^g)]_{j=1}^{m}$). An analogous model was constructed for the positive component of the model. For all predictions we use an effort offset of 1 hectare (0.01 km^2) swept for prediction. Recall that the offset for the positive part of the model we use the logarithm of area swept (so $Y_2 = log(0.01)$).

Each draw of the posterior distribution could thus provide predicted value of $logit(\boldsymbol{\phi})$ (or for the abundance portion of the model, $log(\boldsymbol{\mu})$) at each predicted location. Each component can then be back-transformed to generate a map of predicted probability of occurrence (bounded by 0 and 1) or the expected biomass caught. To calculate the across-year average map we created a mean prediction map for each year and then averaged across these year-specific maps. Thus the NWFSC maps shown in Figs 2.1 to 2.18 are the mean of the mean yearly predictions in each grid cell.

To save computing time, we selected 1,000 evenly spaced draws from the joint posterior distribution, produced a prediction from each of the 1,000 posterior draws. We then calculated the mean, median, and credible intervals for each prediction location.

Because the fixed and spatial components of the above model are additive, it is also possible to produce a map derived exclusively using the habitat covariates. This can be thought of as a predictive map for species occurrence based exclusively on the habitat characteristics unmodified by spatial clustering (we show an example using sablefish in 2010 in Figure A2.1.24). This map without spatial clustering is roughly analogous to earlier EFH efforts to identify suitable habitat (i.e. the HSP model; Anonymous 2005, 2008), though the HSP model was developed using substantially different methods. The spatial component (Figure A2.1.24) can be thought of as a smooth surface that adjusts the predicted probability of occurrence from the fixed habitat effect up or down to better match the observed data. We combine the spatial and habitat effects and back-transform them to the appropriate scale for the probability of occurrence and abundance. We can provide estimates of the average as well as estimates of uncertainty for each predicted point. We show the mean probability of occurrence for sablefish in a single year (2010; Figure A2.1.24) as well as the 5% and 95% predicted quantiles for the same year[2]. While we can provide such maps for each species in each year, to be concise we report an across-year average of for probability of occurrence and abundance in the main text and this appendix (Figs A2.1.1 to A2.1.18).

It is also possible to construct across year averages for the habitat effects and the spatial effects (Figure A2.1.25). The across year average of the spatial component has a particularly intuitive and potentially useful interpretation. Since the spatial component contains the information in the data that is not explained by the habitat model, we can compare the predicted spatial component across years to identify areas that persistently have higher probability of occurrence or abundance than is predicted by underlying habitat. By identifying areas that are persistently different, the spatial effect provides an alternative method for identifying areas of interest where habitat variables do a poor job of predicting occurrence or abundance. We show an example of this average, across-year spatial structure for sablefish in Fig A2.1.25.

Acknowledgments:

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[2] Because the posterior distributions were generated using MCMC, the retained parameter estimates are not independent draws from the posterior distribution; the posterior draws are autocorrelated. This is not a serious problem. Using only 1,000 draws to generate predictions lessened the autocorrelation, but it is important to note that any remaining autocorrelation in the parameter estimates will produce an underestimate of the uncertainty of the predictions at each point. The magnitude of the underestimation will be quite small in most cases

Table 2.1: Habitat covariates included in the preferred NWFSC probability of occurrence model for the six focal species. “X” indicates the covariates included in the preferred model. All columns are habitat covariates except “Year” which designates a categorical offset for each year, and “Single Variance?” which designates if a single spatial variance parameter was estimated for all years (“Y”) or if a spatial variance parameter was estimated for each year (“N”).

Species	Year	Depth and Depth^2	Bottom Temperature	(Bottom Temperature)^2	Sediment Grain Size	(Sediment Grain Size)^2	Sqrt(km to rock)	Single Variance?
Sablefish	X	X	X	X	X	X	X	N
Yelloweye rockfish		X	X		X		X	Y
Petrale sole	X	X	X	X				N
Longspine thornyhead		X	X	X	X	X	X	Y
Greenstriped rockfish	X	X	X	X	X		X	N
Darkblotched rockfish		X	X	X	X	X	X	N

Table 2.2: Habitat covariates included in the preferred NWFSC abundance model. “N/A” indicates that the abundance model was not estimated. See Table 2.1 for more explanation.

Species	Year	Depth and Depth^2	Bottom Temperature	Bottom Temperature^2	Sediment Grain Size	(Sediment Grain Size)^2	Sqrt(km to rock)	Single Variance?
Sablefish	X	X	X	X	X		X	N
Yelloweye rockfish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Petrale sole		X	X	X				N
Longspine thornyhead		X	X	X	X	X	X	Y
Greenstriped		X	X				X	N
Darkblotched rockfish	X	X	X					Y

2.2 SPATIAL MODEL OF SPECIES-HABITAT RELATIONSHIPS (NCCOS MODEAL)

2.2.1 Model Description (Non-technical)

The statistical model used by NCCOS differs from the one used by the NWFSC. The model was chosen to generate predictions at the highest possible spatial resolution (sacrificing the ability to resolve temporal changes for improved spatial resolution. i.e. finer scale "texture," in model outputs). In contrast to the NWFSC model, the NCCOS model is constructed from a frequentist (rather than Bayesian) approach. Practically speaking, this allows the NCCOS model to incorporate more potential predictor variables and interactions among variables and an exact representation of spatial autocorrelation, while still estimating the model in a reasonable amount of time.

Similar to the NWFSC model, NCCOS's models have two distinct components ("stages"), one for predicting the probability of occurrence, and another for predicting relative abundance given presence. The predicted probability of occurrence (Stage I) is multiplied by the predicted abundance conditional on occurrence (Stage II) to produce the final estimate of relative abundance, which is the expected long-term average catch per unit effort (CPUE). The long-term average can be considered the estimated mean from repeated bottom trawls scattered between 2003 and 2010. Within each stage of the model, relationships among groundfishes and their environment were used to predict a trend surface using transformed Generalized Linear Models (GLMs), and spatial autocorrelation in GLM residuals was modeled using geostatistical modeling (kriging). For each species and each stage a model selection routine was used to select which environmental variables would be used in generalized linear models and which ones would be omitted. Final models were selected based on a statistic that balanced model fit to the training dataset with model complexity, and tested on a cross-validation set not included in model fitting. Tables 2.3 and 2.4 identify environmental variables selected for models for each species.

NCCOS's models were developed using fishery-independent groundfish observations and a range of environmental data sets spanning the large marine ecosystem (e.g., depth, slope, surface chlorophyll, bottom temperature). Outputs from the models show continuous gridded predictions of species occurrence, and relative abundance at a spatial resolution of 1km (4x finer resolution than the 2km NWFSC models) along the West Coast from the Washington-Canada border to the California-Mexico border.

2.2.1.1 Groundfish survey observations

NCCOS models used tows extracted from the West Coast Groundfish Bottom Trawl Survey dataset that were taken between 2003 and 2010, and identified as "Fisheries Assessment Acceptable" or "Station Removed From Survey Pool". This subset passed quality control standards based on post-collection analysis of bottom contact, net performance, and other metrics (Stauffer 2004). Stations removed from the survey pool and which passed quality control standards were also included in the analysis to increase sample size and the spatial dispersion of tow sites. All tows meeting our temporal and quality control criteria were merged. This dataset was used in spatial models for each investigated species and resulted in predictions representing the long-term average spatial distribution of the examined species (i.e., a spatial climatology). This approach allows for the maximum possible resolution of spatial differences in the long-term average spatial pattern of species' abundance. The tradeoff (and a key difference from the NWFSC model) is that it does not allow for analysis of temporal changes over time. Any temporal changes that do occur over the period of analysis will be represented as a long-term composite average in this kind of spatial climatological model.

2.2.1.2 Environmental variables

Eleven environmental variables were used as potential independent predictor variables for each species' spatial model (Table A2.2.1). It is important to note that the eleven predictors were only candidates and a model selection process was used to narrow down the set of predictor variables that contributed to any particular species model.

Table A2.2.1: A description of predictors variables used in NCCOS groundfish models

Dataset	**Description**
Depth	The base bathymetry used in the 2005 EFH review aggregated from 500 m to 1km resolution. Downloaded from PACOOS
Depth Polynomial	A species-specific nonlinear function fit between CPUE and depth. Function is a second order polynomial.
Alongshore distance	The distance from the most southerly point in the study area measured along a generalized representation of the coastline.
Region	Lines drawn perpendicular to shoreline at Point Conception and Cape Mendocino used to divide study into three categorical regions.
Bathymetric Position Index	Position on seafloor relative to surrounding seafloor
Rugosity	A measure of variations in depth within a 3x3 km neighborhood
Slope	Maximum change in depth represented by a gradient
Near-bottom temperature climatology	Seasonal climatology of long-term average bottom temperature; new geostatistical model developed from FRAM trawl temperature logger dataset
Surface temperature climatology	Seasonal climatology from POES AVHRR and MODIS Aqua datasets
Surface Chlorophyll climatology	Seasonal climatology from MODIS Aqua dataset
Distance to hardbottom	Distance derived from hardbottom habitats delineated in West Coast benthic habitat maps.

Long-term average seasonal climatologies were developed for bottom temperature, sea surface temperature, and chlorophyll a concentration predictors, because we expected these to have large intra-annual seasonal variation. Data for these predictors collected between May and October were used to prepare seasonal climatologies. These months correspond to the months of data acquisition by the West Coast Groundfish Bottom Trawl Survey and during the timing of upwelling and wind relaxation periods for the study area (Bograd et al. 2009).

Near-bottom temperature was interpolated from the average temperature collected during most FRAM trawls (N=4881). Near-bottom temperate represents the average temperature when the net was on the bottom and positioned at the midpoint of each tow. A new geostatistical predictive model was created to generate a gap-free gridded prediction of bottom temperature from point samples. Data were first detrended using a second order polynomial and then ordinary kriging was applied to the residuals. Ordinary kriging was used because data exhibited approximately stationary spatial autocorrelation (though geometrically anisotropic) over the study area after trend removal. An anisotropic model with a 4 sector neighborhood was applied in ArcGIS 10 (ESRI, Inc.), with a 20 km search neighborhood bandwidth and Gaussian kernel weights to smooth variation in predictions due to the sliding local search neighborhood. Leave one out crossvalidation of the bottom temperature model indicated a root mean square error of 0.58 deg C, suggesting that the model is suitable for predicting thermal habitat at broad scales.

Depth at 500 meter resolution for the entire west coast was downloaded from the PACOOS website (http://pacoos.coas.oregonstate.edu/datasets.html). The model was created by the Active Tectonics and Seafloor Mapping Lab (COAS, Oregon State University) and previously used in spatial models for the 2005 NMFS essential fish habitat review. This dataset was chosen because it has been vetted and widely used, and because it had the best available resolution at the desired spatial extent (i.e., consistently covering the entire study region).

The 500 m bathymetry model was bilinearly resampled to 1000 m and values greater than 0 (values on land) were removed. The new 1000 m bathymetry model was used to derive bathymetric slope and rugosity estimates using the ArcGIS Spatial Analyst and the Jenness DEM Surface Tools extensions for ArcGIS, respectively. A low pass smoothing filter (10km-mean) was applied to the slope model to create a second broader spatial scale slope layer. Preliminary tests examining the correlation of both slope layers with species' CPUE indicated that the slope layer showing broader spatial scale patterns was better correlated to CPUE and it was used in all subsequent analysis. A custom raster script was used to derive a bathymetric position index from the 1000 m bathymetry raster: BPI = Int((depth - focalmean), where the focal mean was in an annulus with an inner radius of 1 cell and outer radius of 3 cells.

Since many species distributions were nonlinearly related to bathymetry, species-specific nonlinear bathymetry predictors from a second order polynomial fit between depth and CPUE were developed. Only records where presence was greater than zero were used in the fit and only significant models (F ratio, $p<0.05$) were used as candidate predictors. Species-specific coefficients were applied to the 1000 m bathymetry model to derive new layers.

Geographic position was defined using a metric to quantify alongshore distance relative to the southern-most extent of the FRAM survey domain and a categorical variable representing distinct regions. Alongshore distance was measured from the most southerly point in the study area along a generalized representation of the coastline given by an elliptical arc. Alongshore distances of all points along a line perpendicular to the arc were identical. The study area was also divided into three regions separated by Point Conception and Cape Mendocino. The alongshore variable was useful to show gradual changes in species' spatial distribution whereas the regional variable was useful for abrupt changes in species' spatial distribution. We had originally used latitude and longitude as spatial predictors, but found the alongshore gradient and regional categories vastly improved model performance.

Chlorophyll a concentration and sea surface temperature (SST) predictors were derived from POES AVHRR and MODIS Aqua sensors. Monthly composites were downloaded from the CoastWatch ERDDAP server. Monthly chlorophyll a concentration composites for 2003-2010 were taken from the MODIS Aqua sensor. When available, monthly SST composites were downloaded (mid-2007-2010) from the POES AVHRR sensor (better resolution than MODIS), but for the earlier portion of the time series, either daily composites were downloaded and used to calculate monthly means (2004-2007), or monthly SST composites were collected from the MODIS Aqua sensor (2003). Monthly composites for both chlorophyll a concentration and SST were averaged for years 2003 - 2010 to develop monthly climatologies and then monthly climatologies for the trawl season (May-October) were averaged to develop seasonal climatologies.

A seamless benthic habitat map was developed for the 2005 EFH review process from two datasets (NMFS 2005). Benthic habitat data for Washington and Oregon were developed by the Active Tectonics and Seafloor Mapping Lab, College of Oceanic and Atmospheric Sciences at Oregon State University. Data for California were developed by the Center for Habitat Studies at Moss Landing Marine Laboratories. We attempted to use the same benthic habitat map and habitat categories applied in the 2005 EFH review process, but found early on that the spatial modeling approach we were using did not work with the 35 unique benthic habitat types used previously. There were too few observations in some categories to correlate groundfish observations to benthic habitat. We then attempted to classify benthic habitat into two categories based on habitat induration: hardbottom and softbottom. Early draft spatial models used two habitat categories, but after viewing draft results a reviewer suggested that we use distance to hardbottom. We changed the categorical two-level habitat variable into a signed continuous variable indicating distance to hardbottom habitats. We measured distance from the hardbottom-softbottom habitat edge, where distance into hardbottom habitats was positive and distance away from hardbottom habitats was negative. Our preliminary tests showed improvements in spatial model diagnostic measures for several species and we decided to us the continuous benthic habitat variable instead of the categorical one.

Newer versions of the benthic habitat map are available from different sources, including Active Tectonics and Seafloor Mapping Lab, but we did not use them. Newer map versions include updates where new seafloor survey information has been collected since 2005. These updates are meant to communicate the best available information. Due to survey costs and scientific priorities there is a bias towards resolving nearshore and hardbottom habitats in more detail. This bias can be difficult to disentangle from species distribution preferences and can lead to spurious predictions. We examined newer benthic habitat maps and decided to use the older 2005 version, because it provided a map classified at more consistent spatial scales across our entire spatial domain.

All predictor processing was carried out using ArcGIS 10 (Environmental Systems Research Group [ESRI], Redlands, CA), with the Spatial Analyst and Geostatistical Analyst extensions.

2.2.1.3 Spatial analytical framework

All predictor grids were co-registered on the same 1 km-resolution sampling grid projected using UTM 10N. We chose a transverse projected coordinate system to keep constant lengths, angles, and areas across the height and width of the predictor grids, and because the projection maps a region of large north-south extent with low distortion. The study area is distributed in both the UTM 10N and UTM 11N zones, but for simplicity we use only the 10 N zone. By using only one UTM zone we incur an area distortion less than 0.5% within our study area, and given the size of the study area and resolution of our analysis this distortion seems negligible.

Groundfish survey data is coupled to all predictors on the same 1 km co-registered grid. Given the ~500 m (5min x 2.2 knots) minimum distance of FRAM tows, the minimum length scale that can be resolved is approximately 1 km or two times the minimum transect length. Thus, the 1 km grid resolution chosen for spatial predictors approaches the finest possible resolution for detecting spatial patterns given the limits of the trawl sampling design data. Most spatial predictors were collected at scales shorter than 1 km and were resampled up to the 1 km scale. Some older satellite chlorophyll and SST data were at coarser resolutions (~4km) and had to be down-sampled to the 1km grid.

Horizontal positional errors are present in both tows and spatial predictor data, but these errors are likely to be small relative to 1 km. All tow positions were collected using a DGPS system with accuracy greater than 10 m or 1% of the sampling resolution. Estimating and integrating horizontal positional errors in spatial models is outside the scope of this analysis, but cross-validation accuracy assessment provides an integrated measure of the uncertainty arising from horizontal positional errors as well as other sources such as error in environmental predictor layers.

2.2.2 Model Description (Technical)

NCCOS adopted a two-stage approach that separates a model of the presence probability of a species from a model of its relative abundance when it is present. This approach has been successfully used to model highly zero-inflated marine distribution data (e.g., Stefánsson, 1996; Ver Hoef and Jansen, 2007). This technique is also referred to in the statistical literature as a hurdle model or a delta model (Cragg, 1971; Potts and Elith, 2006; Ver Hoef and Jansen 2007). In our case we refer to the two parts of the model as Stage I and Stage II. Stage I models the probability, $p_i(x,y)$, that species i is observed in a survey at location (x,y):

$$p_i(x,y) \equiv \text{Prob}[i \text{ observed at } (x,y) \text{ in a single trawl}] \quad \text{(A2.2.1; Stage I)}$$

Here, $p_i(x,y)$ is treated as a spatial random variable whose value is a probability; the details of how it is modeled are discussed below. We do not distinguish between observation and presence; the probability $p_i(x,y)$ is assumed to be equal to the probability that the species was actually present during a single tow conducted over the 8-year study period. In other words, probability of detection when the species is present is assumed to be 1; consequences of this assumption are discussed later.

Stage II models $E\{Z_i(x,y) \mid P_i(x,y)=1\}$, the long-term mean of the observed relative abundance (CPUE), $Z_i(x,y)$, of species i at location (x,y) *when the species is present:*

$$E\{ Z_i(x,y) \mid P_i(x,y)=1\} \quad \text{(A2.2.2; Stage II)}$$

Here $Z_i(x,y)$ is a continuous random variable representing relative abundance (species specific catch weight per square kilometer of trawl-swept area), and $P_i(x,y)$ is a Bernoulli random variable whose probability of success in a single trial is given by $p_i(x,y)$. Note that $E\{A|B\}$ represents the conditional expectation operator, which returns the expected value (arithmetic average over many trials) of the random variable A, given the value of the random variable B. This expected value can be thought of as the average CPUE that would have been recorded if the same location had been visited many times, instead of only once, during the 8-year survey period, and only non-zero values were included in the average. In this model, the observed value of CPUE at each location is our single observation of the random variable $Z_i(x,y)$, conditional on the outcome of $P_i(x,y)$ at that location (0 if species *i* is absent, 1 if present). Over a 8-year period, assuming 6 hours of potential survey per day, approximately 18,000 temporally non-overlapping 15-minute trawl surveys *could have been* conducted at each location. If hypothetical repeat surveys were conducted and averaged (excluding zero observations) and if the relevant assumptions outlined later are also met, then the value of that average would approach the value given by eqn A2.2.2 with repeat surveys, although it may take many surveys for the predicted and observed means to converge.

The groundfish data are conceptually modeled as a set of outcomes of the purely spatial (non-temporal) random variables $P_i(x,y)$ (Stage I) and $Z_i(x,y)$ conditional on $P_i(x,y)=1$ (Stage II). This relies on the basic assumption that the parameters that define these random variables (described in more detail below) do not vary over time among survey years. Implications of this assumption are discussed later. The use of spatial random variables without an explicit temporal component is termed a spatial climatological approach and has been used elsewhere to map "hotspots" and "coldspots" in long-term average patterns of species distribution (e.g., Santora and Reiss, 2011). The word climatology in this context means long-term average.

Both Stage I and Stage II of the model are themselves comprised of two sub-models: a trend model and a residual model, described in more detail below. The trend models are implemented as generalized linear models (GLMs), and predict large-scale variation in a species' distribution from environmental variables. The residual models are implemented as geostatistical models (kriging) to account for spatial autocorrelation in the residuals from the trend (Cressie, 1993; Pebesma, 1998).

The GLM trend component was necessary because exploratory data analysis showed that both probability of presence (Stage I) and abundance when a species is present (Stage II) showed large-scale trends that were related to environmental variables. Notably, presence/absence often showed different large-scale spatial patterns than abundance when the species was present, motivating the two-stage approach. Other types of trend models are possible, and could be explored in future work (e.g., generalized additive models, classification and regression trees).

The geostatistical component was necessary because the data are clustered and unevenly distributed in space, and preliminary analysis after removal of large-scale trends with GLM revealed autocorrelation in the spatial pattern of residuals. When this is the case, spatial dependence must be explicitly modeled to obtain unbiased estimates of GLM coefficients, as well as to properly model uncertainty at unsampled locations (Cressie, 1993; Chiles and Delfiner, 1999). A major advantage of the hybrid GLM-geostatistical approach is that predictions are accompanied by spatially explicit estimates of uncertainty, because spatial dependence in error fields is explicitly modeled (Pebesma, 1998).

The final model prediction of CPUE is the product of Stage I and Stage II maps, which gives the unconditional expected value of $Z_i(x,y)$:

$$\mathrm{E}\{\, Z_i(x,y) \,\} = p_i(x,y) \;*\; \mathrm{E}\{Z_i(x,y) \mid P_i(x,y)=1\} \qquad \text{(A2.2.3; Stage I x II)}$$

This result follows directly from application of laws of probability and conditional expectation for random variables (Cragg, 1971; Ross, 2007). The final predicted value represents the average species catch per unit effort (kg/ha) that would be observed if a site was surveyed repeatedly (using the same standardized tows), including times when the species was not seen as values of 0.

The modeling process can be summarized as follows:

1. Transform dependent variables and potential predictor variables for linearity.
2. Divide data into training and validation ("holdout") subsets for cross-validation purposes.
3. Stage I trend model: Use a GLM (binomial distribution, logit link) to generate a predictive map of the mean probability of species occurrence.
4. Stage I residual model: Use ordinary indicator kriging (OIK) to predict the "residual" probability map, where "residual" is defined as the probability that the regression model leads to an incorrect classification of the presence state ($P_i(x,y)$) of a given location.
5. Final Stage I model: Adjust the trend-predicted probability map using the kriged residual probability map from step 4. The trend from step 3 and residual from step 4 are combined using probability laws.
6. Stage II trend model: Use a GLM (normal distribution, Box-Cox link) to generate a predictive map of the mean abundance of a species when it is present. The Box-Cox link indicates that data were transformed for normality for this part of the analysis using a Box-Cox type transformation (Box and Cox 1964), described further below, and back-transformed for final maps.
7. Stage II residual model: Use Simple Kriging (SK) to predict residual map of the regression model of abundance.
8. Final Stage II model: Add the trend map from step 6 and the residual map from step 7.
9. Final Stage I x II model prediction: Multiply the predicted probability of occurrence at each location by the predicted abundance if present to produce the final prediction of the expected value (long-term average) of abundance at each location.
10. Relative uncertainty calculation: scaled relative uncertainty values were calculated for the trend, residual, and final models for Stage I and Stage II, and for the final Stage IxII prediction.
11. Model evaluation, cross-validation, and relative uncertainty calibration.
12. Post-processing

The sections below describe each of these steps in detail.

Unless otherwise noted, all predictive modeling analyses were carried out in Matlab R2011b (The Mathworks, Natick, MA), with the Statistics, Mapping, and Image Processing toolboxes (Mathworks), mGstat (Hansen 2009, http://mgstat.sourceforge.net/), ROC (Cardillo 2008), partest (Cardillo 2008), lowess (Burkey 2009), ploterr (Zörgiebel 2008), boxcoxlm (Dror 2006), and additional custom code available by contacting the authors. Geostatistical algorithms (kriging, generalized least squares estimation of trend model coefficients, variogram estimation, and variogram model fitting) were implemented by calling the program gstat (standalone version 2.5.1; Pebesma and Wesseling 1998; http://www.gstat.org/) from within Matlab, with the help of the mGstat toolbox. GLM model selection was carried out by calling the R package glmulti (Calcagno and Mazancourt 2010, Calcagno 2011, http://cran.r-project.org/web/packages/glmulti/index.html) from within Matlab. All Matlab code is available for review.

Step 1: Transformation of variables

Transforming independent variables in a multiple linear regression context for normality, centrality, and homogeneity of variance is often desirable for stabilizing estimates of regression parameters, and can also help to linearize relationships between predictors and response (Sokal and Rohlf, 1995). The family of power-law transformations studied by Box and Cox (1964) is particularly useful for improving both normality and linearity. A Box-Cox transformation is defined as follows, where X denotes the original variable and X^* the transformed variable:

$$X^* = \begin{cases} X^{\lambda}, \text{if } \lambda \neq 0 \\ \ln(X), \text{if } \lambda = 0 \end{cases} \qquad \text{(A2.2.4)}$$

Catch per unit effort at non-zero locations were first transformed for normality using a Box-Cox power transform whose parameter λ was chosen by a maximum likelihood procedure (Box and Cox, 1964; Dror, 2006).

We investigated linearizing the relationship between the each transformed species' catch per unit effort and each independent variables using the Box-Tidwell procure (in R CAR package), but found widely different transformations were selected. We chose not to use different transformations, although in the future one could have a different transformation for each species that maximized linearity between predictors and responses. Instead, we transformed chlorophyll a concentration using a logarithmic transformation [Log10(X+1)] and converted depth from negative to positive values to follow convention. Note that the bathymetry transformation changes the sign of the linear relationship between the variable and response; care must therefore be taken in interpreting the signs of regression coefficients for transformed predictors.

Transformed predictor variables were centered and standardized prior to each GLM fit, using the set of values of each predictor variable at the data locations under consideration (centering and standardization was performed each time just prior to running the GLM, because different patterns of missing predictor data could cause different data points to be used, requiring re-centering and re-standardization).

Step 2: Selection of cross-validation data

50% of the observation locations were selected at random to be used in subsequent model-fitting (henceforth referred to as the training set), with the remaining 50% withheld for cross-validation (henceforth referred to as the validation or holdout set). All model selection and model fitting was carried out using only the training set. Cross-validation statistics were calculated by comparing model predictions at the holdout locations to the true data values at the holdout locations. Final predictive maps, however, used all available data by applying the models selected and fit based on training data to the entire original dataset. Cross-validation error estimates are thus conservative in the sense that they were derived from a model fit to a dataset one half the size of the final dataset.

Step 3: Stage I trend model

The trend component of the Stage I model, $\mu_i^I(x,y)$, was estimated as follows.

Observed data $Z_i(x,y)$ were first transformed to a binary indicator variable $P_i(x,y)$, whose value was 1 if $Z_i(x,y)>0$ and 0 otherwise. The initial set of 11 potential predictor variables was then pre-screened to remove any predictors whose pattern of missing values would too greatly influence the data points that could be used to estimate the GLM. Pre-screening criteria are given in Table A2.2.3.

Predictor variables not excluded in the pre-screening process were centered, standardized, and the R package 'glmulti' (Calcagno and Mazancourt, 2010; Calcagno, 2011) was used to search for the model with lowest AICc from the set of possible generalized linear models, allowing two-way interaction effects to be included, but requiring that both corresponding main effects be in the model if an interaction term were to be included (marginality requirement). GLM model used a binomial distribution with a logit link function (Fox, 2008).

The search method used depended on the size of the possible model space, which was restricted by the elimination of some potential predictors in the pre-screening stage (above) and by an upper bound on the number of terms determined by the number of observations. The number of terms in a model (not including the intercept) was restricted to be no greater than the number of observations divided by 10 (Sokal and Rohlf, 1995; Fox, 2008). If the number of predictors and/or maximum number of terms was sufficiently small, then the model space was searched exhaustively for the model with the lowest corrected Akaike's Information Criterion (AICc; Sokal and Rohlf, 1995). If the number of predictors and/or maximum number of terms was intermediate, then a genetic algorithm with the default parameters and stopping criteria of deltaM=0.5, conseq=5 was used (Calcagno and Mazancourt, 2010; Calcagno, 2011). If the number of predictors and/or maximum number of terms was too large for the genetic algorithm to enumerate the model space, then an exhaustive search was performed of all possible models with 5 or fewer main effects (allowing for two-way interactions within each subset).

The selected model structure was then fit to the data using Matlab Statistics Toolbox function 'glmfit', which implements standard Generalized Linear Model fitting by iteratively re-weighted least-squares (Bjorck, 1996; Fox, 2008). As before, a binomial distribution and logit link function were used. Use of binomial distributions and logit link functions involves assumptions that are discussed later. Parametric ± 1 standard error confidence bounds on GLM estimates were calculated using Matlab function 'glmval' (following equations in Fox, 2008).

A standard array of GLM diagnostics was produced, including effect tests, deviance goodness-of-fit tests, several 'pseudo-R^2' measures designed for logistic regression, residual leverage and influence plots, and a variety of other diagnostic measures. An ROC curve analysis was also performed to assess accuracy of the Stage I trend prediction.

Step 4: Stage I residual model

The residual component of the Stage I model, $\varepsilon_i^I\ (x,y)$, was estimated as follows. First, ROC curve analysis was used to determine the optimal cutoff value of the trend probability, $\mu_i^I\ (x,y)$, to use for classifying the presence/absence data (Cardillo, 2008). ROC curve analysis identifies the cutoff probability for classification that optimizes the tradeoff between sensitivity and specificity, given a training dataset. This cutoff was then applied to transform the trend prediction map $\mu_i^I\ (x,y)$ into a binary classification map (0=predicted absence, 1=predicted presence). Use of this ROC curve method to classify the trend can result in global bias of the classification toward the less-common class (usually presences), and the implications of this bias are discussed later.

A binary indicator variable (the "misclassification indicator") was then created that took the value 1 if the binary classification map based on the trend was correct at a data location, and 0 if not. Indicator variograms were estimated and modeled from this misclassification indicator, and Ordinary Indicator Kriging (OIK) was used to produce a map of predicted misclassification probabilities. Kriging predictions >1 or <0 were set to 1 or 0, respectively, to satisfy order relations for probabilities (Deutsch and Journel, 1998; Pebesma, 1998), and the resulting map was the residual component of Stage I, $\varepsilon_i^I\ (x,y)$. Because misclassification of 0's as 1's and 1's as 0's were considered equivalent, the OIK geostatistical model makes the assumption that the spatial patterns of misclassification of 1's and 0's are equivalent (symmetry). Implications of this symmetry assumption are discussed later.

Variogram models were fit automatically by a non-linear weighted least-squares minimization algorithm (Pebesma, 1998; Pardo-Igúzquiza, 1999), using weights proportional to N/h^2 (the number of pairs of observations used to estimate each observation divided by the square of the lag distance), as described by Pebesma (1998). Following standard geostatistical practice, the functional form of the variogram and an initial-guess parameter set was specified prior to the least-squares minimization by inspection of the empirical variogram (Issaks and Srivistava, 1989; Cressie, 1993; Deutsch and Journel, 1998; Chiles and Delfiner, 1999).

OIK produces parametric estimates of uncertainty (kriging standard error) for each location in the residual prediction map (Pebesma, 1998; Deutsch and Journel, 1998). An ROC curve analysis was also performed to assess accuracy of the Stage I residual prediction.

Step 5: Final Stage I model

Because the trend and residual components of the Stage I model are probabilities, they can be combined using the laws of conditional probability to arrive at the full Stage I model as follows (Ross, 2007):

$p_i(x,y)$ = Prob([trend model predicts *i* is present AND trend model is not wrong] OR [trend model predicts *i* is not present AND trend model is wrong]) (A2.2.5)

which can be translated to,

$$p_i(x,y) = \mu_i^I(x,y)\cdot(1-\varepsilon_i^I(x,y)) + (1-\mu_i^I(x,y))\cdot\varepsilon_i^I(x,y) \qquad \text{(A2.2.6)}$$

which simplifies to the final Stage I model:

$$p_i(x,y) = \mu_i^I(x,y) + \varepsilon_i^I(x,y) - 2\cdot\mu_i^I(x,y)\cdot\varepsilon_i^I(x,y) \qquad \text{(A2.2.7)}$$

Parametric ± 1SE confidence intervals for the final Stage I model, $p_i(x,y)$, were derived by applying eqn A2.2.7 to the parametric confidence intervals for $\mu_i^I(x,y)$ and $\varepsilon_i^I(x,y)$ calculated using the GLM model and the geostatistical (OIK) model, respectively.

Step 6: Stage II trend model

The trend component of the Stage II model, $\mu_i^{II}(x,y)$, was estimated as follows. Data at non-zero locations were first transformed for normality using a Box-Cox power transform whose parameter λ was chosen by a maximum likelihood procedure (Box and

Cox 1964, Dror 2006). The initial set of 11 potential predictor variables was then pre-screened to remove any predictors whose pattern of missing values would too greatly influence the data points that could be used to estimate the GLM. Pre-screening criteria are given in Table A2.2.3 .

The predictor variables were centered, standardized, and the R package 'glmulti' (Calcagno and Mazancourt, 2010; Calcagno, 2011) was used to search for the model with lowest AICc in the same way described for Stage I (above), except that in this case the GLM model used a normal distribution with a Box-Cox link function (Fox, 2008) (in practice, we applied a Box-Cox transformation prior to GLM modeling, used an identity link, and then back-transformed to the original scale).

The selected model structure was then fit to the data using Matlab Statistics Toolbox function 'glmfit', which implements standard Generalized Linear Model fitting by iteratively re-weighted least-squares (Bjorck, 1996; Fox, 2008). A normal distribution and identity link function were used. Use of the normal distribution here involves assumptions that are discussed later. Parametric ± 1 standard error uncertainty bounds on GLM estimates were calculated using Matlab function 'glmval' (following equations in Fox, 2008).

Because spatial autocorrelation biases the estimation of GLM parameters, we followed an iterative procedure to fit the final GLM in gstat (Pebesma, 1998; Chiles and Delfiner,1999).

1. Calculate residuals and estimate residual variogram
2. Re-calculate fit with gstat, using residual variogram
3. Re-calculate residuals and repeat fitting with gstat (steps 2 and 3) until residual variogram has converged (determined by inspection).

A standard array of GLM diagnostics was produced, including effect tests, goodness-of-fit F tests, R^2 and several 'pseudo-R^2' measures to allow comparison with the Stage I logistic regression, residual leverage and influence plots, and a variety of other diagnostic measures.

Step 7: Stage II residual model

The residual component of the Stage II model, $\varepsilon_i^{II}(x,y)$, was estimated as follows. First, residuals from the trend model fit were calculated by subtracting the observed values from predicted values. Residuals were calculated in Box-Cox transformed space to satisfy normality assumptions of geostatistical methods. Residual variograms were then estimated and modeled using gstat, and Simple Kriging (SK) was used to produce a map of predicted residuals. The resulting map was the residual component of Stage II, $\varepsilon_i^{II}(x,y)$.

Variogram models were fit automatically by a non-linear weighted least-squares minimization algorithm (Pebesma, 1998; Pardo-Igúzquiza, 1999), using weights proportional to N/h^2 (the number of pairs of observations used to estimate each observation divided by the square of the lag distance), as described by Pebesma (1998). Following standard geostatistical practice, the functional form of the variogram and an initial-guess parameter set was specified prior to the least-squares minimization by inspection of the empirical variogram (Issaks and Srivistava, 1989; Cressie, 1993; Deutsch and Journel, 1998; Chiles and Delfiner, 1999).

SK was also used to produce parametric estimates of uncertainty (kriging standard error) for each location in the residual prediction map (Pebesma, 1998; Deutsch and Journel, 1998).

Step 8: Final Stage II model

In Box-Cox transformed space, the final Stage II model is simply the sum of trend and residual components:

$$\mathrm{E}\{Z_i^{Transformed}(x,y) | P_i(x,y)=1\} = \mu_i^{II}(x,y) + \varepsilon_i^{II}(x,y) \tag{A2.2.8}$$

The result can be back-transformed to yield a prediction in the original units of CPUE:

$$\mathrm{E}\{Z_i\ (x,y) \,|\, P_i(x,y)=1\} = \begin{cases} (\mathrm{E}\{Z_i^{Transformed}(x,y) \,|\, P_i(x,y)=1\})^{1/\lambda}, \text{if } \lambda \neq 0 \\ \exp(\mathrm{E}\{Z_i^{Transformed}(x,y) \,|\, P_i(x,y)=1\}), \text{if } \lambda = 0 \end{cases} \tag{A2.2.9}$$

Back-transforms were constrained to lie between 0 and 110% of the observed data maximum. Back-transformation in this way yields an estimate of the mean that is biased to produce lower values than the true arithmetic mean on the original scale; the bias is proportional to the magnitude of the abundance prediction and to the prediction variance. Effectively, the highest and most uncertain values are downweighted, resulting in more conservative (lower) predictions of expected abundance. This systematic bias can be corrected with a simple formula, although in this version the uncorrected back-transformed estimates are shown, resulting in systematic underestimation of very high abundances, especially in places where model predictions are very uncertain.

Parametric ± 1SE confidence intervals for the final back-transformed Stage II model, $\mathrm{E}\{\ Zi(x,y) \,|\, P_i(x,y)=1\}$, were derived by applying eqn A2.2.8 and A2.2.9 to the parametric confidence intervals for μ_i^{II} *(x,y)* and ε_i^{II} *(x,y)* calculated using the GLM model and the geostatistical (SK) model, respectively.

Step 9: Final Stage I x II model

Stage I and Stage II models were combined as described in eqn A2.2.3 to produce each predictive map of the unconditional expected value of CPUE, which we will refer to as the "Stage I x II" prediction map or $E\{Z_i(x,y)\}$. Specifically, $E\{Z_i(x,y)\}$ is equal to the product of eqn A2.2.9 (the final back-transformed Stage II prediction) and eqn A2.2.7 (the final Stage I model prediction). Note that the Stage I x II predictions are in back-transformed units (CPUE).

Parametric uncertainty bounds (± 1SE) for the final Stage I x II maps were obtained by plugging the confidence intervals for μ_i^{I} *(x,y)*, ε_i^{I} *(x,y)*, μ_i^{II} *(x,y)*, and ε_i^{II} *(x,y)* described above into eqn A2.2.7 and A2.2.9 and multiplying eqn A2.2.7 by eqn A2.2.9 for each set of uncertainty bounds.

Step 10: Relative uncertainty calculations

In order to simplify comparison of uncertainties among different model components, uncertainties were converted to relative values that fall between 0 and 1, with 0 representing low uncertainty (high certainty) and 1 representing high uncertainty (low certainty). The implications of a particular relative uncertainty value for model performance can be determined by examining the diagnostic tables, which give cross-validation error statistics for each certainty class, and the cross-validation relative uncertainty calibration plots.

Stage I

The relative uncertainty of Stage I model predictions is expressed as the scaled negative log (odds ratio), *SNLOR*. The negative log odds ratio, *NLOR*, is the negative natural logarithm of the ratio of the odds of correct binary classification (absence= 0, presence= 1) using the Stage I model to the odds of correct binary classification under a null model:

$$NLOR = -\ln\left(\frac{Odds_{model}}{Odds_{null}}\right) \qquad \text{(A2.2.10)}$$

To calculate the odds of correct classification under the Stage I model, $Odds_{model}$, we first consider uncertainty of the Stage I model prediction relative to the cutoff probability c used for binary classification (in this case, the optimal cutoff probability determined by ROC curve analysis). The uncertainty around the Stage I model prediction p can be modeled by a normal curve on the logit scale, with mean equal to the Stage I prediction and standard deviation equal to the larger of the upper and lower 1SE confidence intervals:

$$z_p \sim N(\mathrm{logit}[p], \max(\mathrm{logit}[p^{+1SE}] - \mathrm{logit}[p], \mathrm{logit}[p] - \mathrm{logit}[p^{-1SE}]))$$
(A2.2.11)

Then the probability of the true predicted value lying above the cutoff probability c is given by

$$p_{above} = \mathrm{Prob}(z_p > \mathrm{logit}(c)) \quad \text{(A2.2.12)}$$

and the probability of the true predicted value falling below the cutoff probability is

$$p_{below} = \mathrm{Prob}(z_p < \mathrm{logit}(c)) \quad \text{(A2.2.13)}$$

The classifier itself is subject to error, which we estimate by its performance in cross-validation: the true positive ($\hat{p}_{TP}$), true negative ($\hat{p}_{TN}$), false positive ($\hat{p}_{FP}$), and false negative ($\hat{p}_{FN}$), rates of the classifier from the cross-validation confusion matrix at cutoff value c. The odds of correct classification using the Stage I model can then be calculated as:

$$Odds_{model} = \frac{p_{above} \cdot \hat{p}_{TP} + p_{below} \cdot \hat{p}_{TN}}{p_{above} \cdot \hat{p}_{FP} + p_{below} \cdot \hat{p}_{FN}} \quad \text{(A2.2.14)}$$

To calculate the odds of correct classification under a null model, $Odds_{null}$, we consider a null model in which the true and predicted presence/absence (1/0) states are given by Bernoulli random variables with probabilities p_1 (equal to the global prevalence of the species) and c (equal to the optimal cutoff probability from ROC curve analysis), respectively. Then the null odds of correct classification are:

$$Odds_{null} = \frac{(1-p_1) \cdot c + p_1 \cdot (1-c)}{(1-p_1) \cdot (1-c) + p_1 \cdot c} \quad \text{(A2.2.15)}$$

For a given set of cross-validation error rates ($\hat{p}_{TP}$, $\hat{p}_{TN}$, $\hat{p}_{FP}$, and $\hat{p}_{FN}$), the minimum and maximum possible values of the *NLOR* are:

$$Odds_{\mathrm{mod}\,el}^{\min} = \min\left(\frac{\hat{p}_{TP}}{\hat{p}_{FP}}, \frac{\hat{p}_{TN}}{\hat{p}_{FN}}\right),\ Odds_{\mathrm{mod}\,el}^{\max} = \max\left(\frac{\hat{p}_{TP}}{\hat{p}_{FP}}, \frac{\hat{p}_{TN}}{\hat{p}_{FN}}\right) \quad \text{(A2.2.16)}$$

The scaled *NLOR*, *SNLOR*, is calculated so that *SNLOR*=0 at the minimum possible value of the *NLOR* and *SNLOR*=1 at the maximum possible value of the *NLOR*:

$$SNLOR = \frac{\ln(\frac{Odds_{model}^{\max}}{Odds_{null}}) - \ln(\frac{Odds_{model}}{Odds_{null}})}{\ln(\frac{Odds_{model}^{\max}}{Odds_{null}}) - \ln(\frac{Odds_{model}^{\min}}{Odds_{null}})} \qquad \text{(A2.2.17)}$$

Values of *SNLOR* closer to 0 indicate model predictions that have relatively high odds of being correct compared to a null model (high certainty), whereas values closer to 1 indicate model predictions that have relatively low odds of being correct compared to a null model (low certainty). Relative uncertainties were calculated in this way for the Stage I trend, Stage I residual, and the final Stage I model, using the cross-validation ROC curve cutoff *c* and cross-validation error rates ($\hat{p}_{TP}$, $\hat{p}_{TN}$, $\hat{p}_{FP}$, and $\hat{p}_{FN}$) determined from the ROC analysis of trend, residual, and final Stage I predictions, respectively. Below, the final Stage I relative uncertainty is denoted $\sigma^{I,rel}(x,y)$, and is equal to the value of SNLOR for the final Stage I model for species *i* at location *(x,y)*.

Stage II

Relative uncertainty of Stage II trend, residual, and final model predictions were calculated as the ratio of prediction variances to the appropriate error variance (trend prediction variance: total sample variance minus residual variogram sill; residual variance: residual variogram sill; final prediction variance: total sample variance). Below, the final Stage II relative uncertainty is denoted $\sigma^{II,rel}(x,y)$.

Stage IxII

The relative uncertainty of final Stage IxII model predictions was calculated by combining the relative uncertainties of final Stage I and Stage II models as follows:

$$\sigma_i^{IxII,rel}(x,y) = p_i(x,y) \cdot [\sigma_i^{II,rel}(x,y)] + (1 - p_i(x,y)) \cdot \sigma_i^{I,rel}(x,y) \qquad \text{(A2.2.18)}$$

The rationale behind eqn A2.2.18 is that the Stage II relative uncertainty applies if the species is present (which is true with probability $p_i(x,y)$), whereas the Stage I relative uncertainty applies if the species is absent (which is true with probability [1- $p_i(x,y)$]).

Step 11: Model evaluation and uncertainty calibration

In addition to the standard GLM effect tests and diagnostics, model predictive performance was evaluated in and out of the training set using a variety of error statistics, error plots and ROC curve analysis. As a final summary of model performance in cross-validation and aid to the user in interpreting relative uncertainty values for the final Stage IxII model, an uncertainty calibration plot was produced. For each location in the holdout set, the model developed from training data was used to predict the value at that location, and the magnitude of the difference between actual and predicted values (absolute error) was plotted versus the Stage I x II relative uncertainty value. Robust linear loess smoothing lines (Burkey, 2009) are plotted to show how actual out-of-set average prediction errors relate to parametric relative uncertainty estimates. Separate lines are plotted for overall error, and error when the species was present (since most species are relatively rare in any given survey, presences are harder to predict than absences). Similar relative uncertainty calibration plots are produced for Stage I predictions (presence/absence).

Uncertainty calibration plots, ROC analyses, error statistics, and other model evaluation diagnostics are included in the diagnostic table at the end of this report, and in the Online Supplements for each species.

Model Diagnostics and Display

Model predictions were evaluated using model diagnostic measures, visual comparisons with input observations and reviewer expertise. In some cases model predictor sets were modified to exclude potential predictors, because of evidence of overfitting (gauged by the degradation of model performance in cross-validation). The models were rerun without the selected predictors and if model overfitting was reduced the new model was used to make groundfish predictions. Excluded predictors are identified for each species in Table A2.2.3.

Model predictions were clipped by relative uncertainty, known latitude and depth limits for each species and the area of the NMFS trawl survey sampling domain. Relative uncertainty was calculated as part of the modeling process and was used to eliminate predictions with relative uncertainty estimates greater than 1.1 in Stage I, and 2.0 in stage II and stage IxII outputs. Species specific depth and latitude limits were taken from published literature including: Love et al. (2002), Love and Yoklavich (2008), and the Habitat Use Database (HUD) fish species details compiled by the Northwest Fisheries Science Center, Fishery Resource Analysis & Monitoring Division. Predictions within known depth and latitude limits are shown and predictions outside the limits were eliminated. Predictions outside of the NMFS trawl sampling domain were eliminated, such as the Cowcod Conservation Areas or in areas hazardous to fish in.

As part of the model validation process, probability of occurrence (Stage I) predictions were assessed for bias. Bias was computed by applying the GLM and spatial autocorrelation parameters fitted to the training trawl dataset to predict probability of occurrence at testing dataset locations. The difference between the predicted and observed probability of occurrence was used to compute a bias correction multiplier which was then used to correct probability of occurrence predictions for all final models. Table A2.2.4 shows the bias correction factor for each species. It should be noted that this bias correction corrects for the bias in Stage I (occurrence probability), but not for any bias that may be present in Stage II (conditional abundance), which is discussed above.

Table A2.2.4: Bias correction factors applied to the final species predictive models.

Species	**Bias Correction Factor**
Sablefish	1.12
Yelloweye rockfish	0.10
Petrale sole	0.92
Longspine thornyhead	0.98
Greenstriped rockfish	0.77
Darkblotched rockfish	0.61
Dover sole	1.13
Lingcod	0.75
Shortspine thornyhead	1.00
Pacific ocean perch	0.40
Chilipepper	0.61

NCCOS Results

Overall, diagnostic statistics indicated that most models were successful in describing aspects of species distribution, although model performance varied over space and from species to species. Tables 2.3, 2.4, and A2.2.5, A2.2.6 summarize the relative importance of different environmental predictor variables across the predictive models, and model variance components, respectively. The relative importance of different model components (trend, spatial model, 'white noise' error term) varied from Stage I to Stage II and among species. Model performance also varied, and any application of these models should consider the performance metrics most relevant to the application in question. Table A2.2.6 summarizes several selected cross-validation performance diagnostics from predictive models and gives a qualitative assessment (e.g., poor, good, excellent) of each model based on a combination of the Area under Curves (AUC), Spearman's rank correlation coefficients and mean absolute error calculated on cross-validation holdout datasets.

We present the predicted probability of occurrence and abundance maps for the six focal species and five additional species in Figs. 2.1 to 2.23.

Table A2.2.5: Variance components (percentages of all variance) for 10 groundfish species models developed by NCCOS.

	Stage I			Stage II		
Species	Trend	Spatial Noise	White Noise	Trend	Spatial Noise	White Noise
Sablefish	80.44	4.78	14.78	30.51	0.00	69.49
Yelloweye rockfish	93.15	4.26	2.59	40.26	0.00	59.74
Petrale sole	97.75	0.00	2.25	21.12	7.43	71.45
Longspine thornyhead	99.29	0.00	0.71	72.50	9.96	17.55
Greenstriped	99.06	0.13	0.80	41.24	10.90	47.86
Darkblotched rockfish	97.63	0.82	1.56	41.54	6.83	51.63
Dover sole	82.36	6.51	11.13	57.28	14.71	28.01
Lingcod	98.85	0.20	0.96	28.73	2.64	68.63
Shortspine thornyhead	93.89	0.00	6.11	27.40	27.17	45.42
Pacific ocean perch	98.99	0.38	0.63	53.17	8.48	38.35

Table A2.2.6:

	Qualitative		R	% correct within 1SD	Mean Absolute Error	AUC	
Species	Stage I	Stage IxII	Stage IxII	Stage IxII	Stage IxII	Stage I	Stage IxII
Sablefish	Excellent	Good	0.56	80.10	1.75	0.88	0.79
Yelloweye rockfish	Excellent	Poor	0.27	52.94	0.70	0.85	0.65
Petrale sole	Excellent	Poor	0.39	72.36	1.15	0.96	0.69
Longspine thornyhead	Excellent	Excellent	0.87	75.53	2.38	0.99	0.94
Greenstriped rockfish	Excellent	Good	0.65	72.81	5.56	0.93	0.80
Darkblotched rockfish	Excellent	Fair	0.57	68.83	0.86	0.92	0.76
Dover sole	Excellent	Good	0.74	71.57	4.92	0.90	0.87
Lingcod	Excellent	Fair	0.45	72.59	1.26	0.89	0.71
Shortspine thornyhead	Excellent	Good	0.62	76.50	0.93	0.97	0.80
Pacific ocean perch	Excellent	Fair	0.49	67.65	4.18	0.94	0.73

2.2.3 Summary and implications of model assumptions

The predictive modeling approach described above makes a number of assumptions. To the extent these assumptions are violated, accuracy of predictions and uncertainty estimates may suffer. In this section we briefly review the major assumptions and their implications. The degree to which violations of model assumptions affect the performance of any given model can be assessed by considering the cross-validation performance statistics and reported in diagnostic tables.

2.2.3.1 Important general assumptions

Stationarity of pattern over time among years

Statistically, stationarity in this context means that the region-wide mean, variance, and spatial structure of abundance and occurrence patterns do not change over the time period we studied. Ecologically, stationarity implies that the ecosystem has not undergone any fundamental shifts in patterns and processes (e.g., climate trends, ocean climate regime shifts, introduced species, changes in patterns of human activities like fishing). If this assumption is violated, temporal variation will show up as non-spatially structured error (“white noise”) in the model result. Model parameters and predictions may also be biased (cross-validation errors will not be centered at 0). The predicted spatial pattern may be an amalgam of different patterns that occurred at different time periods (e.g., “smearing” of hotspots that moved from year to year). If there are major changes in the underlying processes, the model will also be less generalizable to other time periods.

Stationarity of environmental predictor climatologies

The use of long-term climatologies of time-varying environmental predictors (such as SST and stratification), assumes that the long-term mean spatial patterns of these variables have not changed over time. Major changes in the underlying environmental patterns and processes will make the model less generalizable to other time periods.

Perfect detectability; freedom from other kinds of sample bias

To the extent that a given species is not perfectly detectable by the sampling protocol, relative occurrence and abundance indices will be biased compared to true abundance and occurrence values. Given the diversity of fishes, life-history characteristics and habitats in the study area, the survey did not equally detect and enumerate species. Unequal biases, systematized by the standard survey protocol, arise from a combination of factors including: gear type, mesh size, tow length and speed, surveyed and omitted habitats, and species life-history characteristics. Predictions from this model should be considered relative, rather than absolute, estimates of occurrence and abundance. Severely undersampled species or life-stages may require other survey and modeling approaches to improve information.

Constant relationship between sampling effort, relative indices of occurrence and abundance, and true values of occurrence and abundance

Not only are species unlikely to be perfectly detectable, the relationship between our relative indices of occurrence and abundance and the true values of occurrence and abundance could vary in time and space, depending on differences in observers, weather conditions, animal behavior, etc. Such variation introduces an un-accounted for source of measurement error into data.

Important Stage I assumptions

Binomial distribution and logit link function

To the extent that these distributional assumptions are violated, trend predictions may be biased and parametric confidence intervals inaccurate.

Use of receiver operating characteristic (ROC) curve optimal cutoff analysis to classify residuals from the trend model

Use of the ROC classifier may introduce bias into the final presence probability estimates at the expense of balancing overall sensitivity and specificity. We have estimated this bias using cross-validation and corrected for it in final presentation of model results.

Symmetry assumption for misclassification probability field

Misclassification of absences as presences may not show the same spatial pattern as misclassification of presences as absences; if that is the case, then model predictions may be biased and the model may perform better for one type of misclassification than for others, even though parametric uncertainty estimates are the same.

Important Stage II assumptions

Normality and linearity of Box-Cox transformed predictors and responses in the Stage II trend model

We assume that the Box-Cox transform in Stage II is sufficient to achieve normality of residual variances and linearity of underlying response-predictor relationships. Since the underlying fish relative abundance data are based on counts (divided by area swept to create a quasi-continuous density estimate), this requires that we assume the continuous Box-Cox transformed Gaussian distribution used to represent non-zero relative abundance is an adequate approximation to the underlying discrete probability distribution. The appropriateness of these assumptions is difficult to test directly and the reader should rely on cross-validation performance statistics to judge the extent to which these assumptions were approximately correct.

Trans-Gaussian assumption in the Stage II residual (geostatistical) model

Simple Kriging also assumes approximate normality; therefore the adequacy of the Box-Cox transformation to achieve normality of the residual distribution is also important to the accuracy of the kriging prediction (especially the validity of the kriging variance).

Back-transform issues (extrapolation of the CDF tail)

When back-transforming Stage II predictions, we have arbitrarily cut off the upper end of the distribution at 110% of the data maximum, which may not always be appropriate. This is only expected to influence the highest predicted values.

Important Stage IxII assumptions

Separability of abundance and presence/absence patterns

We have assumed that abundance is conditionally independent of presence/absence (that is, abundance can be modeled independently of presence probability). If this assumption is violated, then the Stage IxII estimates will be biased. The direction of this bias will depend on the sign of the dependence, and on the Box-Cox transformation parameter. The degree of bias in predictions can be assessed (and corrected for) by examining cross-validation bias statistics in the diagnostic tables.

Table 2.3: Probability of occurrence parameters included in the plotted NCCOS models. “X” indicates a covariate used as a main effect, “Y” indicates a covariate used as part of an interaction term, and “N/A” indicates a term that was omitted from the model.

Species	Depth	Depth Polynomial	Alongshore distance	Region	Bathymetric Position Index	Rugosity	Slope	Near-bottom temperature	Surface temperature	Surface Chlorophyll	Distance to hardbottom
Sablefish	X	X	Y	X	Y	Y	Y	X	Y	Y	
Yelloweye rockfish	X		X		X				X	X	
Petrale sole	X	Y	Y	X	Y	Y	Y	X	Y	X	Y
Longspine thornyhead	X	X	X	X	Y	X	X	X	X	Y	
Greenstriped rockfish	X	N/A	X	Y	X	X		X	Y	X	X
Darkblotched rockfish	X	X	X	X					X		
Dover sole	X	X	Y	X	X	Y	X	X	Y	X	X
Lingcod	X	Y	X	X	Y	X	X	X	X	X	
Shortspine thornyhead	X	X	X	X	Y		X	Y	Y	X	Y
Pacific ocean perch		X	Y	X				X			
Chilipepper	Y	X	X	X	X	Y		X	X		X

Table 2.4: Abundance parameters included in the plotted NCCOS models. “X” indicates a covariate used as a main effect, “Y” indicates a covariate used as part of an interaction term, and “N/A” indicates a term that was omitted from the model.

Species	Depth	Depth Polynomial	Alongshore distance	Region	Bathymetric Position Index	Rugosity	Slope	Near-bottom temperature	Surface temperature	Surface Chlorophyll	Distance to hardbottom
Sablefish	X	X	Y	Y			X		Y	Y	Y
Yelloweye rockfish			X		X		X	X			
Petrale sole	X	Y	Y	X	Y	X	Y	Y	X	X	Y
Longspine thornyhead	X	Y	Y	X	Y	X	X	X	X	Y	Y
Greenstriped rockfish	Y	N/A	Y	X	X		Y	X	X	X	X
Darkblotched rockfish	X	X			X			X			
Dover sole	X	X	Y	X		Y	X		Y	Y	X
Lingcod		X			X			Y	X	X	
Shortspine thornyhead	Y	Y	X		Y		Y	Y	X	X	Y
Pacific ocean perch		X	X				X	X	X		
Chilipepper	Y	X		X	X	Y		Y			

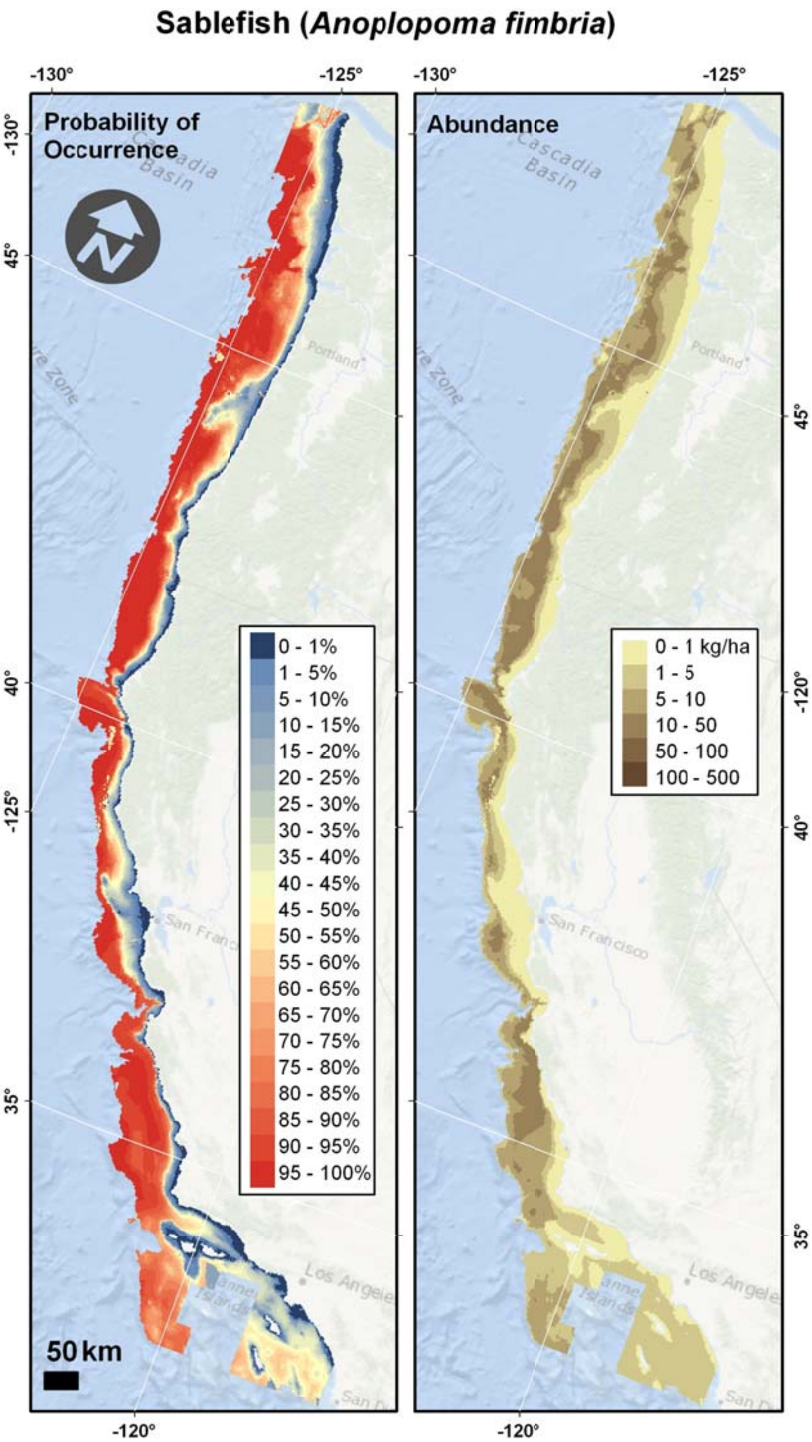

Figure 2.1: Sablefish mean predicted probability of occurrence and mean predicted abundance. NWFSC model projections.

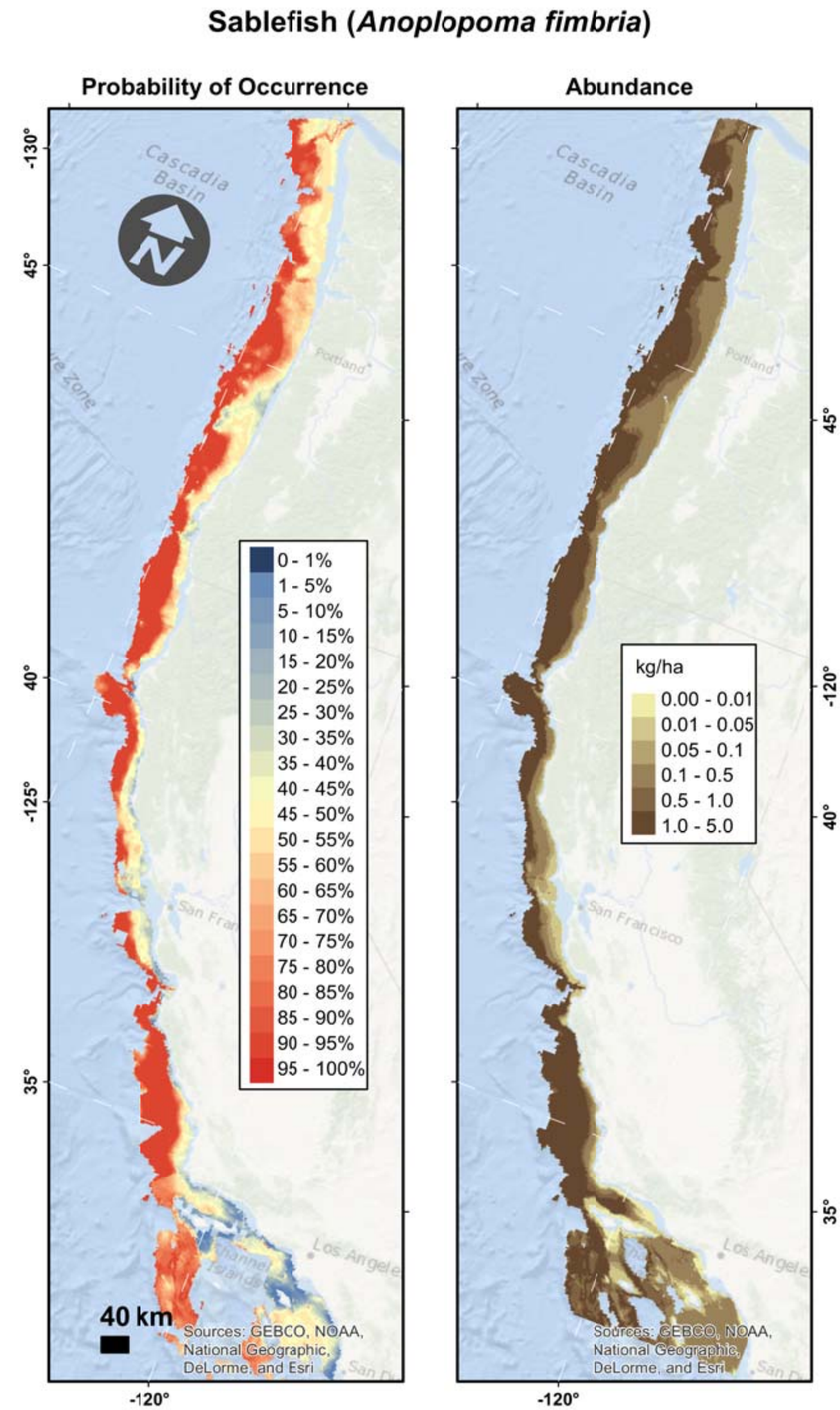

Figure 2.2: Sablefish mean predicted probability of occurrence and mean predicted abundance. NCCOS model projections.

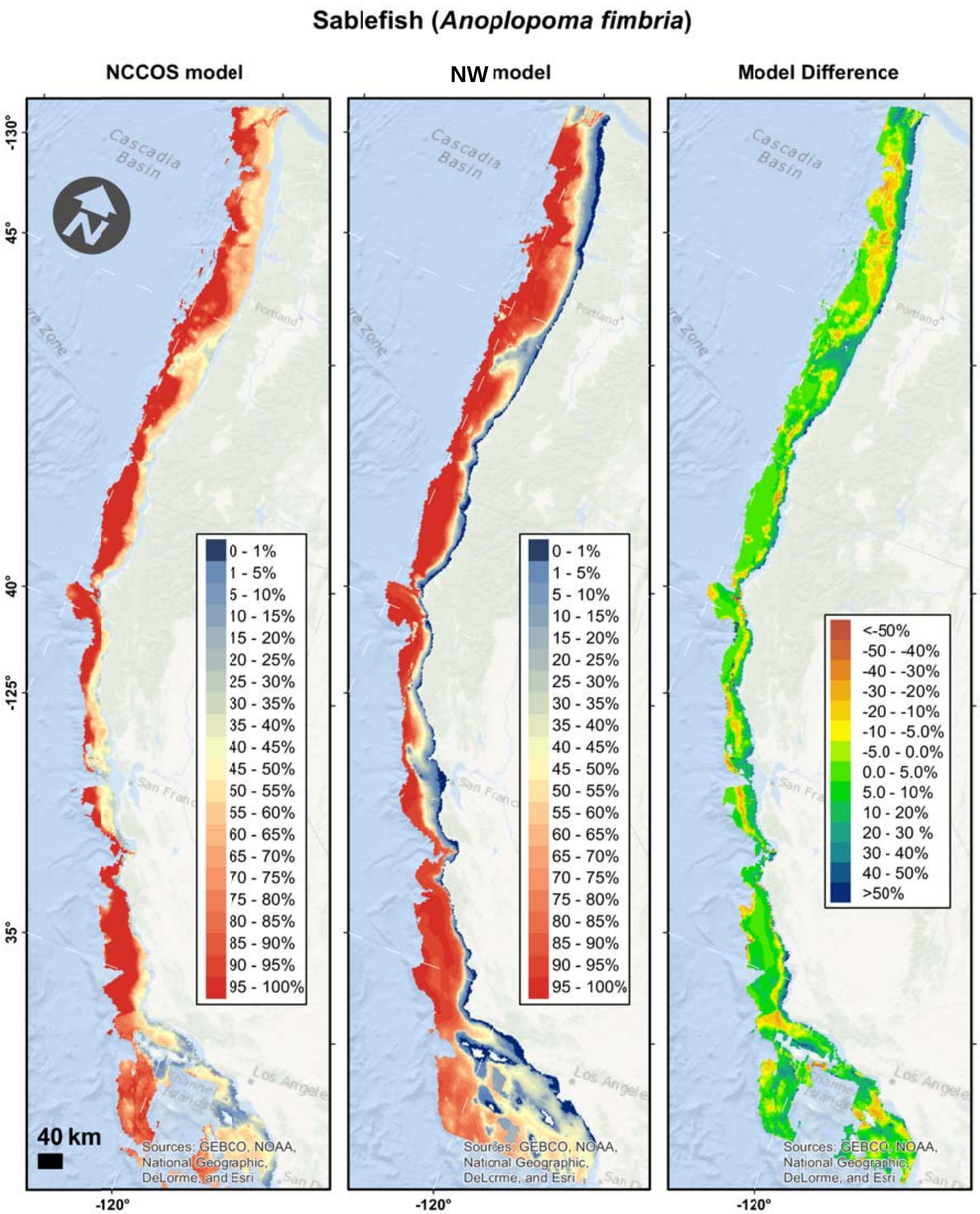

Figure 2.3: Sablefish predicted mean probability of occurrence from the NCCOS (left) and NWFSC (center) models. Right panel shows a plot of the difference between the NCCOS and NWFSC models (NCCOS – NWFSC). Positive values indicate NCCOS is greater than NWFSC

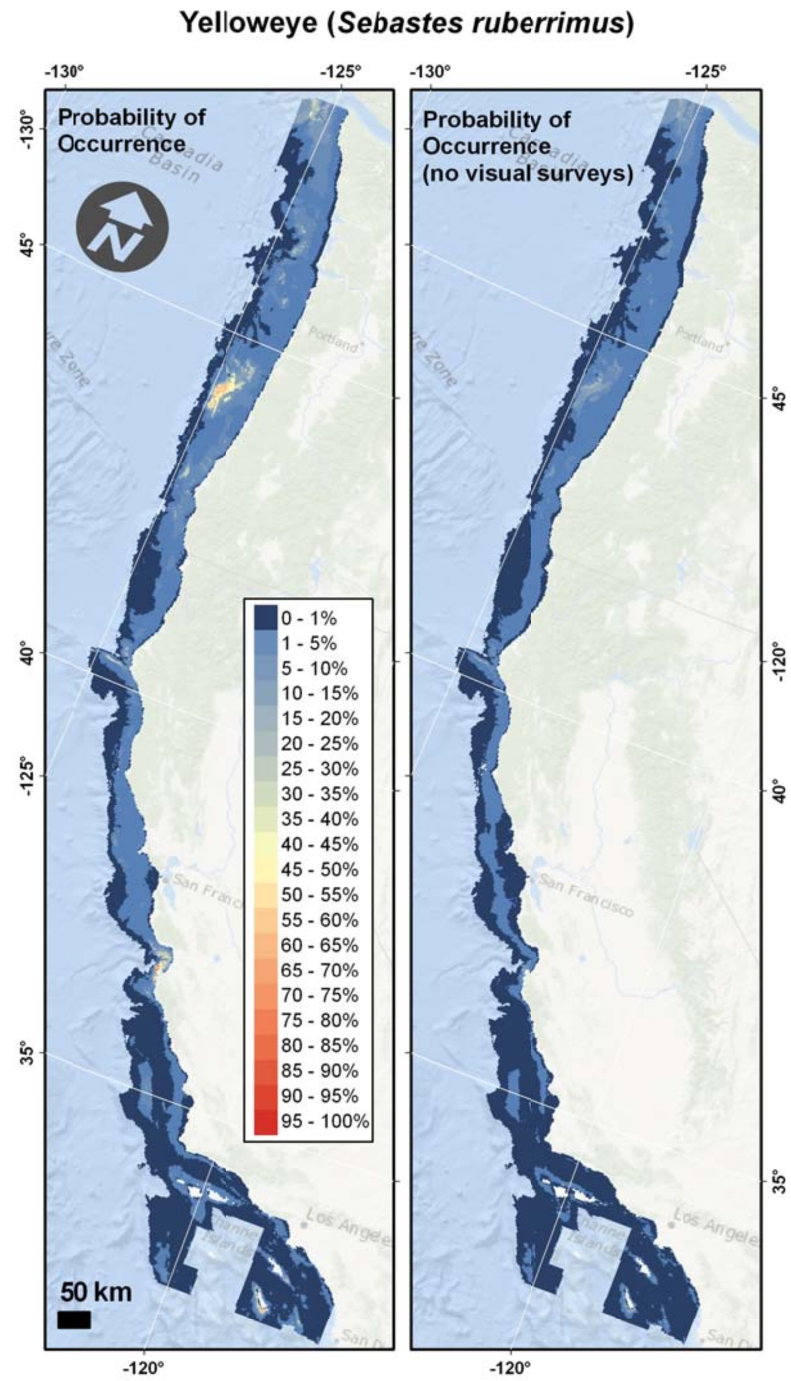

Figure 2.4: Yelloweye rockfish mean predicted probability of occurrence. NWFSC model projections. Left panel shows results using trawl survey data and visual survey data from submersible transects. Right panel shows results using only trawl survey data. We did not construct an abundance model for yelloweye rockfish.

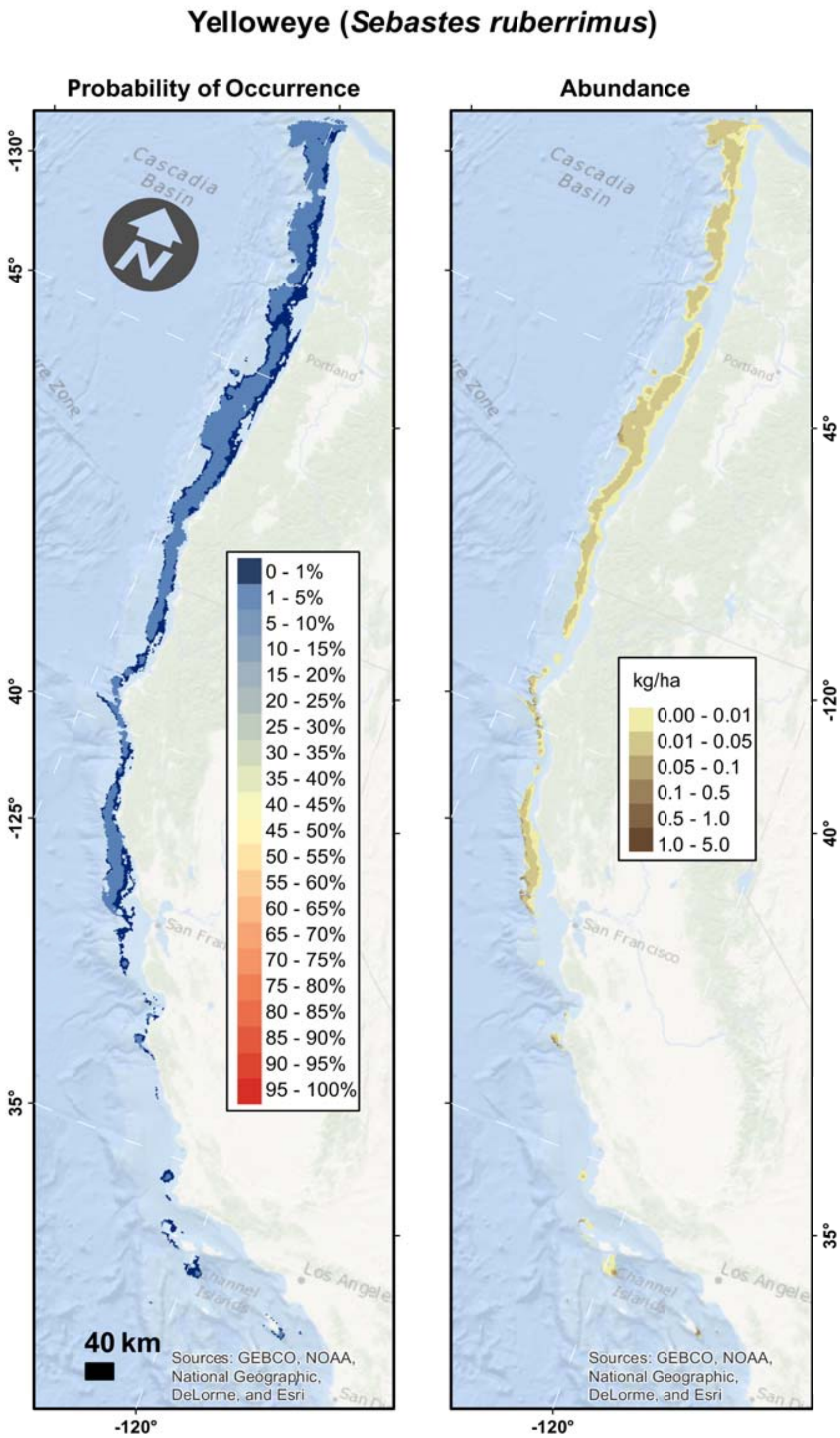

Figure 2.5: Yelloweye rockfish predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

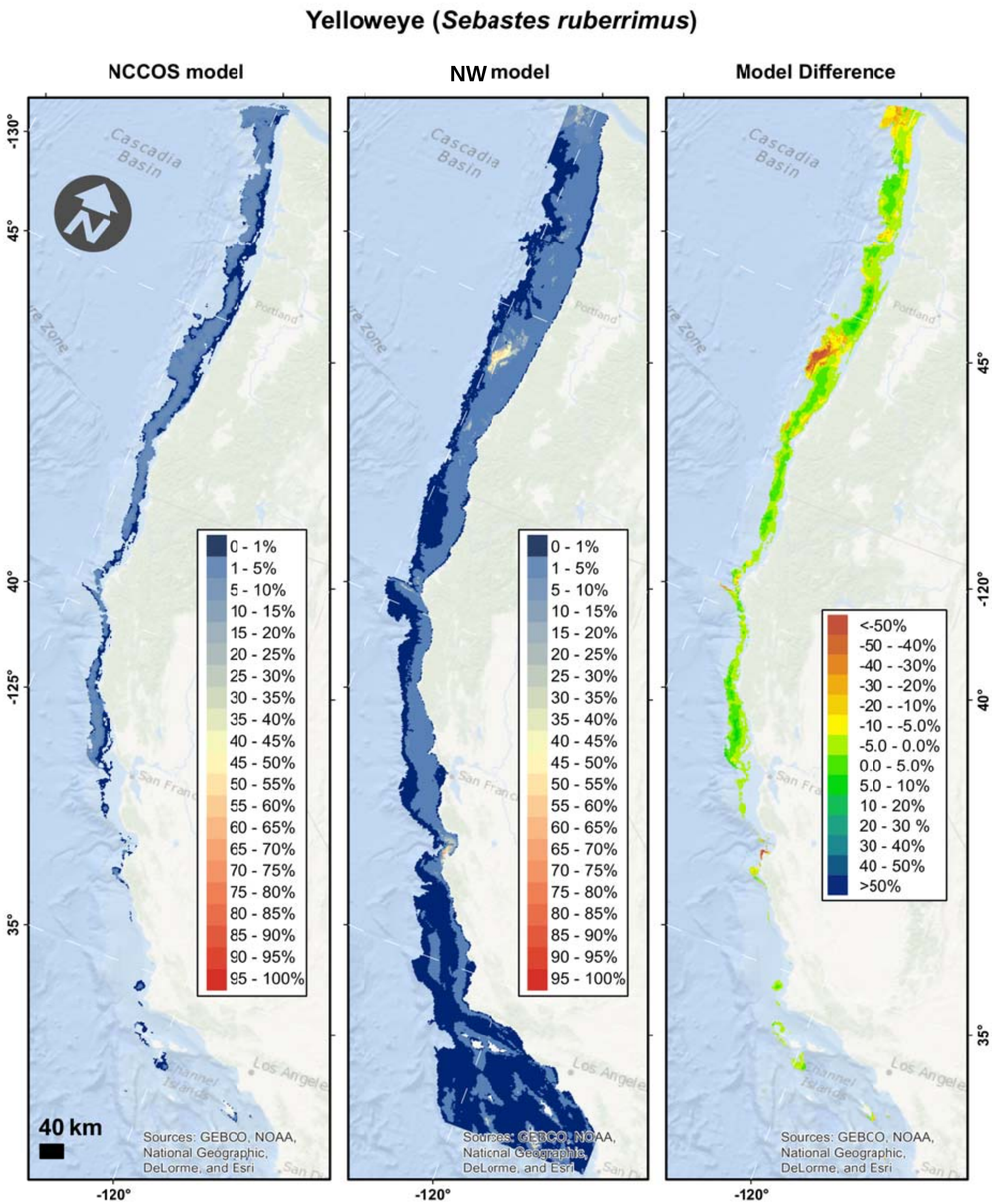

Figure 2.6: Yelloweye rockfish predicted mean probability of occurrence from the NCCOS (left) and NWFSC (center) models. Right panel shows a plot of the difference between the NCCOS and NWFSC models (NCCOS – NWFSC). Positive values indicate NCCOS predicts higher probability of occurrence than NWFSC.

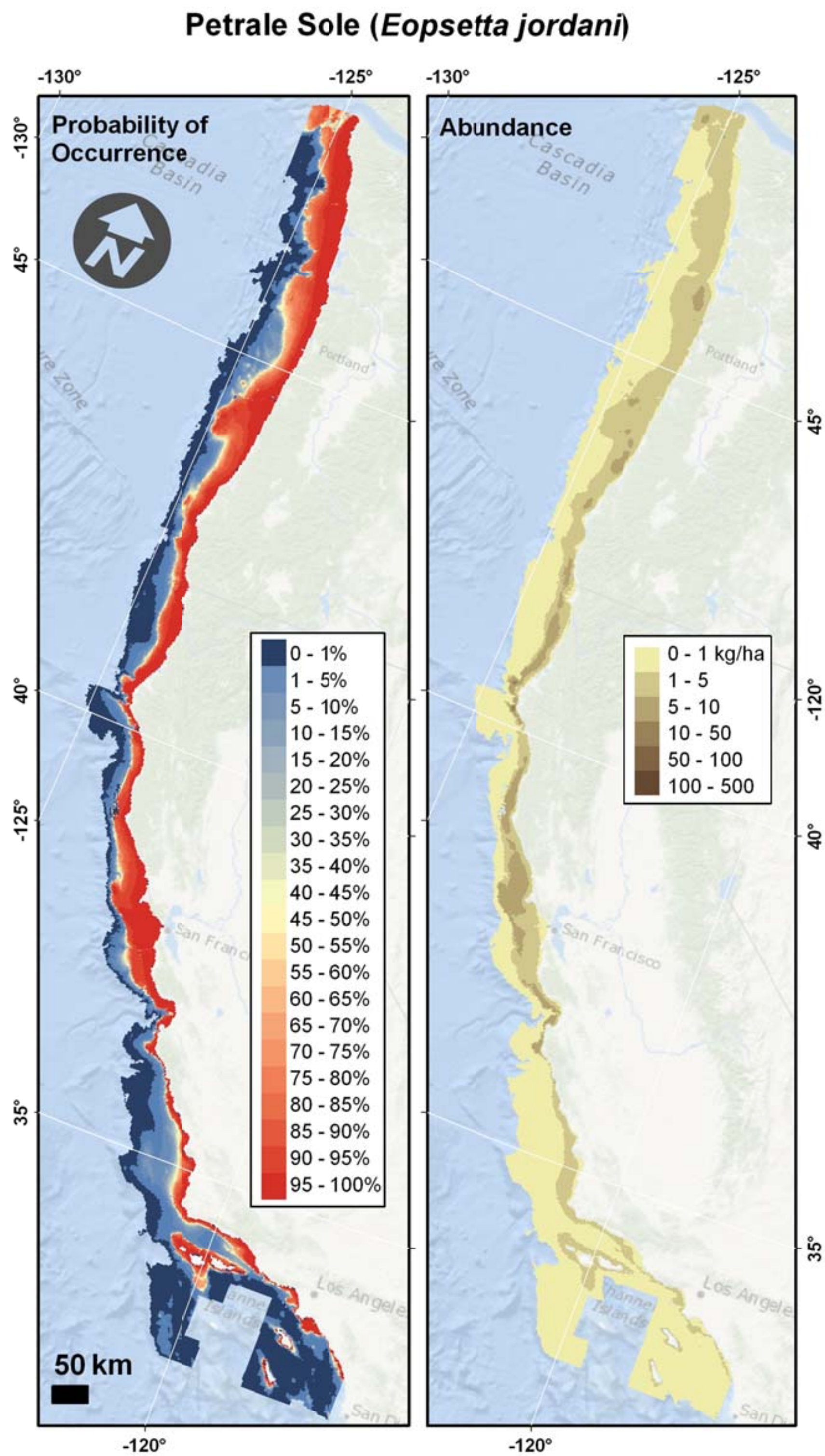

Figure 2.7: Petrale sole mean predicted probability of occurrence and predicted mean abundance. NWFSC model projections.

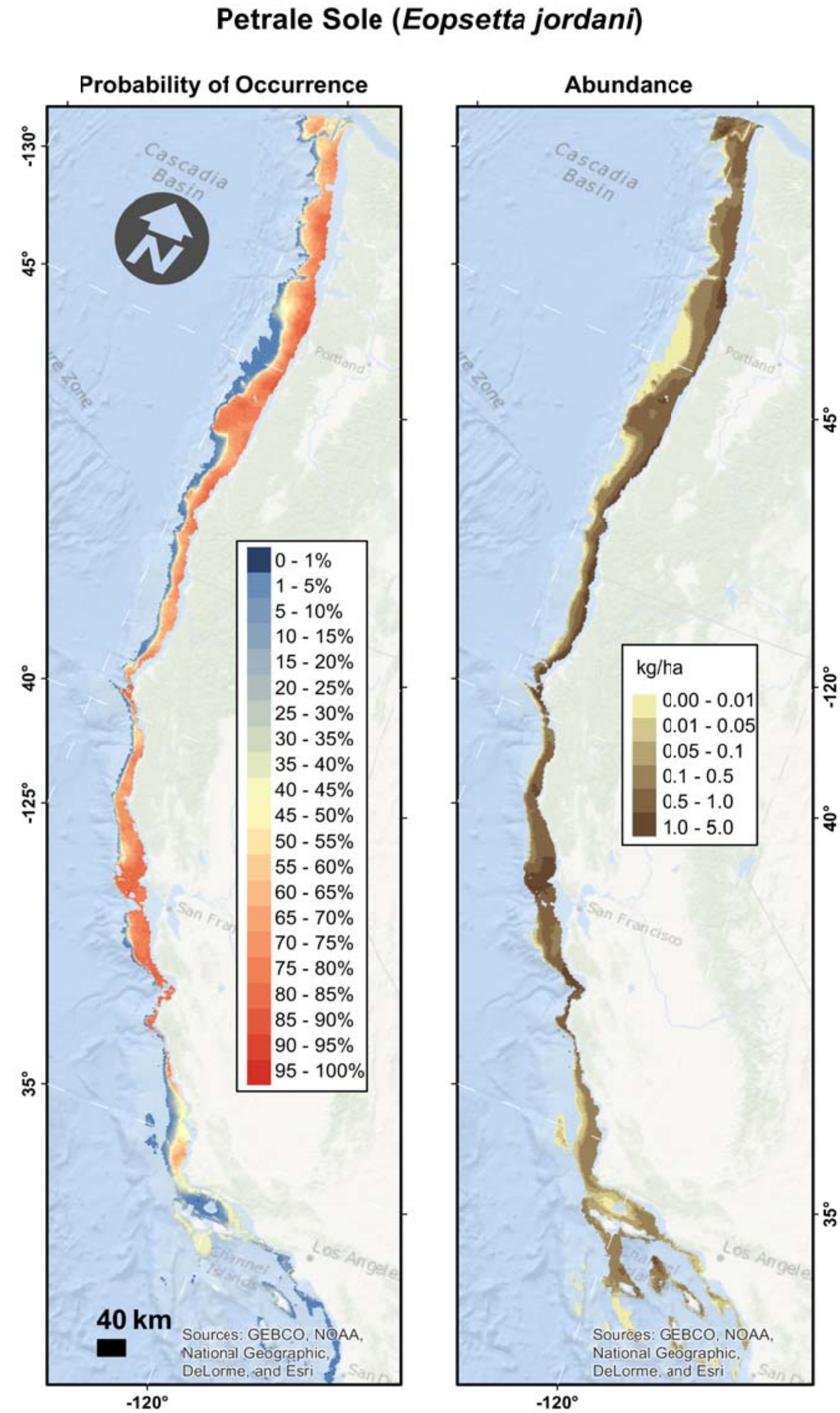

Figure 2.8: Petrale sole predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

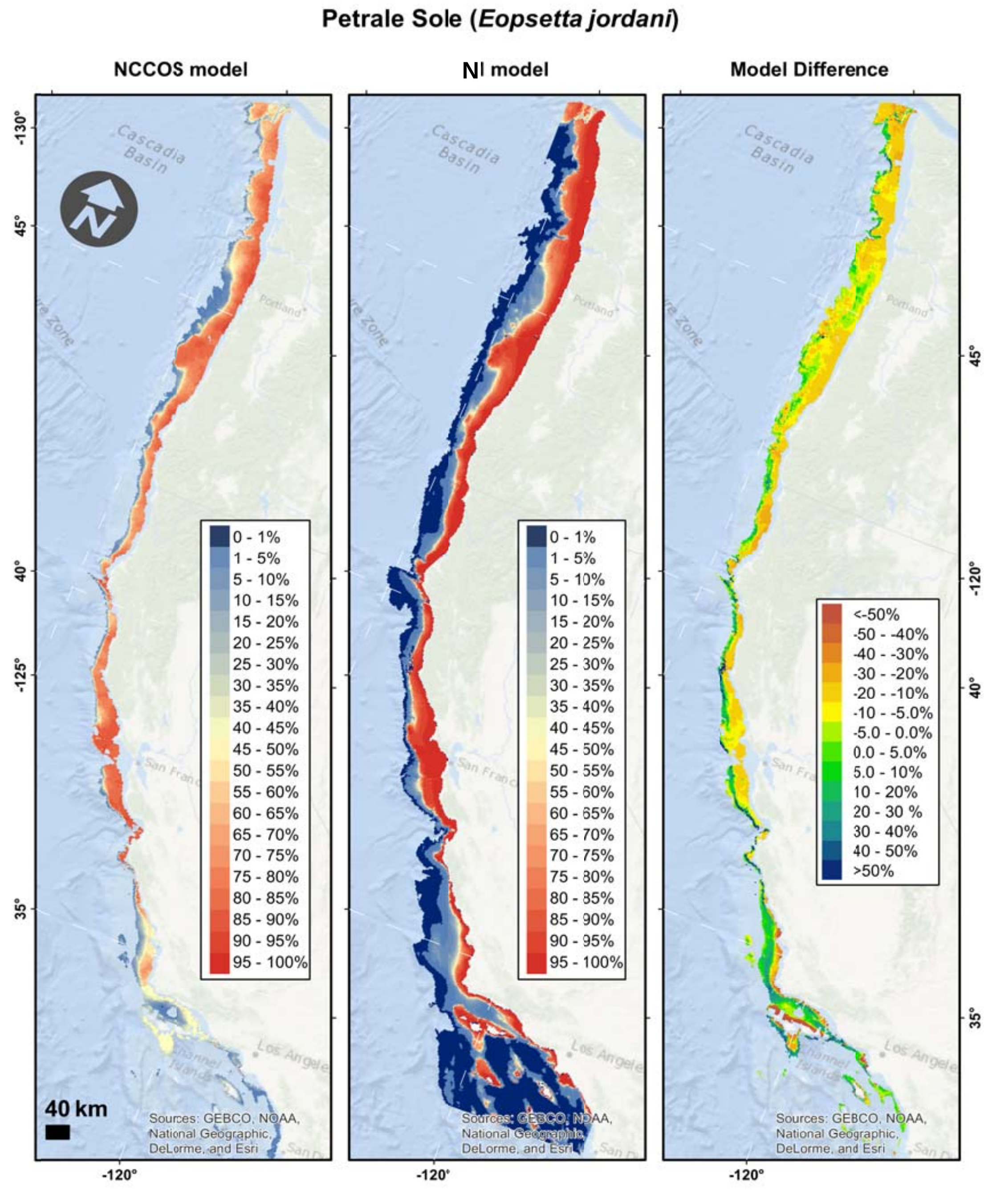

Figure 2.9: Petrale sole predicted mean probability of occurrence from the NCCOS (left) and NWFSC (center) models. Right panel shows a plot of the difference between the NCCOS and NWFSC models (NCCOS – NWFSC). Positive values indicate NCCOS predicts higher probability of occurrence than NWFSC.

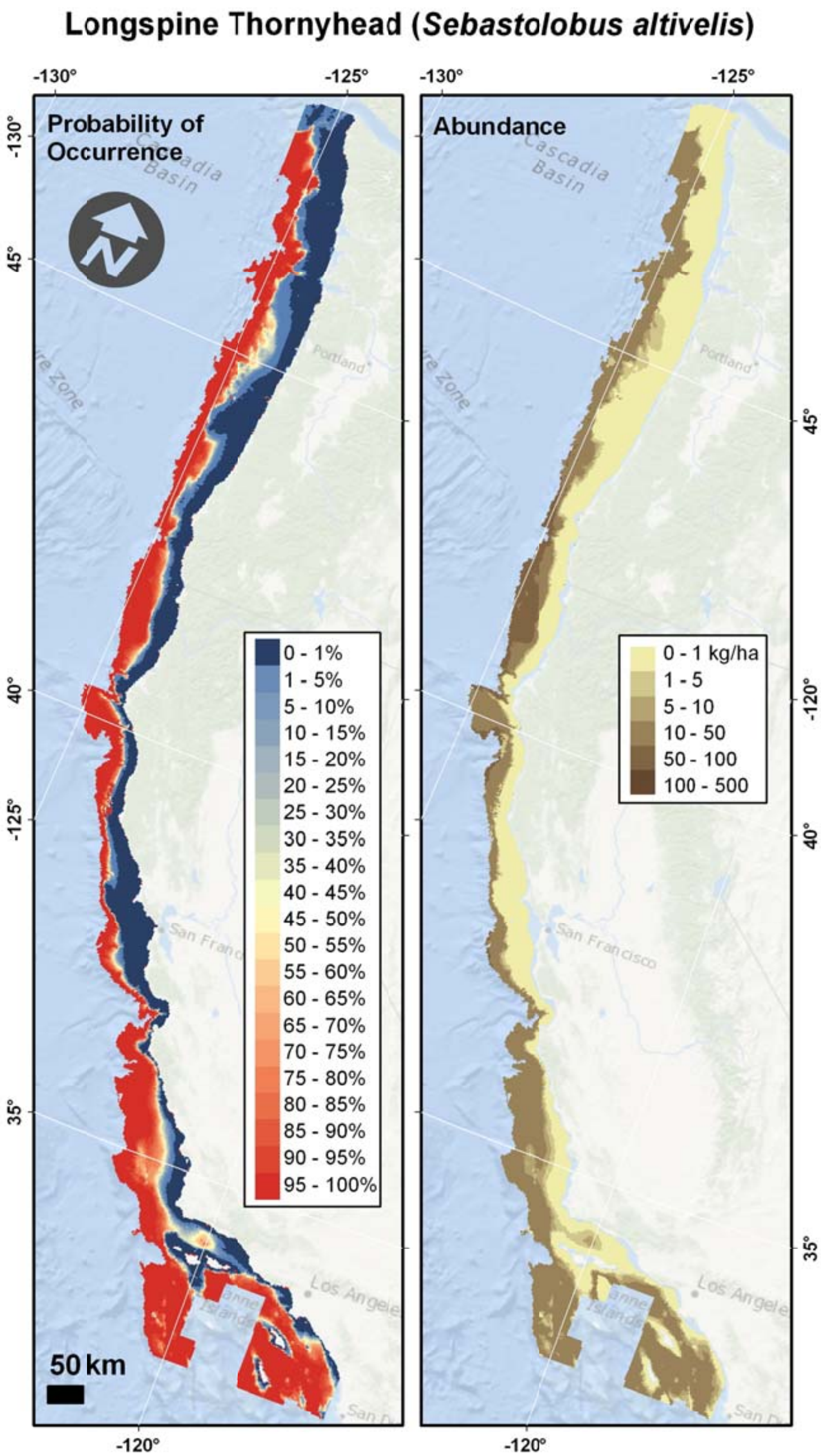

Figure 2.10: Longspine thornyhead sole mean predicted probability of occurrence and predicted mean abundance. NWFSC model projections.

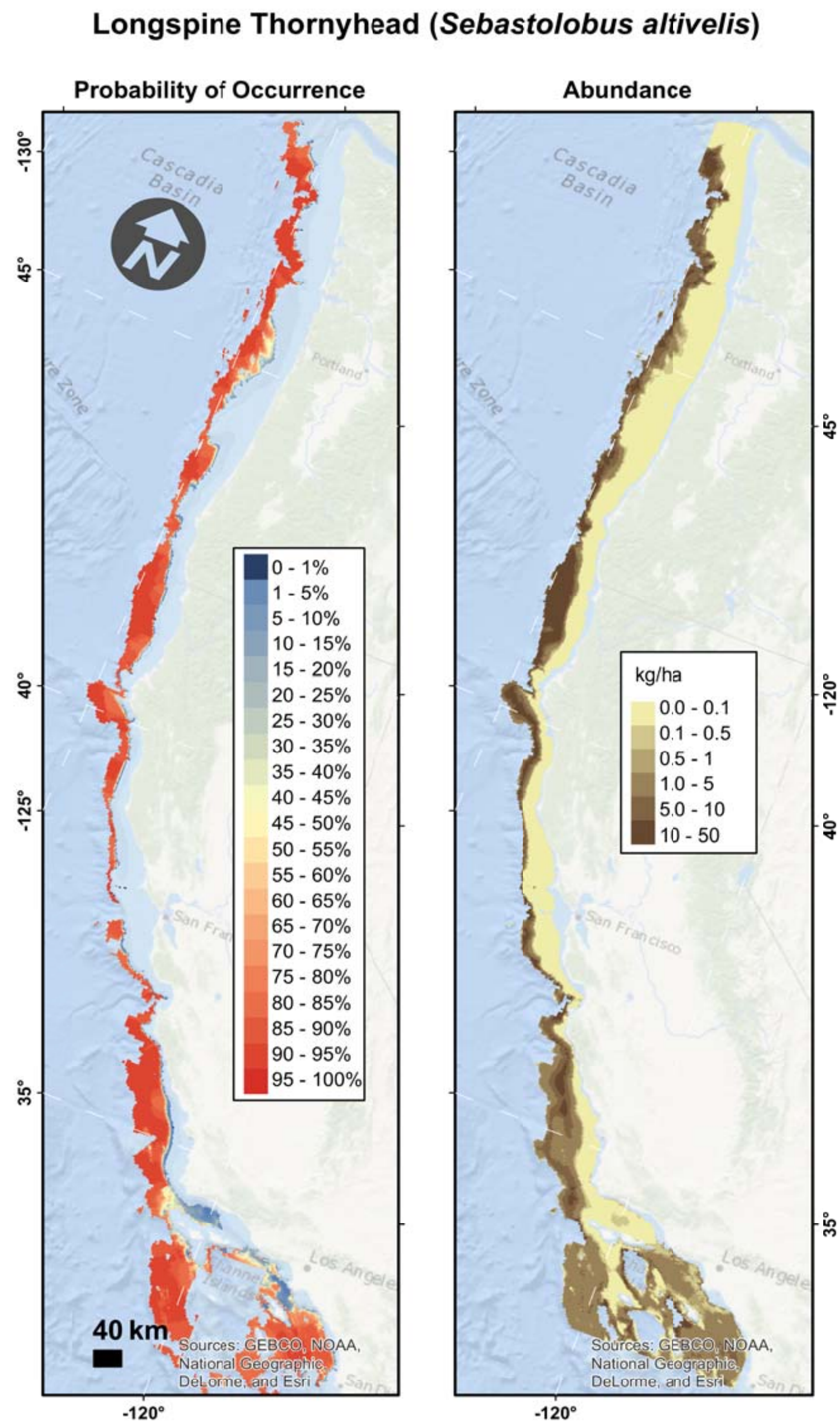

Figure 2.11: Longspine thornyhead predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

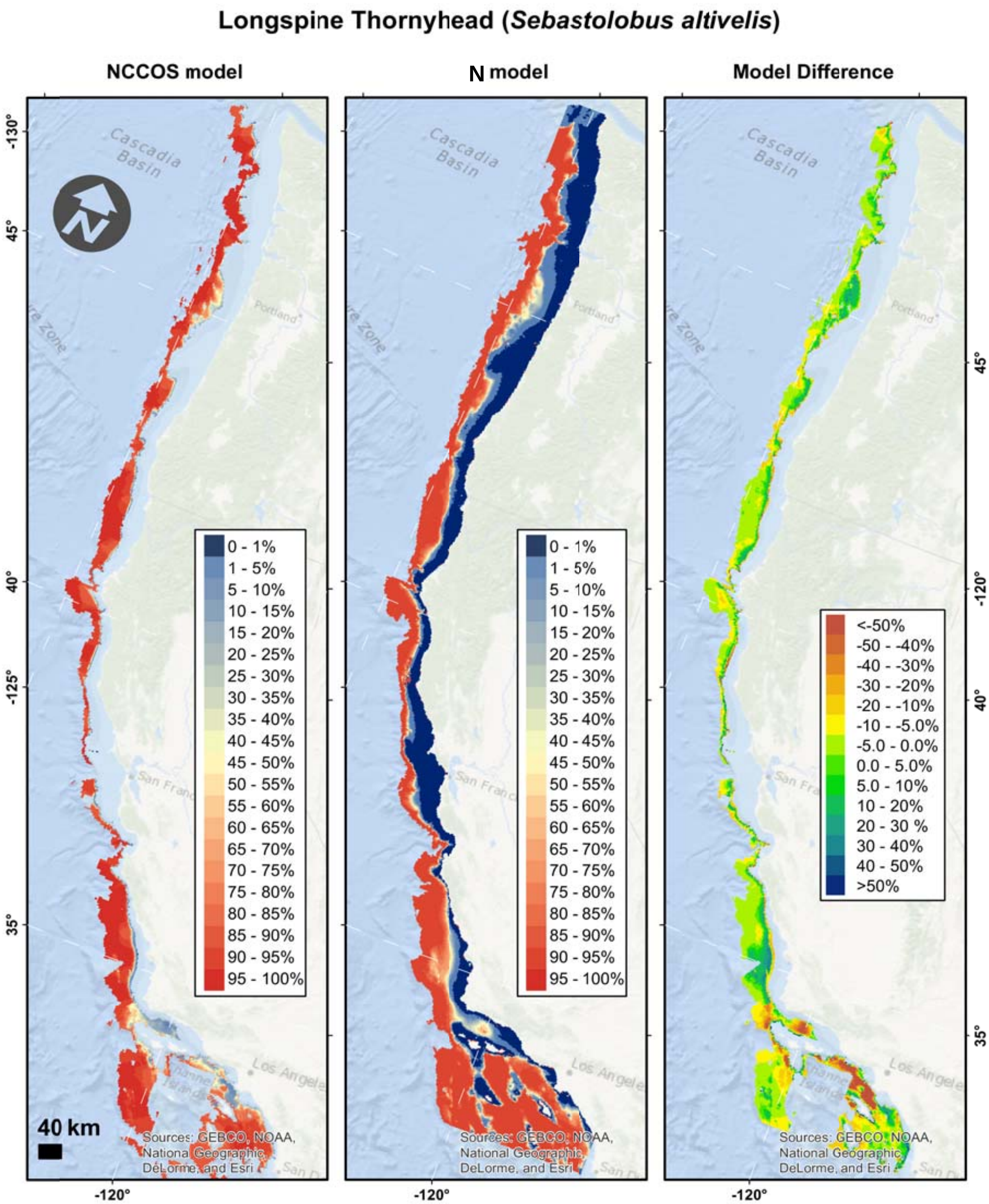

Figure 2.12: Longspined thornyhead predicted mean probability of occurrence from the NCCOS (left) and NWFSC (center) models. Right panel shows a plot of the difference between the NCCOS and NWFSC models (NCCOS – NWFSC). Positive values indicate NCCOS predicts higher probability of occurrence than NWFSC.

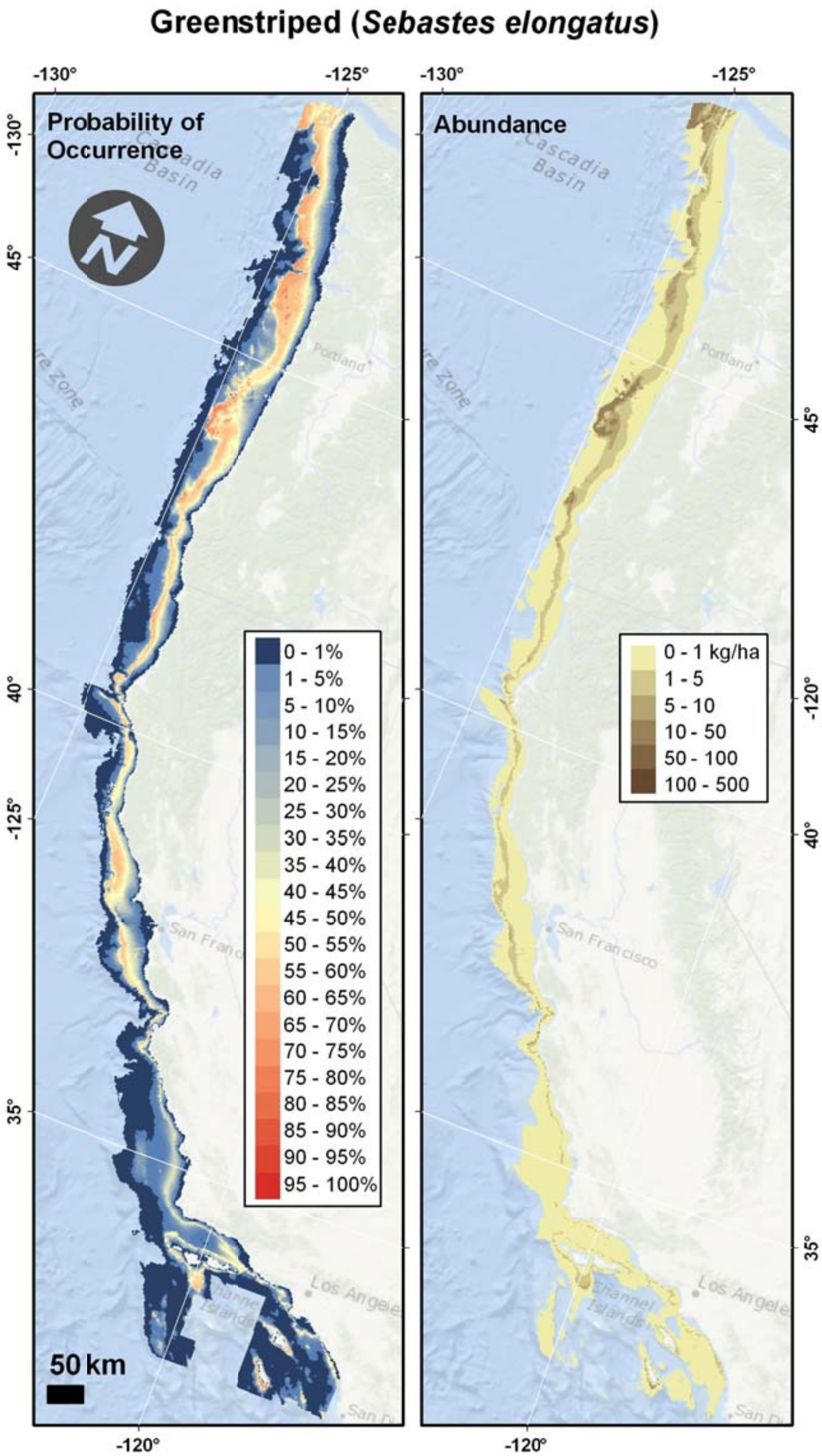

Figure 2.13: Greenstriped rockfish mean predicted probability of occurrence and predicted mean abundance. NWFSC model projections.

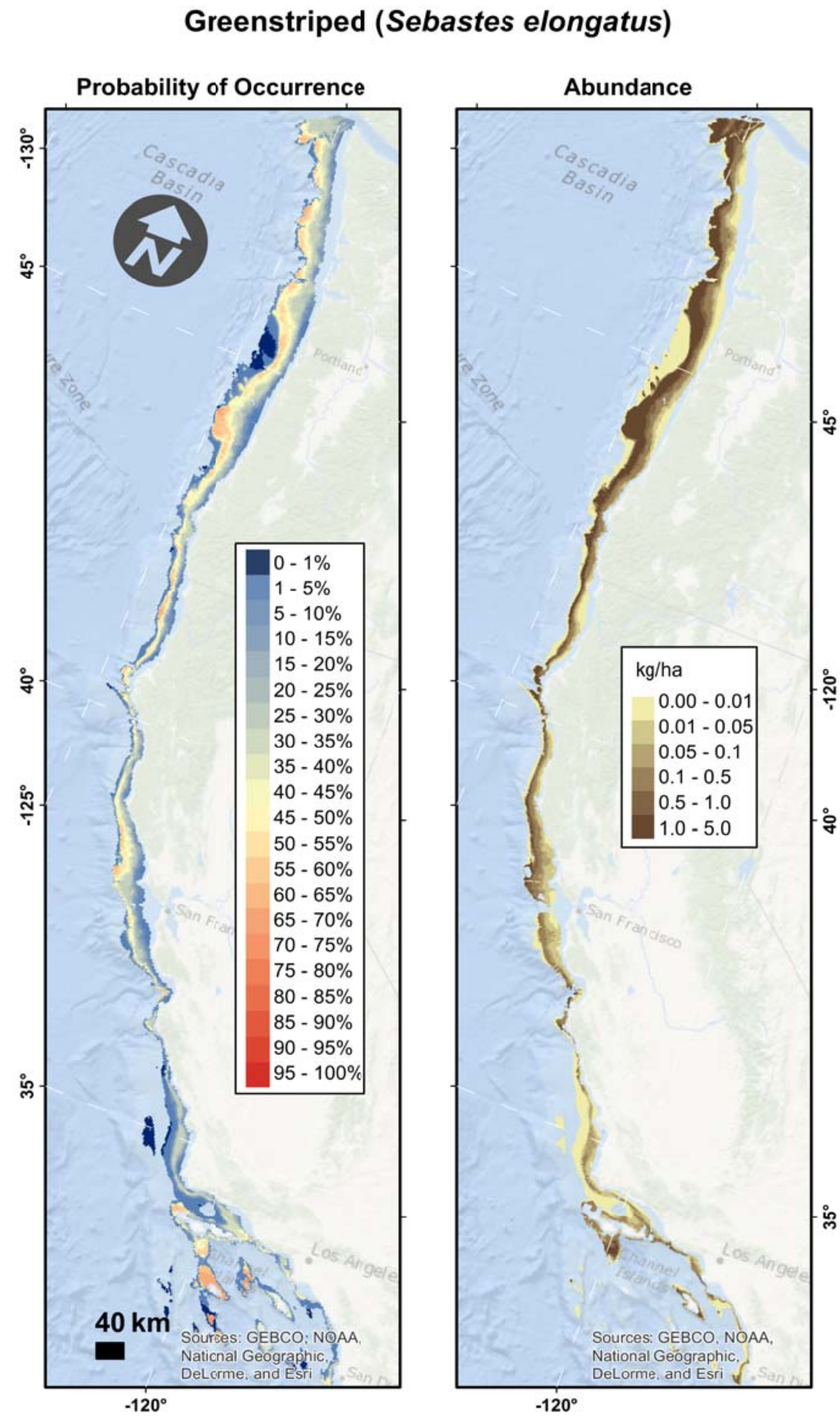

Figure 2.14: Greenstriped rockfish predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

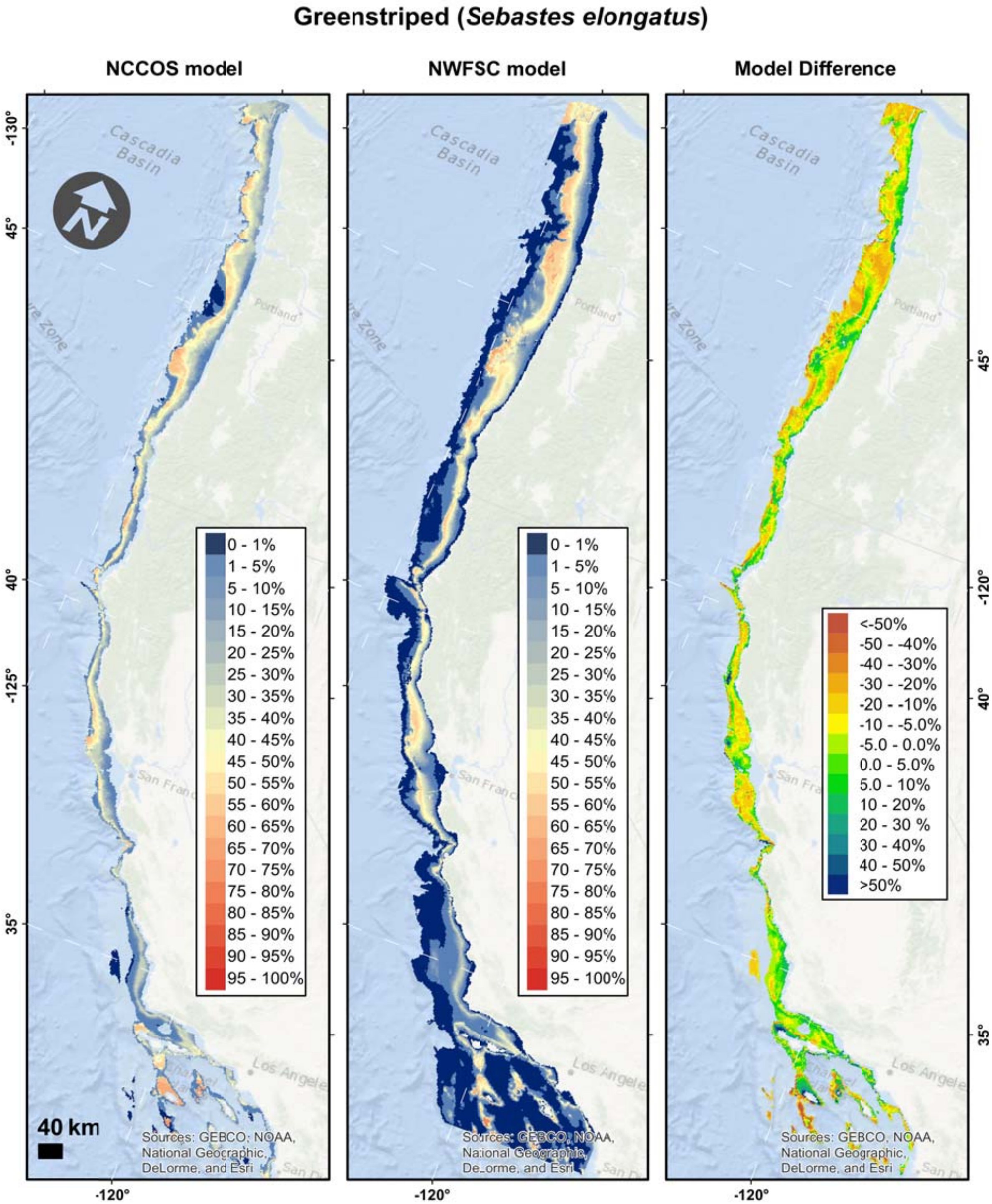

Figure 2.15: Greenstriped rockfish predicted mean probability of occurrence from the NCCOS (left) and NWFSC (center) models. Right panel shows a plot of the difference between the NCCOS and NWFSC models (NCCOS – NWFSC). Positive values indicate NCCOS predicts higher probability of occurrence than NWFSC.

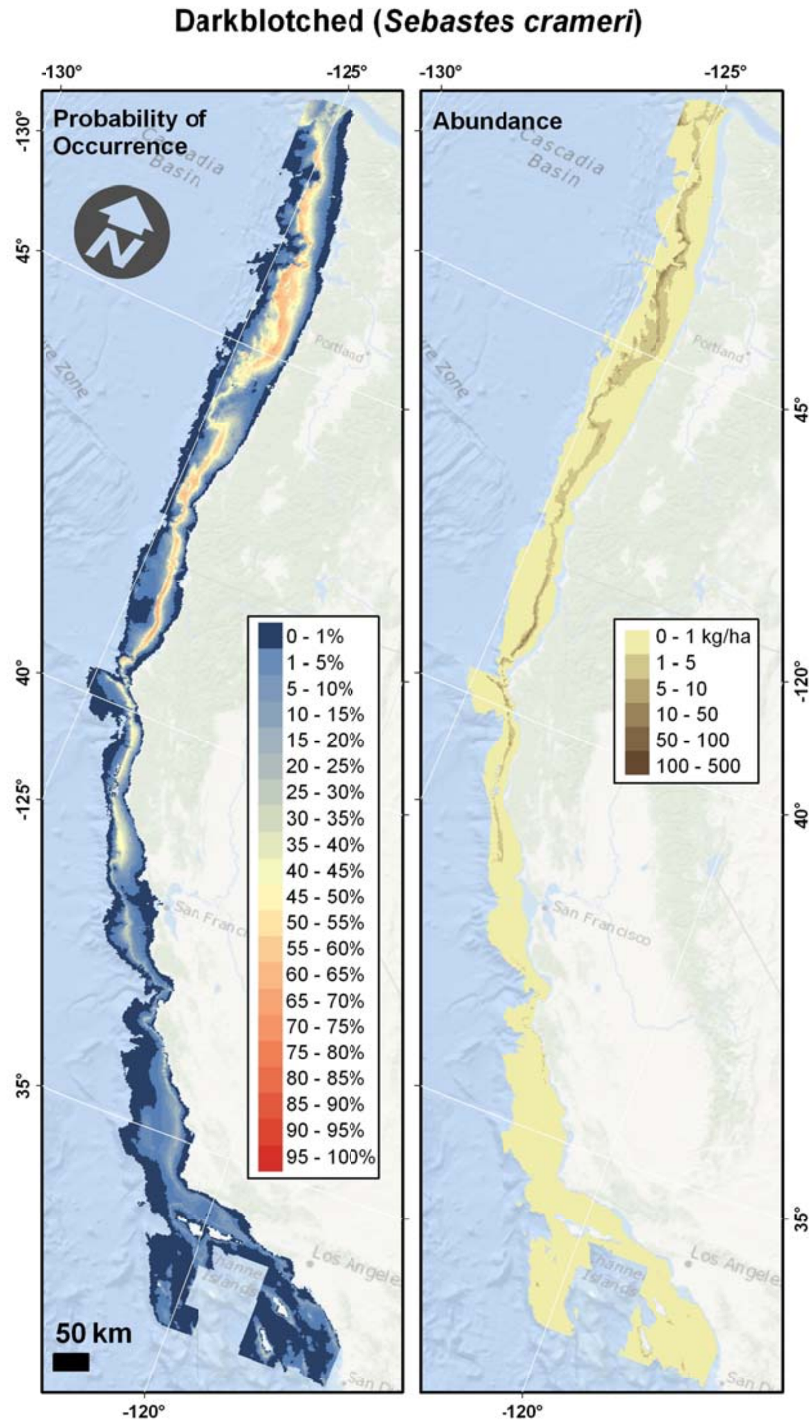

Figure 2.16: Darkblotched mean predicted probability of occurrence and predicted mean abundance. NWFSC model projections.

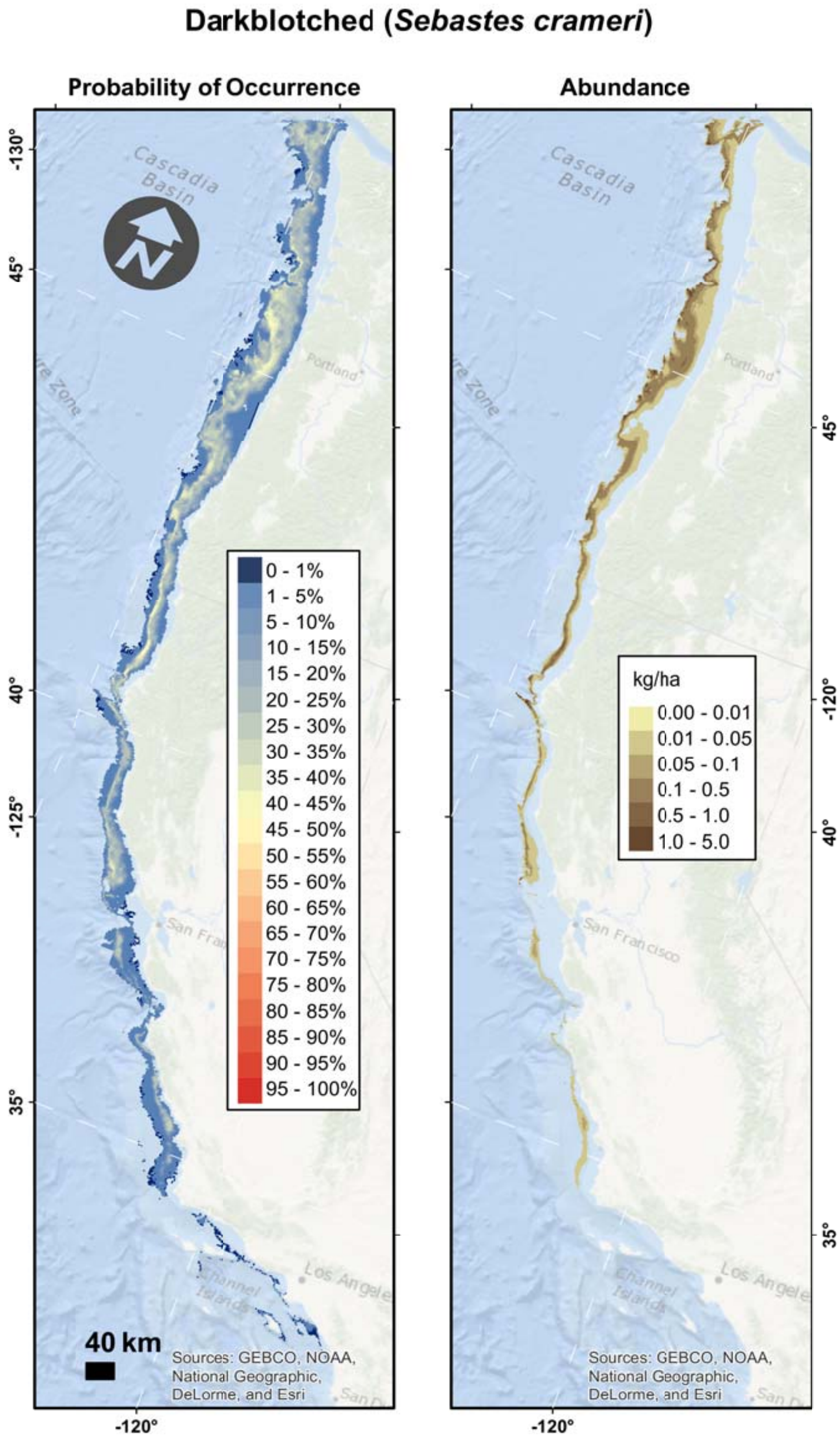

Figure 2.17: Darkblotched rockfish predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

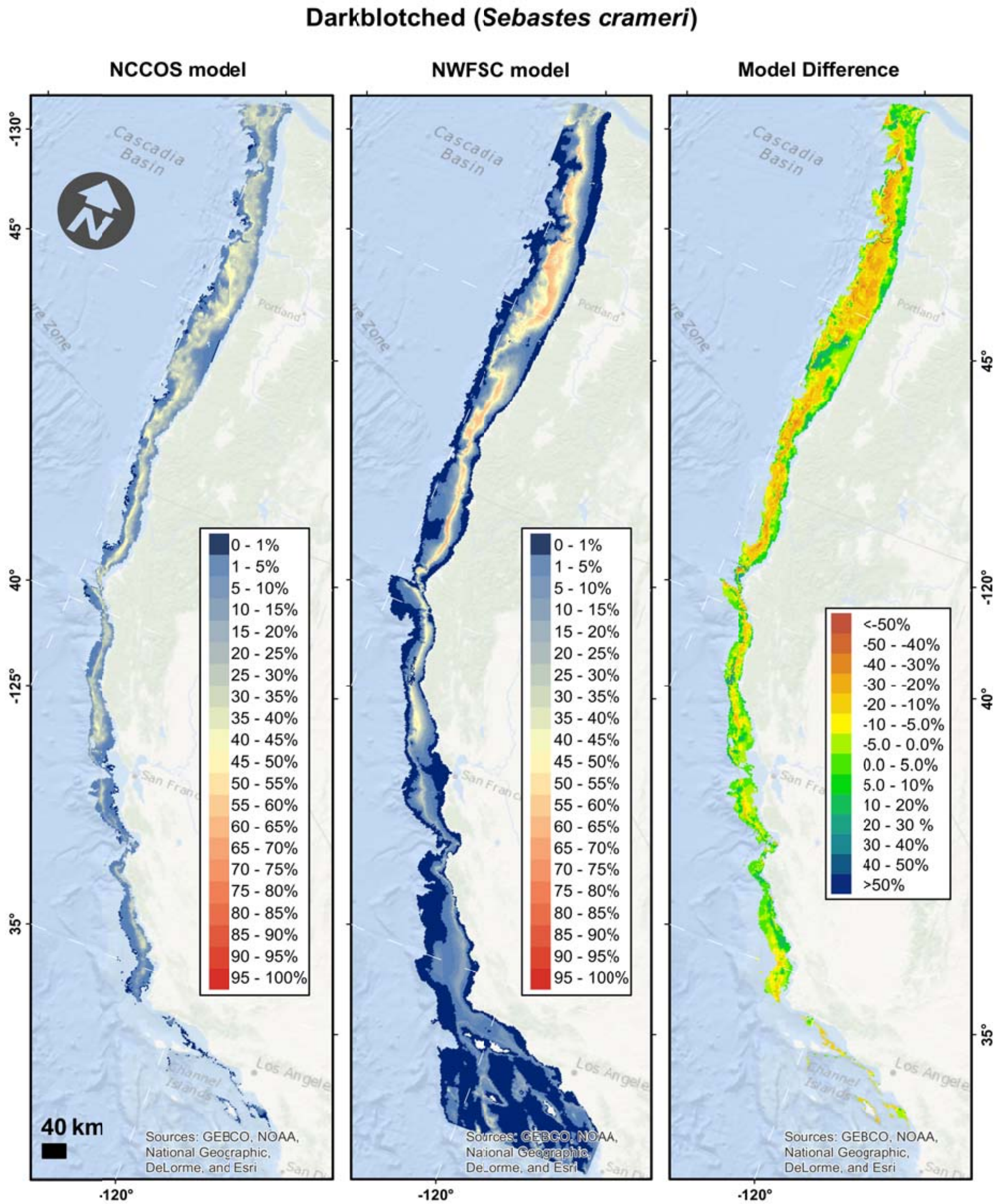

Figure 2.18: Darkblotched rockfish mean probability of occurrence from the NCCOS (left) and NWFSC (center) models. Right panel shows a plot of the difference between the NCCOS and NWFSC models (NCCOS – NWFSC). Positive values indicate NCCOS predicts higher probability of occurrence than NWFSC.

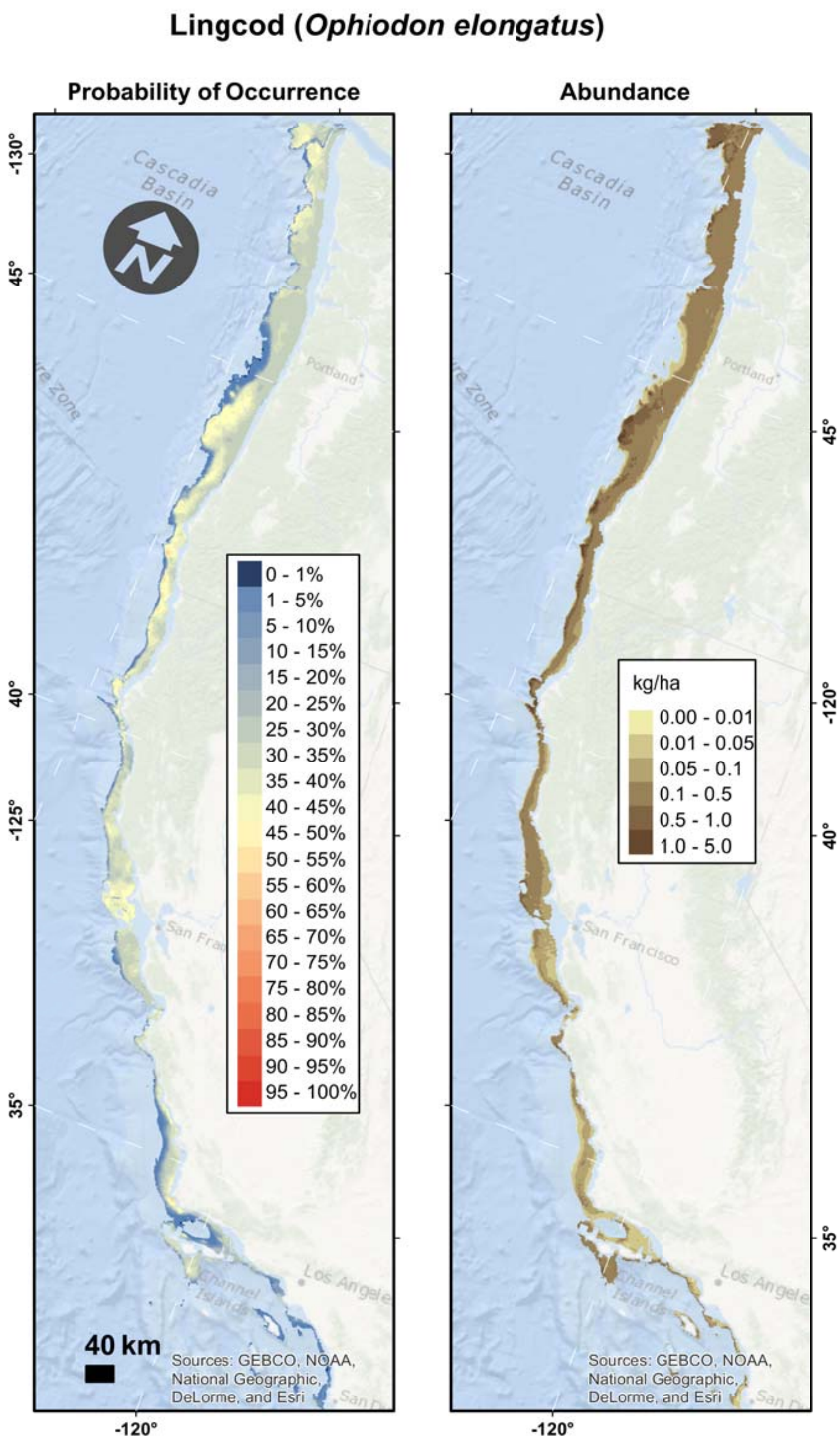

Figure 2.19: Lingcod predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

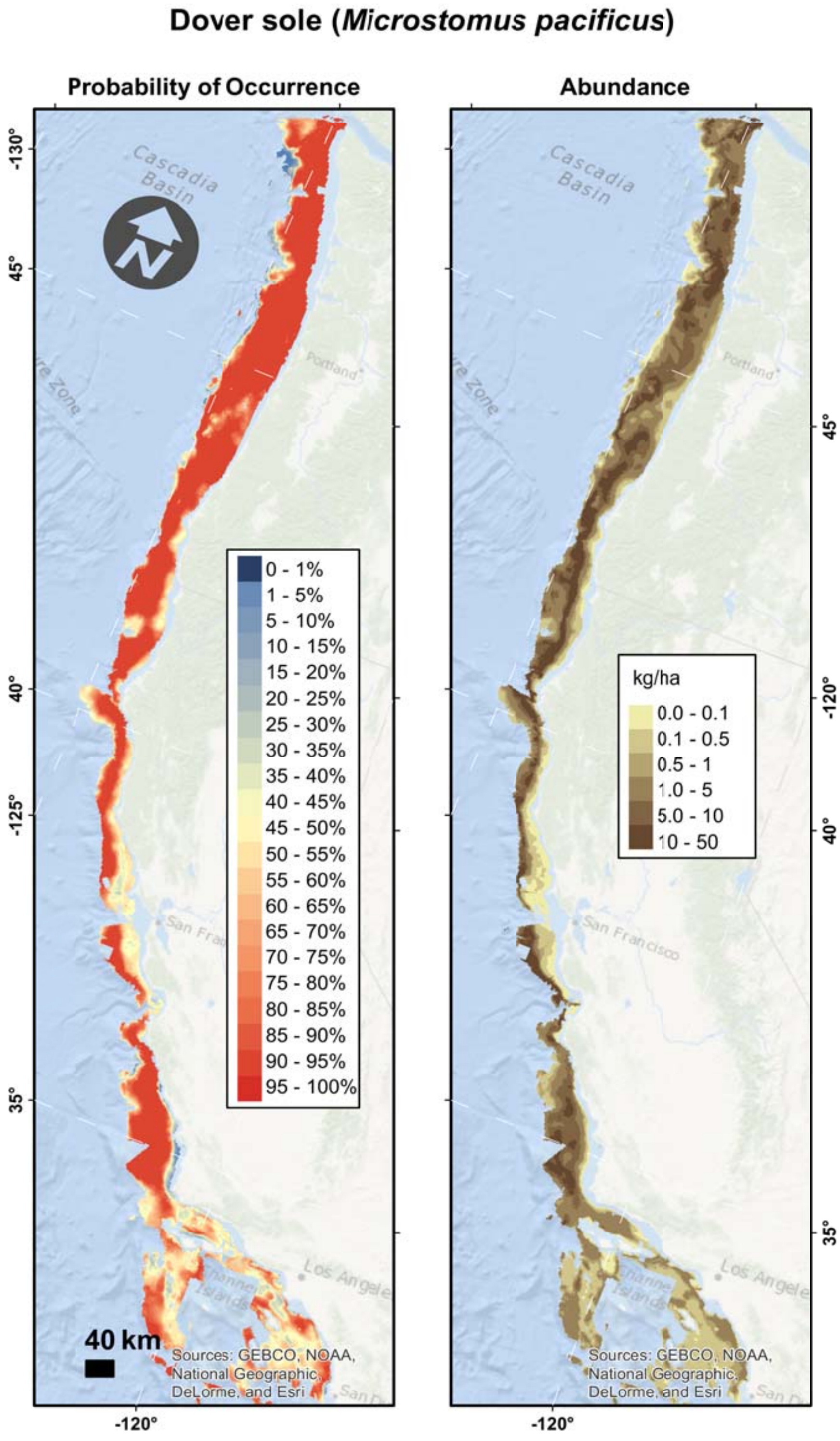

Figure 2.20: Dover sole predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

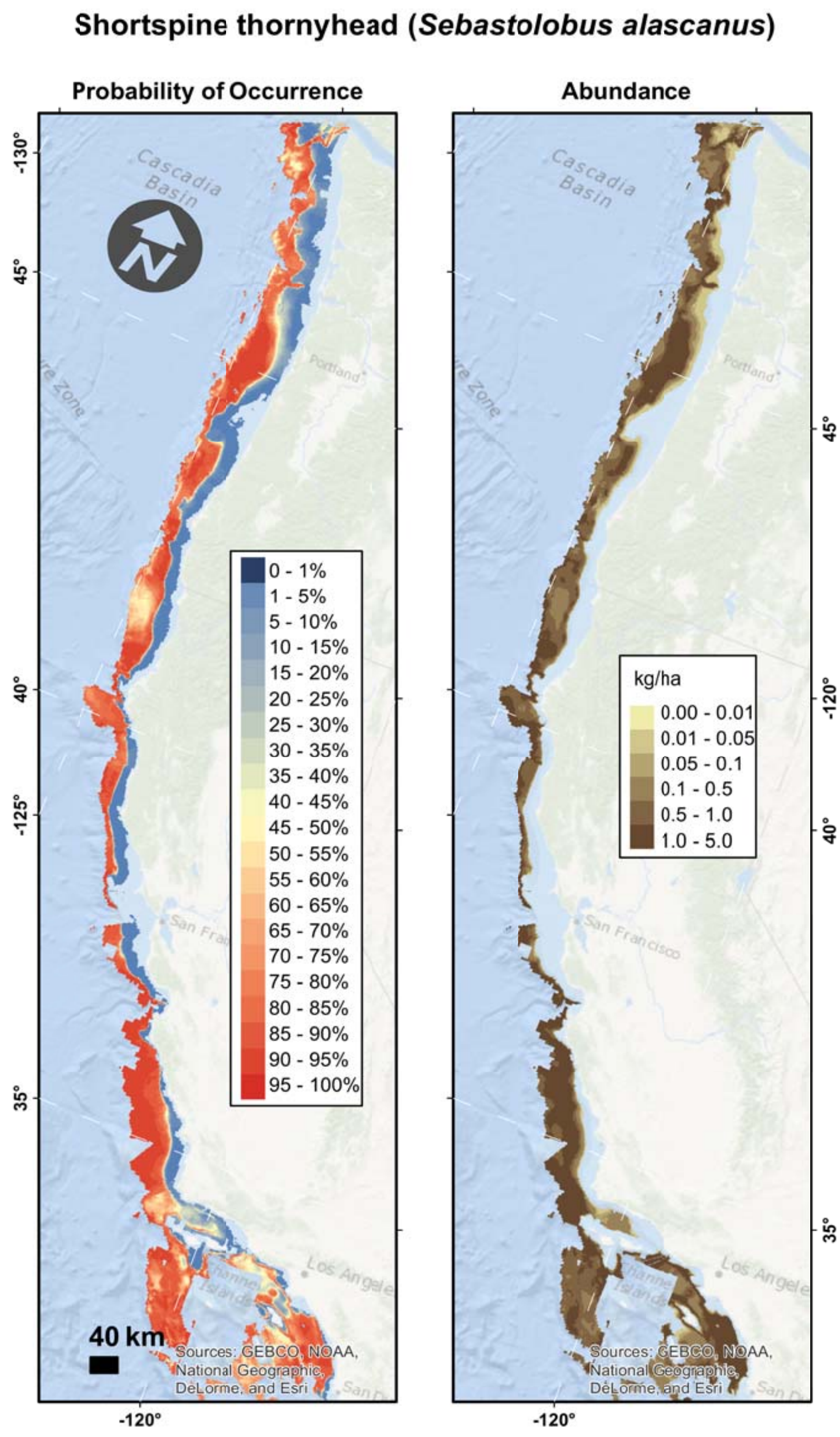

Figure 2.21: Shortspine thornyhead predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

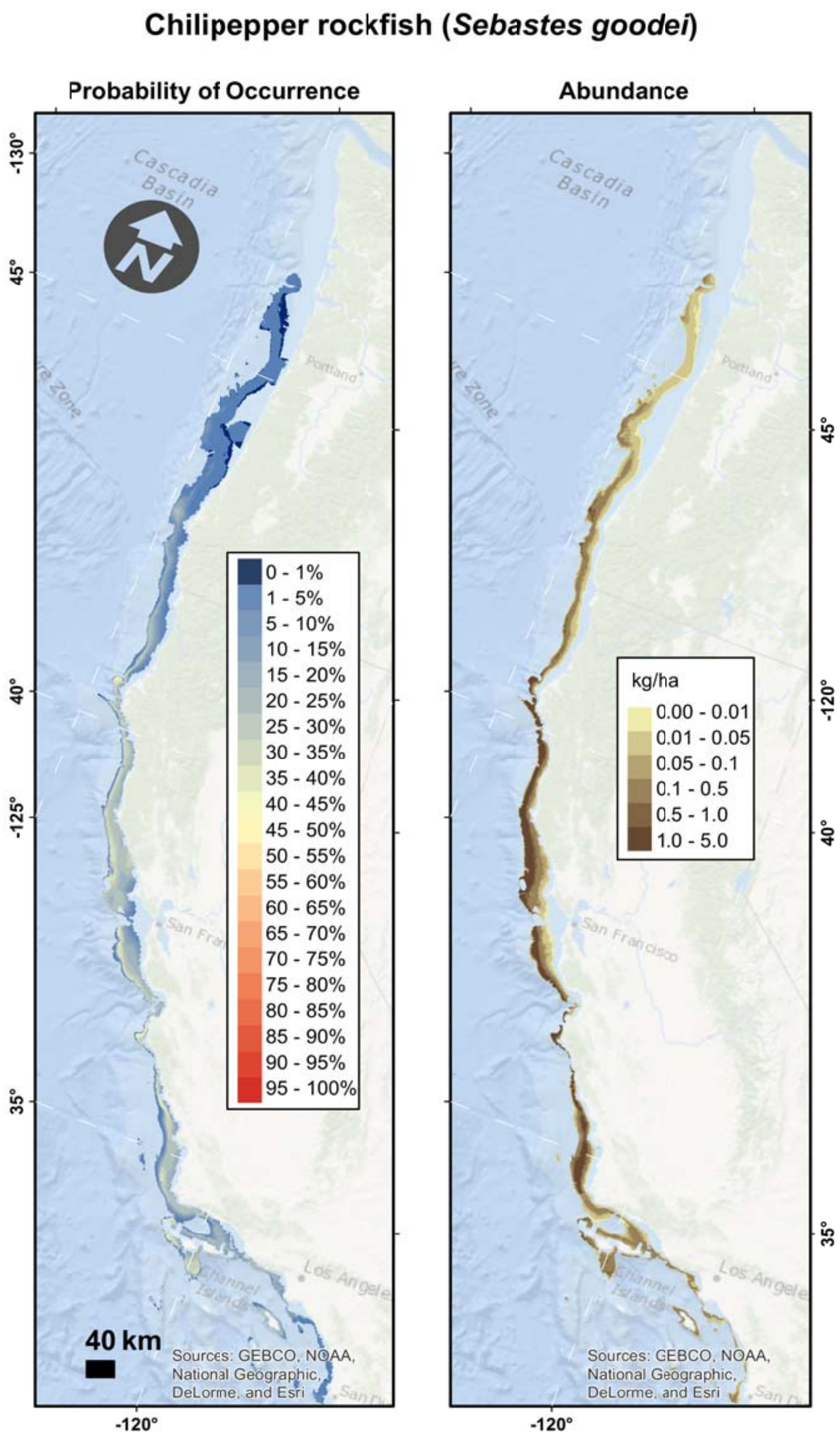

Figure 2.22: Chilipepper rockfish predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

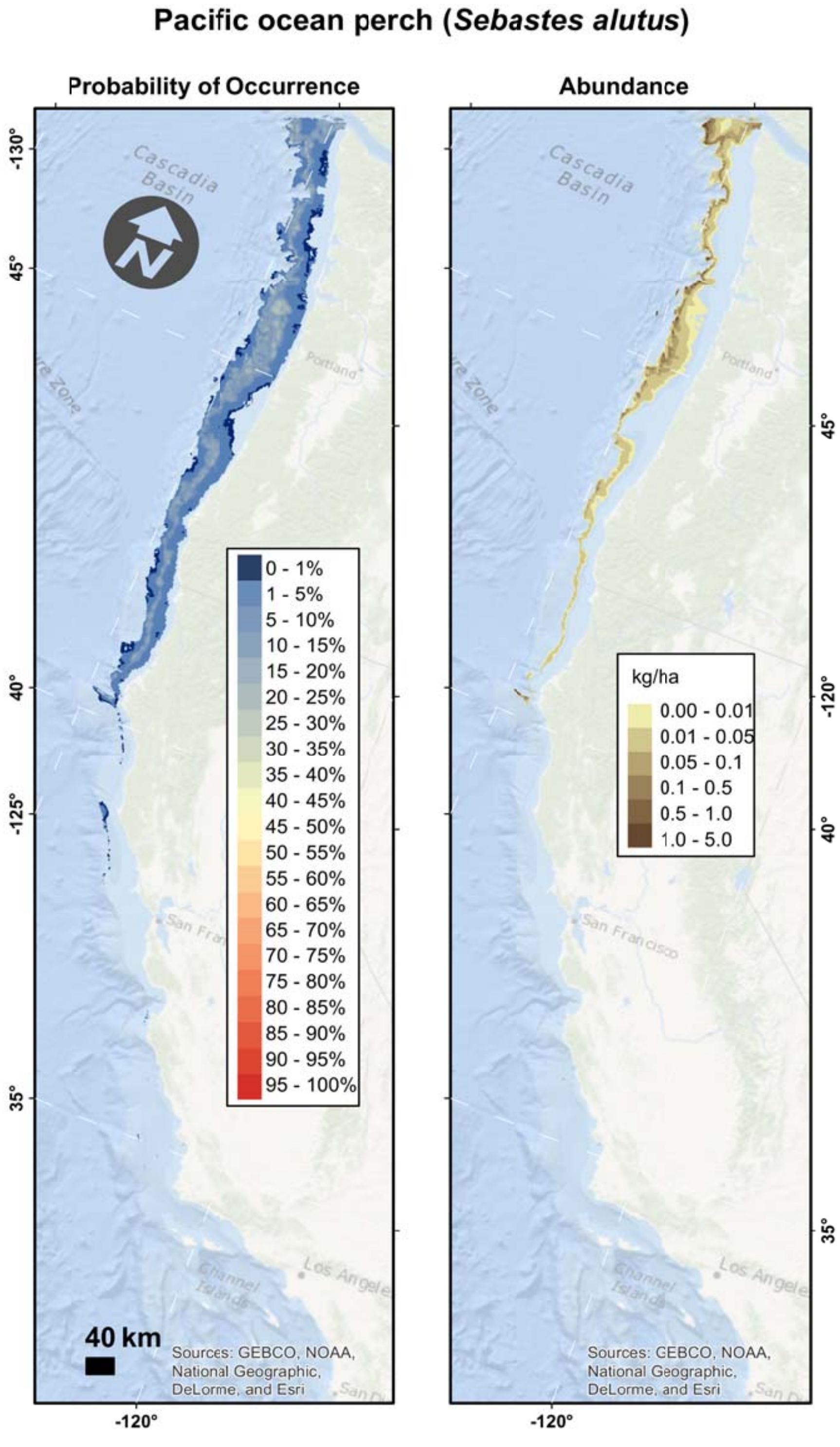

Figure 2.23: Pacific Ocean perch predicted mean probability of occurrence and predicted mean abundance. NCCOS model projections.

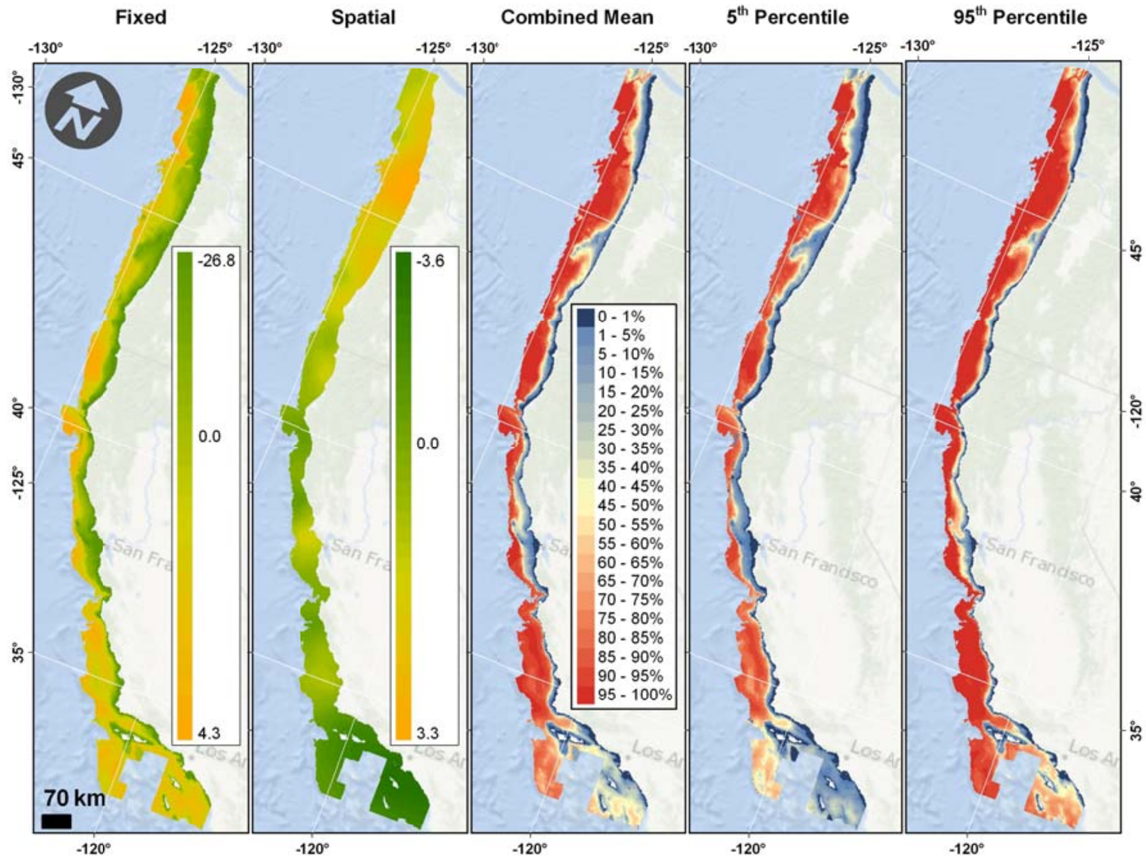

Figure 2.24: Components of the NWFSC probability of occurrence model for sablefish in 2010. Panels from left to right: A. Predicted mean habitat covariate fixed effect (logit scale), B. Predicted mean spatial effect (logit scale), C. Predicted mean probability of occurrence (ie. habitat + spatial effects; proportion scale); D. Predicted 5th quantile (proportion scale); E. Predicted 95th quantile (proportion scale). Together panels D and E bound the 90% credible interval.

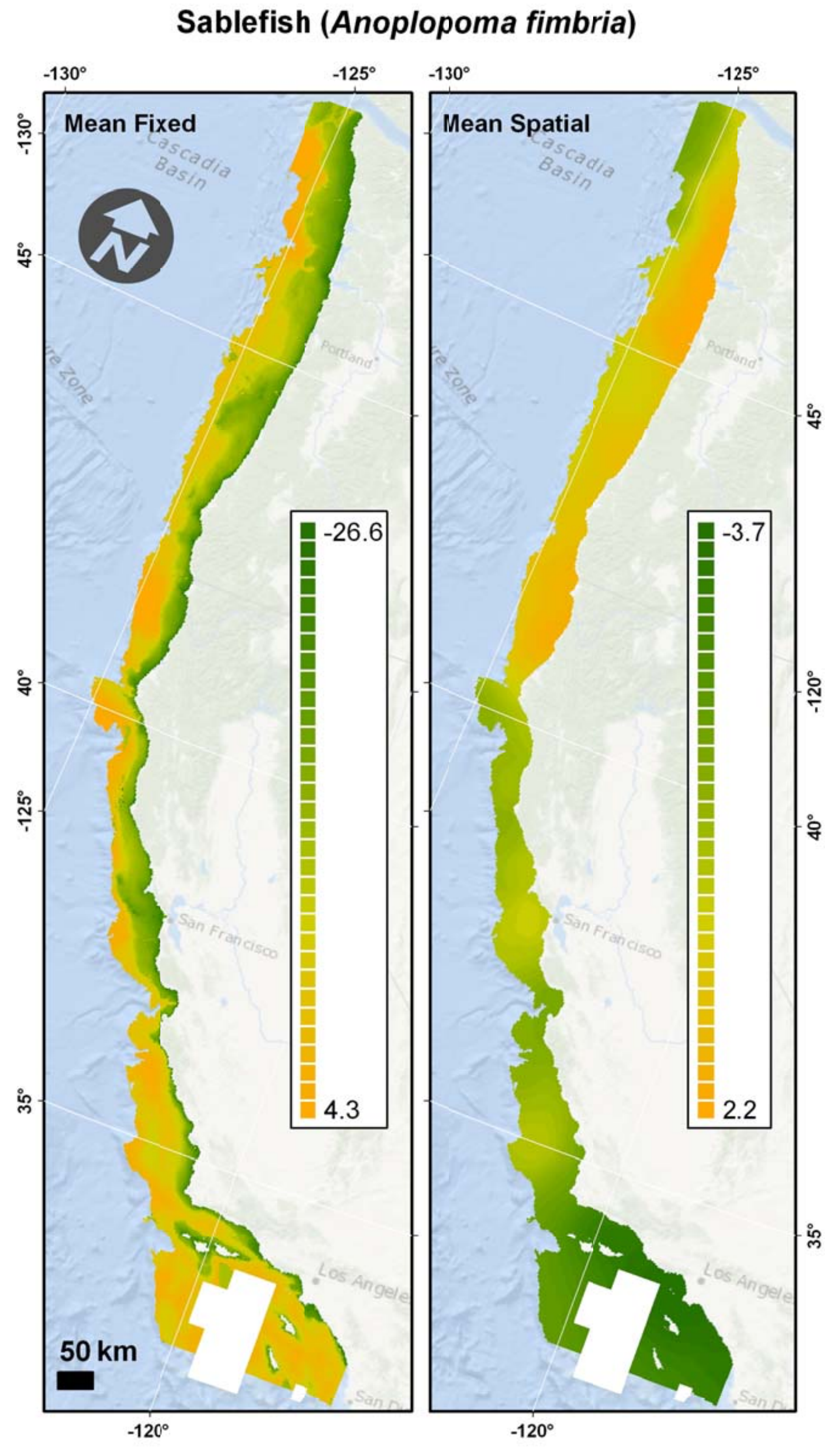

Figure 2.25: Mean of predicted, across-year fixed habitat effect (left panel). Mean of predicted, across-year spatial effect (right panel). Both are on the logit scale.

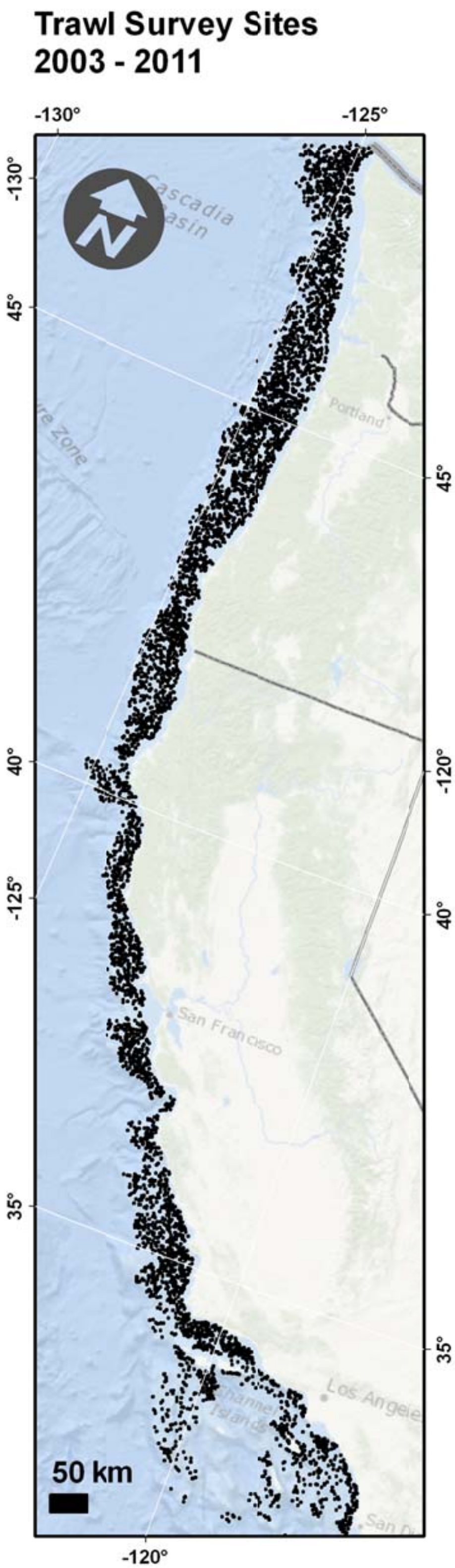

Figure 2.26: NOAA trawl survey locations 2003 to 2011.

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3.0 METHODS FOR EXAMINING STRESSORS TO EFH

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3.1 FISHERY PRESSURES

Methodology used in this synthesis for reviewing fishing impacts is partially described in the EFH 5-year review Phase 1 document presented to the PFMC (PFMC 2012). Specific data was utilized as described in section 4.4 Magnuson Act Fisheries Effects, 4.4.1 Distribution of Commercial Fishing Effort for bottom trawl effort, midwater trawl effort, and fixed gear effort.

However, an update to the spatial representation of observed fixed gear data was made, related to specific concerns about weighting the level of impact which various fixed gear types exert on seafloor habitats. Rather than the spatial representation of fixed gear as points of both the deployment and retrieval locations as in the Phase 1 report, spatial representations were divided into a towline model or a single point of the average of deployment and retrieval coordinates, based on observed fishery and gear code. The following were represented as a towline model: fishing events using longline gear, fishing events in the limited entry sablefish-endorsed primary season using pot gear. The following were represented as an averaged point location: fishing events using hook-and-line gear codes (other than longline), and fishing events in the open access fixed gear or state-permitted nearshore fixed gear sectors using pot gear.

ArcGIS^{TM} geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California) was used to conduct overlays ("Identity" tool) of each fishing fleet's spatial representation of either towlines or the average point of deployment and retrieval coordinates, and the stratification, spatial management boundaries, etc. summarized in this synthesis. A common, customized Transverse Mercator coordinate system specifically designed for the US Pacific west coast was used by all authors for any spatial analysis or mapping (see metadata). Subsequent analyses were carried out using R software (v. 2.8.1; R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria).

3.1.1 Cumulative fishery pressures

Fishing pressures act upon groundfish essential fish habitat collectively and thus quantifying a cumulative pressure index is an important tool in assessing overall fishing impacts. We used a weighted approach by assuming that fishing pressures were additive, but with a weighting scheme applied for the sensitivity of various habitat types to individual fishing gears. The weighting scheme was adapted from information summarized for a report on the effects of fishing gear on habitats developed for the 2005 groundfish EFH Environmental Impact

Statement (PSMFC 2004, NMFS 2005). The report included the development of habitat sensitivity levels to gear impacts and recovery times for habitats impacted by fishing gears. The sensitivity scale consisted of four levels (0, 1, 2, and 3) representing relative sensitivity to gear impacts (Table A3a.1). The descriptors for the sensitivities at each level were based on the actual impacts reported in the literature and referenced in the report. The recovery scale was in units of time (years) with the values taken directly from each report cited (Table A3a.1).

For the current synthesis, indices of sensitivity were prepared by extracting the sensitivity levels from the 2005 groundfish EFH EIS for hard and soft substrates for the three seabed habitat depth zones; shelf, upper slope and lower slope, and four major gear types; bottom trawl, midwater trawl, fixed gear represented by a distance metric (i.e., longline gear and pot gear), and fixed gear represented by a point metric (i.e., hook-and-line gear other than longline gear and open access fixed gear or state-permitted nearshore fixed gear sectors using pot gear (Table A3a.2.). Sensitivity levels for mixed substrate were considered to be the mid-range between hard and soft substrates. In developing the sensitivity values, the ranges were considered in relation to several reviews (Dayton et al. 2002, NRC 2002, Chuenpagdee et al. 2003, Morgan and Chuenpagdee 2003, NEFMC 2011). For comparison, impact levels for four major gear types (out of ten considered), adapted from Morgan and Cheunpagdee (2003) are shown in Table A3a.3. The impacts shown in Table A3a.3. were derived from two sources: 1) an experts workshop where participants rated both physical and biological impacts and 2) a respondent survey where participants rated the severity of ecological impacts. A second set of impact levels ("vulnerabilities"), for relevant fishing gears, is shown for trawlable seabed substrates in Table A3a.4. This overview is drawn from a recent analysis of swept area seabed impact for the New England Fisheries Management Council (NEFMC 2011). Impact levels for three major gear types (out of five considered) is shown as vulnerability of geological and biological features, according to substrate type, and low and high energy environments.

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Table A3a.1. Descriptions of sensitivity levels and recovery time (years) for gear impacts from PFMC 2004.

Sensitivity Level	**Sensitivity Description**
0	No detectable adverse impacts on seabed; i.e. no significant differences between impact and control areas in any metrics.
1	Minor impacts such as shallow furrows on bottom; small differences between impact and control sites, <25% in most measured metrics.
2	Substantial changes such as deep furrows on bottom; differences between impact and control sites 25 to 50% in most metrics measured.
3	Major changes in bottom structure such as re-arranged boulders; large losses of many organisms with differences between impact and control sites >50% in most measured metrics.
Recovery Time	**Recovery Description**
0	No recovery time required because no detectable adverse impacts on seabed.
n	n = time (years) required for return to pre-impact condition; i.e. no significant differences between impact and control areas in any metrics.

Table A3a.2. Part A. Sensitivity level ranges for four major gear and three bottom types adapted from PFMC 2004 (0 = no detectable impacts, 1 = minor impacts, 2 = substantial changes, 3 = major changes in bottom structures).

Part A Sensitivity Levels	Bottom Trawl	Midwater Trawl	Fixed Gear Distance	Fixed Gear Point
Hard shelf	2.5	0.1	0.3	0.1
Hard upper slope	2.8	0.1	0.3	0.1
Hard lower slope	2.8	0.1	0.3	0.1
Mixed shelf	1.9	0.1	0.2	0.1
Mixed upper slope	1.9	0.1	0.2	0.1
Mixed lower slope	1.9	0.1	0.2	0.1
Soft shelf	1.2	0.1	0.1	0.1
Soft upper slope	1.0	0.1	0.1	0.1
Soft lower slope	1.0	0.1	0.1	0.1

Table A3a.2. Part B. Recovery time (years) for four major gear and and three bottom types adapted from PFMC 2004.

Part B Recovery Times	Bottom Trawl	Midwater Trawl	Fixed Gear Distance	Fixed Gear Point
Hard shelf	2.8	na	0.1	0.1
Hard upper slope	2.8	na	0.3	0.1
Hard lower slope	2.8	na	0.3	0.1
Mixed shelf	2.8	na	0.4	0.1
Mixed upper slope	2.8	na	0.4	0.1
Mixed lower slope	2.8	na	0.4	0.1
Soft shelf	0.4	na	0.4	0.1
Soft upper slope	1.0	na	0.4	0.1
Soft lower slope	1.0	na	0.4	0.1

Table A3a.3. Impact levels for four major gear types, adapted from Morgan and Cheunpagdee 2003, and Cheunpagdee et al. 2003.

	Bottom Trawl	Midwater Trawl	Fixed Gear Distance	Fixed Gear Point
Impact based on expert workshop (n = 13 experts; ave. physical & biological impacts; scale 1 = very low, 5 = very high)	5	1	2.3	1
Severity ranking of ecological impacts based on respondent survey (n= 70 respondents; scale of 0 = least severe to 100= most severe)	91	4	34	4

Table A3a.4. Impact levels (scale of 0-3) for three major gear types represented as vulnerability of geologiacal and biological features to trawl impacts according to substrate, and low and high energy environments, adapted from NEFMC 2011.

	Bottom Trawl		**Longline**		**Trap**	
Vulnerability (S) as percent reduction in “functional value” S = 0, 0-10%; S=1, 10-25%; S=2, 25-50%; S=3, 50-100%	**Geological**	**Biological**	**Geological**	**Biological**	**Geological**	**Biological**
High energy mud / sand	**1.8–2.0**	**1.3-1.5**	**0.3-0.4**	**0.0**	**0.6-1.0**	**0.6-0.8**
Low energy mud / sand	**1.8-2.0**	**1.4-1.6**	**0.3-0.4**	**0.0**	**0.8-1.0**	**0.7-0.8**
High energy pebble / cobble /boulder	**1.0-1.7**	**1.6-1.7**	**0.0-0.3**	**0.0-1.5**	**0.0-0.3**	**0.9-0.9**
Low energy pebble / cobble /boulder	**1.0-2.0**	**1.7-1.8**	**0.0-0.5**	**0.0-1.5**	**0.0-0.5**	**0.9-1.0**

Table A3a.5. Distribution of bottom trawl fishing effort (distance, meters) from 2002-2010 by seabed habitat type, and by depth zones both coastwide and in four biogeographic sub-regions: “Northern” (i.e., Cape Flattery, WA to Cape Mendocino, CA), “Central” (i.e., Cape Mendocino, CA to Point Conception, CA), “Southern” (i.e., Point Conception, CA to U.S.-Mexico maritime border) and “Salish Sea” (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Percentage values represent relative contribution to the sub-region. The “Salish Sea” only encompasses the shallowest (“shelf”) depth zone. Data source: PacFIN trawl logbooks, based on a towline model that depicts a line from the gear deployment to retrieval coordinates.

		BIOGEOGRAPHIC SUB-REGION								COASTWIDE	
		Northern		Central		Southern		Salish Sea		Combined	
Depth Zone	***Substrate***	*Distance (m)*	*%*	*Distance (m)*	*%*	*Distance (m)*	*%*	*Distance (m)*	*%*	*Distance (m)*	*%*
Shelf[1]	**Total**	**465,744,267**	**34.5%**	**135,584,061**	**39.4%**	**57,556,112**	**98.2%**	**3,652,788**	**100.0%**	**662,537,227**	**37.7%**
	hard	4,168,770	0.3%	1,103,097	0.3%	281,647	0.5%	5,767	0.2%	5,559,281	0.3%
	mixed	3,730,922	0.3%	89,351	0.0%	238,597	0.4%	9,969	0.3%	4,068,840	0.2%
	soft	457,844,575	33.9%	134,391,612	39.1%	57,035,868	97.4%	3,637,052	99.6%	652,909,107	37.1%
	undefined	0	0.0%	0	0.0%	0	0.0%		0.0%	0	0.0%
Upper Slope[2]	**Total**	**884,755,328**	**65.5%**	**208,141,081**	**60.5%**	**1,026,193**	**1.8%**	**0**	**0.0%**	**1,093,922,602**	**62.2%**
	hard	22,508,956	1.7%	3,738,955	1.1%	14,917	0.0%	0	0.0%	26,262,828	1.5%
	mixed	32,343,926	2.4%	128,515	0.0%	1,393	0.0%	0	0.0%	32,473,835	1.8%
	soft	829,902,445	61.4%	204,273,611	59.4%	1,009,883	1.7%	0	0.0%	1,035,185,939	58.9%
	undefined	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Lower Slope[3]	**Total**	**1,279,842**	**0.1%**	**198,966**	**0.1%**	**4,716**	**0.0%**	**0**	**0.0%**	**1,483,524**	**0.1%**
	hard	118,706	0.0%	1,155	0.0%	4,716	0.0%	0	0.0%	124,577	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	1,161,136	0.1%	197,812	0.1%	0	0.0%	0	0.0%	1,358,947	0.1%
	undefined	0	0.0%	0	0.0%		0.0%	0	0.0%	0	0.0%
Total		**1,351,779,436**	**100.0%**	**343,924,108**	**100.0%**	**58,587,021**	**100.0%**	**3,652,788**	**100.0%**	**1,757,943,353**	**100.0%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

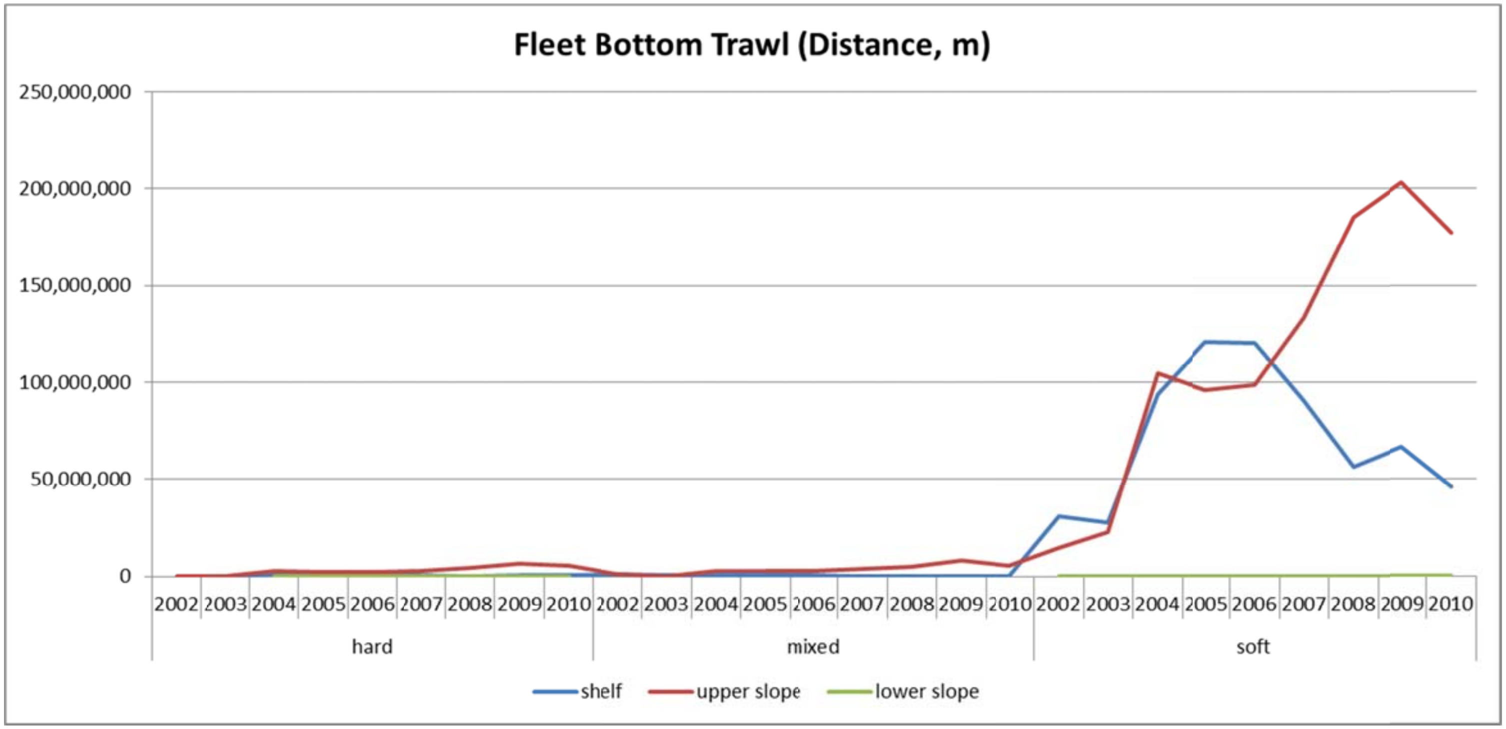


Figure A3a.1. Annual distribution of bottom trawl fishing effort (distance, meters) from 2002-2010, by seabed habitat type and depth zones.

Table A3a.6. Distribution of midwater trawl fishing effort (distance, meters) from 2002-2010 by seabed habitat type, and by depth zones both coastwide and in four biogeographic sub-regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Percentage values represent relative contribution to the sub-region. The "Salish Sea" only encompasses the shallowest ("shelf") depth zone. Data source: At-Sea Hake Observer Program (NWFSC), based on a towline model which depicts a line from the gear deployment to retrieval coordinates.

		BIOGEOGRAPHIC SUB-REGION								COASTWIDE	
		Northern		Central		Southern		Salish Sea		Combined	
Depth Zone	***Substrate***	*Distance (m)*	*%*	*Distance (m)*	*%*	*Distance (m)*	*%*	*Distance (m)*	*%*	*Distance (m)*	*%*
Shelf[1]	**Total**	**26,732,815**	**14.1%**	**0**	**0.0%**	**0**	**0.0%**	**80,811**	**100.0%**	**26,813,626**	**14.1%**
	hard	406,100	0.2%	0	0.0%	0	0.0%	3,146	3.9%	409,246	0.2%
	mixed	2,356,373	1.2%	0	0.0%	0	0.0%	39,155	48.5%	2,395,528	1.3%
	soft	23,970,342	12.6%	0	0.0%	0	0.0%	38,510	47.7%	24,008,853	12.6%
	undefined	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Upper Slope[2]	**Total**	**161,885,915**	**85.2%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**161,885,915**	**85.2%**
	hard	5,807,496	3.1%	0	0.0%	0	0.0%	0	0.0%	5,807,496	3.1%
	mixed	10,502,163	5.5%	0	0.0%	0	0.0%	0	0.0%	10,502,163	5.5%
	soft	145,576,257	76.7%	0	0.0%	0	0.0%	0	0.0%	145,576,257	76.6%
	undefined	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Lower Slope[3]	**Total**	**1,277,669**	**0.7%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**1,277,669**	**0.7%**
	hard	90,633	0.0%	0	0.0%	0	0.0%	0	0.0%	90,633	0.0%
	mixed	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	soft	1,187,036	0.6%	0	0.0%	0	0.0%	0	0.0%	1,187,036	0.6%
	undefined	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Total		**189,896,400**	**100.0%**	**0**	**0.0%**	**0**	**0.0%**	**80,811**	**100.0%**	**189,977,211**	**100.0%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.

[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.

[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

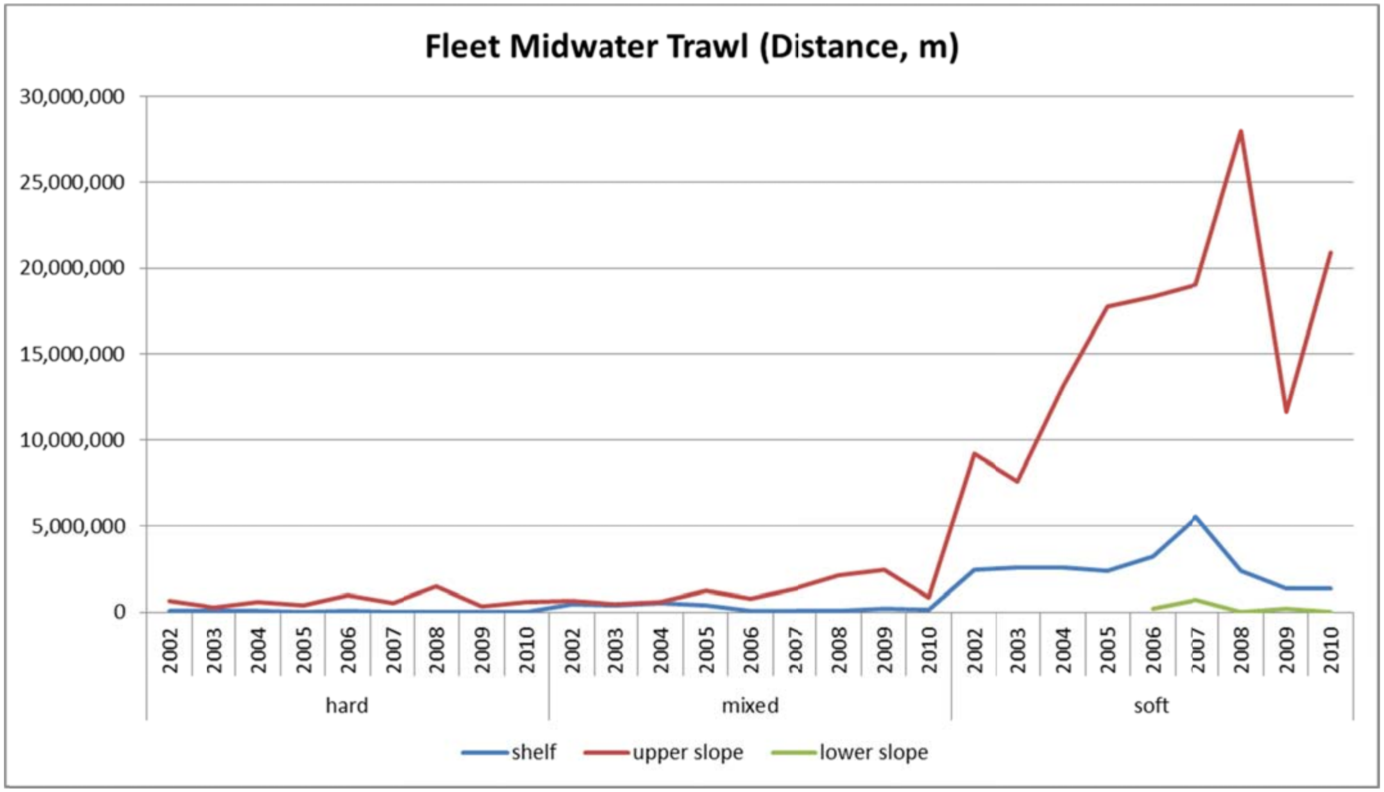


Figure A3a.2. Annual distribution of midwater trawl fishing effort (distance, meters) from 2002-2010, by seabed habitat type and depth zones.

Table A3a.7. Distribution of observed groundfish fixed gear fishing effort (# of fishing events) from 2002-2010 by seabed habitat type, and by depth zones both coastwide and in four biogeographic sub-regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Percentage values represent relative contribution to the sub-region. The "Salish Sea" only encompasses the shallowest ("shelf") depth zone. Data source: West Coast Groundfish Observer Program (NWFSC), based on either a towline model which depicts a line from the gear deployment to retrieval coordinates (longlines or pot strings), or on points representing the average of gear deployment and retrieval coordinates (other hook-and-line gears or pot/trap gears), depending on gear type.

		BIOGEOGRAPHIC SUB-REGION								COASTWIDE	
		Northern		Central		Southern		Salish Sea		Combined	
Depth Zone	***Substrate***	*# of Events*	*%*	*# of Events*	*%*	*# of Events*	*%*	*# of Events*	*%*	*# of Events*	*%*
Shelf[1]	**Total**	**3,459**	**32.4%**	**905**	**49.3%**	**319**	**14.0%**	**0**	**0.0%**	**4,683**	**31.7%**
	hard	825	7.7%	435	23.7%	108	4.7%	0	0.0%	1,368	9.3%
	mixed	462	4.3%	37	2.0%	2	0.1%	0	0.0%	501	3.4%
	soft	2172	20.4%	433	23.6%	209	9.2%	0	0.0%	2,814	19.0%
	undefined		0.0%		0.0%		0.0%	0	0.0%	0	0.0%
Upper Slope[2]	**Total**	**7,085**	**66.4%**	**911**	**49.7%**	**1,947**	**85.3%**	**0**	**0.0%**	**9,943**	**67.3%**
	hard	722	6.8%	119	6.5%	127	5.6%	0	0.0%	968	6.5%
	mixed	836	7.8%	3	0.2%	0	0.0%	0	0.0%	839	5.7%
	soft	5527	51.8%	789	43.0%	1820	79.7%	0	0.0%	8,136	55.0%
	undefined		0.0%		0.0%		0.0%	0	0.0%	0	0.0%
Lower Slope[3]	**Total**	**122**	**1.1%**	**18**	**1.0%**	**17**	**0.7%**	**0**	**0.0%**	**157**	**1.1%**
	hard	57	0.5%	2	0.1%	9	0.4%	0	0.0%	68	0.5%
	mixed	65	0.6%	13	0.7%	0	0.0%	0	0.0%	78	0.5%
	soft	0	0.0%	3	0.2%	8	0.4%	0	0.0%	11	0.1%
	undefined		0.0%		0.0%		0.0%	0	0.0%	0	0.0%
Total		**10,666**	**100.0%**	**1,834**	**100.0%**	**2,283**	**100.0%**	**0**	**0.0%**	**14,783**	**100.0%**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

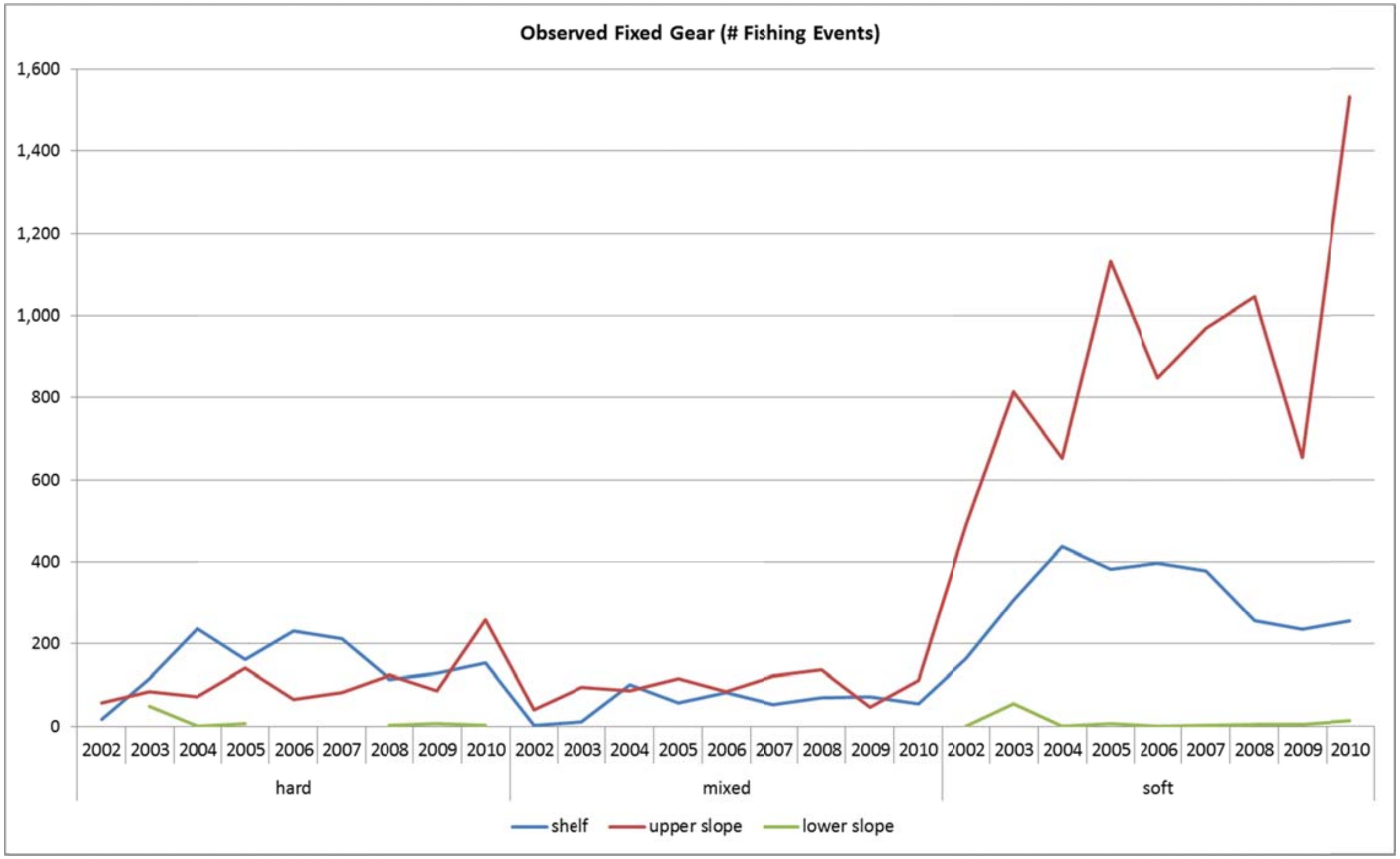
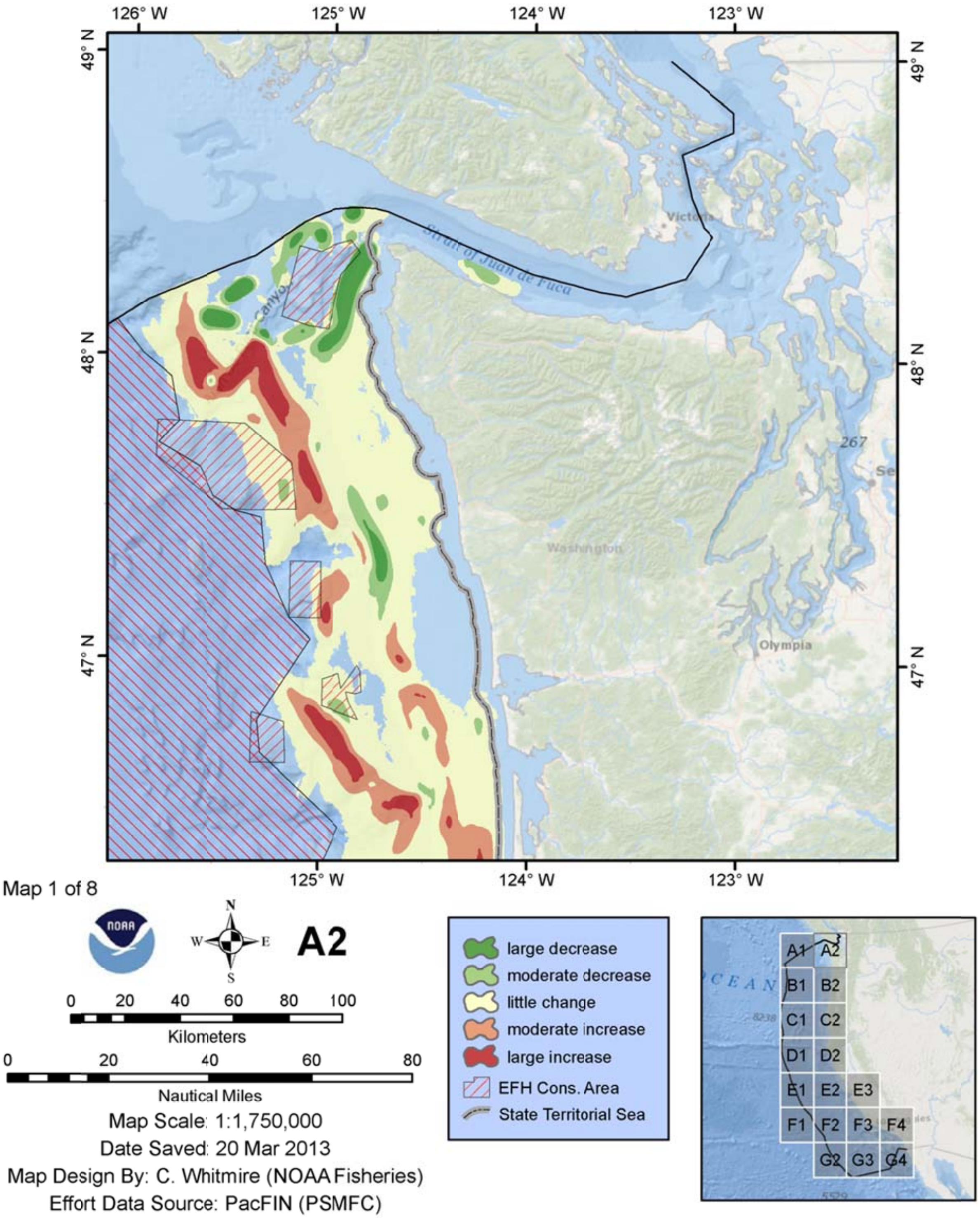


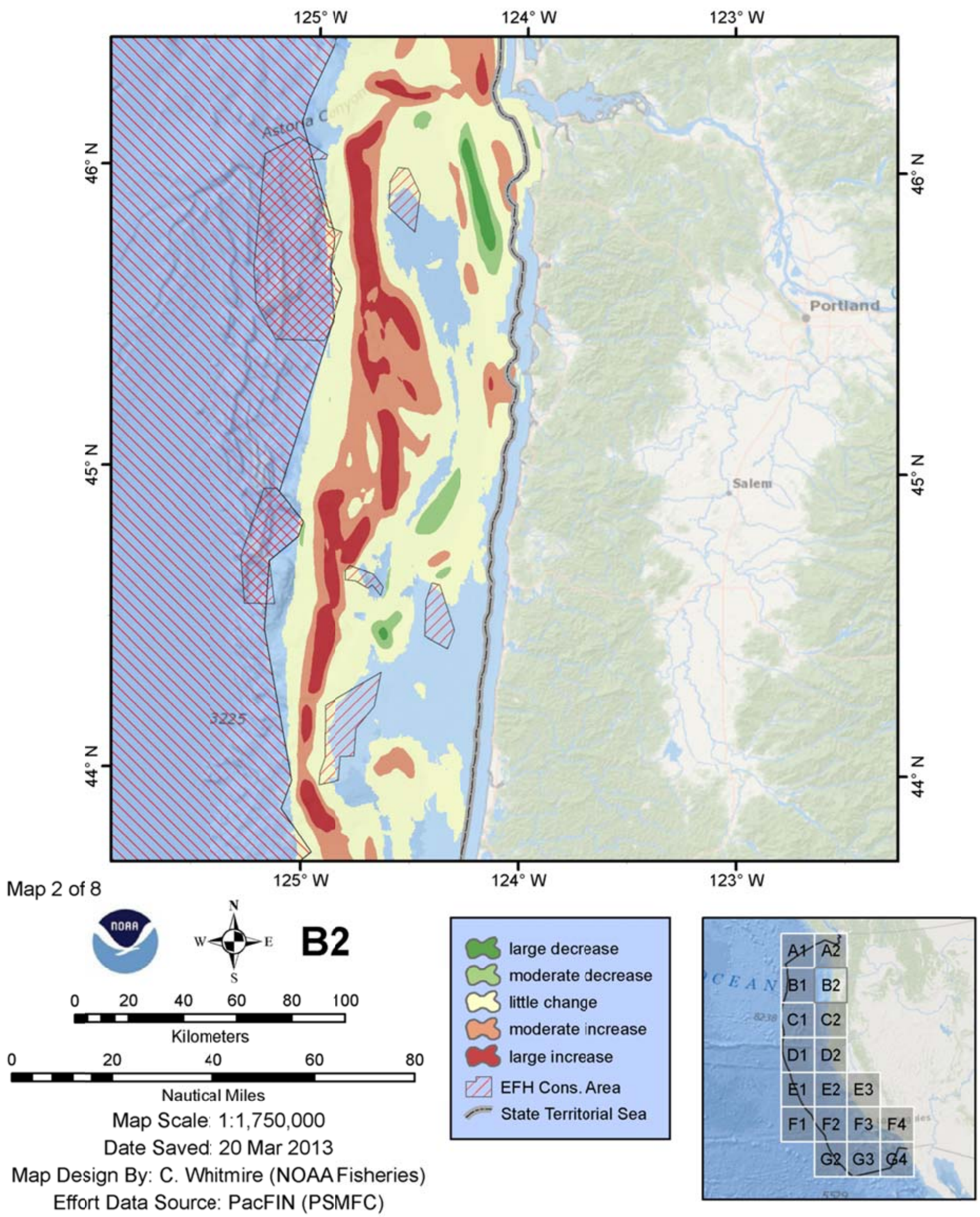
Figure A3a.3. Annual distribution of observed fixed gear fishing effort (# of fishing events) from 2002-2010, by seabed habitat type and depth zones.

Figure A3a.4. Map views (following pages; plates A2-F4) showing change in bottom trawl effort between two time periods: “before” (i.e., 1 Jan 2002 – 11 Jun 2006) and “after” (i.e., 12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulatory measures.

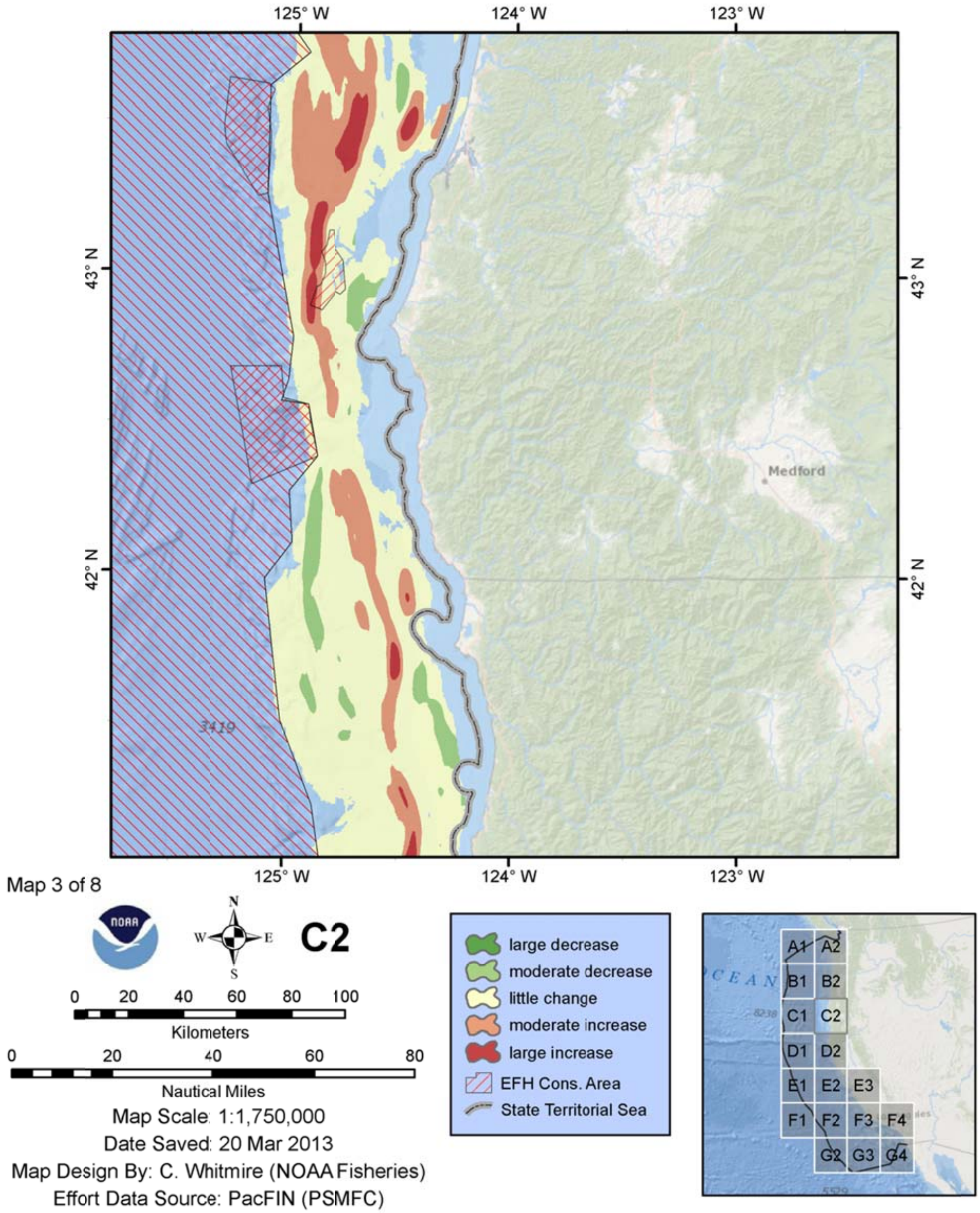
Bottom Trawl Effort (Temporal Change)



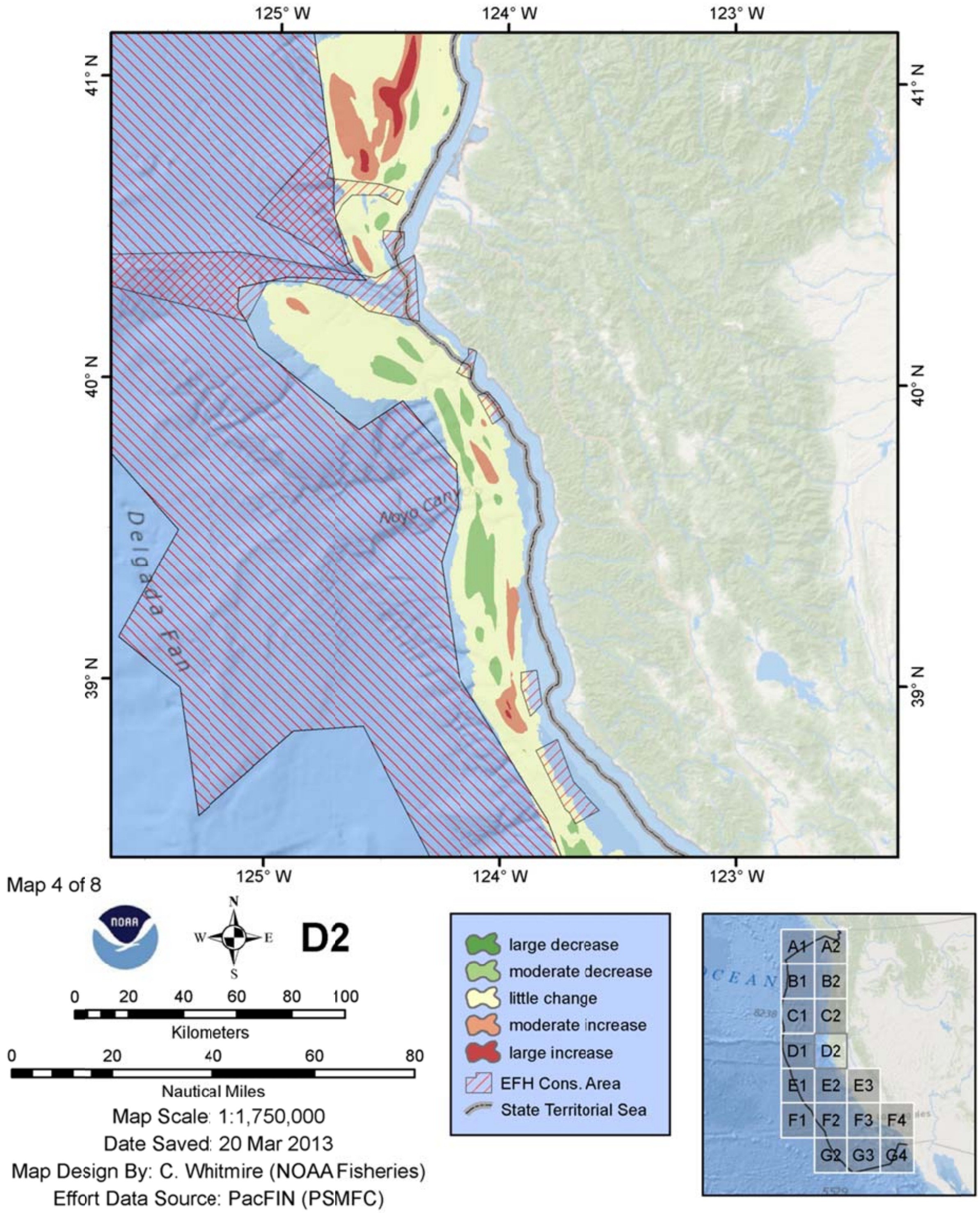
Bottom Trawl Effort (Temporal Change)



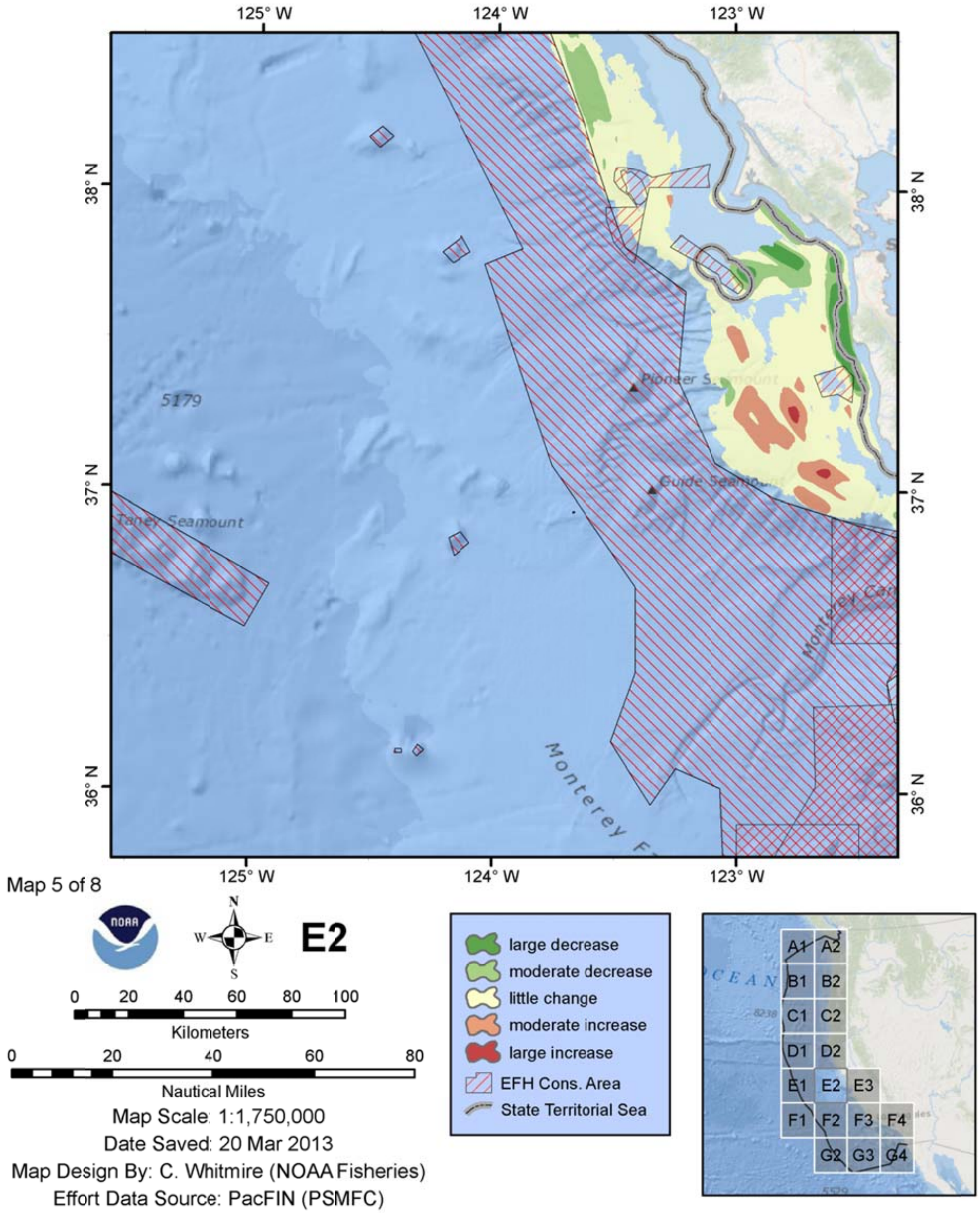
Bottom Trawl Effort (Temporal Change)



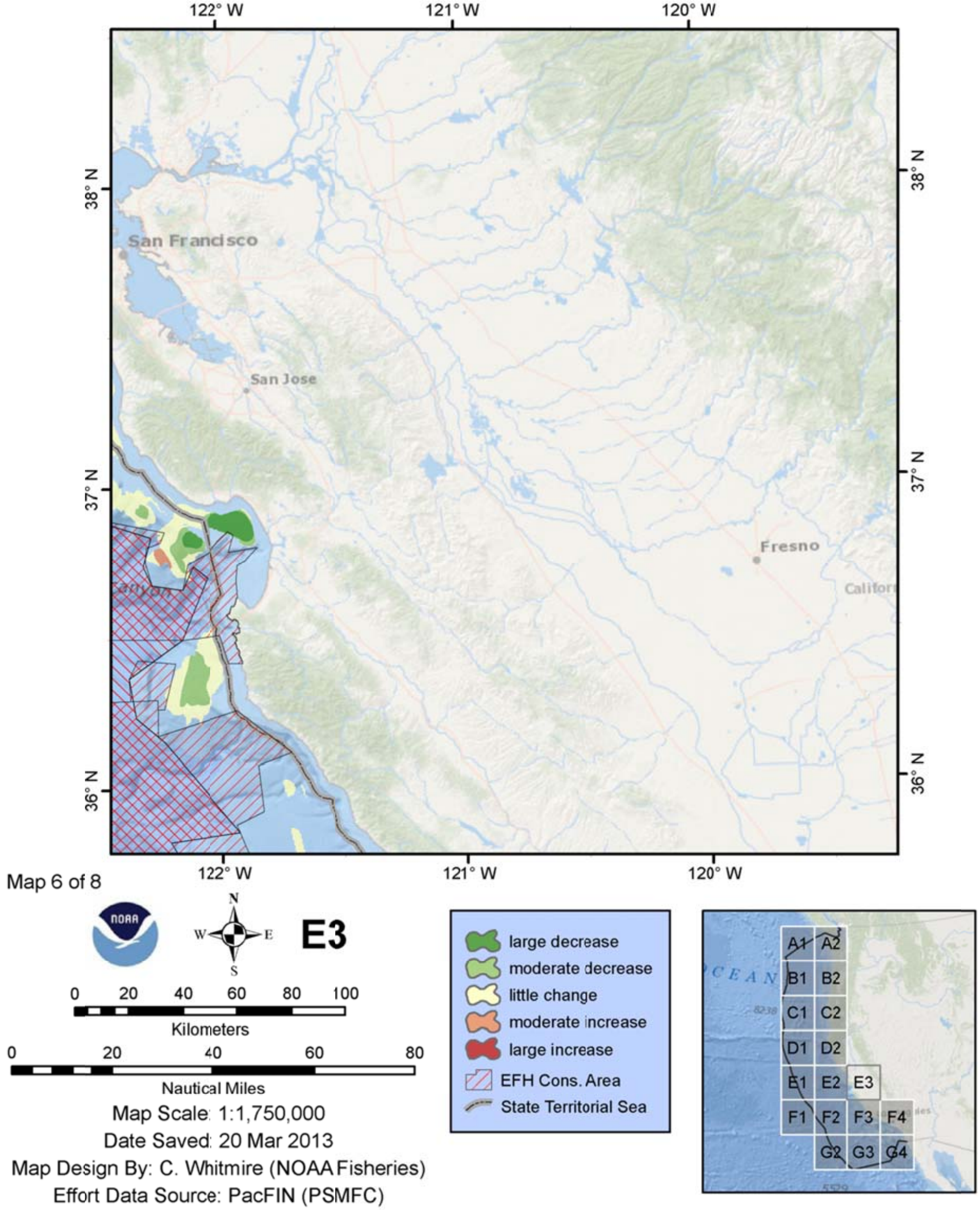
Bottom Trawl Effort (Temporal Change)



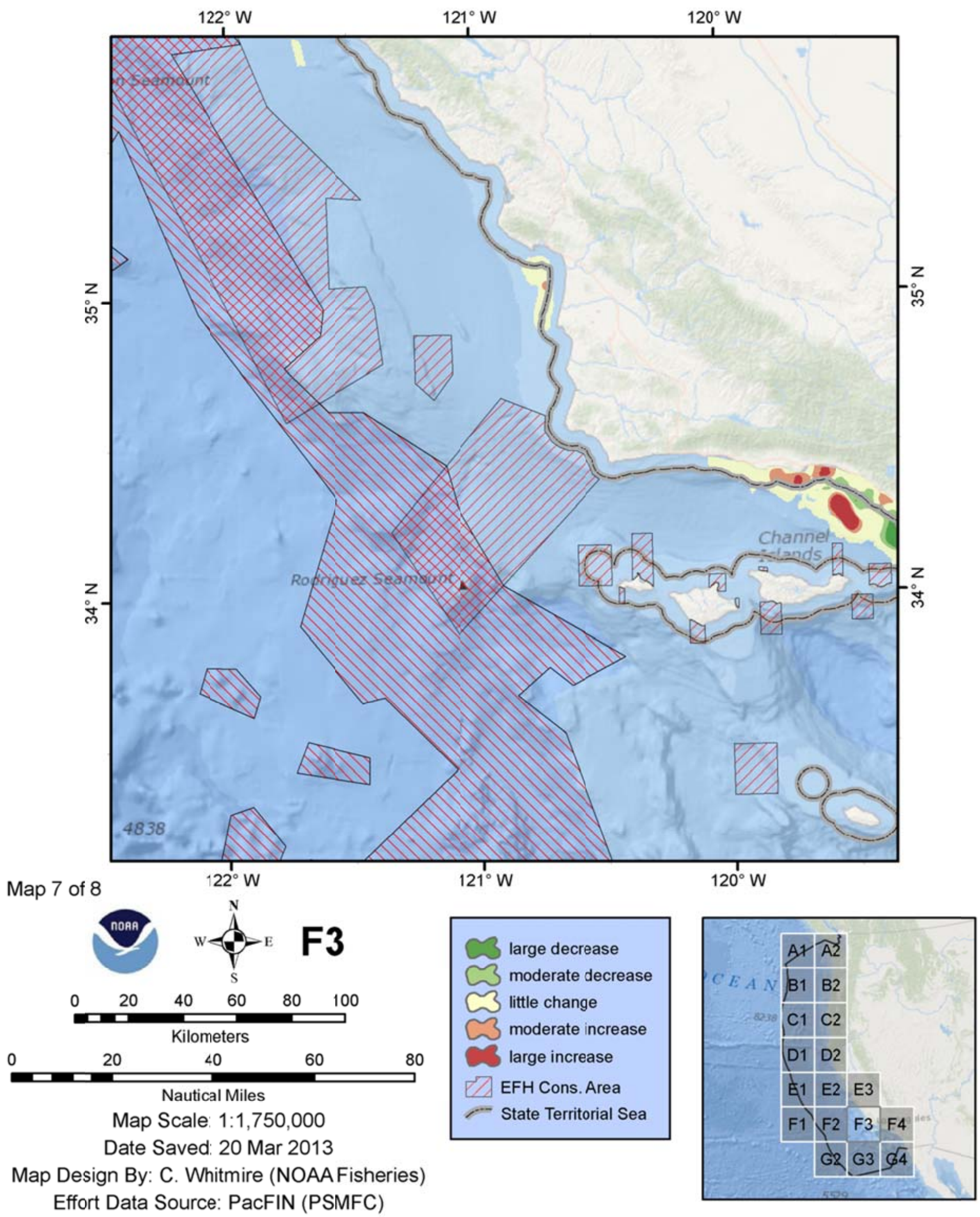
Bottom Trawl Effort (Temporal Change)



Bottom Trawl Effort (Temporal Change)



Bottom Trawl Effort (Temporal Change)



Bottom Trawl Effort (Temporal Change)

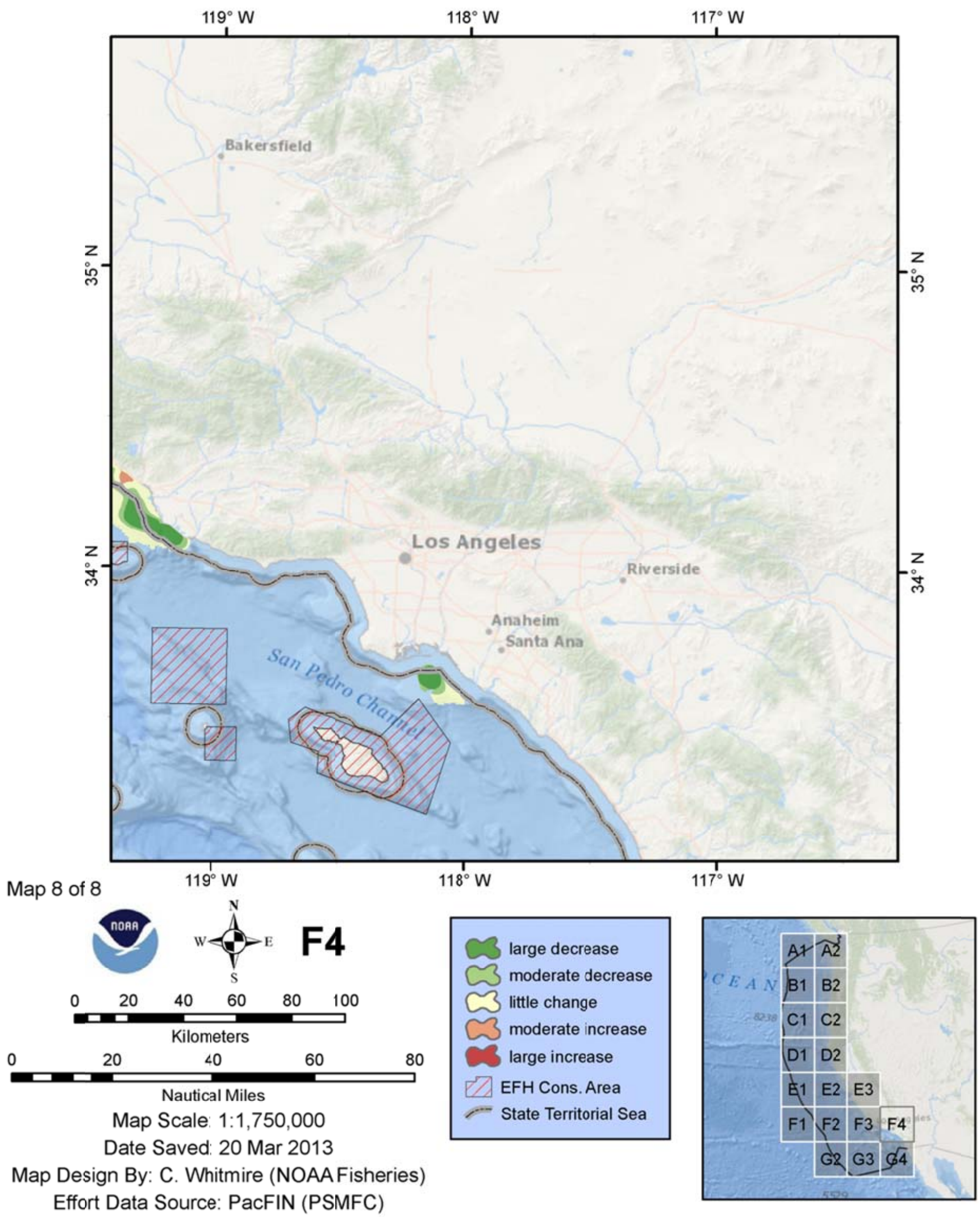
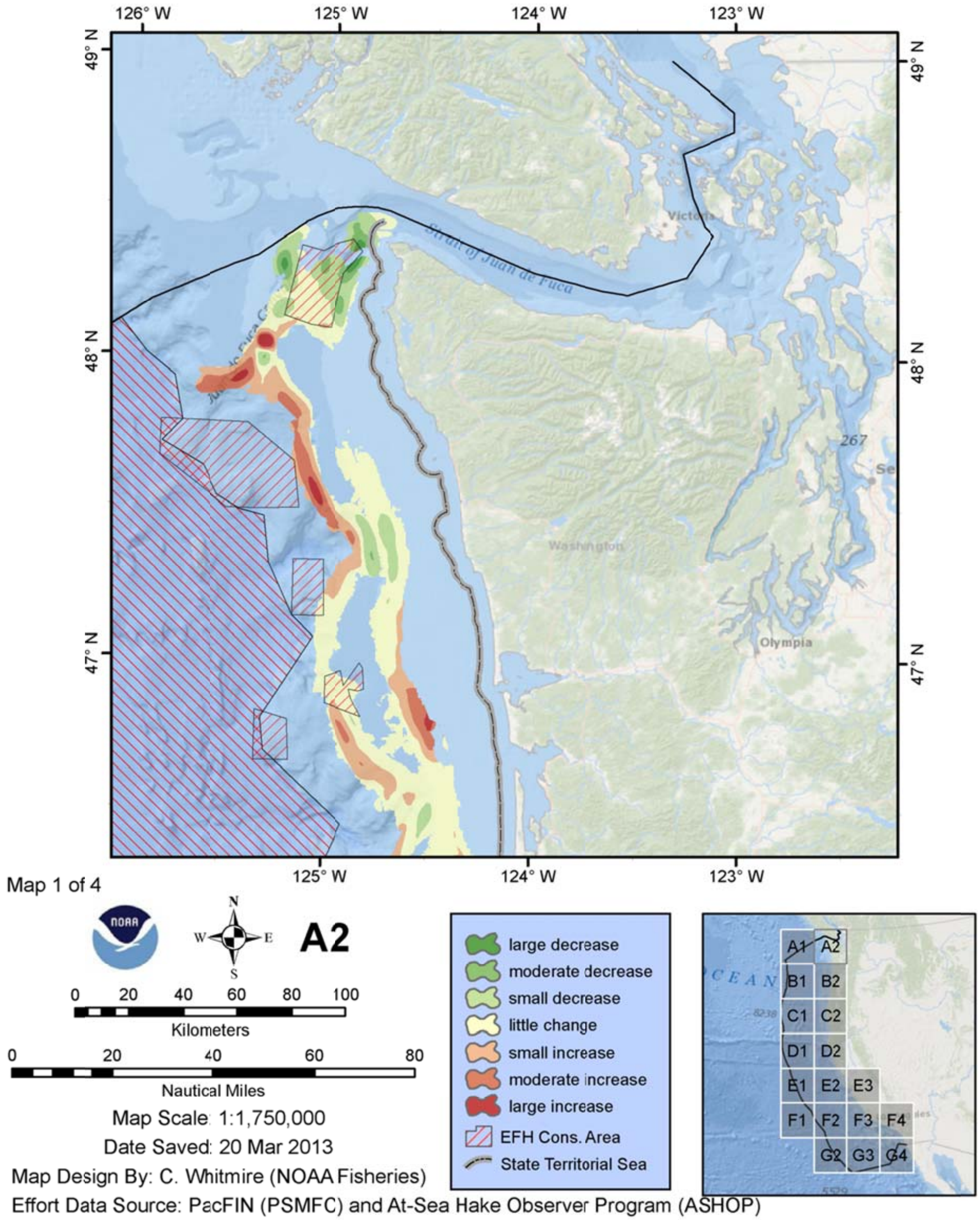
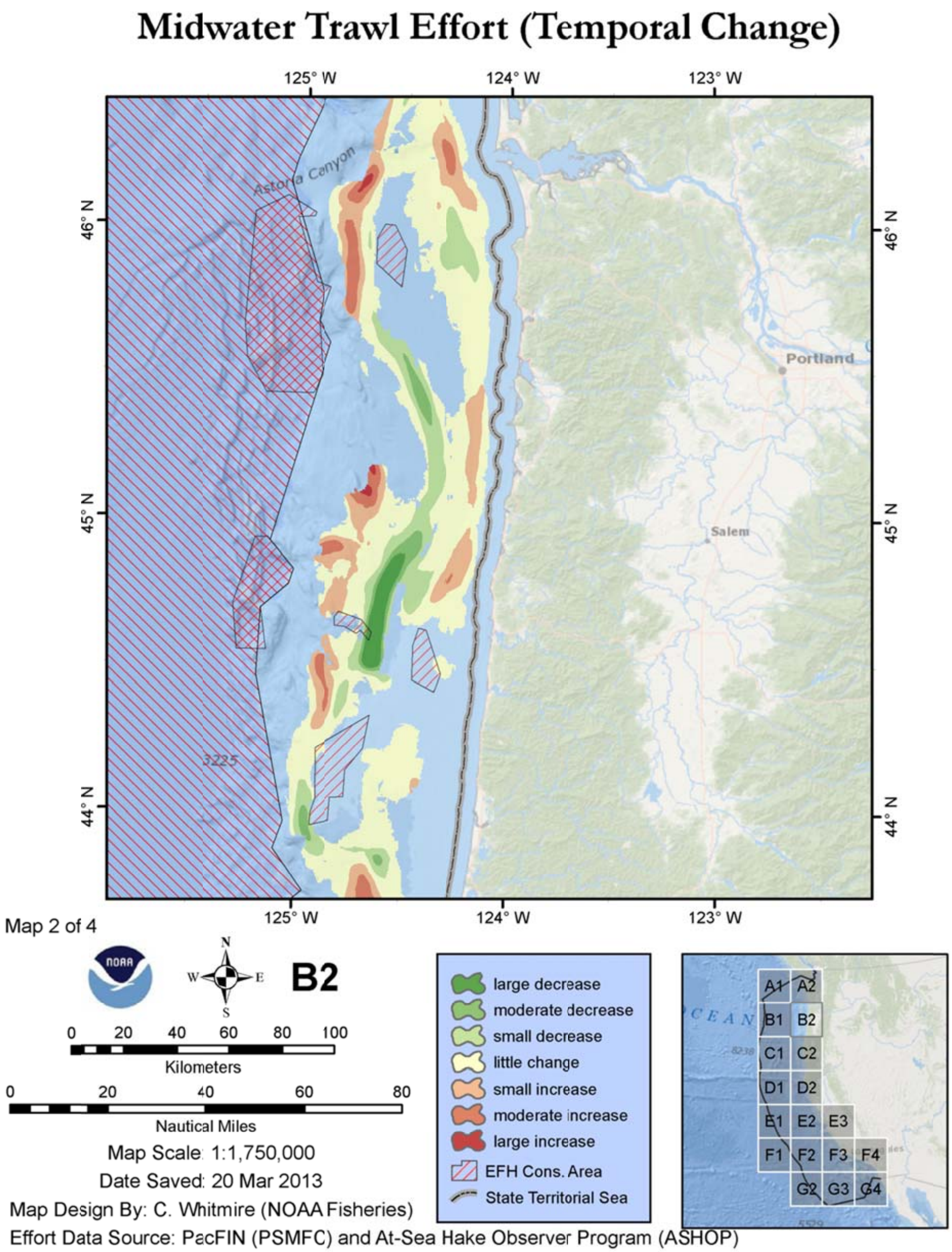


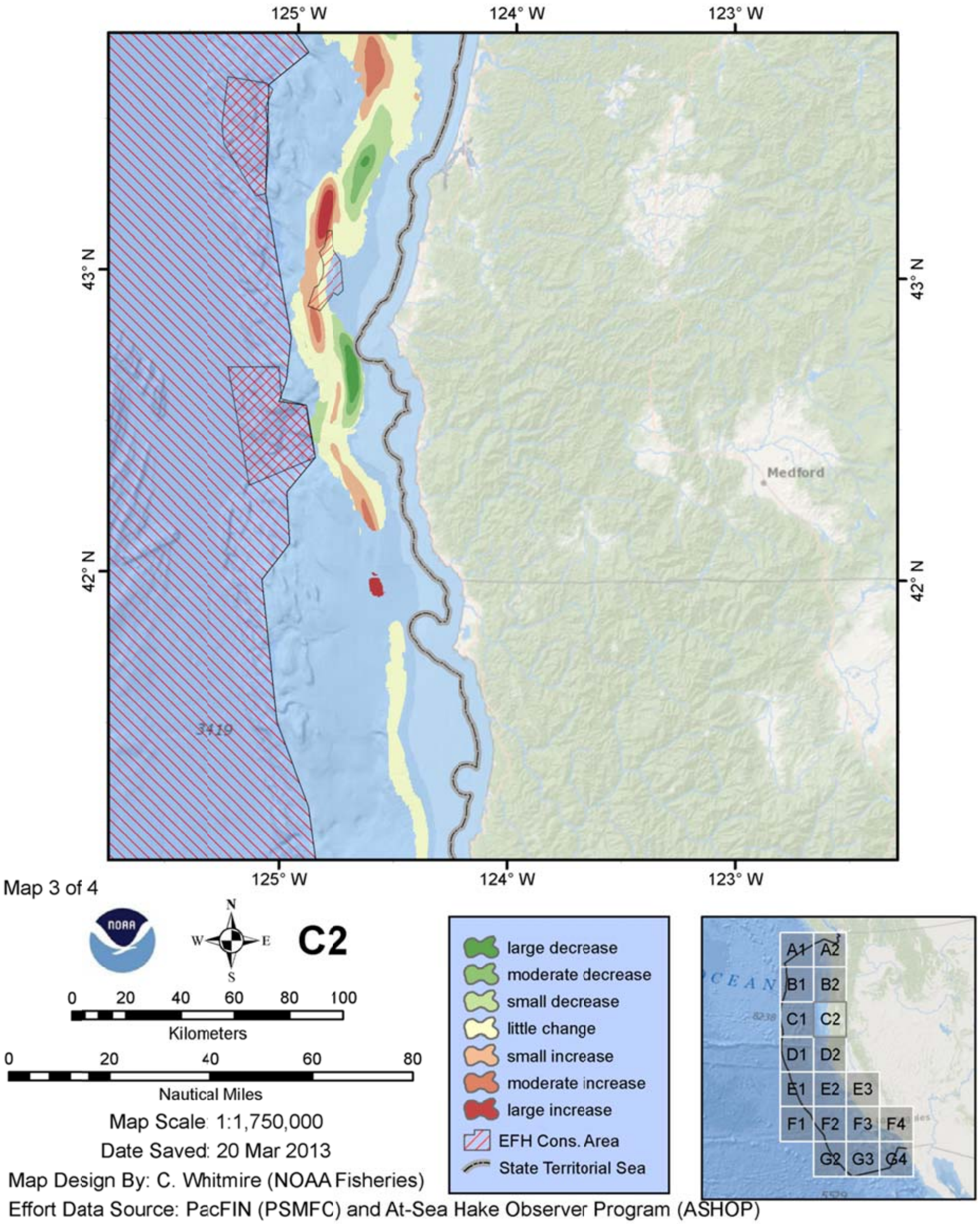
Figure A3a.5. Map views (following pages; plates A2-D2) showing change in midwater trawl effort between two time periods: “before” (i.e., 1 Jan 2002 – 11 Jun 2006) and “after” (i.e., 12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulatory measures.

Midwater Trawl Effort (Temporal Change)




Midwater Trawl Effort (Temporal Change)
125° W
124° W
123° W
46° N
45° N
44° N
Astoria Canyon
Portland
Salem
3225
Map 2 of 4
NOAA
N
S
W
E
B2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:1,750,000
Date Saved: 20 Mar 2013
Map Design By: C. Whitmire (NOAA Fisheries)
Effort Data Source: PacFIN (PSMFC) and At-Sea Hake Observer Program (ASHOP)
large decrease
moderate decrease
small decrease
little change
small increase
moderate increase
large increase
EFH Cons. Area
State Territorial Sea
A1
A2
B1
B2
C1
C2
D1
D2
E1
E2
E3
F1
F2
F3
F4
G2
G3
G4

Midwater Trawl Effort (Temporal Change)



Midwater Trawl Effort (Temporal Change)

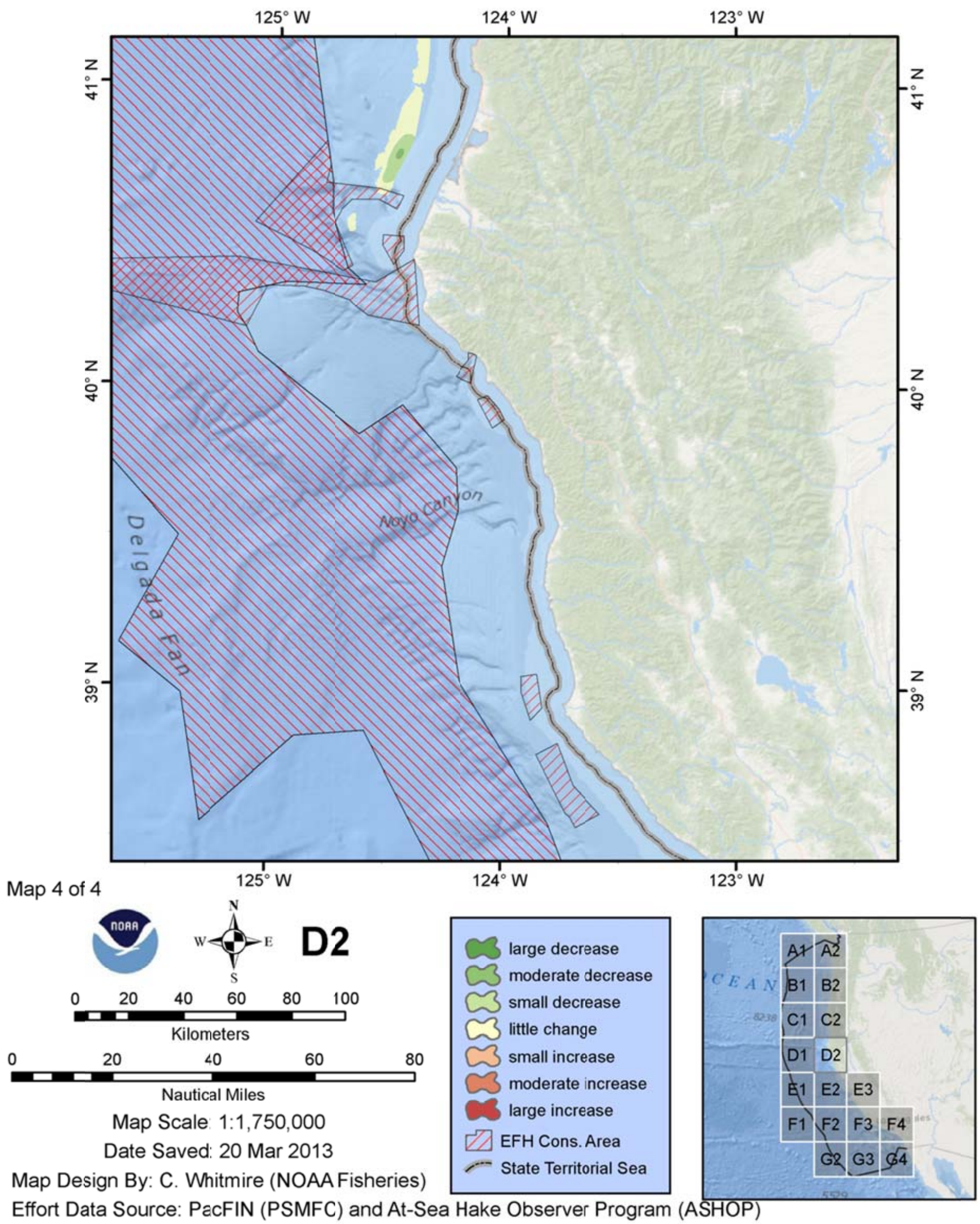
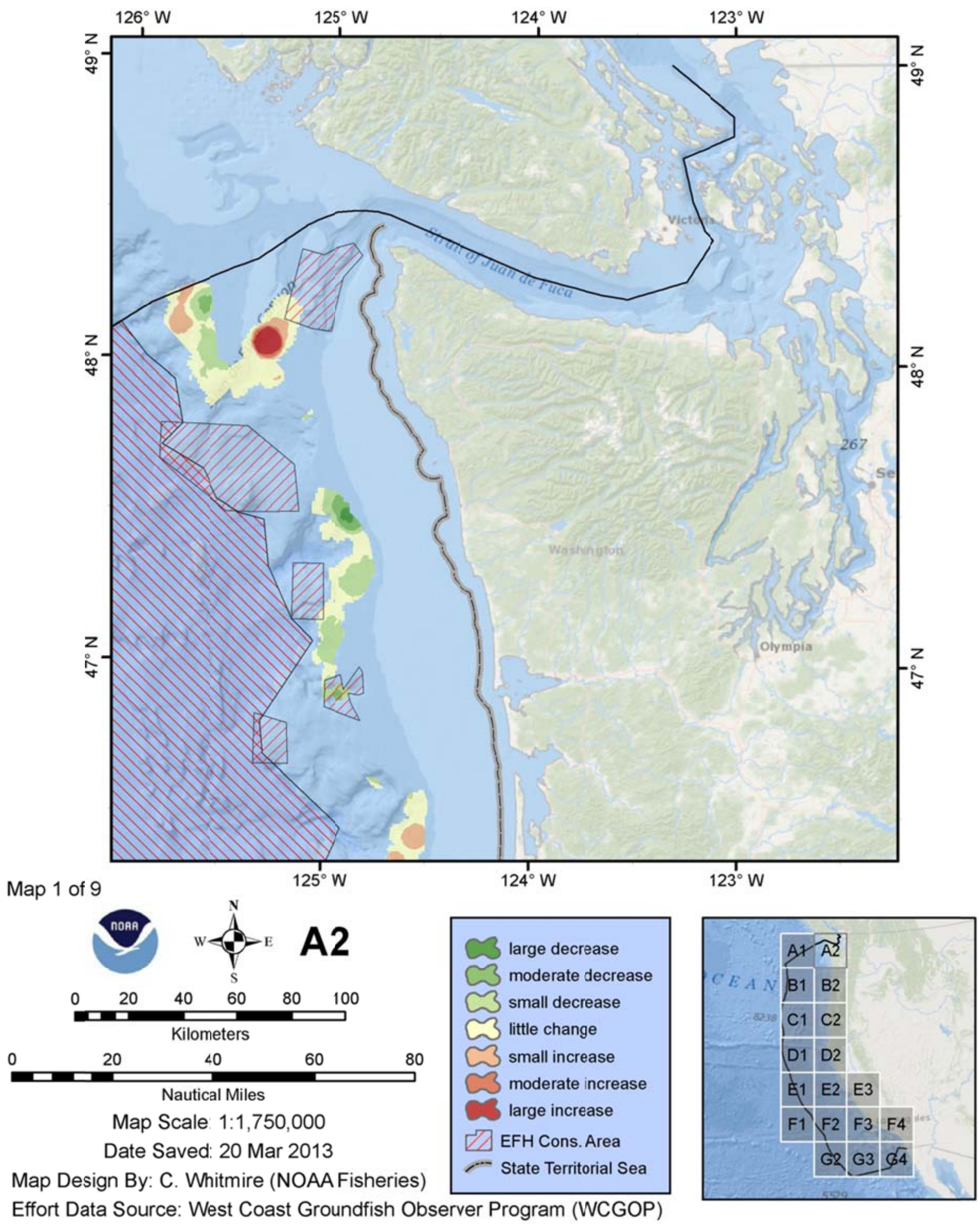
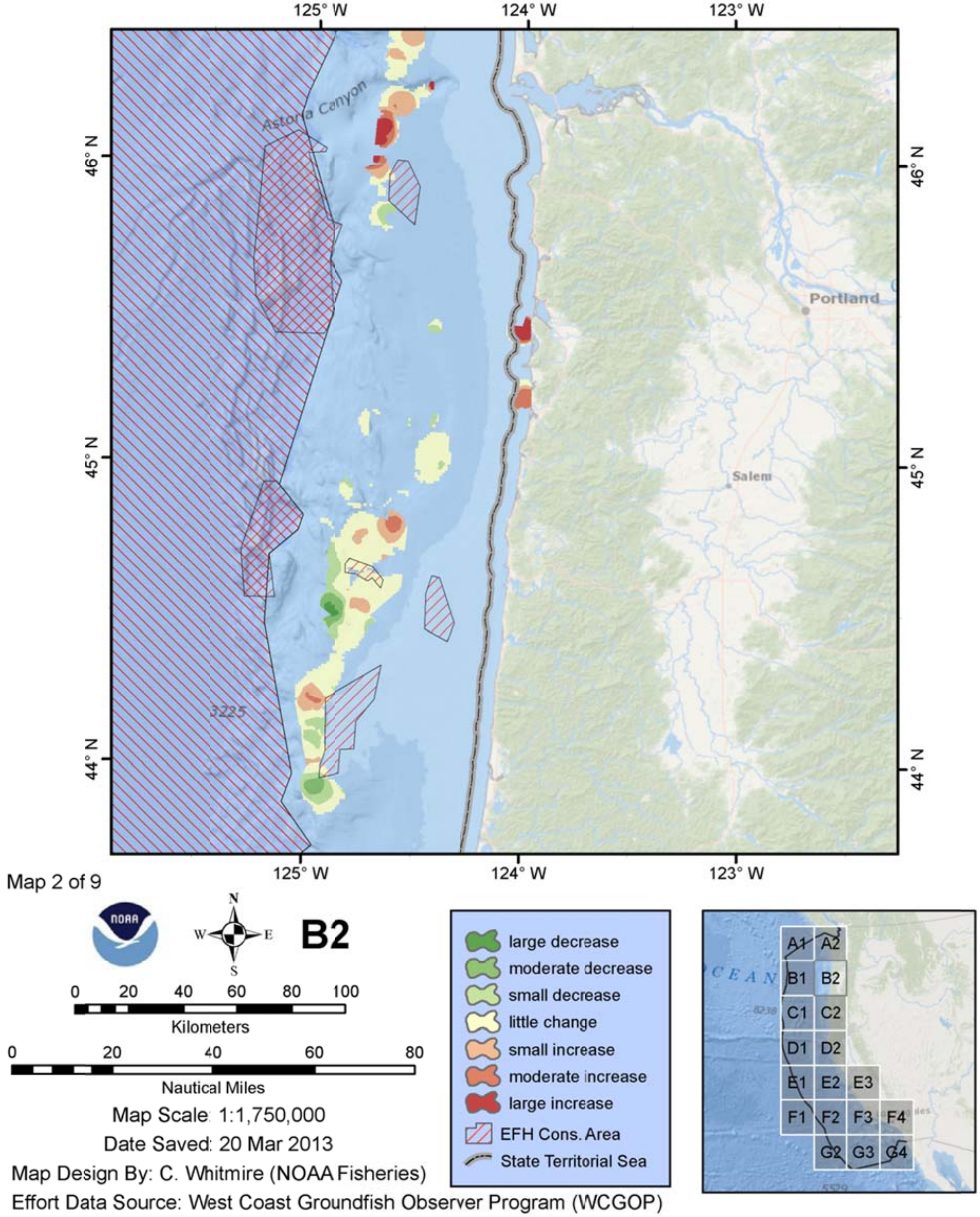


Figure A3a.6. Map views (following pages; plates A2-G4) showing change in observed fixed gear effort between two time periods: “before” (i.e., 1 Jan 2002 – 11 Jun 2006) and “after” (i.e., 12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulatory measures.

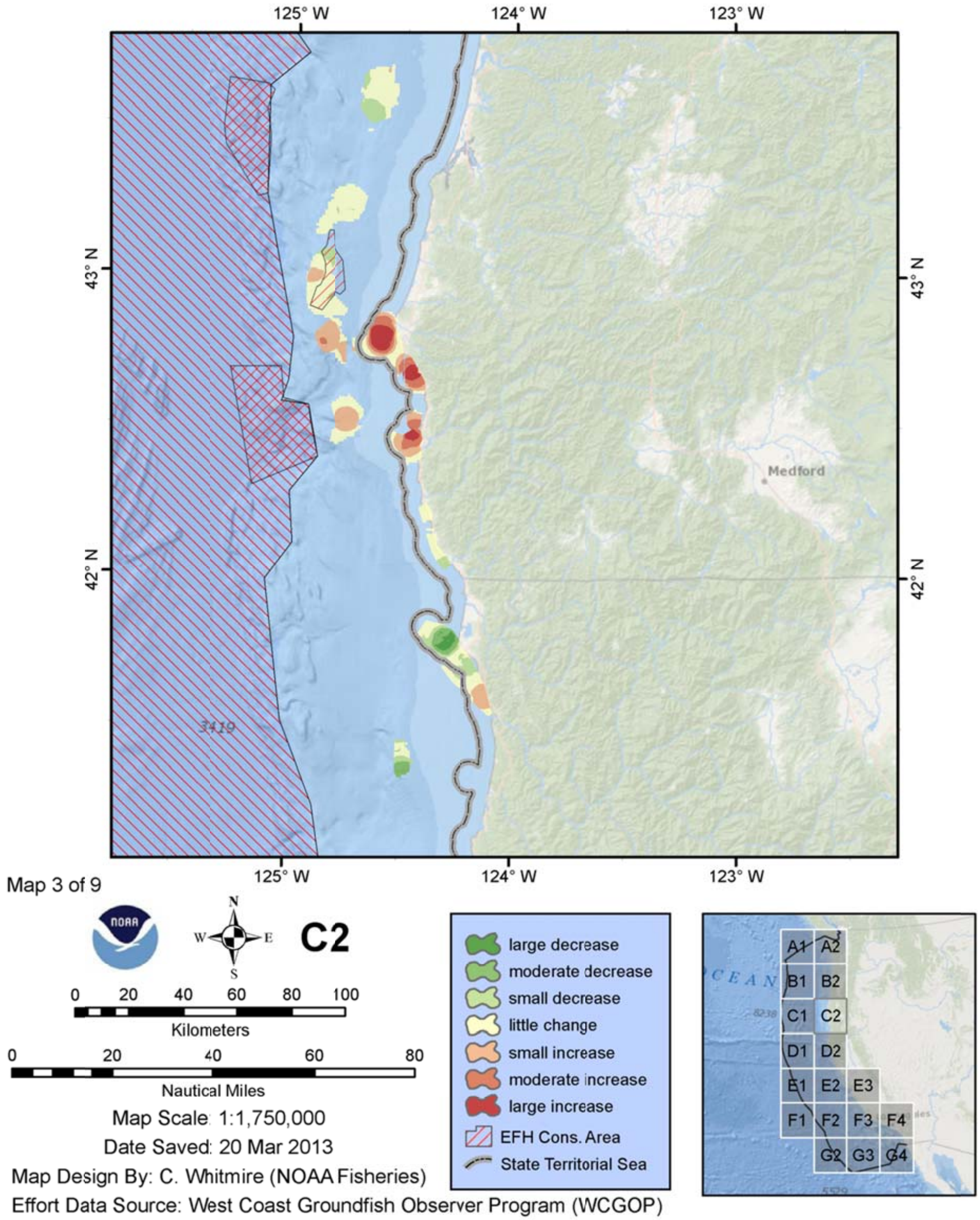
Observed Fixed Gear Effort (Temporal Change)

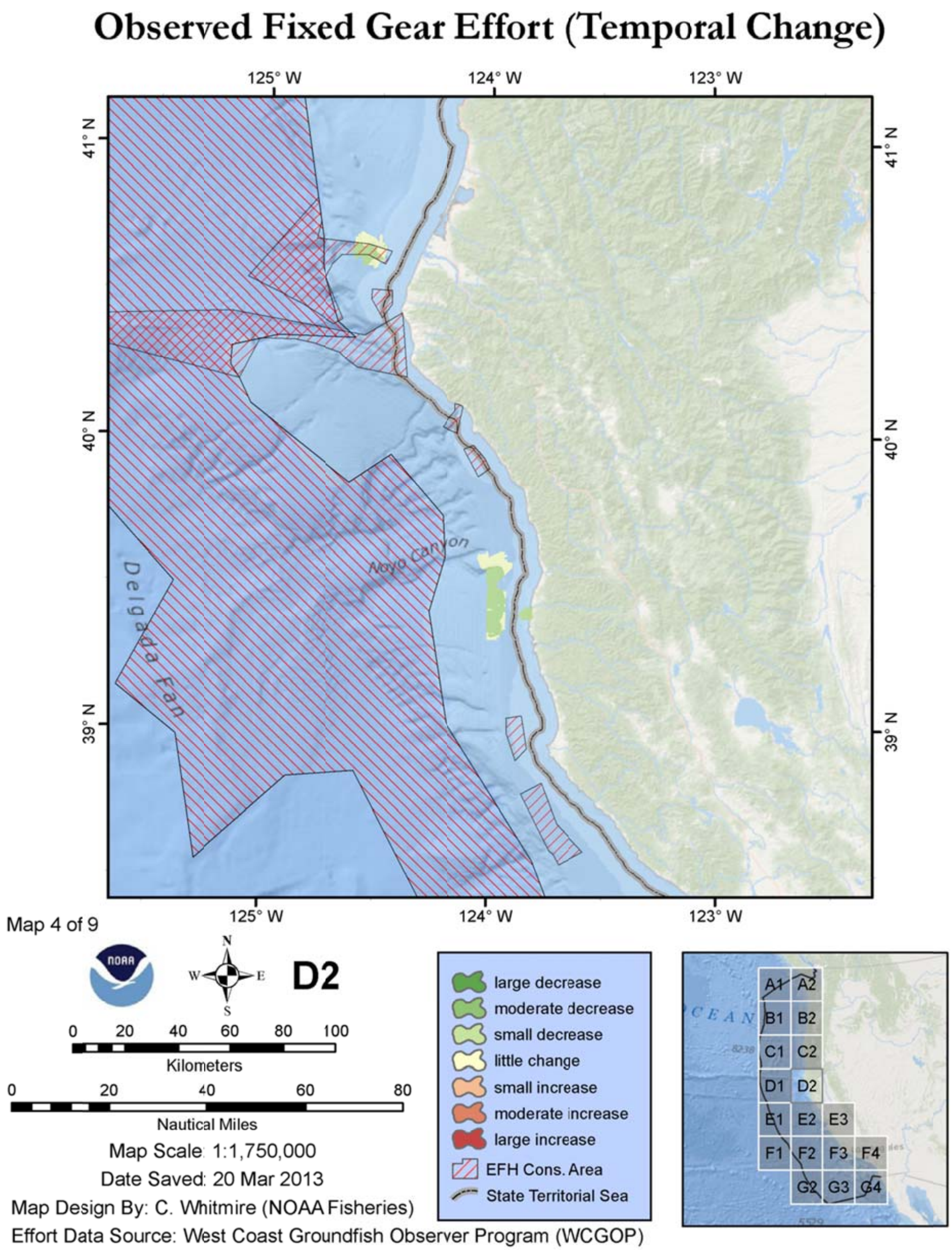


Observed Fixed Gear Effort (Temporal Change)

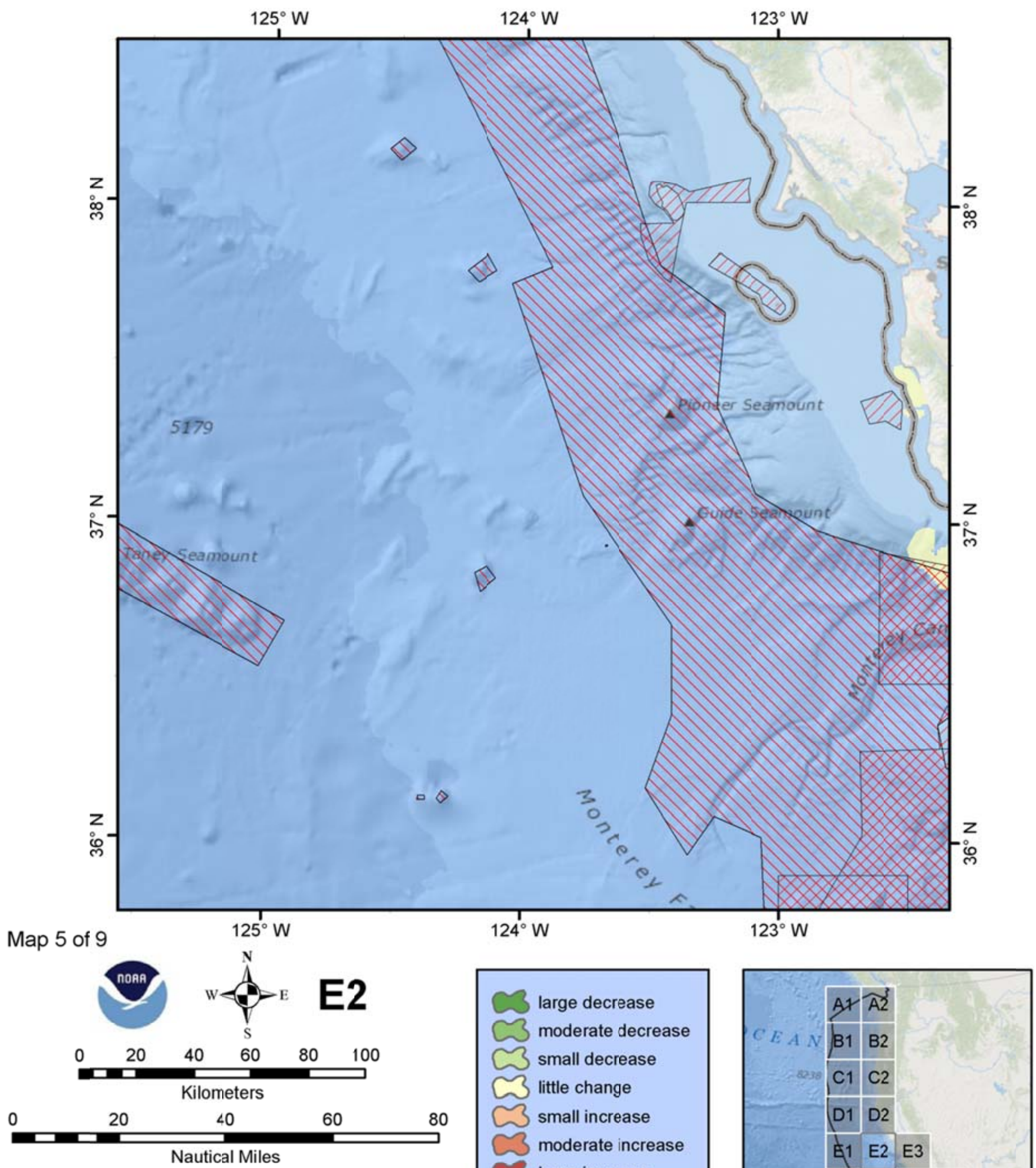


Observed Fixed Gear Effort (Temporal Change)



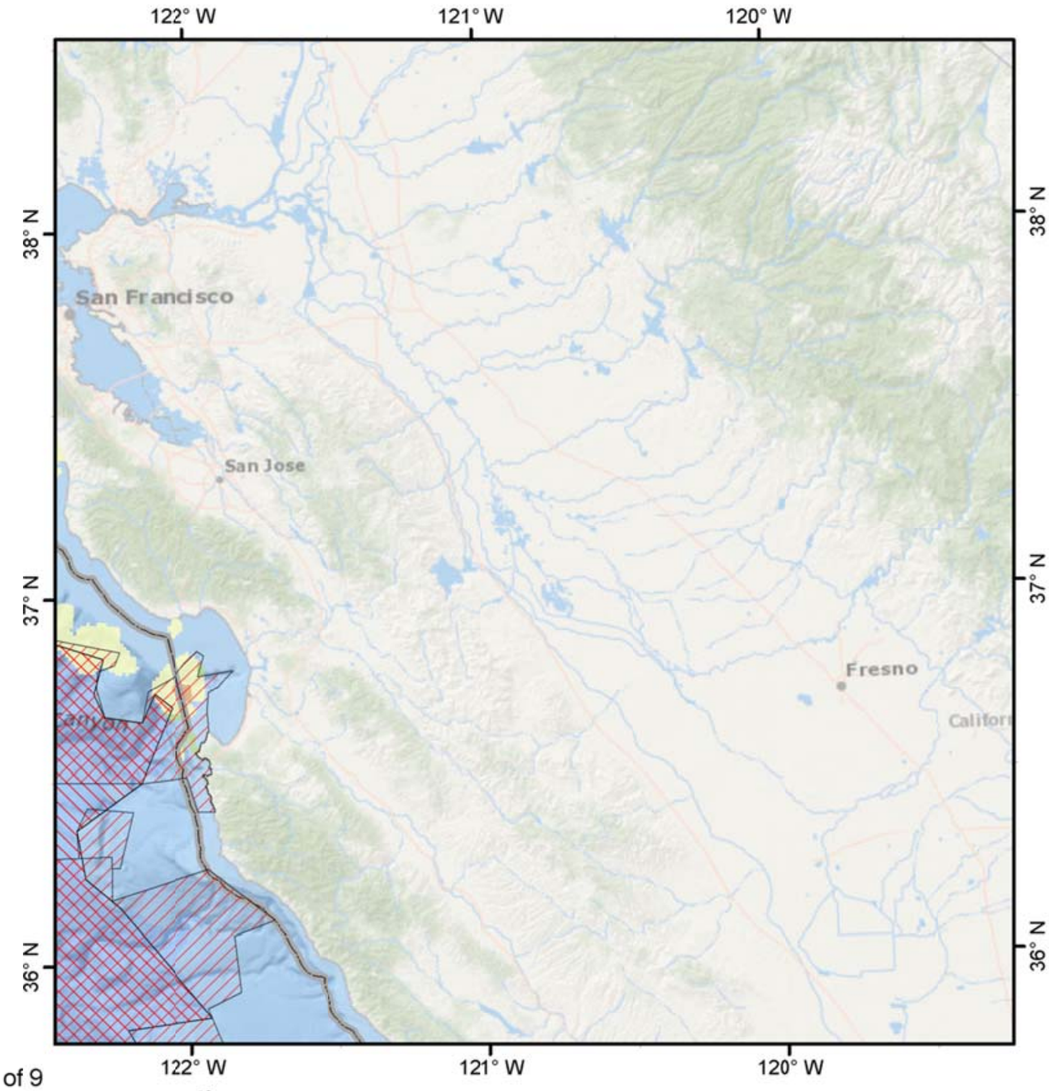

Observed Fixed Gear Effort (Temporal Change)
125° W
124° W
123° W
41° N
40° N
39° N
Noyo Canyon
Delgada Fan
Map 4 of 9
NOAA
N
W
E
S
D2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:1,750,000
Date Saved: 20 Mar 2013
Map Design By: C. Whitmire (NOAA Fisheries)
Effort Data Source: West Coast Groundfish Observer Program (WCGOP)
large decrease
moderate decrease
small decrease
little change
small increase
moderate increase
large increase
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

Observed Fixed Gear Effort (Temporal Change)

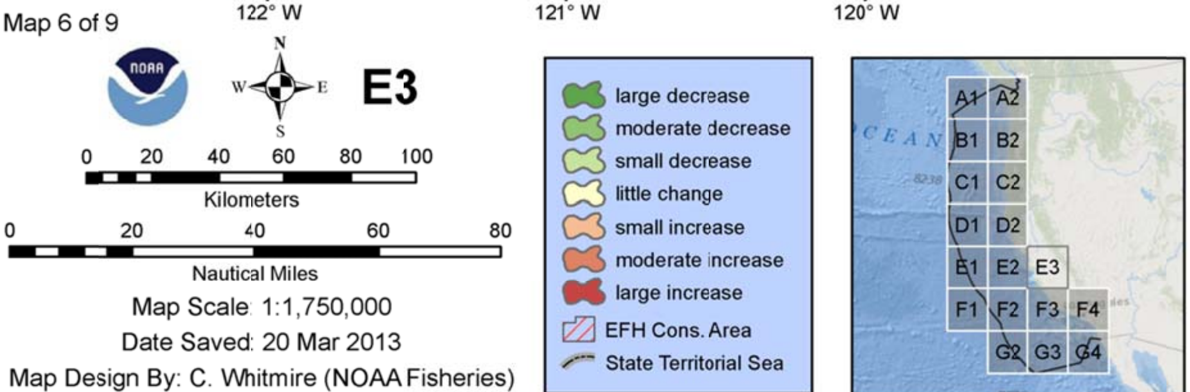


Map Scale: 1:1,750,000
Date Saved: 20 Mar 2013
Map Design By: C. Whitmire (NOAA Fisheries)
Effort Data Source: West Coast Groundfish Observer Program (WCGOP)

Observed Fixed Gear Effort (Temporal Change)



Map 6 of 9



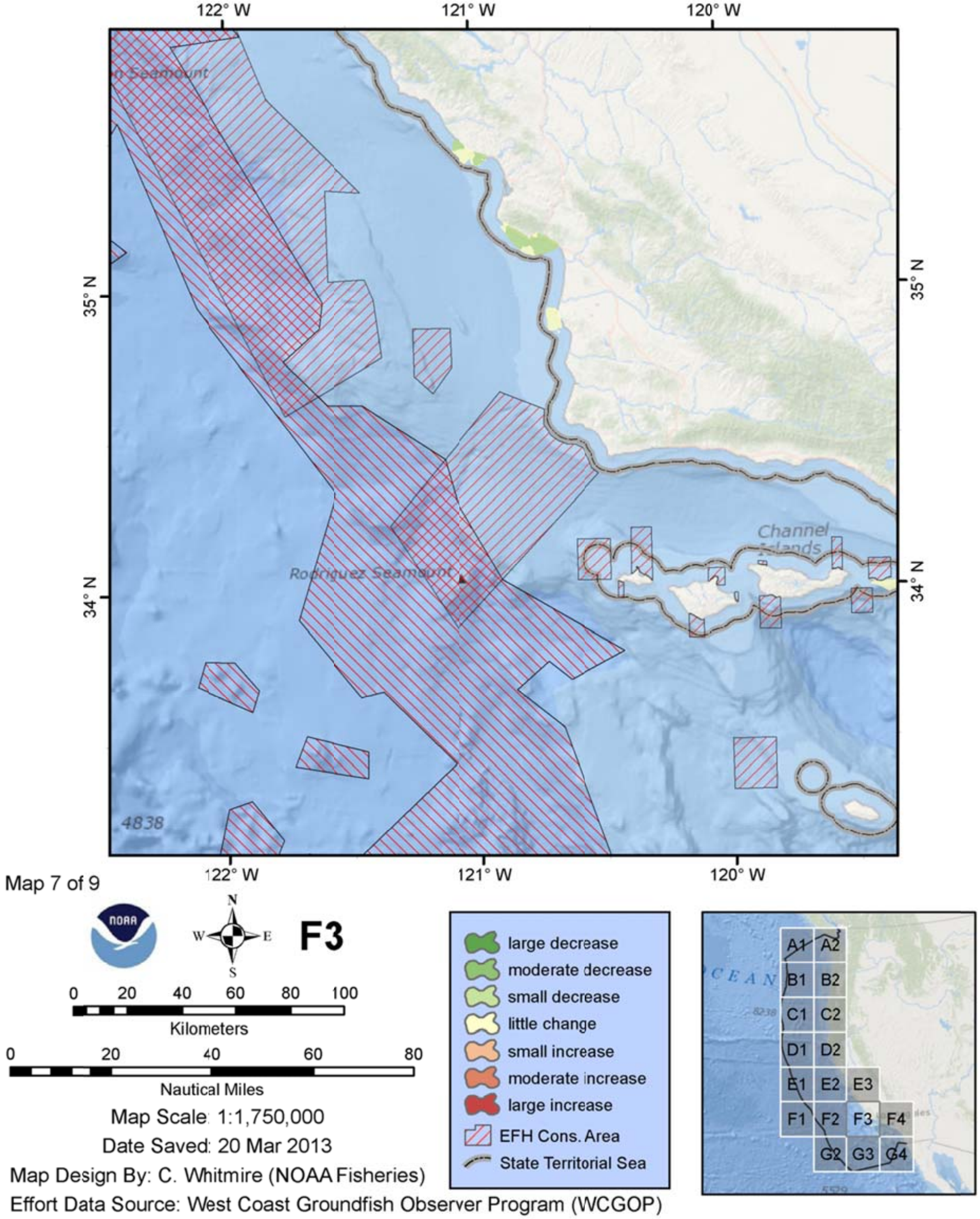
Map Scale: 1:1,750,000

Date Saved: 20 Mar 2013

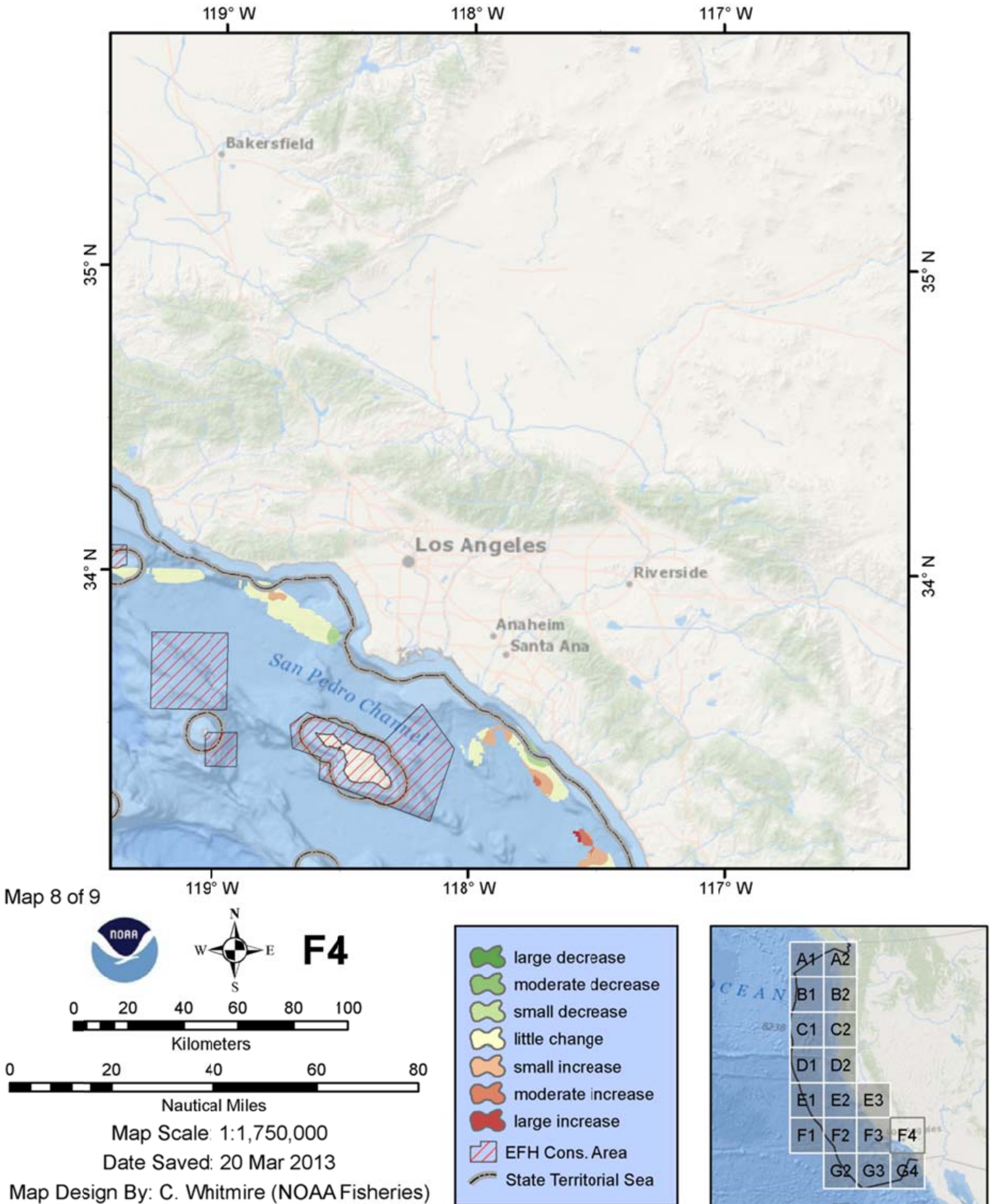
Map Design By: C. Whitmire (NOAA Fisheries)

Effort Data Source: West Coast Groundfish Observer Program (WCGOP)

Observed Fixed Gear Effort (Temporal Change)

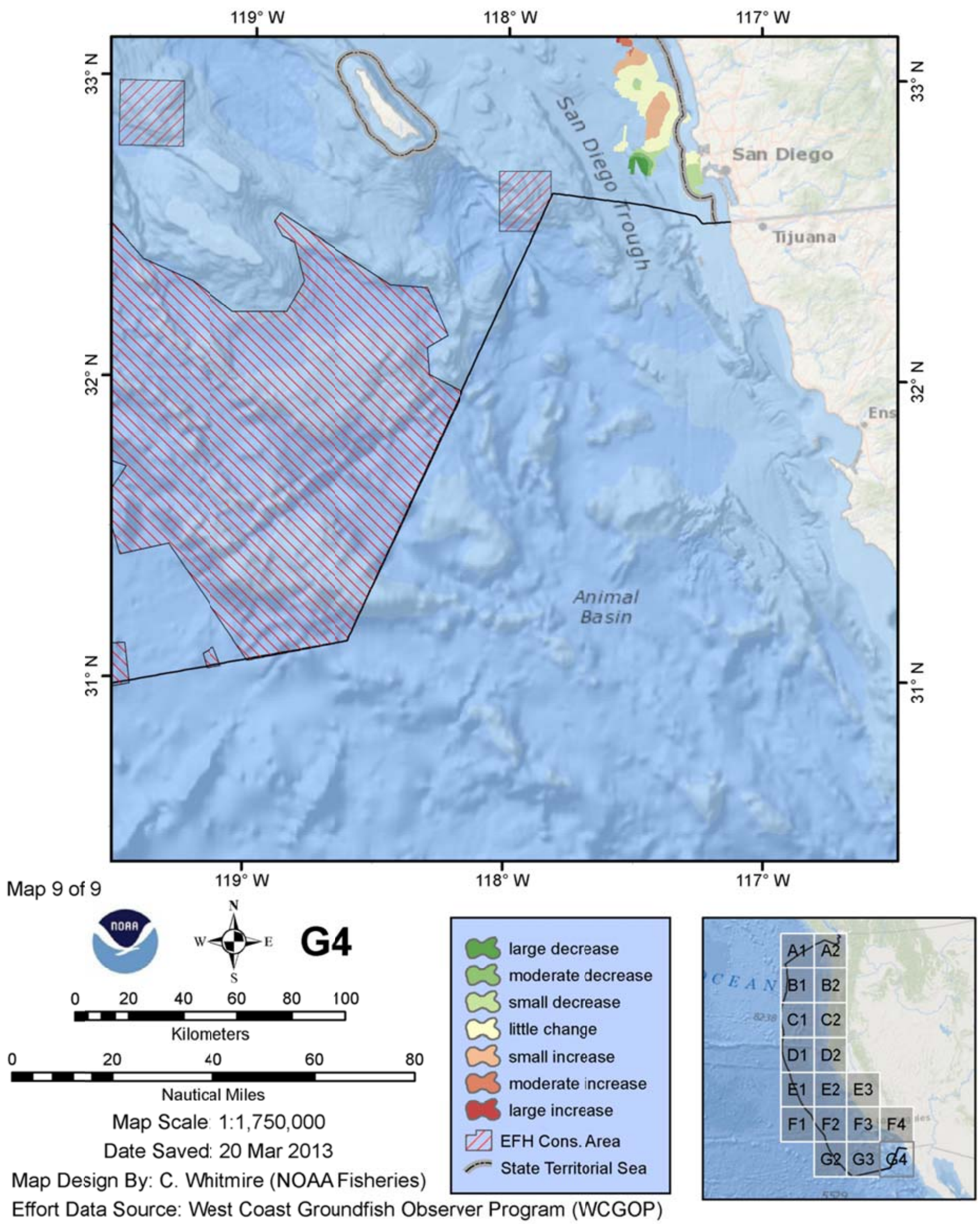


Observed Fixed Gear Effort (Temporal Change)



Map Scale: 1:1,750,000
Date Saved: 20 Mar 2013
Map Design By: C. Whitmire (NOAA Fisheries)
Effort Data Source: West Coast Groundfish Observer Program (WCGOP)

Observed Fixed Gear Effort (Temporal Change)



3.2 NON-FISHERIES PRESSURES

Kelly S. Andrews, Conservation Biology Division, Northwest Fisheries Science Center

3.2.1 Introduction

As human population size and demand for marine resources and waterways increases along the coast, numerous human activities in the ocean (e.g., fishing and shipping activity) and on land (e.g., pollutants from industrial activities and runoff from agricultural activities) need to be recognized and incorporated into management of marine resources. There are numerous non-fisheries related pressures acting upon groundfish essential fish habitat (EFH) along the West Coast of the United States (PFMC 2005). This document is not meant to be an exhaustive description of all these pressures, but a synthesis of how non-fisheries pressures can be analyzed in order to be incorporated into the management framework for West Coast groundfish EFH.

First, we take advantage of 16 spatially-explicit data layers available from Halpern et al. (2009) to quantify the intensity of non-fisheries pressures among various regions, depth strata, habitat substrate types, and spatial management boundaries related to West Coast groundfish EFH. The pressure data layers were produced from data collected prior to 2007, but represent the most standardized and rigorous analysis of the relative spatial intensity of non-fisheries pressures across the West Coast of the United States. These data layers are currently being updated and will provide estimates for future analyses of non-fisheries pressures on West Coast groundfish EFH.

From the 16 non-fisheries related pressures, we identified seven (Table A3b.1) that were most relevant to West Coast groundfish EFH and which had enough data to be useful for a coastwide analysis. We report on these pressures along with two climate change pressures individually below. In order to summarize the distribution of non-fisheries pressures, we combined all 16 non-fisheries pressures into a “combined” pressures data layer and report on the findings below. Each pressure data layer was normalized to values between 0 and 1 so they could be compared and combined into a cumulative impact layer for the Halpern et al. (2009) project; thus, the data layers were easily combined for our purposes.

3.2.2 Data and Methods

3.2.2.1 Non-fisheries pressures data

The data and models used to create the non-fisheries pressure data layers are described in detail in the supporting materials found in Halpern et al. (2008, 2009). Briefly, the raw data values produced for each ~1km^2 (0.00913 decimal degrees) cell throughout the U.S. West Coast economic exclusive zone (EEZ) were log transformed and normalized to the maximum value for each pressure layer independently to allow for direct comparison and incorporation into cumulative impact effects models for the Halpern et al. (2009) project. Values for each pressure range from 0 to 1.

Table A3b.1. Non-fisheries pressures data layers from Halpern et al. (2009).

NON-FISHERIES PRESSURES DATA LAYERS	
Pressures reported individually	Brief description of data used to create data layer
Atmospheric pollution	Deposition of sulfates derived from the National Atmospheric Deposition Program.
Inorganic pollution	Point source pollution from factories and mines and non-point source pollution that scales with the amount of impervious surface area.
Organic pollution	Input of pesticides.
Ocean-based pollution	Combination of “Commercial shipping activity” and “Invasive species” below.
Nutrient input	Nitrogen input from farming and atmospheric deposition.
Sediment decrease	Sediment input from watersheds with dams.
Sediment increase	Sediment input from watersheds without dams.
Combined pressures	Sum of all 16 pressures.
Additional pressures for calculating “Combined Pressures”	
Coastal trash	Amount of trash collected from beach clean-up efforts in CA.
Recreational beach use	Beach attendance.
Power plants	Locations of coastal power plants.
Light pollution	Stable lights at night database (National Geophysical Data Center).
Coastal engineering	Location of hardened shorelines.
Commercial shipping activity	Vessel track lines from the World Meteorological Organization Voluntary Observing Ships Scheme and ferries.
Oil rig platforms	Locations of offshore oil rigs.
Aquaculture – fish net-pens	Locations of fish net-pens.
Species invasions	Based on annual tonnage of goods passing through each port.

3.2.2.2 Data preparation

Pressure data layers from Halpern et al. (2009) were used to calculate all pressure metrics related to biogeographic regions, depth strata, habitat substrate, specific spatial management boundaries, biogenic habitat suitability, and species-habitat relationships found in *“Section 4.4: Non-fisheries pressures”* of the main body of this report. Pressure data layers were downloaded from the National Center for Ecological Analysis and Synthesis website (http://www.nceas.ucsb.edu/globalmarine/ca_current_data) and imported into ESRI®ArcMap 10.0, ArcGIS Desktop 10 Service Pack 4. All pressure data layers were clipped to the U.S.’s economic exclusive zone and projected using a customized “WGS 1984 Transverse Mercator” coordinate system. We report on seven of the most relevant pressure data layers individually and used all 16 pressure data layers to calculate a “combined pressures” data layer. Two other climate change pressure data layers were used as examples of ways to incorporate climate change into the EFH management framework (Table A3b.2).

Table A3b.2. Identification of all GIS data layers used in calculations related to non-fisheries pressures. EFH CA: essential fish habitat conservation areas; HAPC: habitat areas of particular concern.

ALL DATA LAYERS USED IN NON-FISHERIES ANALYSES					
Pressures reported individually	*Additional pressures for calculating "Combined Pressures"*	*Climate change pressures*	*Habitat*	*Spatial management boundaries*	*Species distributions*
*Atmospheric pollution	Coastal trash	Ocean acidification	*Sub-regions	*EFH CA	Darkblotched rockfish
*Inorganic pollution	Recreational beach use	Sea-surface temperature anomalies	*Depth strata	*HAPC	Greenstriped rockfish
*Organic pollution	Power plants		*Substrate type	*Commercial fishing	Yelloweye rockfish
*Ocean-based pollution	Light pollution		Biogenic habitat occurrence	*Bottom-trawl fishing	Longspine thornyhead
*Nutrient input	Coastal engineering		Coral habitat suitability probabilities	*Fixed-gear fishing	Petrale sole
*Sediment decrease	Commercial shipping activity			*Mid-water trawling	Sablefish
*Sediment increase	Oil rig platforms			*Recreational fishing	
*Combined pressures	Aquaculture – fish net-pens				
	Species invasions				

*Data layers that were combined to calculate mean pressure values across habitat and spatial management boundaries.

We used the same sub-regions, depth strata, habitat substrate type, and spatial management boundary data layers as described in the methods for habitat in *"Section 2: Habitat Distribution"* in the main body of this report. For substrate type, "undefined" substrate was defined as any habitat in the U.S. economic exclusive zone not characterized in *"Section 2: Habitat Distribution"* of the main report; this primarily included lower slope habitat or nearshore bays and estuaries (e.g., Puget Sound proper of the Salish Sea sub-region) that have not been surveyed or nearshore areas that weren't included in *"Section 2: Habitat Distribution"* (Columbia River and San Francisco Bay estuaries). In addition, we used the "habitat areas of particular concern" (HAPC) data layer found at: http://efh-catalog.coas.oregonstate.edu/platesES/ (Table A3b.2). For

"Commercial fishing", "Bottom-trawl fishing", "Fixed-gear fishing", "Mid-water trawling", and "Recreational fishing", we combined fishing restrictions from EFH conservation areas, rockfish conservation areas, and state territorial sea restrictions found in NOAA's Marine Protected Area Inventory (http://www.mpa.gov/dataanalysis/mpainventory/). We also used two biogenic habitat maps to describe the relative exposure intensity to ocean acidification. The first was the biogenic habitat occurrence data layer that was developed in *"Section 2: Habitat Distribution*" to characterize the spatial distribution of living habitats (i.e. corals and sponges). The second biogenic habitat data layer was output for the California Current ecosystem based on predictive habitat modeling for deep sea corals developed by Davies & Guinotte (2011) & Guinotte & Davies (2012). Using several habitat variables, the model predicts how suitable the habitat in each cell is for deep sea corals. All data layers were converted to rasters and projected to the same customized "WGS 1984 Transverse Mercator" coordinate system as the pressure data layers.

We also converted each of the six species-habitat relationship maps based on the presence/absence models developed in *"Section 3: Species-habitat associations"* in the main body of this report to rasters using the combined mean probability values across all years. These data layers were used to calculate exposure intensity values for each species to sea-surface temperature anomaly data.

For each map in *"Section 4.4: Non-fisheries pressures"* and this Appendix, we classified the data using the "quantile" method with 5 categories within ArcMap; thus, each color symbolizes 20% of the data.

3.2.2.3 Data analysis

Combined pressures

Importantly, individual pressures do not act upon groundfish EFH individually, but collectively. Pressures from terrestrial-based pollution, shipping, offshore energy development, fisheries and coastal development exert cumulative effects on the ecosystem and should be managed in a holistic way (Vinebrooke et al. 2004, Crain et al. 2008, Halpern et al. 2008, Curtin and Prellezo 2010, Stelzenmüller et al. 2010). However, quantifying the cumulative effects of these pressures is a difficult task. Previous studies developing cumulative impact metrics have used qualitative risk metrics (Stelzenmüller et al. 2010) or expert-based scoring systems (Halpern et al. 2008, 2009, Teck et al. 2010) that weight the relative importance of each pressure prior to summing scores across pressures. However, qualitative risk and expert-based scoring systems have been heavily criticized for two reasons. First, the weighting of pressures qualitatively or by expert surveys may be heavily influenced by a range of heuristic and cognitive biases that may lead to arbitrary or misleading results (Hubbard 2009). Second, our understanding of whether the effects of multiple pressures are additive, synergistic, or antagonistic is relatively poor (Darling and Côté 2008, Hoegh-Guldberg and Bruno 2010). Several studies have suggested that multiple pressures interact on various ecosystem components in non-additive ways, either causing effects greater than (synergistic) or less than (antagonistic) that explained by the sum of individual pressures (Sala and Knowlton 2006, Darling and Côté 2008, Griffith et al. 2012, Sunda and Cai 2012). Thus, linear combinations of weighted pressures will not account for these interactions. Because of these unknowns and time constraints, we did not try to calculate cumulative effects values of non-fisheries pressures on groundfish EFH; instead, we used a simplified approach which simply summed the pressure intensity values of all 16 non-fisheries pressures (Table A3b.1) for each 1 km^2 cell within the U.S. EEZ to calculate a "combined pressures" data layer. The values for each individual pressure layer range between 0 and 1, so the maximum value for this layer was 16. This data layer simply shows the additive sum of all overlapping pressures within each cell; it is not intended to describe the cumulative impacts of all pressures present in each cell.

3.2.2.4 Calculation of mean pressure intensity values

In order to calculate mean values for each pressure among various habitat and spatial management boundaries, we combined 18 different data layers (asterisks in Table A3b.2) using the "Combine" tool in ArcMap. Prior to combining, all pressure data layers were multiplied by 1000 because the "Combine" tool only works for integer data and would truncate the decimal values. Values were returned to the original scale during subsequent processing. Also, any missing data values in any data layer were given the value 10000 so that no cells were discarded during the combining process. After combining, these cells were given values of -99999 to represent 'no data'. The value attribute table for this combined raster file was then exported as a text file. We then used the "aggregate" function within R, ver. 2.15.1 (R Development Team 2012) to calculate the mean intensity value for each of the eight non-fisheries pressures (7 individual pressures and 1 combine pressures index) within every combination of depth strata, habitat substrate type and spatial management boundary categories. The results are presented as tables and figures for each sub-region and pressure below.

3.2.3 Summary of non-fisheries pressures

We begin by presenting a summary of the distribution of non-fisheries pressures across the U.S. West Coast using the "combined pressures" data layer and then describe the distribution of each individual pressure separately.

The distribution of combined pressures showed the distinct influence of land-based pollution pressures in nearshore habitats and the exposure of offshore habitats to ocean-based pollution and commercial shipping activity (Fig. A3b.1). Overall, mean intensity values were highest in the Salish Sea biogeographic sub-region and in the shelf depth strata (Fig. A3b.2a). The Salish Sea was most exposed because the vast majority of the region is exposed to highly populated areas and is completely locked within the shelf habitat, which is the most exposed depth stratum. The northern sub-region was the next most-greatly exposed region, but this varied among depth strata (Table A3b.3). For example, pressure intensity values were highest in lower slope habitat

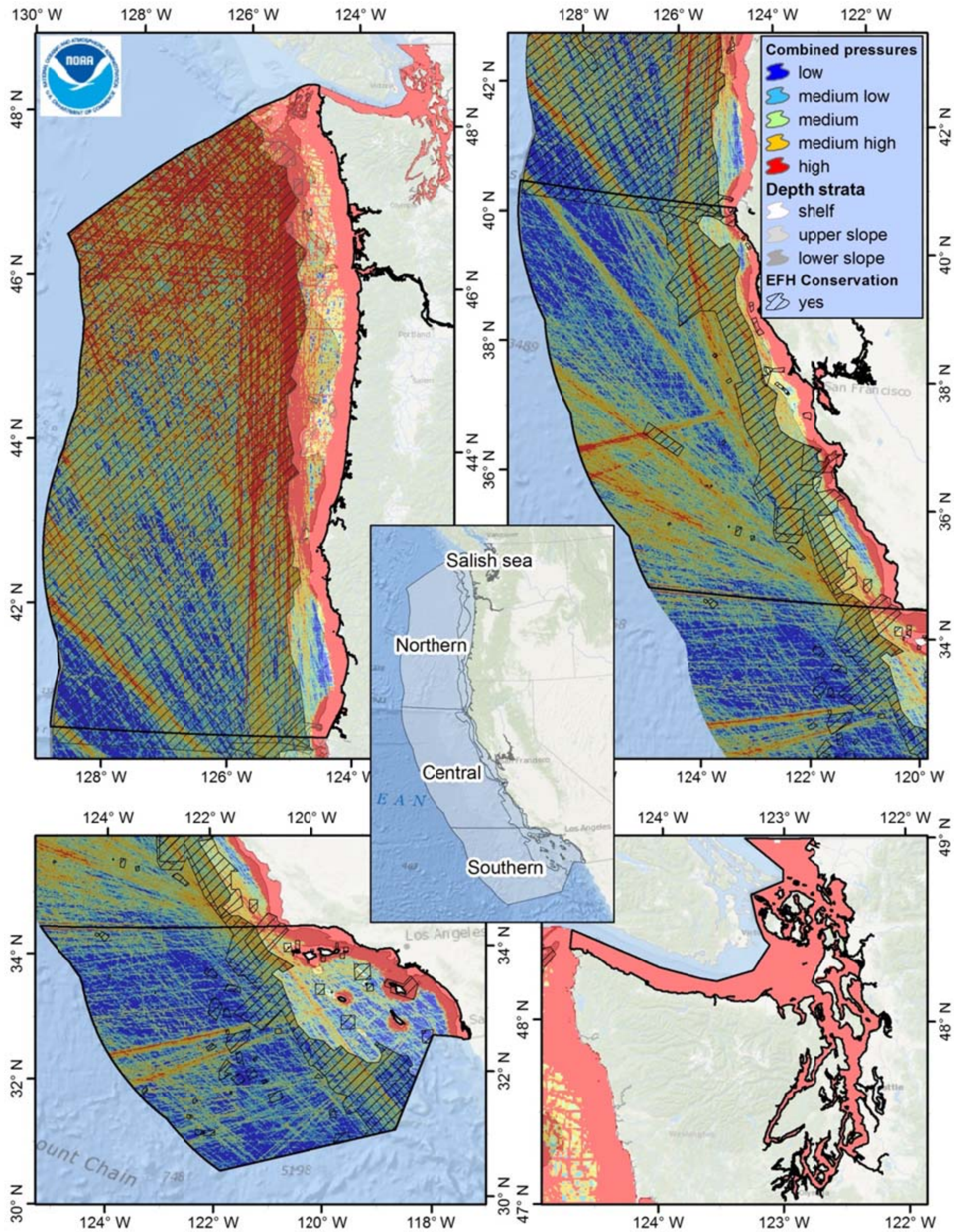


Figure A3b.1. Distribution of combined pressures intensity values among biogeographic sub-regions, depth strata and essential fish habitat (EFH) conservation areas. Combined pressures data is the sum of 16 non-fisheries pressures identified in Table A3b.1. Data for each pressure comes from Halpern et al. 2009.

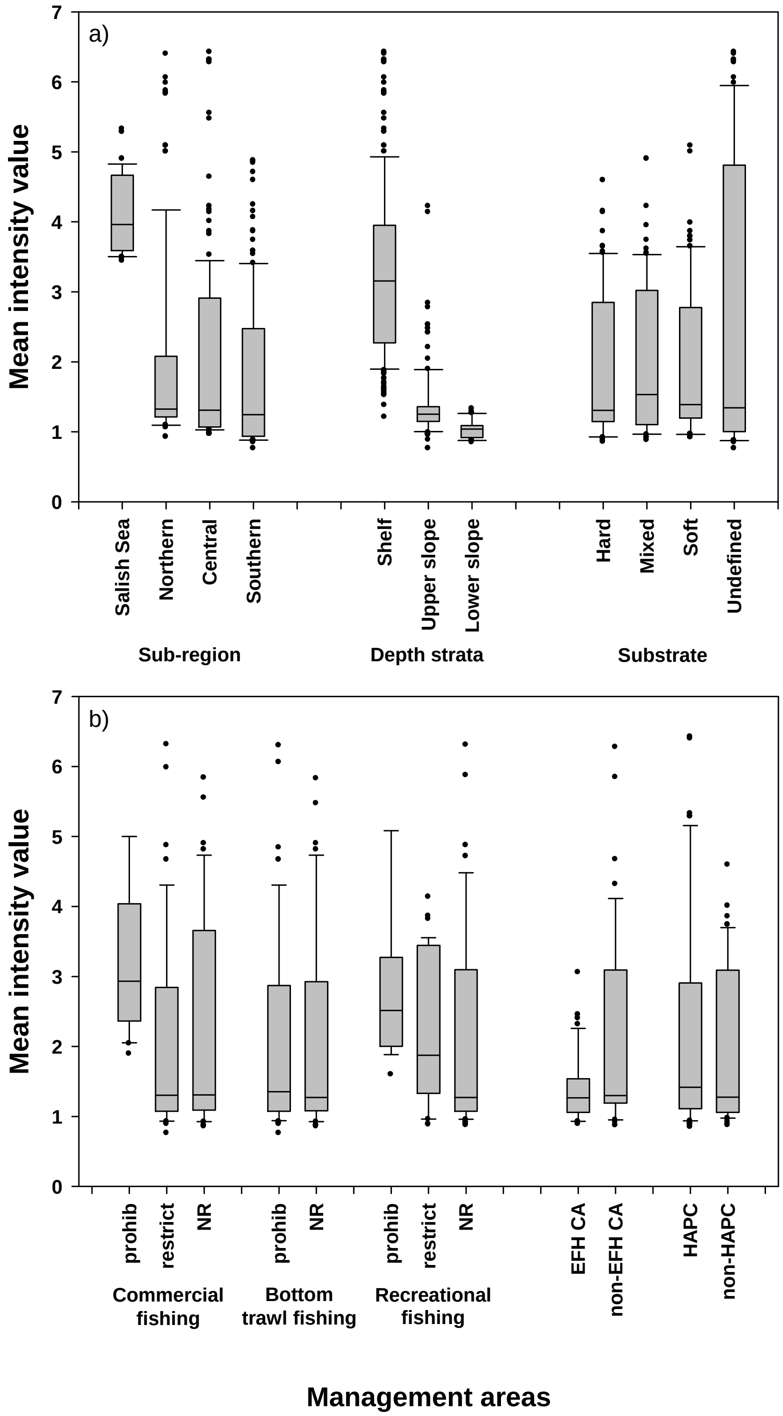


Figure A3b.2. Mean intensity values of combined pressures across a) sub-regions, depth strata, substrate, and b) management areas. The shaded box indicates the 25th to 75th percentile, the line within the box marks the median, the whiskers indicate the 10th and 90th percentiles, and the dots indicate all outliers. prohib: type of fishing is prohibited; restrict: type of fishing is restricted; NR: type of fishing has no restrictions; EFH CA: essential fish habitat conservation areas for West Coast groundfish; HAPC: habitat areas of particular concern. Fishing restrictions include areas within EFH CA, rockfish conservation areas (RCAs), and state territorial sea restrictions.

Table A3b.3. Mean intensity values for combined non-fisheries pressures by depth zones and seabed substrate types across 4 biogeographic regions: “Northern” (i.e., Cape Flattery, WA to Cape Mendocino, CA), “Central” (i.e., Cape Mendocino, CA to Point Conception, CA), “Southern” (i.e., Point Conception, CA to U.S.-Mexico maritime border) and “Salish Sea” (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from the sums of 16 pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1.

COMBINED PRESSURES						
Depth Zone	*Substrate*	*Northern*	*Central*	*Southern*	*Salish Sea*	*Coastwide*
Shelf[1]	All	2.20	2.71	2.92	4.31	2.63
	hard	1.76	3.00	2.57	3.57	2.30
	mixed	1.98	3.04	2.41	3.55	2.31
	soft	2.18	2.45	2.93	3.64	2.40
	undefined	5.85	6.27	4.71	4.67	5.03
Upper Slope[2]	All	1.22	1.22	1.28	NA	1.25
	hard	1.28	1.15	1.17	NA	1.18
	mixed	1.34	1.37	0.98	NA	1.29
	soft	1.21	1.23	1.29	NA	1.25
	undefined	NA	1.05	1.00	NA	1.03
Lower Slope[3]	All	1.08	0.98	0.88	NA	1.00
	hard	1.26	1.05	0.90	NA	1.03
	mixed	1.10	1.09	0.91	NA	0.99
	soft	1.26	1.06	0.95	NA	1.10
	undefined	1.06	0.97	0.87	NA	0.98
Grand mean	All	1.22	1.10	1.04	4.31	1.15

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

in the north, but pressures were higher in the southern sub-region in shelf and upper slope habitat. High values in the lower slope of the northern sub-region were most likely the result of high atmospheric pollution values (see *‘Atmospheric pollution’* below), whereas multiple land-based pressures (see individual pressures below) were responsible for high values in the shelf and upper-slope in the southern sub-region. Within each depth stratum, pressure intensity values varied across habitat types, but showed no clear trend.

We used EFH conservation areas (EFH CA), rockfish conservation areas, and state territorial sea restrictions to define management areas that were prohibited, restricted, or had no restrictions on fishing. Identifying differences in pressure intensity values among management boundaries were more difficult to determine, but pressure intensity values seemed to be higher in areas where commercial and recreational fishing was prohibited (Fig. A3b.2b). This was likely because many prohibited areas were located nearshore or inside bays where pressure intensity values were relatively high because of numerous land-based pressures. We also found there was relatively little variation in non-fisheries pressures in EFH CA compared to nearly all other habitat or management regions (Fig. A3b.2). This was likely because EFH CA are located offshore and are not exposed to most land-based pressures along the coast (Fig. A3b.1). It should be noted that mean intensity values were simply calculated using all cell values (units were ~1km^2 cells across the entire U.S. EEZ) within the habitat or management boundaries; this analysis does not take spatial autocorrelation into account. Future work will account for spatial autocorrelation and make explicit statistical comparisons among habitats and management boundaries.

We also calculated what proportion of various management areas were exposed to the highest pressure intensity values (i.e. the "high" values in Fig. A3b.1 represent the top 20% of all pressure intensity values coastwide). EFH CA and non-EFH CA were equally exposed to the highest combined non-fisheries pressures, but this pattern varied among individual pressures (Fig. A3b.3). Habitat areas of particular concern (HAPC) were most exposed to the highest non-fisheries pressures with nearly 40% of all area within HAPC boundaries exposed to the highest combined pressures intensity values (Fig. A3b.3). This was most distinct across land-based pressures as most HAPCs are located in nearshore habitats. However, differences observed coastwide among management areas varied among sub-regions (Table A3b.4). For example, in the northern sub-region, the proportion of EFH CA exposed to the highest combined pressures (23%) was less than the proportion of areas with no commercial fishing restrictions exposed to high pressures (58%), whereas in the central and southern sub-regions we found that EFH CA and areas with no commercial fishing restrictions were equally exposed.

Overall, we found four main findings from non-fisheries pressures that may potentially affect management of West Coast groundfish EFH. First, non-fisheries pressures were greatest in the Salish Sea, but this is because the entire region is in shelf habitat and is highly exposed to numerous land-derived pressures. Second, among other sub-regions, pressure intensity values varied across depth strata. Lower slope habitat was exposed to higher pressure intensity values in the northern sub-region (offshore pressures), while shelf and upper-slope habitat was exposed to higher pressure intensity values in the southern sub-region (nearshore pressures). Third, we found little variation in mean intensity values for non-fisheries pressures across EFH conservation areas compared to other spatial management regions. This was likely because EFH conservation areas were located offshore and relatively unexposed to land-based pressures. Fourth, we found that HAPCs were proportionately more exposed to high non-fisheries pressures than other spatial management areas, and this is generally true across other individual pressures.

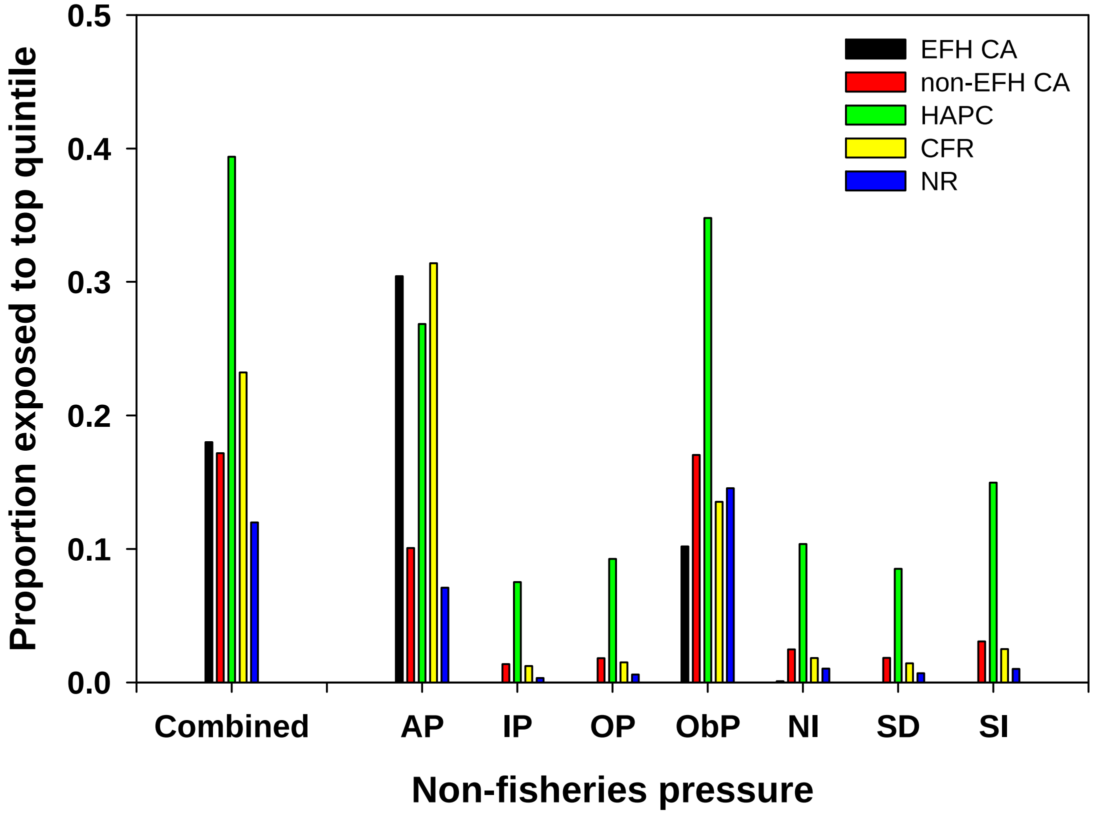


Figure A3b.3. Proportion of coastwide habitat in each management area exposed to the highest intensity values (top 20% - "high" values in Fig. 3b.1) for each pressure. EFH CA: essential fish habitat conservation areas; HAPC: habitat areas of particular concern; CFR: all commercial fishing restricted areas, including EFH CA, Rockfish Conservation Areas and state territorial sea restrictions; NR: areas with no commercial fishing restrictions.

Table A3b.4. Proportion of habitat within management boundaries exposed to the highest (top 20% - "high" values in Fig. 3b.1) intensity values for each pressure within each biogeographic sub-region and across the entire U.S. West Coast. EFH CA: essential fish habitat conservation areas; CFR: all commercial fishing restricted areas, including EFH CA, Rockfish Conservation Areas and state territorial sea restrictions; NR: no commercial fishing restrictions; NA: no habitat in this category.

	BIOGEOGRAPHIC SUB-REGIONS														
	Northern			*Central*			*Southern*			*Salish Sea*			*Coastwide*		
Pressures	*EFH CA*	*CFR*	*NR*	*EFH CA*	*CFR*	*NR*	*EFH CA*	*CFR*	*NR*	*EFH CA*	*CFR*	*NR*	*EFH CA*	*CFR*	*NR*
Atmospheric pollution	0.44	0.46	0.64	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.98	N/A	0.30	0.31	0.07
Inorganic pollution	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.02	0.00	N/A	0.23	N/A	0.00	0.01	0.00
Organic pollution	0.00	0.00	0.04	0.00	0.02	0.00	0.00	0.02	0.00	N/A	0.29	N/A	0.00	0.01	0.01
Ocean-based pollution	0.03	0.05	0.27	0.36	0.38	0.19	0.09	0.11	0.05	N/A	0.96	N/A	0.10	0.14	0.15
Nutrient input	0.00	0.00	0.05	0.00	0.03	0.00	0.00	0.03	0.01	N/A	0.32	N/A	0.00	0.02	0.01
Sediment decrease	0.00	0.00	0.03	0.00	0.02	0.00	0.00	0.02	0.01	N/A	0.27	N/A	0.00	0.01	0.01
Sediment increase	0.00	0.01	0.06	0.00	0.05	0.01	0.00	0.02	0.00	N/A	0.51	N/A	0.00	0.02	0.01
Combined pressures	0.23	0.26	0.58	0.06	0.14	0.06	0.06	0.14	0.06	N/A	0.98	N/A	0.18	0.23	0.12

3.2.4 Individual pressures

3.2.4.1 Atmospheric pollution

The impact of pollutants deposited from the atmosphere on groundfish populations and their respective habitats is largely unstudied; however, many nutrient, chemical and heavy-metal pollutants are introduced to marine ecosystems from sources that are geographically far away via this process (Ramanathan and Feng 2009). Substances such as sulfur dioxide, nitrogen oxide, carbon monoxide, lead, volatile organic compounds, particulate matter, and other pollutants are returned to the earth through either wet or dry atmospheric deposition (Johnson et al. 2008). Atmospheric nitrogen input is rapidly approaching global oceanic estimates for N_2 fixation and is predicted to increase further due to emissions from combustion of fossil fuels and production and use of fertilizers (Paerl et al. 2002, Duce et al. 2008). Atmospheric deposition is one of the most rapidly increasing means of nutrient loading to both freshwater systems and the coastal zone, as well as one of the most important anthropogenic sources of mercury pollution in aquatic systems (Johnson et al. 2008). Industrial activities have increased atmospheric mercury levels, with modern deposition flux estimated to be 3-24 times higher than preindustrial flux (Swain et al. 1992, Hermanson 1998, Bindler 2003). In the southwestern U.S., atmospheric deposition rates have been calculated at the upper end of this range, 24 times higher than pre-industrial deposition rates (Heyvaert et al. 2000). We assume these pollutants represent similar pressures on groundfish habitat as pollutants introduced through other mechanisms (e.g., urban runoff and dumping).

For specific details on the creation of each pressure data layer, see Halpern et al. (2008, 2009). Briefly, data from 19 stations along the U.S. west coast in the National Atmospheric Deposition Program were spatially kriged over the landscape and waters of the California Current.

Atmospheric pollution was widely distributed across the U.S. West Coast with the highest intensity values in the Salish Sea and northern biogeographic sub-regions (Figs. A3b.4-5; Table A3b.5). Habitat within the central biogeographic region was exposed to the lowest values of atmospheric pollution. Atmospheric pollution was nominally greatest in shelf habitat, whereas there was no consistent pattern among substrate types (Fig. A3b.5, Table A3b.5) or management boundaries (Fig. A3b.6, Table A3b.6). These coastwide patterns were generally reflected within each biogeographic sub-region (Figs. A3b.7-10, Tables A3b.7-10).

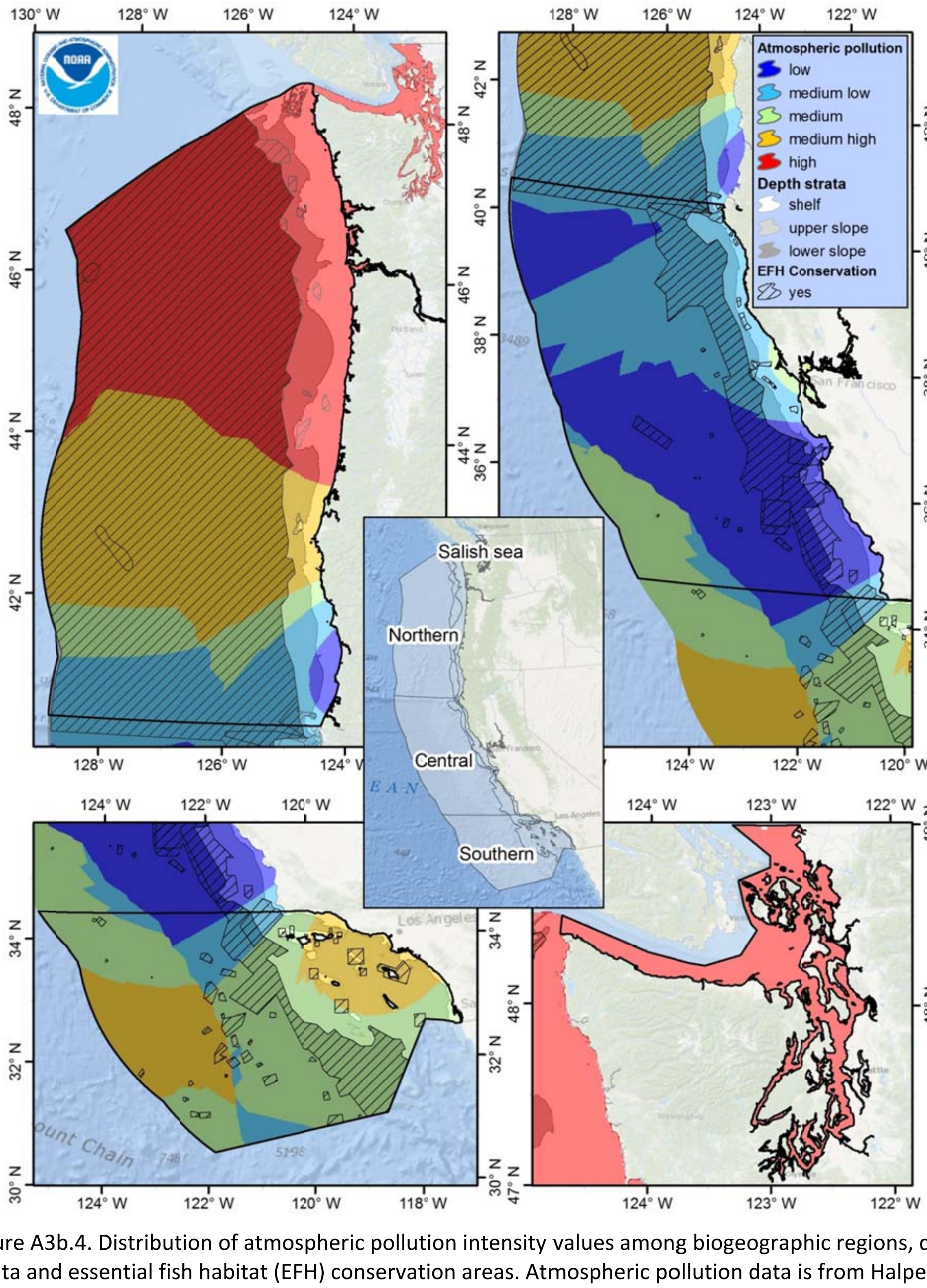


Figure A3b.4. Distribution of atmospheric pollution intensity values among biogeographic regions, depth strata and essential fish habitat (EFH) conservation areas. Atmospheric pollution data is from Halpern et al. 2009.

Table A3b.5. Mean intensity values for atmospheric pollution by depth zones and seabed substrate types across 4 biogeographic regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1.

ATMOSPHERIC POLLUTION						
Depth Zone	*Substrate*	*Northern*	*Central*	*Southern*	*Salish Sea*	*Coastwide*
Shelf[1]	All	0.76	0.40	0.51	0.89	0.65
	hard	0.77	0.38	0.51	0.95	0.63
	mixed	0.82	0.38	0.51	0.95	0.72
	soft	0.76	0.40	0.52	0.95	0.64
	undefined	0.68	0.46	0.40	0.86	0.78
Upper Slope[2]	All	0.71	0.35	0.51	NA	0.53
	hard	0.72	0.33	0.50	NA	0.46
	mixed	0.82	0.40	0.51	NA	0.75
	soft	0.70	0.36	0.51	NA	0.53
	undefined	NA	0.36	0.48	NA	0.40
Lower Slope[3]	All	0.67	0.38	0.47	NA	0.51
	hard	0.70	0.37	0.47	NA	0.52
	mixed	0.42	0.31	0.47	NA	0.42
	soft	0.75	0.36	0.46	NA	0.52
	undefined	0.66	0.39	0.48	NA	0.51
Grand mean	All	0.69	0.38	0.48	0.89	0.53

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

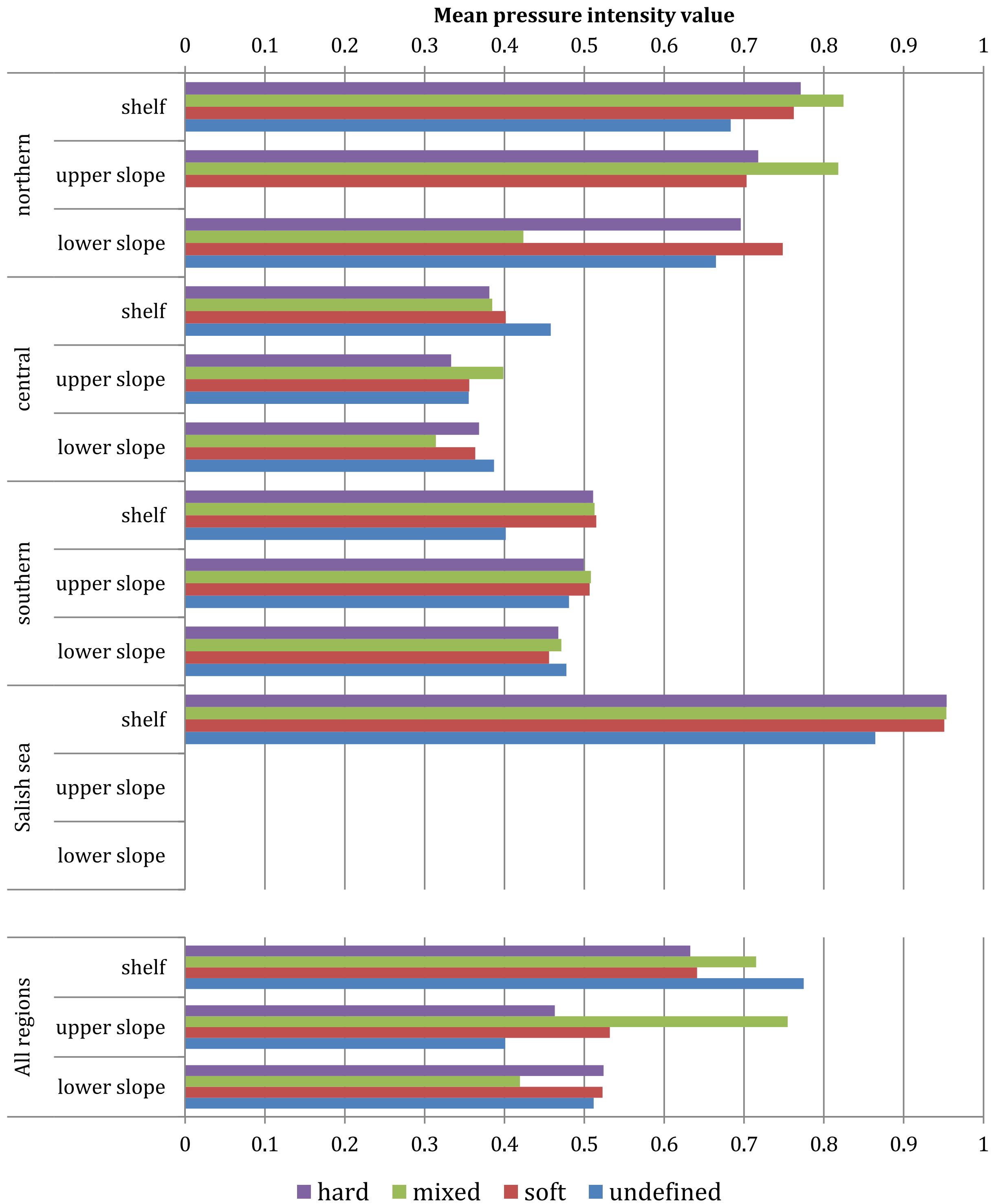


Figure A3b.5. Atmospheric pollution. Mean pressure intensity values among seabed substrate types by depth zones across 4 biogeographic sub-regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound).

nsity values for atmospheric pollution by depth zones and seabed substrate types across various management
sity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across
Economic Zone which ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were
mercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat
C = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no
of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish
state territorial sea restrictions.

ON											
	EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawling*		*Recreational fishing*			*Coastwide*
ate			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
	0.55	0.69	0.45	0.69	0.63	0.63	0.67	0.45	0.84	0.62	0.65
	0.60	0.65	0.42	0.60	0.70	0.58	0.71	0.42	0.75	0.62	0.63
	0.74	0.70	0.42	0.74	0.69	0.66	0.78	0.41	0.88	0.61	0.72
	0.51	0.68	0.46	0.67	0.63	0.58	0.67	0.45	0.84	0.60	0.64
ned	0.35	0.73	0.47	0.79	0.64	0.79	0.64	0.40	0.86	0.77	0.78
	0.49	0.49	0.50	0.52	0.53	0.51	0.54	0.50	0.56	0.53	0.53
	0.37	0.44	0.55	0.42	0.50	0.39	0.50	0.55	0.51	0.46	0.46
	0.74	0.74	0.28	0.76	0.75	0.76	0.75	NA	0.78	0.74	0.75
	0.50	0.53	0.51	0.53	0.53	0.52	0.54	0.50	0.55	0.53	0.53
ned	0.35	0.38	NA	0.35	0.46	0.35	0.46	NA	NA	0.40	0.40
	0.60	0.50	NA	0.60	0.42	0.60	0.42	NA	0.48	0.51	0.51
	0.52	0.50	NA	0.52	0.58	0.52	0.58	NA	0.48	0.52	0.52
	0.42	0.41	NA	0.42	NA	0.42	NA	NA	NA	0.42	0.42
	0.53	0.48	NA	0.53	0.43	0.53	0.43	NA	0.49	0.52	0.52
ned	0.62	0.51	NA	0.62	0.42	0.62	0.42	NA	NA	0.51	0.51
	0.59	0.56	0.46	0.60	0.46	0.60	0.47	0.46	0.68	0.52	0.53

coastline to continental shelf break), as defined by regional habitat layers.
e (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the

e (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

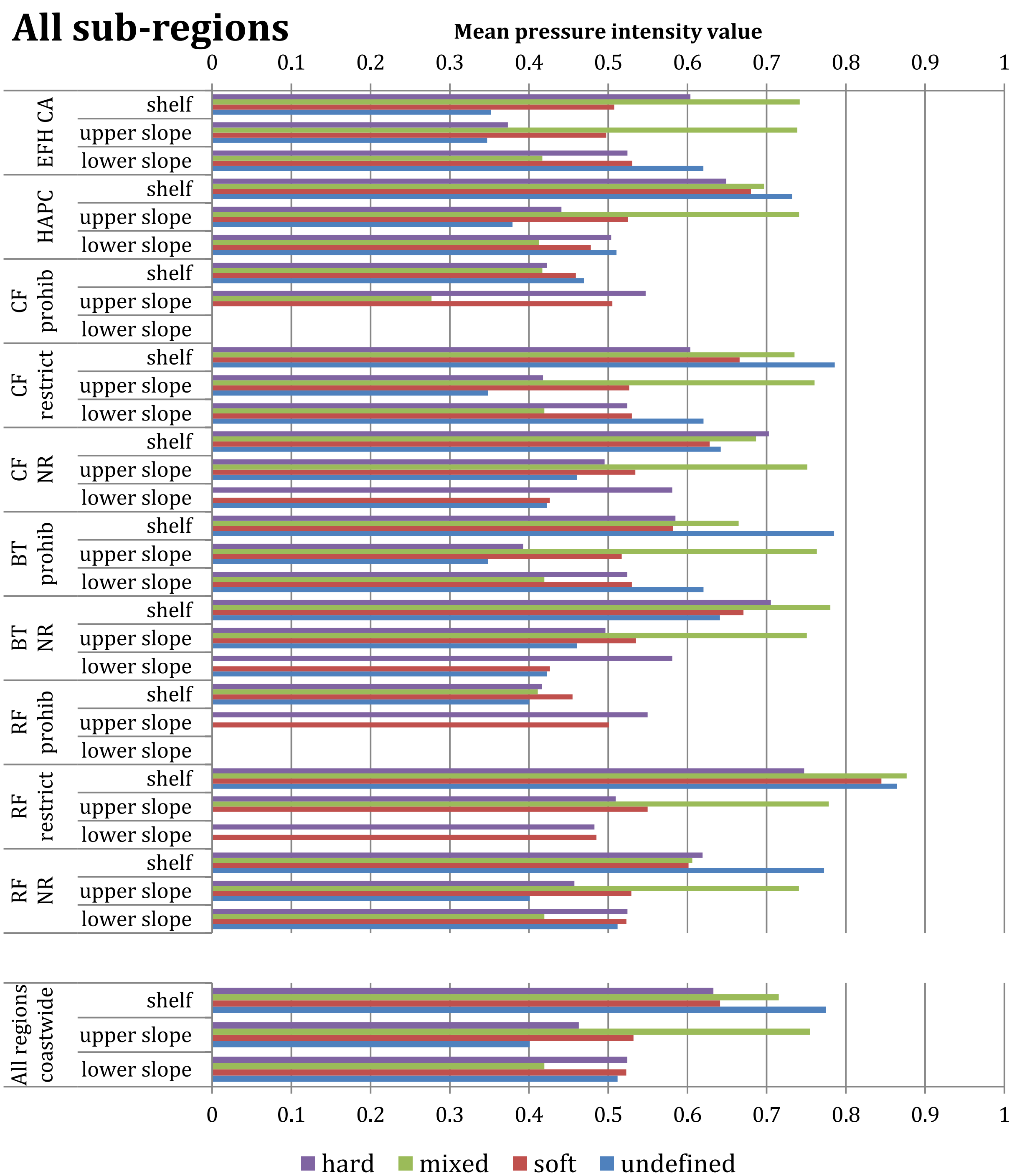


Figure A3b.6. Atmospheric pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries across all biogeographic regions. EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.7. Mean intensity values for atmospheric pollution by depth zones and seabed substrate types across various management boundaries in the "Northern" biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

ATMOSPHERIC POLLUTION	NORTHERN BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.82	0.83	0.90	0.83	0.73	0.75	0.77	0.90	0.93	0.72	0.65
	hard	0.77	0.79	NA	0.80	0.75	0.78	0.76	NA	0.92	0.75	0.63
	mixed	0.87	0.79	NA	0.89	0.71	0.85	0.81	NA	0.94	0.71	0.72
	soft	0.84	0.86	0.90	0.83	0.73	0.74	0.77	0.90	0.93	0.72	0.64
	undefined	NA	0.76	NA	0.75	0.67	0.74	0.67	NA	0.97	0.68	0.78
Upper Slope[2]	All	0.86	0.76	NA	0.82	0.68	0.80	0.69	NA	0.95	0.70	0.53
	hard	0.69	0.72	NA	0.72	0.72	0.71	0.72	NA	0.95	0.71	0.46
	mixed	0.91	0.87	NA	0.92	0.77	0.91	0.78	NA	0.95	0.77	0.75
	soft	0.86	0.75	NA	0.82	0.68	0.80	0.69	NA	0.95	0.69	0.53
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.40
Lower Slope[3]	All	0.67	0.68	NA	0.67	0.72	0.67	0.72	NA	NA	0.67	0.51
	hard	0.70	0.69	NA	0.70	0.61	0.70	0.61	NA	NA	0.70	0.52
	mixed	0.42	0.42	NA	0.42	NA	0.42	NA	NA	NA	0.42	0.42
	soft	0.75	0.71	NA	0.75	0.77	0.75	0.77	NA	NA	0.75	0.52
	undefined	0.66	0.65	NA	0.66	0.58	0.66	0.58	NA	NA	0.66	0.51
Grand mean	All	0.68	0.75	0.90	0.68	0.70	0.68	0.73	0.90	0.93	0.68	0.53

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

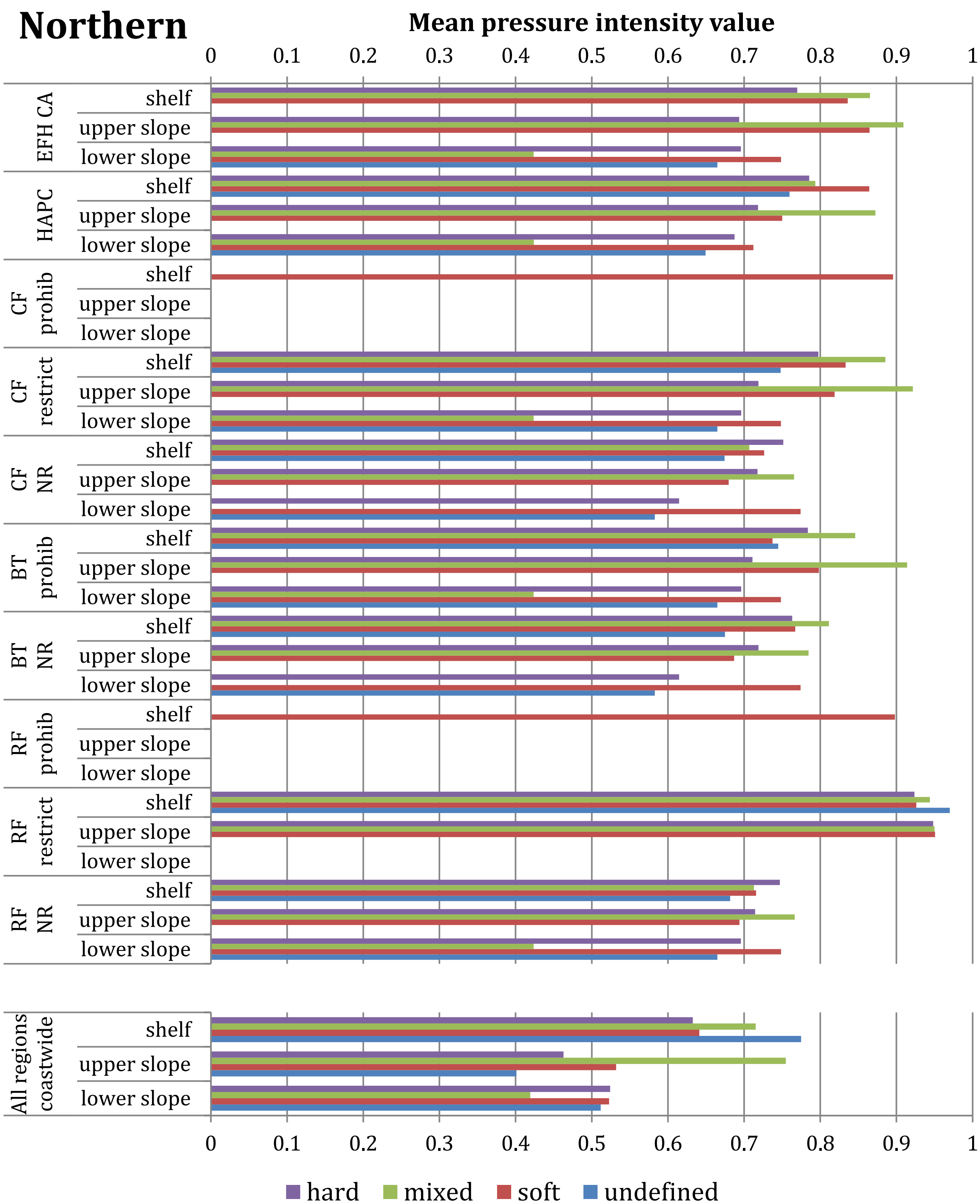


Figure A3b.7. Atmospheric pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Northern" biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.8. Mean intensity values for atmospheric pollution by depth zones and seabed substrate types across various management boundaries in the "Central" biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

ATMOSPHERIC POLLUTION	CENTRAL BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	Substrate			Prohib	Restr	NR	Prohib	NR	Prohib	Restr	NR	
Shelf[1]	All	0.39	0.42	0.39	0.40	0.41	0.40	0.41	0.39	0.37	0.40	0.65
	hard	0.38	0.38	0.37	0.39	0.36	0.38	0.36	0.36	0.37	0.38	0.63
	mixed	0.39	0.40	0.35	0.39	0.36	0.39	0.37	0.35	0.37	0.39	0.72
	soft	0.39	0.39	0.40	0.39	0.41	0.39	0.41	0.40	0.38	0.40	0.64
	undefined	0.36	0.47	0.42	0.46	0.32	0.46	0.31	0.34	0.29	0.46	0.78
Upper Slope[2]	All	0.33	0.34	0.26	0.33	0.36	0.33	0.36	0.26	0.28	0.35	0.53
	hard	0.32	0.33	NA	0.32	0.35	0.32	0.35	NA	0.31	0.33	0.46
	mixed	0.31	0.32	0.28	0.39	0.41	0.39	0.41	NA	NA	0.40	0.75
	soft	0.33	0.35	0.26	0.33	0.36	0.33	0.36	0.26	0.28	0.36	0.53
	undefined	0.35	0.38	NA	0.35	0.40	0.35	0.40	NA	NA	0.36	0.40
Lower Slope[3]	All	0.37	0.36	NA	0.37	0.39	0.37	0.39	NA	NA	0.38	0.51
	hard	0.37	0.37	NA	0.37	NA	0.37	NA	NA	NA	0.37	0.52
	mixed	0.31	0.32	NA	0.31	NA	0.31	NA	NA	NA	0.31	0.42
	soft	0.36	0.34	NA	0.36	0.36	0.36	0.36	NA	NA	0.36	0.52
	undefined	0.38	0.38	NA	0.38	0.39	0.38	0.39	NA	NA	0.39	0.51
Grand mean	All	0.37	0.37	0.39	0.37	0.39	0.37	0.39	0.38	0.37	0.38	0.53

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

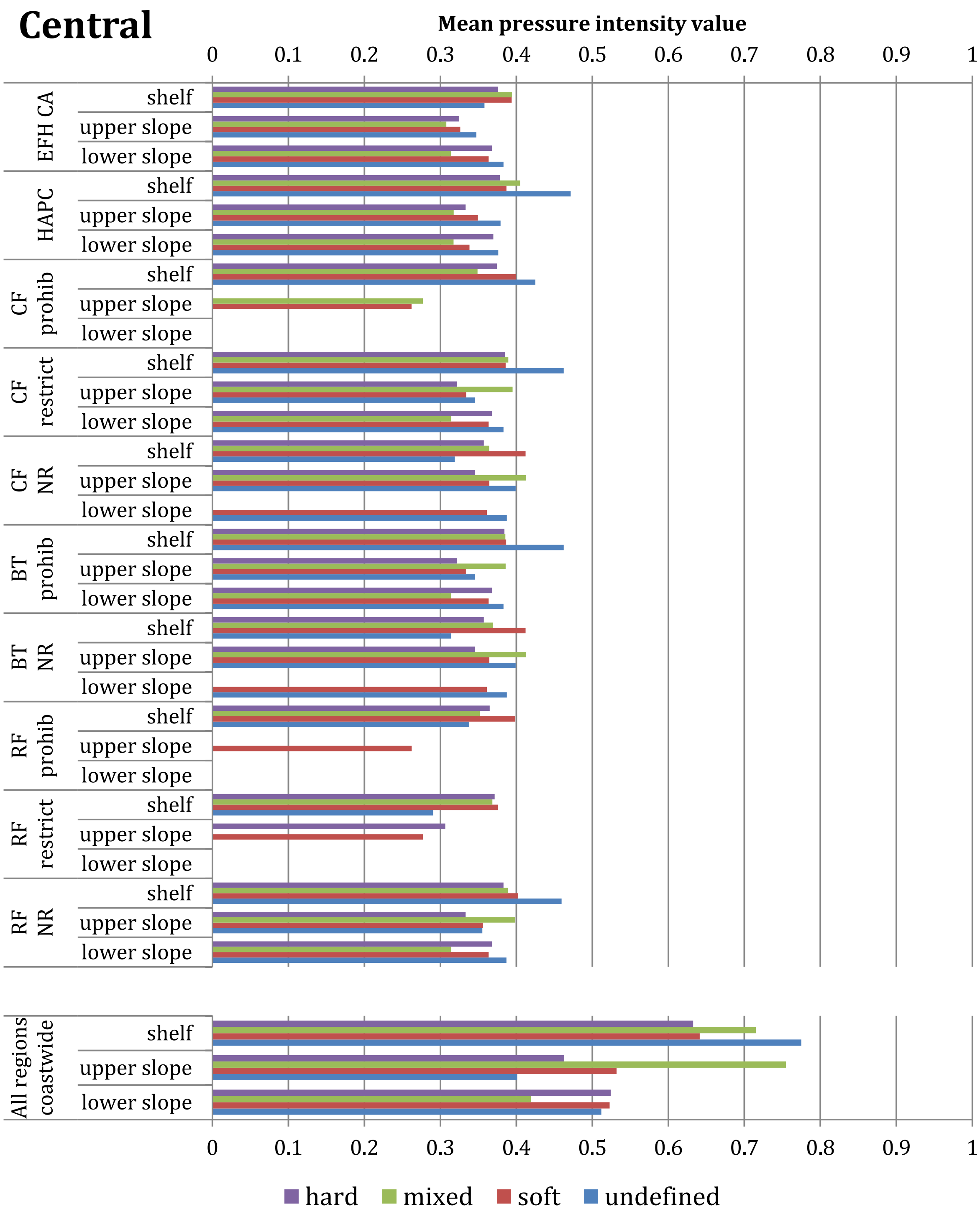


Figure A3b.8. Atmospheric pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Central" biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.9. Mean intensity values for atmospheric pollution by depth zones and seabed substrate types across various management boundaries in the "Southern" biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

ATMOSPHERIC POLLUTION		SOUTHERN BIOGEOGRAPHIC SUB-REGION										COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.52	0.51	0.49	0.51	0.52	0.51	0.52	0.49	0.52	0.51	0.65
	hard	0.51	0.52	0.49	0.51	0.55	0.50	0.53	0.49	0.51	0.51	0.63
	mixed	0.53	0.52	0.51	0.52	0.48	0.52	0.50	0.51	0.52	0.51	0.72
	soft	0.52	0.52	0.49	0.52	0.52	0.51	0.52	0.49	0.52	0.52	0.64
	undefined	0.35	0.34	0.40	0.41	0.31	0.41	0.31	0.53	0.49	0.39	0.78
Upper Slope[2]	All	0.49	0.51	0.54	0.51	0.50	0.50	0.51	0.54	0.51	0.50	0.53
	hard	0.52	0.50	0.55	0.51	0.49	0.52	0.50	0.55	0.50	0.50	0.46
	mixed	0.51	0.51	NA	0.51	0.51	0.51	0.51	NA	0.51	0.52	0.75
	soft	0.49	0.52	0.54	0.51	0.50	0.50	0.51	0.54	0.51	0.50	0.53
	undefined	NA	NA	NA	0.47	0.48	0.47	0.48	NA	NA	0.48	0.40
Lower Slope[3]	All	0.46	0.47	NA	0.46	0.48	0.46	0.48	NA	0.48	0.47	0.51
	hard	0.47	0.47	NA	0.47	0.47	0.47	0.47	NA	0.48	0.47	0.52
	mixed	0.47	0.47	NA	0.47	NA	0.47	NA	NA	NA	0.47	0.42
	soft	0.46	0.47	NA	0.46	0.43	0.46	0.43	NA	0.49	0.46	0.52
	undefined	0.47	0.48	NA	0.47	0.48	0.47	0.48	NA	NA	0.48	0.51
Grand mean	All	0.47	0.49	0.50	0.48	0.48	0.47	0.48	0.50	0.51	0.48	0.53

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

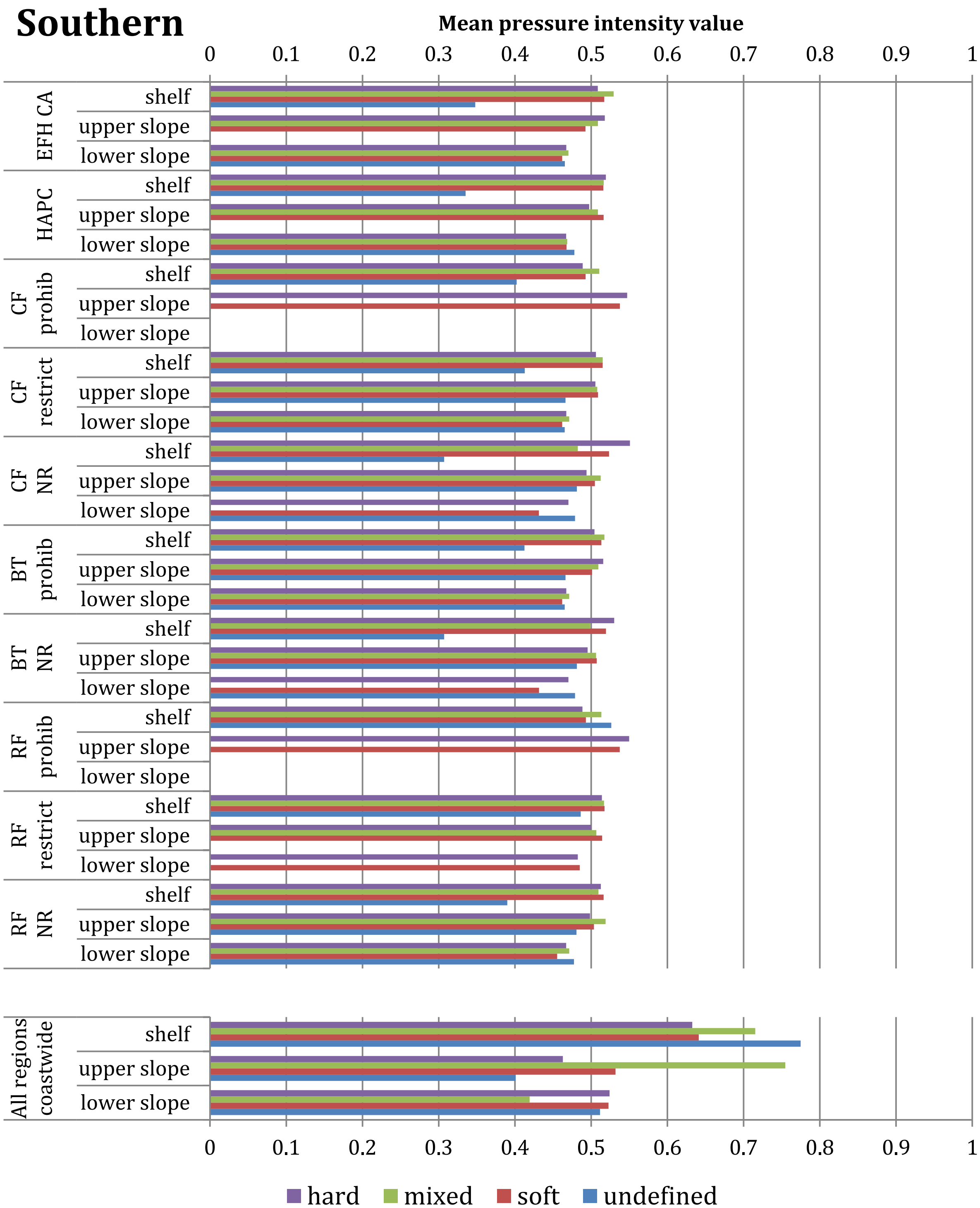


Figure A3b.9. Atmospheric pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Southern" biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.10. Mean intensity values for atmospheric pollution by depth zones and seabed substrate types across various management boundaries in the “Salish Sea” biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where “Commercial fishing” was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

ATMOSPHERIC POLLUTION	SALISH SEA BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	NA	0.84	0.67	0.89	NA	0.89	NA	NA	0.91	0.89	0.65
	hard	NA	0.99	NA	0.95	NA	0.95	NA	NA	0.92	0.99	0.63
	mixed	NA	0.97	NA	0.95	NA	0.95	NA	NA	0.95	0.97	0.72
	soft	NA	0.91	NA	0.95	NA	0.95	NA	NA	0.91	0.98	0.64
	undefined	NA	0.84	0.67	0.87	NA	0.86	NA	NA	0.91	0.86	0.78
Upper Slope[2]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.53
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.46
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.75
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.53
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.40
Lower Slope[3]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.51
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.52
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.42
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.52
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.51
Grand mean	All	NA	0.84	0.67	0.89	NA	0.89	NA	NA	0.91	0.89	0.53

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

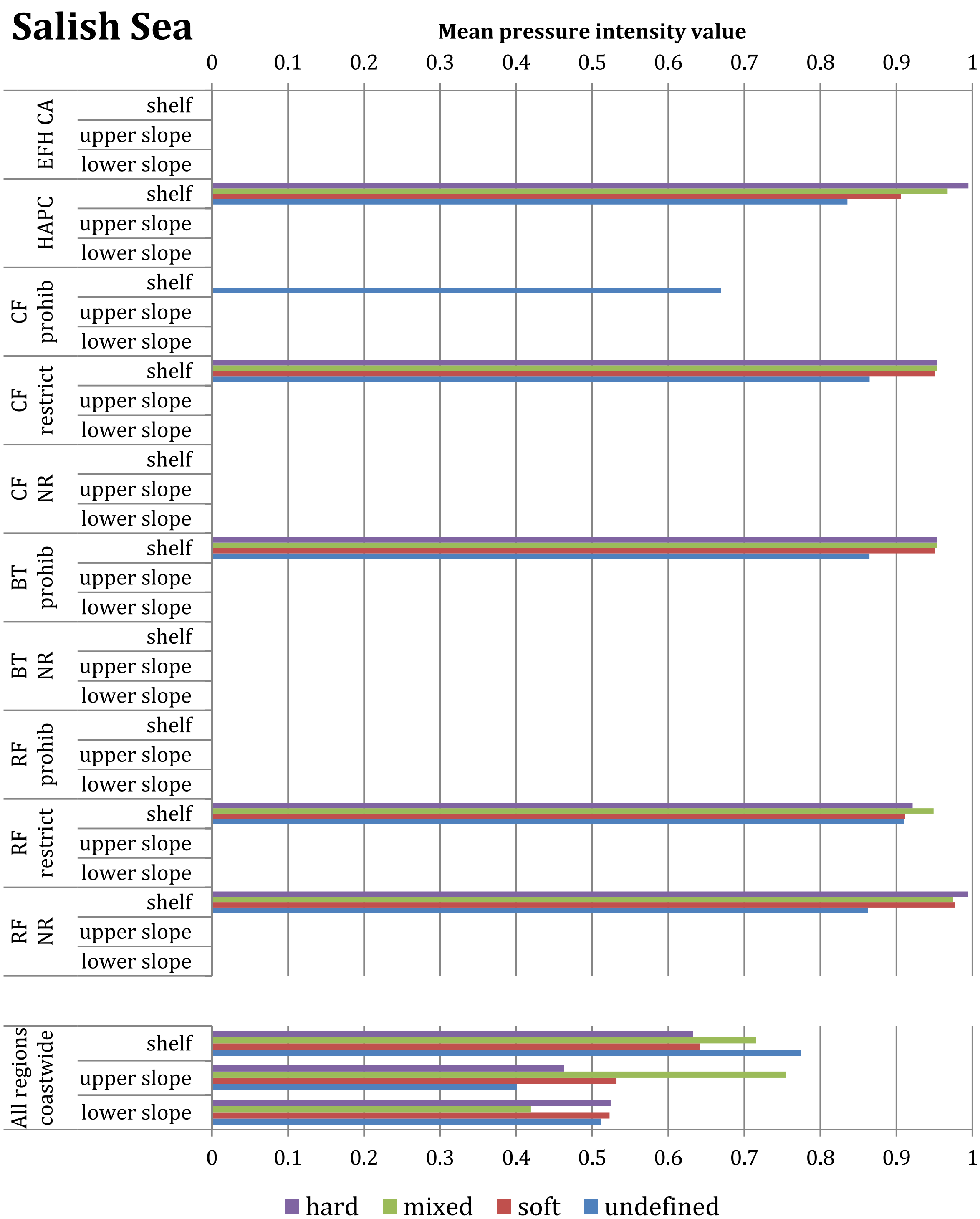


Figure A3b.10. Atmospheric pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

3.2.4.2 Inorganic pollution

Tens of thousands of chemicals are used by industries and businesses in the United States for the production of goods which our society depends. Many of the chemicals used in the manufacturing and production of these goods are toxic at some level to humans and other organisms and some are inevitably released into the environment. The production, use and release of various toxic chemicals have changed over time depending on economic indices, management methods (recycling and treatment of chemicals), and environmental regulations (USEPA 2010). The pathway of these chemicals to estuarine and marine environments can be direct (e.g., wastewater discharge into coastal waters or rivers) or diffuse (e.g., atmospheric deposition or urban runoff). Over the past 40 years, direct discharges have been greatly reduced; however, the input of pollutants to the marine environment from more diffuse pathways such as runoff from land-based activities is still a major concern (Boesch et al. 2001).

While all pollutants can become toxic at high enough levels, there are a number of compounds that are toxic even at relatively low levels (Johnson et al. 2008). The US Environmental Protection Agency (USEPA) has identified and designated more than 126 analytes as “priority pollutants.” According to the USEPA, “priority pollutants” of particular concern for aquatic systems include: (1) dichlorodiphenyl trichloroethane (DDT) and its metabolites; (2) chlorinated pesticides other than DDT (e.g., chlordane and dieldrin); (3) polychlorinated biphenyl (PCB) congeners; (4) metals (e.g., cadmium, copper, chromium, lead, mercury); (5) polycyclic aromatic hydrocarbons (PAHs); (6) dissolved gases (e.g., chlorine and ammonium); (7) anions (e.g., cyanides, fluorides, and sulfides); and (8) acids and alkalis (Kennish 1998, USEPA 2003). While acute exposure to these substances produce adverse effects on aquatic biota and habitats, chronic exposure to low concentrations probably is a more significant issue for fish population structure and may result in multiple substances acting in “an additive, synergistic or antagonistic manner” that may render impacts relatively difficult to discern (Thurberg and Gould 2005).

Coastal and estuarine pollution can affect all life stages of fish, but fish can be particularly sensitive to toxic contaminants during the first year of life (Rosenthal and Alderdice 1976). Over time, organisms will accumulate contaminants from water, sediments or food in their tissues, which then transfers to offspring through reproduction and throughout the food web via trophic interactions. One of the most widely recognized effects of inorganic pollution was the decline of bald eagles and brown pelicans during the 1960’s and 1970’s. These birds accumulated DDT in their tissues which changed their ability to metabolize calcium, which resulted in birds producing abnormally thin eggshells which led to reproductive failure (Hickey and Anderson 1968, Blus et al. 1971). Negative impacts of pollution on commercial fish stocks have generally not been demonstrated, largely due to the fact that only drastic changes in marine ecosystems are detectable and the difficulty in distinguishing pollution-induced changes from those due to other causes (Sindermann 1994). Normally, chronic and sublethal changes take place very slowly and it is impossible to separate natural fluctuations from anthropogenic causes. Furthermore, fish populations themselves are estimated only imprecisely, so the ability to detect and partition contaminant effects is made even more difficult. However, measurements of marine biodiversity have shown that species richness and evenness are reduced in areas of anthropogenic pollution (Johnston and Roberts 2009).

For specific details on the creation of each pressure data layer, see Halpern et al. (2008, 2009). Briefly, data from point source pollution from factories and mines and non-point source pollution that scales with the amount of impervious surface area (ISA) was the basis for the layer. Pollution from point sources were summed across watersheds that drain into the California Current. The total area of ISA within a watershed was used as a proxy for non-point source pollution. Point source and ISA estimates were log-transformed, normalized, summed, and re-normalized for a single value for each watershed. These values were then distributed to streams and river mouths in the watersheds and the diffusive 'spread' of these pollutants was modeled downstream.

Inorganic pollution was generally only observed in shelf habitat (Figs. A3b.11-13; Table A3b.11-12). Habitat within the Salish Sea and the southern biogeographic regions were exposed to the highest values of inorganic pollution, while the northern sub-region was exposed to the lowest values (Figs. A3b.11-12, Table A3b.11). Inorganic pollution was generally higher in HAPCs and in areas prohibited to commercial and recreational fishing (Fig. A3b.13, Table A3b.12); however, this was likely because these management areas were in nearshore habitats that were more exposed to land-based pressures and had little to do with EFH-related management boundaries. These coastwide patterns were generally reflected within each biogeographic sub-region (Figs. A3b.14-17, Tables A3b.13-16).

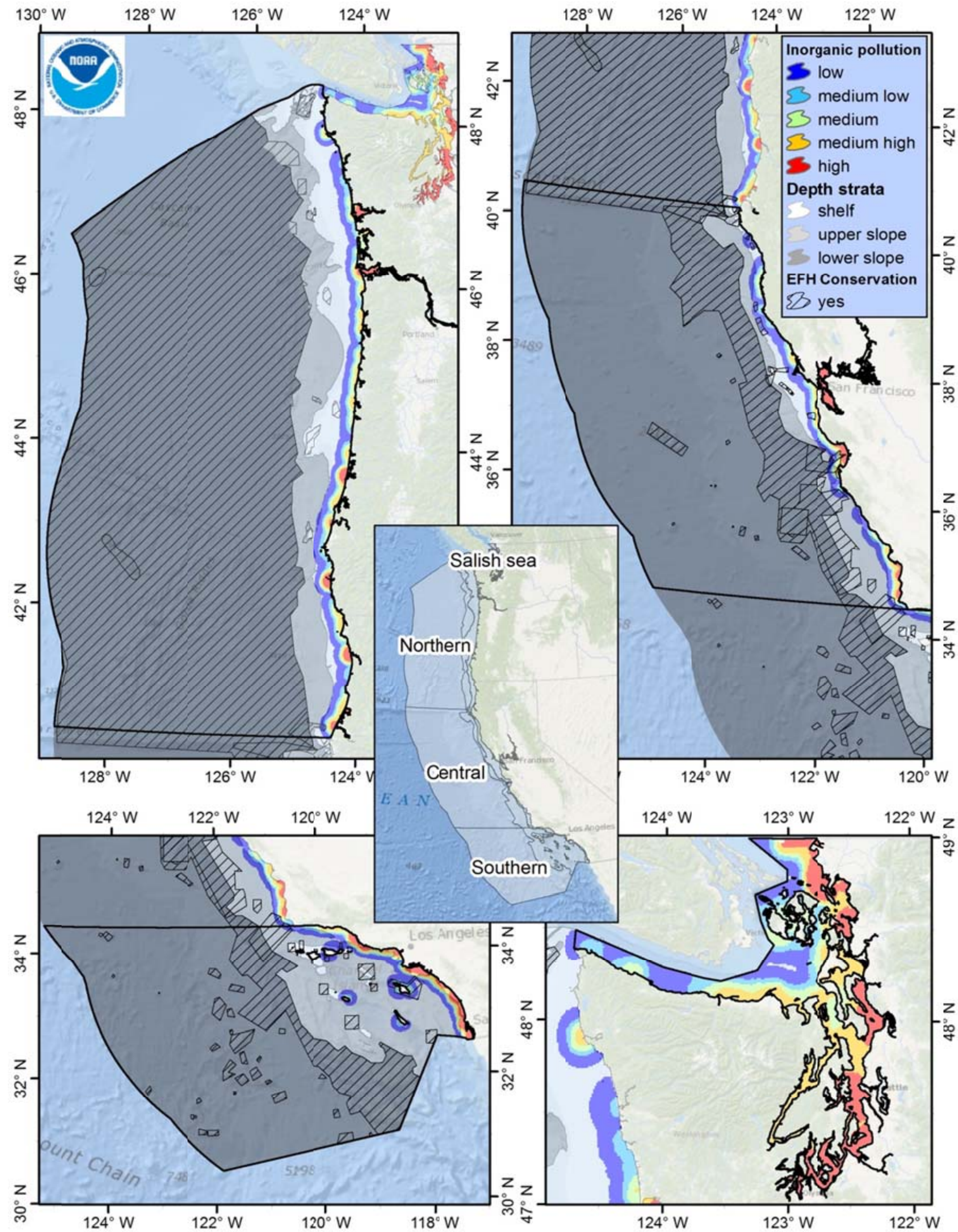


Figure A3b.11. Distribution of inorganic pollution intensity values among biogeographic regions, depth strata and essential fish habitat (EFH) conservation areas. Inorganic pollution data is from Halpern et al. 2009.

Table A3b.11. Mean intensity values for inorganic pollution by depth zones and seabed substrate types across 4 biogeographic regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1.

INORGANIC POLLUTION						
Depth Zone	*Substrate*	*Northern*	*Central*	*Southern*	*Salish Sea*	*Coastwide*
Shelf[1]	All	0.04	0.08	0.12	0.16	0.07
	hard	0.03	0.08	0.10	0.06	0.05
	mixed	0.01	0.09	0.05	0.04	0.03
	soft	0.03	0.05	0.13	0.06	0.05
	undefined	0.54	0.45	0.26	0.21	0.28
Upper Slope[2]	All	0.00	0.00	0.01	NA	0.00
	hard	0.00	0.00	0.00	NA	0.00
	mixed	0.00	0.01	0.00	NA	0.00
	soft	0.00	0.00	0.01	NA	0.00
	undefined	NA	0.00	0.00	NA	0.00
Lower Slope[3]	All	0.00	0.00	0.00	NA	0.00
	hard	0.00	0.00	0.00	NA	0.00
	mixed	0.00	0.00	0.00	NA	0.00
	soft	0.00	0.00	0.00	NA	0.00
	undefined	0.00	0.00	0.00	NA	0.00
Grand mean	All	0.00	0.00	0.01	0.16	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

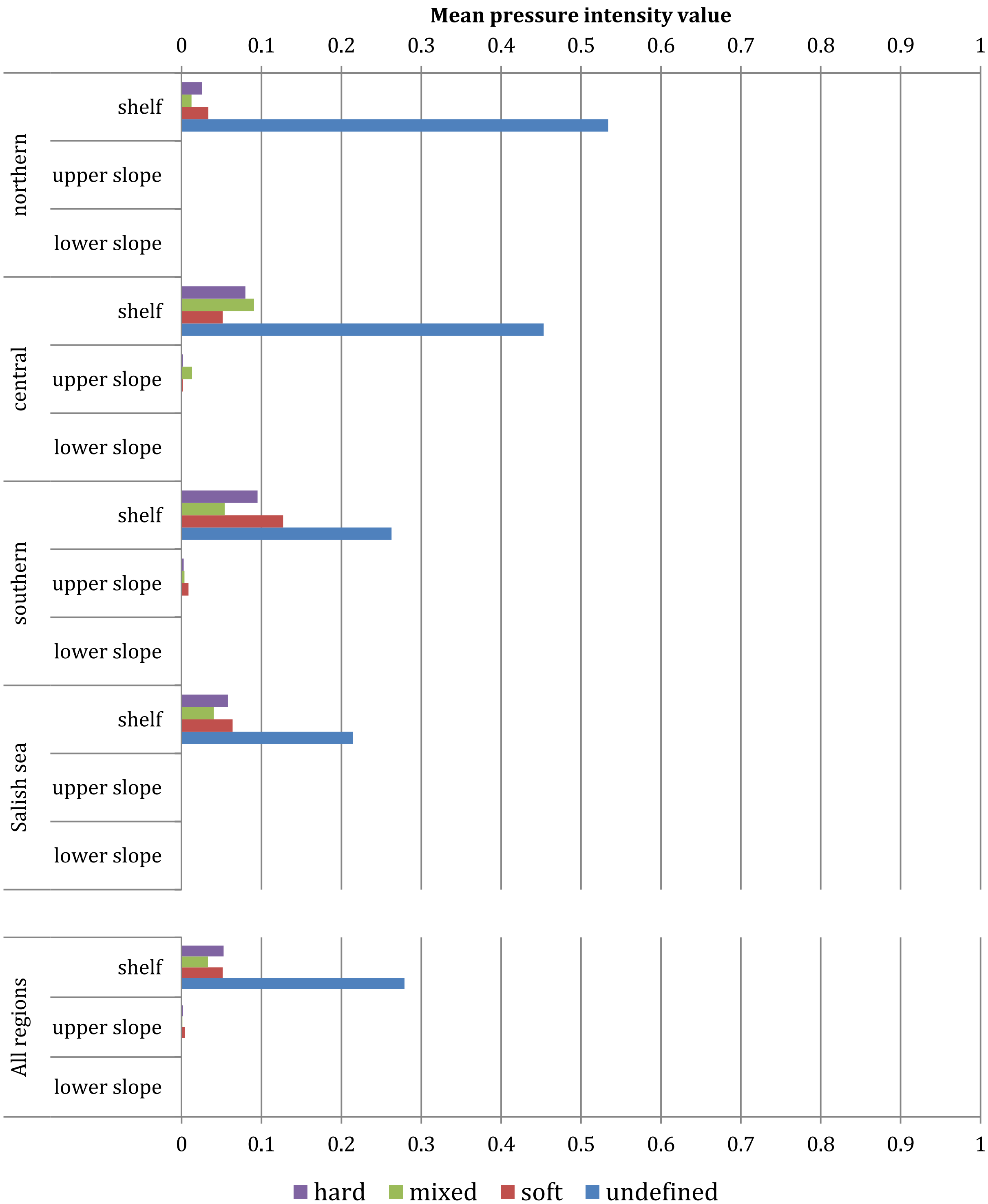


Figure A3b.12. Inorganic pollution. Mean pressure intensity values among seabed substrate types by depth zones across 4 biogeographic sub-regions: “Northern” (i.e., Cape Flattery, WA to Cape Mendocino, CA), “Central” (i.e., Cape Mendocino, CA to Point Conception, CA), “Southern” (i.e., Point Conception, CA to U.S.-Mexico maritime border) and “Salish Sea” (i.e., Straits of Juan de Fuca, Georgia and Puget Sound).

Table A3b.12. Mean intensity values for inorganic pollution by depth zones and seabed substrate types across various management boundaries. Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

INORGANIC POLLUTION												
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawling*		*Recreational fishing*			*Coastwide*
Depth Zone	***Substrate***			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	**All**	**0.01**	**0.15**	**0.08**	**0.10**	**0.04**	**0.12**	**0.04**	**0.07**	**0.02**	**0.08**	**0.07**
	hard	0.02	0.03	0.12	0.05	0.05	0.06	0.04	0.11	0.03	0.05	0.05
	mixed	0.01	0.02	0.09	0.03	0.03	0.05	0.02	0.08	0.01	0.05	0.03
	soft	0.02	0.06	0.07	0.07	0.04	0.09	0.03	0.06	0.02	0.06	0.05
	undefined	0.05	0.36	0.25	0.26	0.52	0.26	0.51	0.06	0.05	0.29	0.28
Upper Slope[2]	**All**	**0.00**	**0.00**	**0.05**	**0.00**	**0.00**	**0.01**	**0.00**	**0.04**	**0.00**	**0.00**	**0.00**
	hard	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
	mixed	0.00	0.00	0.23	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	soft	0.00	0.01	0.04	0.01	0.00	0.01	0.00	0.04	0.00	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Lower Slope[3]	**All**	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**0.00**
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	**All**	**0.00**	**0.05**	**0.07**	**0.01**	**0.00**	**0.01**	**0.00**	**0.06**	**0.01**	**0.01**	**0.01**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

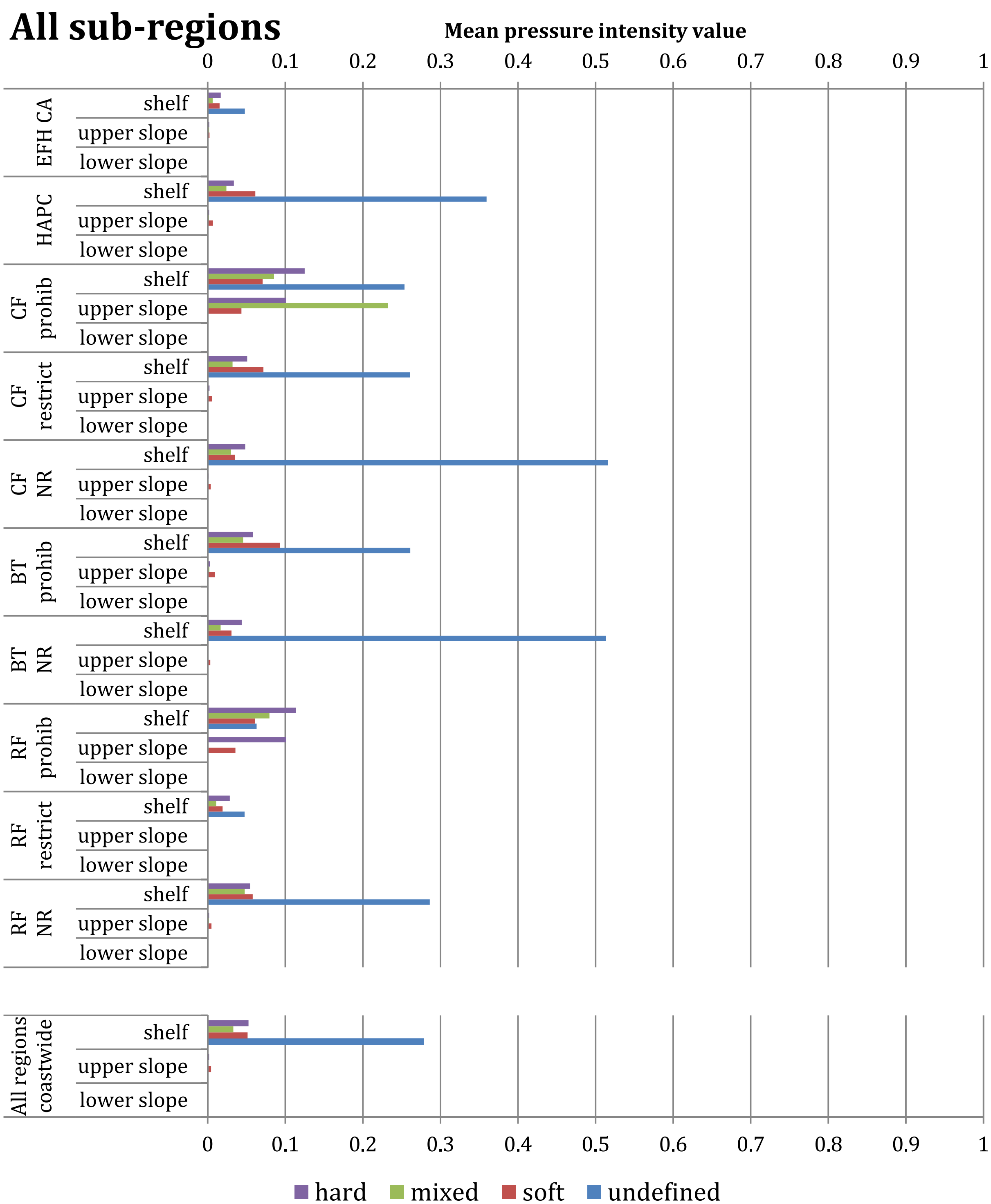


Figure A3b.13. Inorganic pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries across all biogeographic regions. EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.13. Mean intensity values for inorganic pollution by depth zones and seabed substrate types across various management boundaries in the “Northern” biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where “Commercial fishing” was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

INORGANIC POLLUTION	**NORTHERN BIOGEOGRAPHIC SUB-REGION**											**COASTWIDE**
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.00	0.09	0.24	0.04	0.04	0.06	0.03	0.24	0.01	0.05	0.07
	hard	0.00	0.01	NA	0.01	0.04	0.01	0.04	NA	0.01	0.03	0.05
	mixed	0.00	0.01	NA	0.00	0.03	0.01	0.02	NA	0.00	0.02	0.03
	soft	0.00	0.08	0.24	0.04	0.03	0.07	0.03	0.24	0.01	0.04	0.05
	undefined	NA	0.60	NA	0.52	0.54	0.53	0.54	NA	0.01	0.54	0.28
Upper Slope[2]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	mixed	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.00	0.04	0.24	0.00	0.02	0.00	0.02	0.24	0.01	0.00	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

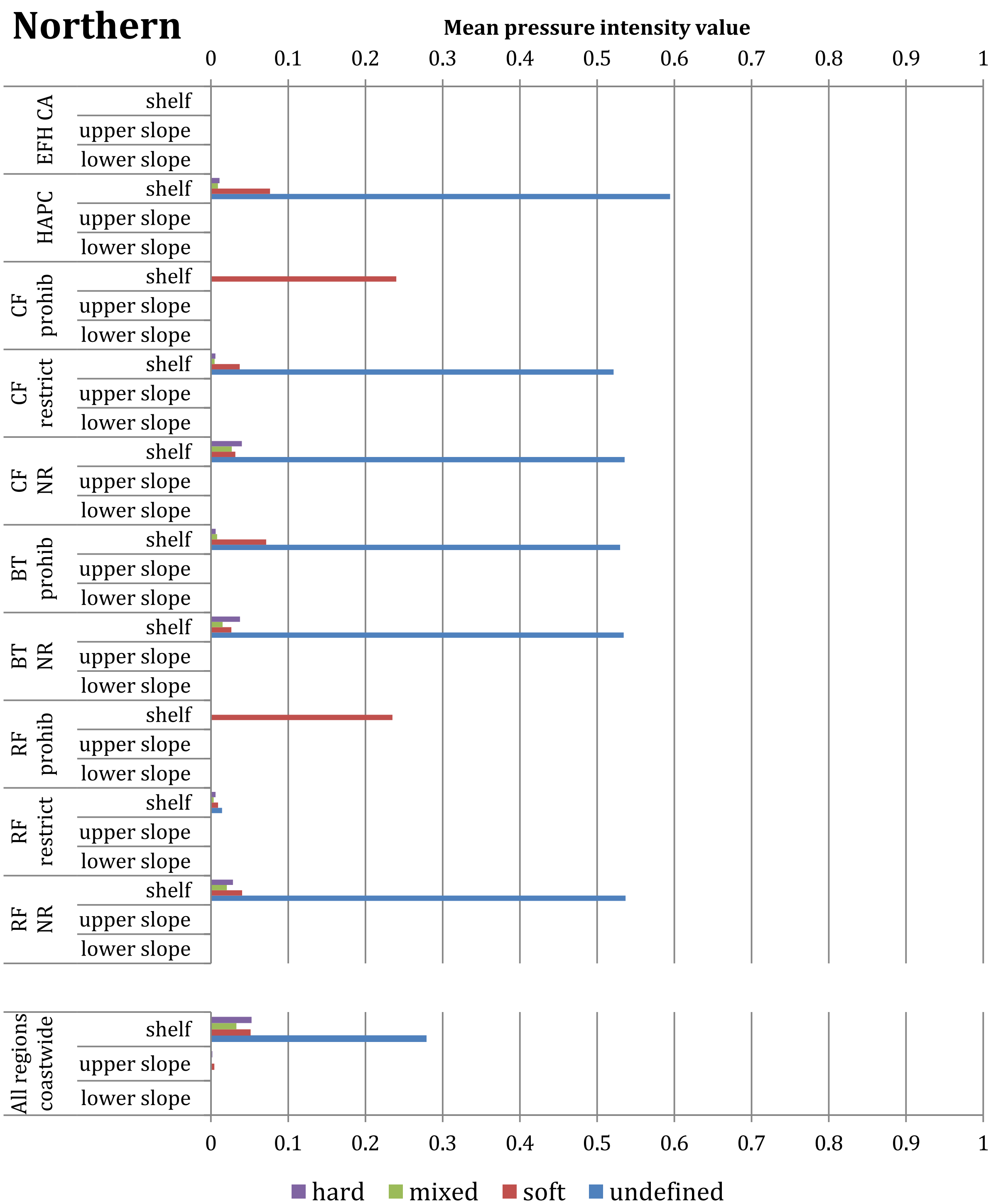


Figure A3b.14. Inorganic pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Northern" biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.14. Mean intensity values for inorganic pollution by depth zones and seabed substrate types across various management boundaries in the "Central" biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

INORGANIC POLLUTION	CENTRAL BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.03	0.22	0.11	0.14	0.02	0.14	0.02	0.11	0.09	0.08	0.07
	hard	0.05	0.07	0.10	0.09	0.02	0.09	0.02	0.11	0.13	0.07	0.05
	mixed	0.03	0.09	0.11	0.09	0.06	0.09	0.06	0.11	0.12	0.09	0.03
	soft	0.02	0.07	0.11	0.09	0.02	0.09	0.02	0.11	0.08	0.05	0.05
	undefined	0.08	0.47	0.30	0.46	0.37	0.46	0.36	0.01	0.20	0.46	0.28
Upper Slope[2]	All	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.12	0.00	0.00
	mixed	0.09	0.08	0.23	0.01	0.00	0.02	0.00	NA	NA	0.01	0.00
	soft	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	hard	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.00	0.05	0.10	0.01	0.00	0.01	0.00	0.10	0.09	0.00	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

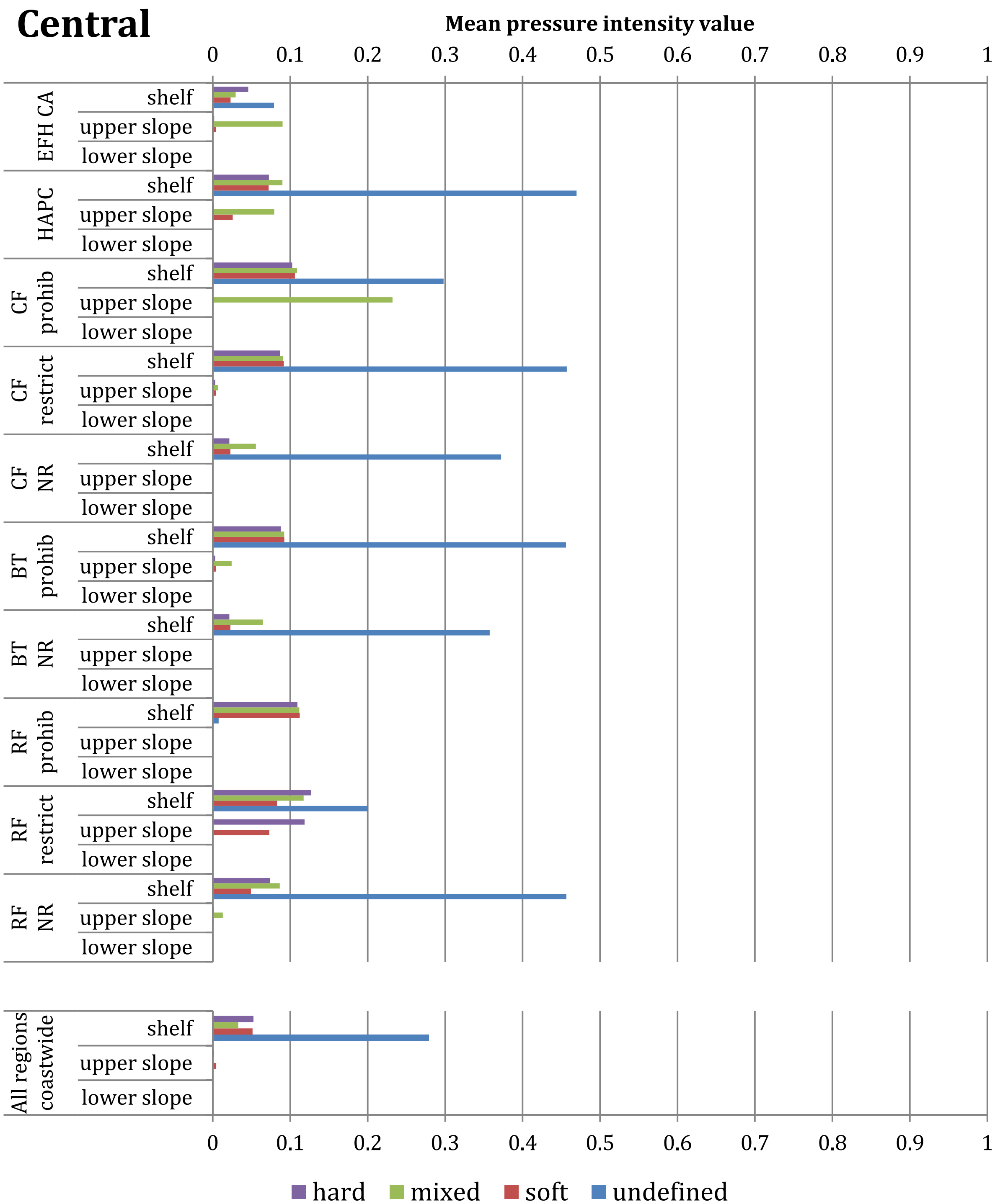


Figure A3b.15. Inorganic pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Central" biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.15. Mean intensity values for inorganic pollution by depth zones and seabed substrate types across various management boundaries in the “Southern” biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where “Commercial fishing” was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

INORGANIC POLLUTION	**SOUTHERN BIOGEOGRAPHIC SUB-REGION**											**COASTWIDE**
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.01	0.03	0.06	0.12	0.17	0.12	0.13	0.03	0.02	0.16	0.07
	hard	0.00	0.06	0.16	0.07	0.20	0.09	0.11	0.12	0.01	0.13	0.05
	mixed	0.00	0.01	0.05	0.05	0.09	0.06	0.02	0.02	0.01	0.09	0.03
	soft	0.01	0.02	0.05	0.12	0.17	0.13	0.13	0.02	0.02	0.16	0.05
	undefined	0.03	0.28	0.17	0.28	0.17	0.27	0.17	0.17	0.09	0.28	0.28
Upper Slope[2]	All	0.00	0.00	0.05	0.01	0.01	0.02	0.01	0.04	0.00	0.01	0.00
	hard	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
	mixed	0.00	0.00	NA	0.00	0.03	0.00	0.01	NA	0.00	0.03	0.00
	soft	0.00	0.00	0.05	0.01	0.01	0.02	0.01	0.04	0.00	0.01	0.00
	undefined	NA	NA	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.00	0.01	0.05	0.01	0.00	0.02	0.00	0.04	0.00	0.01	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

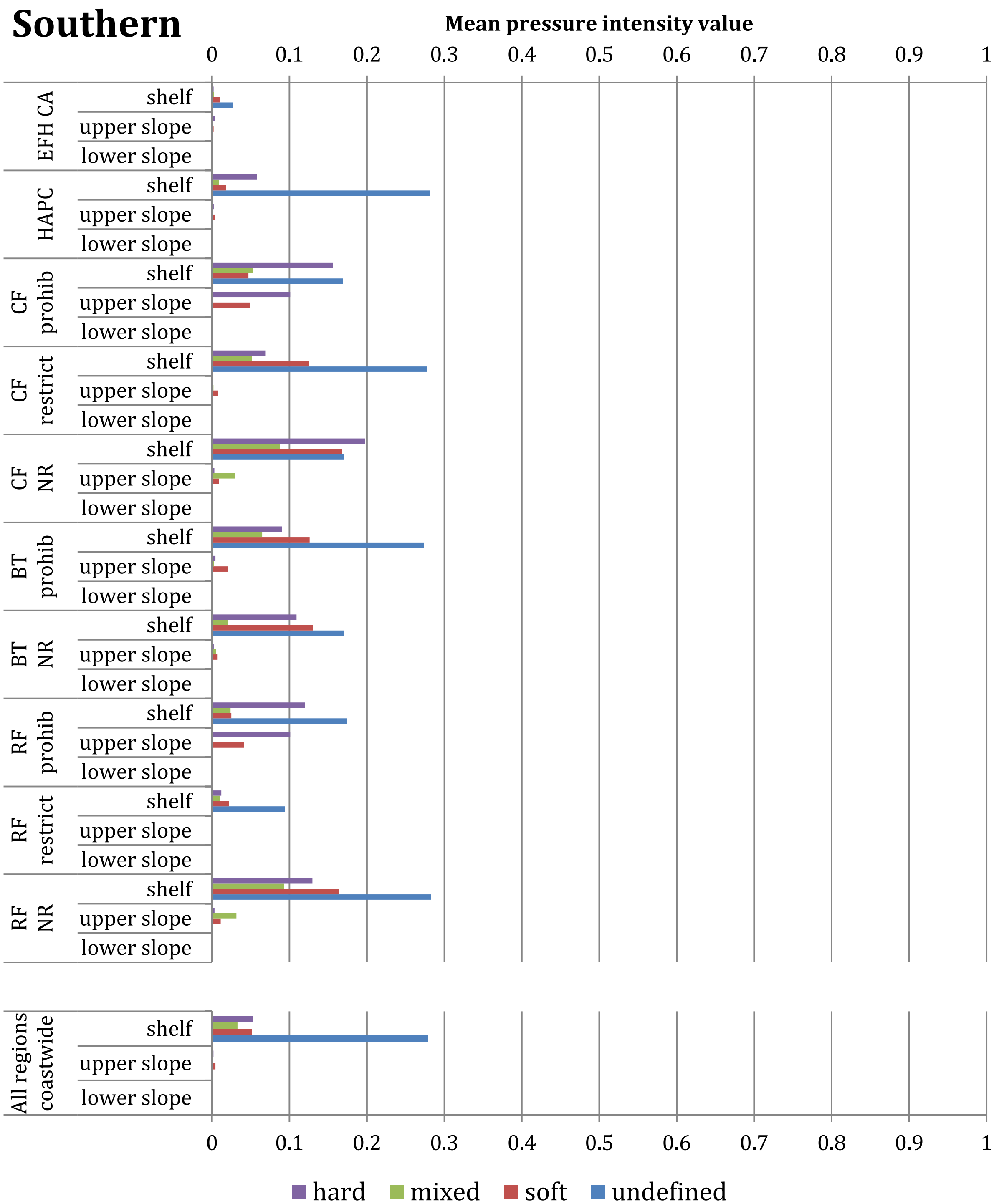


Figure A3b.16. Inorganic pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the “Southern” biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.16. Mean intensity values for inorganic pollution by depth zones and seabed substrate types across various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

INORGANIC POLLUTION	SALISH SEA BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	Substrate			Prohib	Restr	NR	Prohib	NR	Prohib	Restr	NR	
Shelf[1]	All	NA	0.28	0.21	0.16	NA	0.16	NA	NA	0.06	0.18	0.07
	hard	NA	0.05	NA	0.05	NA	0.05	NA	NA	0.06	0.06	0.05
	mixed	NA	0.03	NA	0.04	NA	0.04	NA	NA	0.03	0.08	0.03
	soft	NA	0.06	NA	0.06	NA	0.06	NA	NA	0.07	0.06	0.05
	undefined	NA	0.28	0.21	0.21	NA	0.21	NA	NA	0.04	0.22	0.28
Upper Slope[2]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Lower Slope[3]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Grand mean	All	NA	0.28	0.21	0.16	NA	0.16	NA	NA	0.06	0.18	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

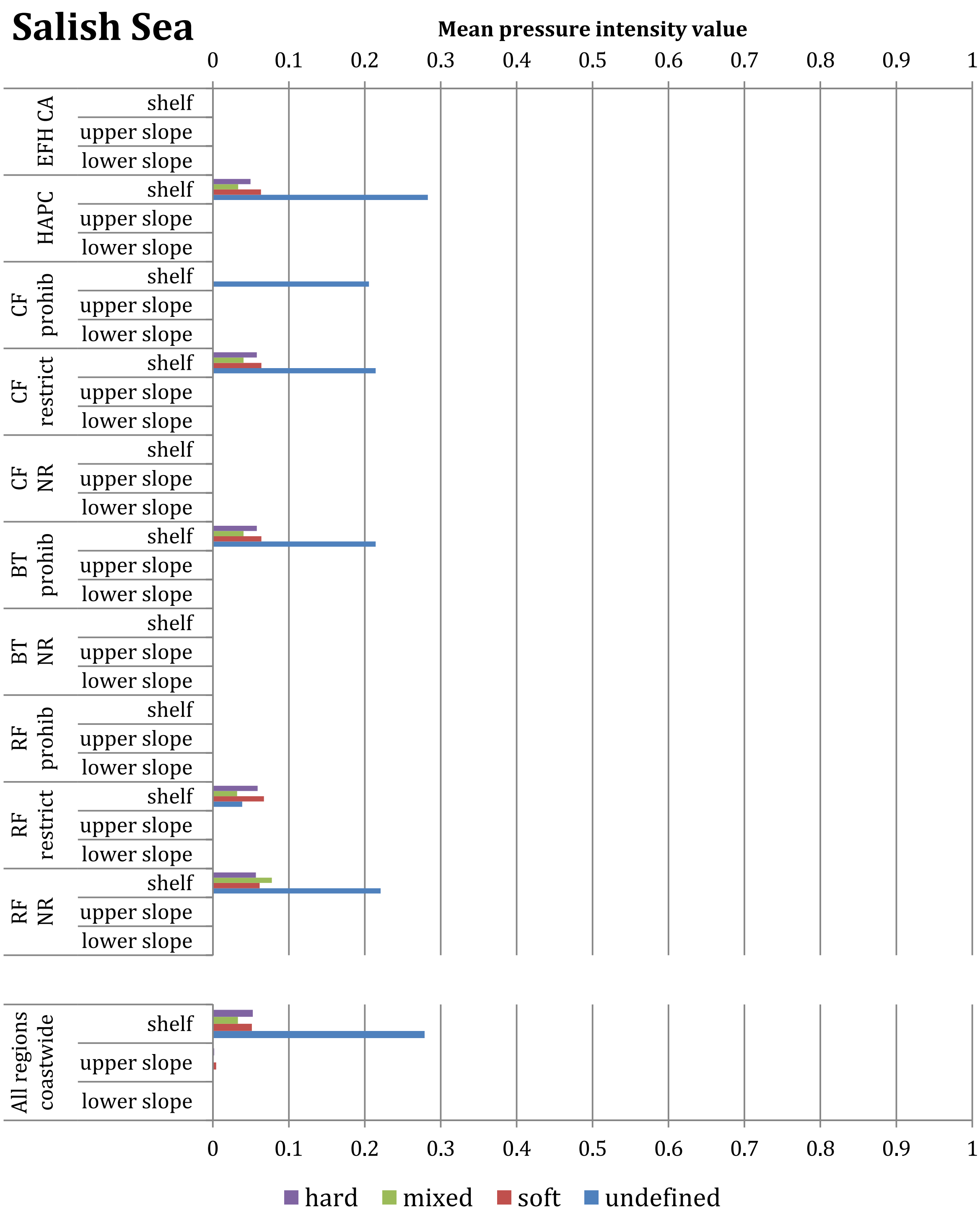


Figure A3b.17. Inorganic pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

3.2.4.3 Organic pollution

Organic pollution encompass numerous classes of chemicals including pesticides, polycyclic aromatic hydrocarbons (PAHs) and other persistent organic pollutants (POPs) and is introduced to the marine environment via runoff to rivers, streams and groundwater, poor-disposal practices and the discharge of industrial wastewater. Pesticides can affect the health and productivity of biological populations in three basic ways: (1) direct toxicological impact on the health or performance of exposed individuals; (2) indirect impairment of the productivity of the ecosystem; and (3) loss or degradation of vegetation that provides physical structure for fish and invertebrates (Hanson et al. 2003, Johnson et al. 2008). For many marine organisms, the majority of effects from pesticide exposures are sublethal, meaning that the exposure does not directly lead to the mortality of individuals. Sublethal effects can be of concern, as they impair the physiological or behavioral performance of individual animals in ways that decrease their growth or survival, alter migratory behavior, or reduce reproductive success (Hanson et al. 2003, Johnson et al. 2008), but in general the sublethal impacts of pesticides on fish health are poorly understood. Early development and growth of organisms involve important physiological processes and include the endocrine, immune, nervous, and reproductive systems. Many pesticides have been shown to impair one or more of these physiological processes in fish (Gould et al. 1994, Moore and Waring 2001). The direct and indirect effects that pesticides have on fish and other aquatic organisms can be a key factor in determining the impacts on the structure and function of ecosystems (Preston 2002).

Petroleum products, including PAHs, consist of thousands of chemical compounds which can be particularly damaging to marine biota because of their extreme toxicity, rapid uptake, and persistence in the environment (Johnson et al. 2008). PAHs have been found to be significantly higher in urbanized watersheds when compared to non-urbanized watersheds. Low-level chronic exposure to petroleum components and byproducts (i.e., polycyclic aromatic hydrocarbons [PAH]) have been shown in Atlantic salmon *Salmo salar* to increase embryo mortality, reduce growth (Heintz et al. 2000), and lower the return rates of adults returning to natal streams (Wertheimer et al. 2000). Effects of exposure to PAH in benthic species of fish include liver lesions, inhibited gonadal growth, inhibited spawning, reduced egg viability and reduced growth (Johnson et al. 2002). In general, the early life history stages of most species are most sensitive, juveniles are less sensitive, and adults least so.

Municipal wastewater treatment facilities have made great advances in treatment practices to eliminate pollutants prior to discharge, but any discharges will undoubtedly affect the quality of habitat in estuarine environments (Diaz and Rosenberg 1995, Kam et al. 2004). Several studies have shown that many benthic species increase in abundance and biomass in response to increased organic loading (Weston 1990, Savage et al. 2002, Alves et al. 2012). However, excessive nutrient enrichment can lead to hypoxia and potentially anoxic conditions, consequently leading to declines or shifts in biomass and diversity in the benthic community (Ysebaert et al. 1998, Essington and Paulsen 2010). Species richness among benthic communities has been shown to increase in relation to both temporal and spatial distance from organic loading sources (Savage et al. 2002, Wear and Tanner 2007). In addition to municipal wastewater treatment facilities, widely-distributed poorly-maintained septic systems contaminate shorelines in many places (Macdonald et al. 2002).

For specific details on the creation of each pressure data layer, see Halpern et al. (2008, 2009). Briefly, input rates of organic pollutants were calculated from national level statistics on pesticide use and land-use data. Pesticide data were distributed onto the landscape using dasymetric mapping techniques (Halpern et al. 2008) to get annual pesticide use per km^2. These values were then distributed to streams and river mouths in the watersheds and the diffusive 'spread' of these pollutants was modeled downstream.

Organic pollution intensity values were highest in the Salish Sea sub-region (Figs. A3b.18-19; Table A3b.17). Habitat within the northern sub-region was exposed to the lowest values of organic pollution. Similar to inorganic pollution and other land-based pressures, organic pollution was highest in shelf habitat and nearly absent from the slope habitats (Figs. A3b.18-20, Tables A3b.17-18). Organic pollution was generally higher in HAPCs and in areas prohibited to commercial and recreational fishing (Fig. A3b.20, Table A3b.18); however, this was likely because these management areas were in nearshore habitats that were more exposed to land-based pressures and had little to do with EFH-related management boundaries. These coastwide patterns were generally reflected within each biogeographic sub-region (Figs. A3b.21-24, Tables A3b.19-22).

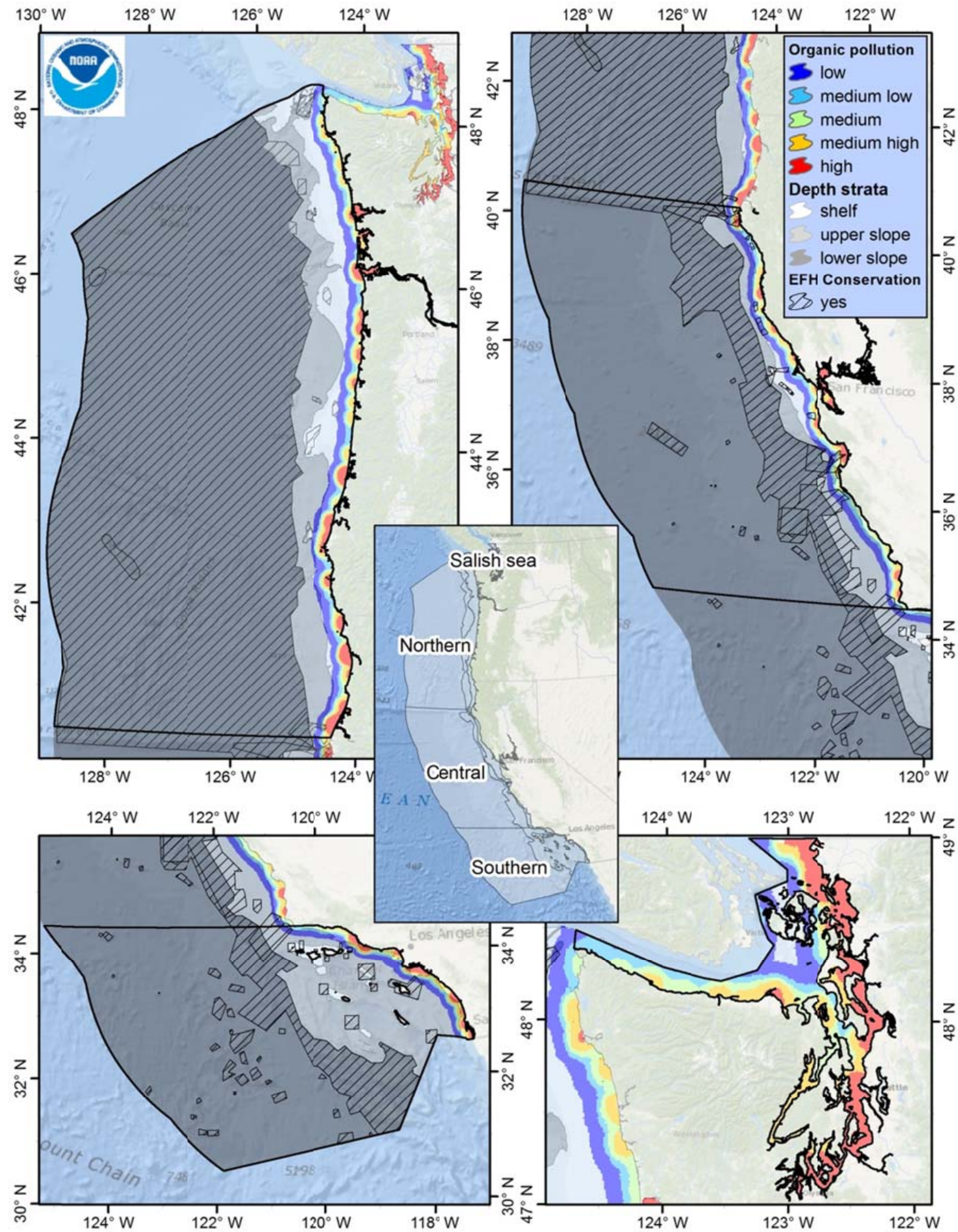


Figure A3b.18. Distribution of organic pollution intensity values among biogeographic regions, depth strata and essential fish habitat (EFH) conservation areas. Organic pollution data is from Halpern et al. 2009.

Table A3b.17. Mean intensity values for organic pollution by depth zones and seabed substrate types across 4 biogeographic regions: “Northern” (i.e., Cape Flattery, WA to Cape Mendocino, CA), “Central” (i.e., Cape Mendocino, CA to Point Conception, CA), “Southern” (i.e., Point Conception, CA to U.S.-Mexico maritime border) and “Salish Sea” (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1.

ORGANIC POLLUTION						
Depth Zone	*Substrate*	*Northern*	*Central*	*Southern*	*Salish Sea*	*Coastwide*
Shelf[1]	All	0.12	0.19	0.15	0.27	0.16
	hard	0.08	0.22	0.11	0.14	0.12
	mixed	0.07	0.25	0.08	0.09	0.11
	soft	0.11	0.16	0.15	0.15	0.13
	undefined	0.65	0.57	0.26	0.33	0.39
Upper Slope[2]	All	0.00	0.01	0.01	NA	0.01
	hard	0.00	0.01	0.01	NA	0.00
	mixed	0.00	0.03	0.00	NA	0.00
	soft	0.00	0.01	0.01	NA	0.01
	undefined	NA	0.00	0.00	NA	0.00
Lower Slope[3]	All	0.00	0.00	0.00	NA	0.00
	hard	0.00	0.00	0.00	NA	0.00
	mixed	0.00	0.00	0.00	NA	0.00
	soft	0.00	0.00	0.00	NA	0.00
	undefined	0.00	0.00	0.00	NA	0.00
Grand mean	All	0.01	0.01	0.01	0.27	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

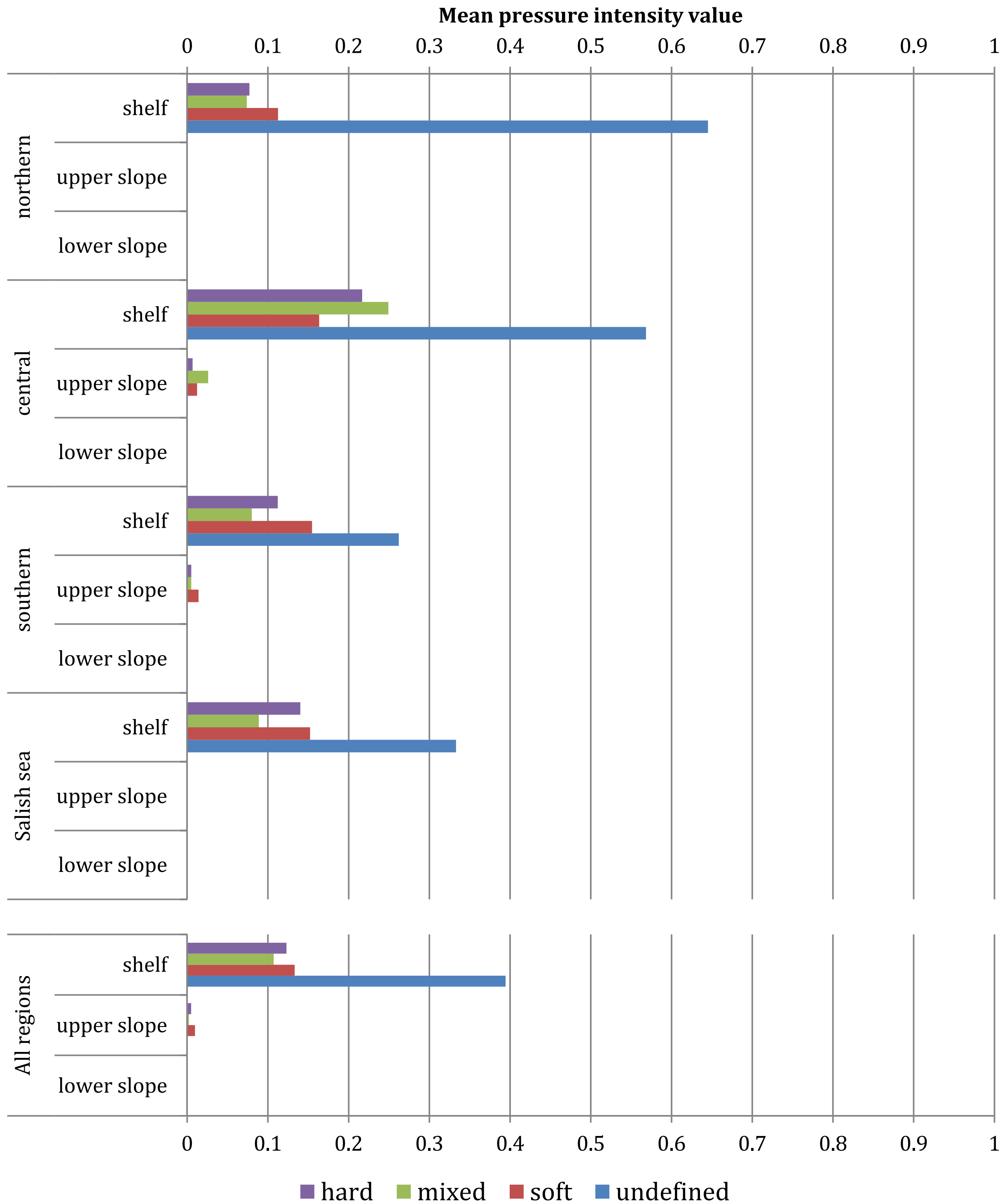


Figure A3b.19. Organic pollution. Mean pressure intensity values among seabed substrate types by depth zones across 4 biogeographic sub-regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound).

Table A3b.18. Mean intensity values for organic pollution by depth zones and seabed substrate types across various management boundaries. Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

ORGANIC POLLUTION												
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawling*		*Recreational fishing*			*Coastwide*
Depth Zone	**Substrate**			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	**All**	**0.06**	**0.27**	**0.17**	**0.20**	**0.12**	**0.23**	**0.10**	**0.16**	**0.07**	**0.17**	**0.16**
	hard	0.05	0.09	0.22	0.13	0.11	0.14	0.10	0.21	0.10	0.12	0.12
	mixed	0.03	0.10	0.21	0.08	0.17	0.12	0.09	0.21	0.03	0.16	0.11
	soft	0.07	0.20	0.16	0.16	0.11	0.20	0.10	0.15	0.07	0.15	0.13
	undefined	0.05	0.49	0.33	0.38	0.62	0.38	0.62	0.12	0.08	0.40	0.39
Upper Slope[2]	**All**	**0.01**	**0.01**	**0.08**	**0.01**	**0.01**	**0.02**	**0.01**	**0.08**	**0.00**	**0.01**	**0.01**
	hard	0.01	0.00	0.13	0.01	0.00	0.01	0.00	0.13	0.00	0.01	0.00
	mixed	0.00	0.00	0.37	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	soft	0.01	0.02	0.08	0.01	0.01	0.02	0.01	0.08	0.00	0.01	0.01
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Lower Slope[3]	**All**	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**0.00**
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	**All**	**0.00**	**0.09**	**0.15**	**0.02**	**0.01**	**0.02**	**0.01**	**0.14**	**0.03**	**0.01**	**0.01**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

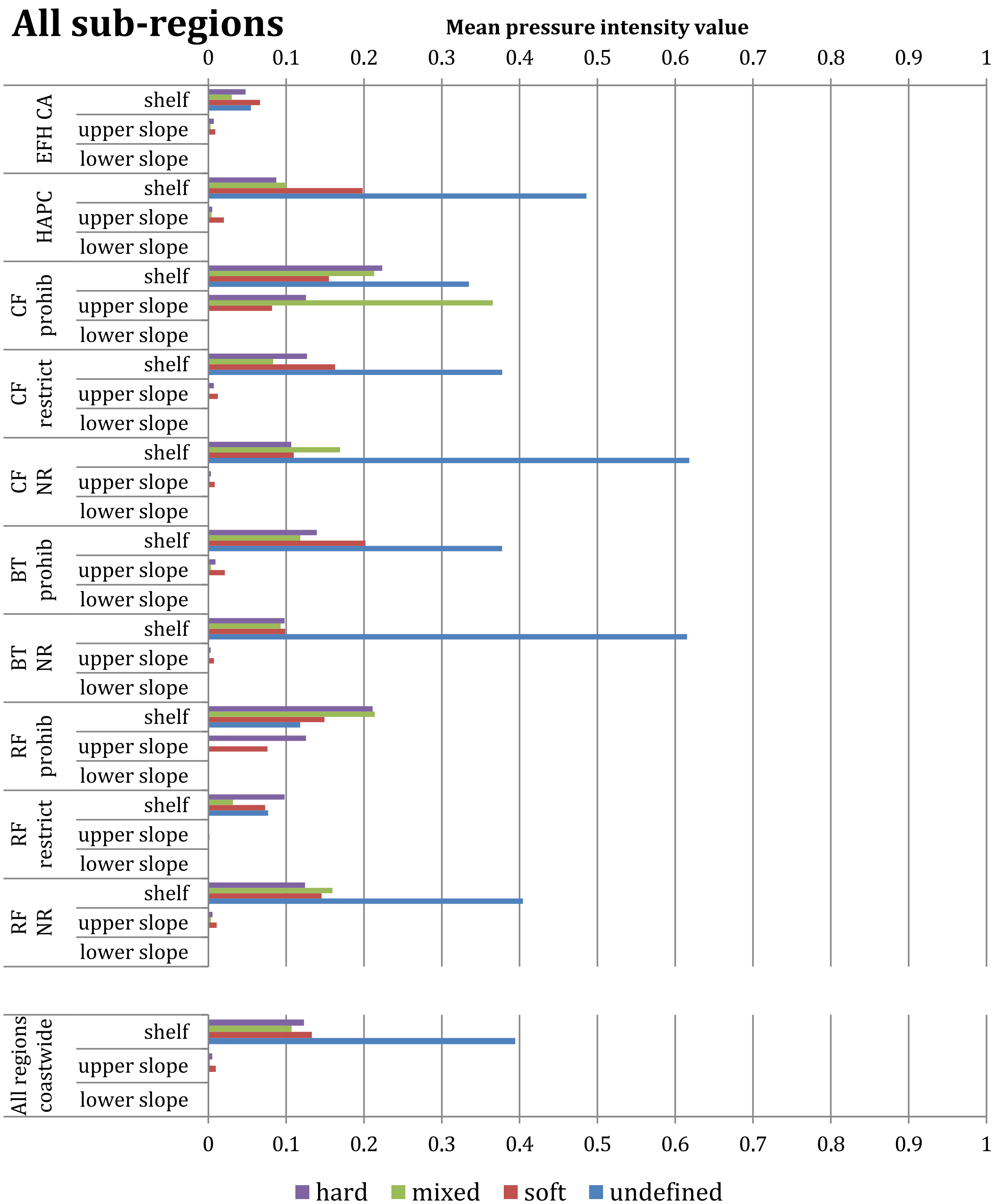


Figure A3b.20. Organic pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries across all biogeographic regions. EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.19. Mean intensity values for organic pollution by depth zones and seabed substrate types across various management boundaries in the “Northern” biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where “Commercial fishing” was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

ORGANIC POLLUTION	**NORTHERN BIOGEOGRAPHIC SUB-REGION**											**COASTWIDE**
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.00	0.23	0.52	0.12	0.11	0.21	0.10	0.52	0.07	0.13	0.16
	hard	0.00	0.05	NA	0.06	0.09	0.06	0.09	NA	0.12	0.07	0.12
	mixed	0.00	0.09	NA	0.03	0.17	0.04	0.09	NA	0.02	0.12	0.11
	soft	0.01	0.27	0.52	0.13	0.10	0.23	0.09	0.52	0.07	0.12	0.13
	undefined	NA	0.72	NA	0.67	0.64	0.68	0.64	NA	0.16	0.65	0.39
Upper Slope[2]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.01
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	mixed	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.01
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.00	0.10	0.52	0.01	0.05	0.00	0.05	0.52	0.06	0.01	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

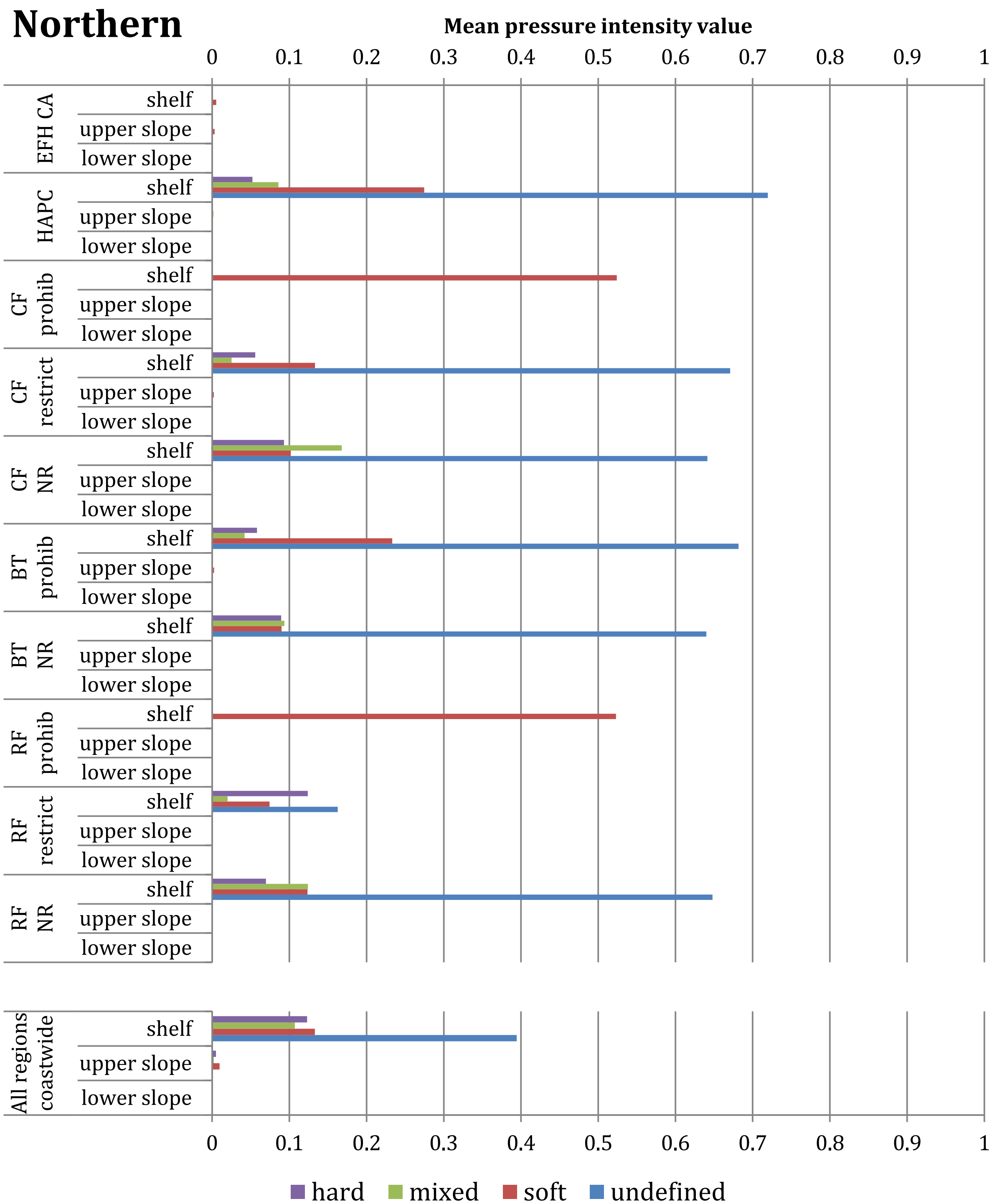


Figure A3b.21. Organic pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Northern" biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.20. Mean intensity values for organic pollution by depth zones and seabed substrate types across various management boundaries in the "Central" biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

ORGANIC POLLUTION	CENTRAL BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.13	0.34	0.29	0.28	0.11	0.28	0.11	0.29	0.24	0.19	0.16
	hard	0.13	0.18	0.26	0.23	0.12	0.23	0.12	0.26	0.30	0.21	0.12
	mixed	0.14	0.21	0.32	0.25	0.18	0.25	0.19	0.31	0.28	0.24	0.11
	soft	0.13	0.21	0.29	0.24	0.11	0.24	0.11	0.30	0.23	0.16	0.13
	undefined	0.14	0.59	0.41	0.57	0.45	0.57	0.44	0.09	0.29	0.57	0.39
Upper Slope[2]	All	0.02	0.03	0.21	0.02	0.01	0.02	0.01	0.20	0.24	0.01	0.01
	hard	0.01	0.01	NA	0.01	0.00	0.01	0.00	NA	0.28	0.01	0.00
	mixed	0.15	0.15	0.37	0.02	0.00	0.04	0.00	NA	NA	0.03	0.00
	soft	0.02	0.11	0.20	0.03	0.01	0.03	0.01	0.20	0.24	0.01	0.01
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	hard	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.00	0.09	0.29	0.03	0.00	0.03	0.00	0.29	0.24	0.01	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

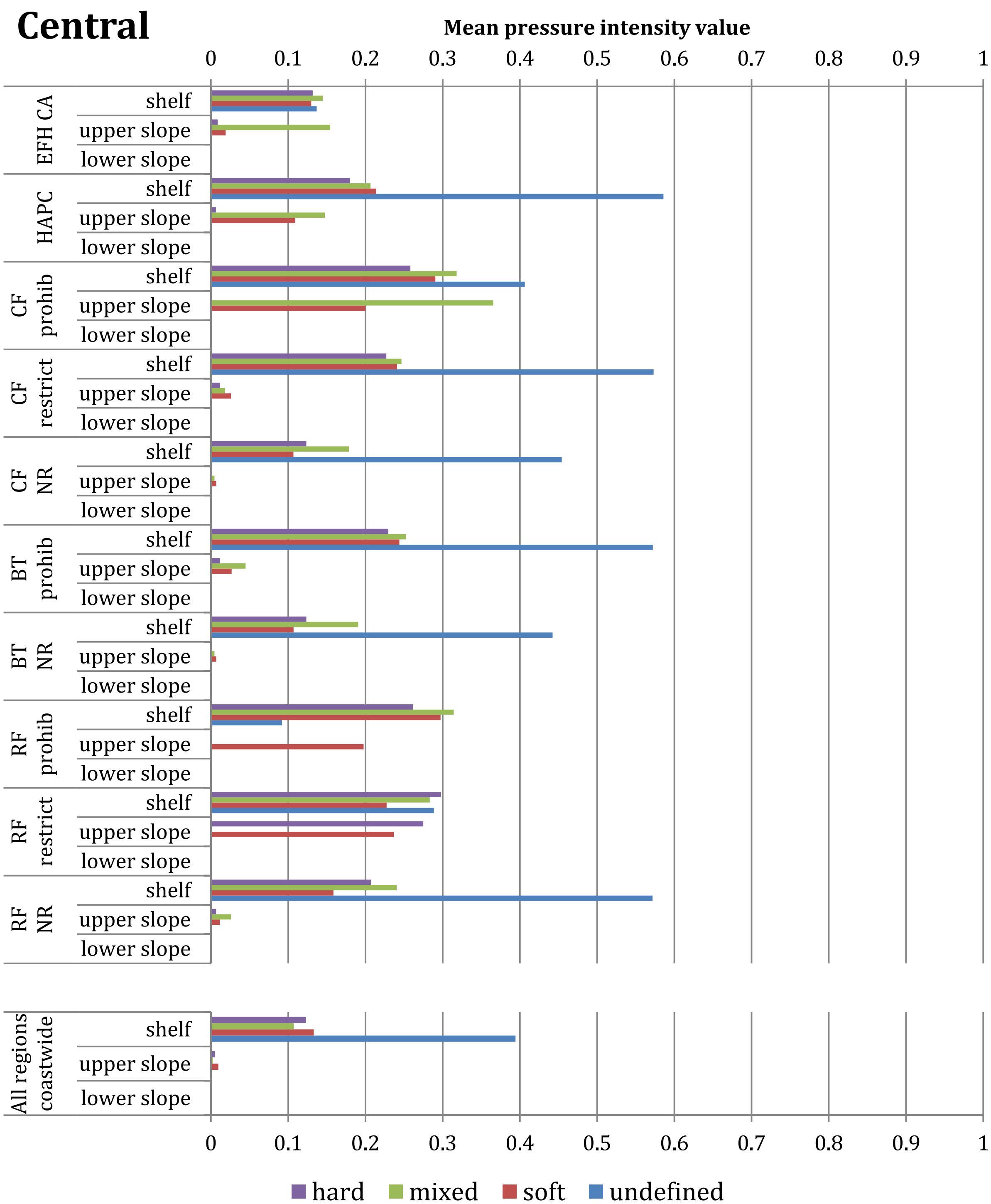


Figure A3b.22. Organic pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Central" biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.21. Mean intensity values for organic pollution by depth zones and seabed substrate types across various management boundaries in the "Southern" biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

ORGANIC POLLUTION		SOUTHERN BIOGEOGRAPHIC SUB-REGION										COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.00	0.03	0.07	0.14	0.24	0.14	0.18	0.05	0.02	0.20	0.16
	hard	0.00	0.07	0.18	0.08	0.26	0.10	0.14	0.14	0.01	0.16	0.12
	mixed	0.00	0.02	0.07	0.07	0.20	0.09	0.05	0.04	0.01	0.14	0.11
	soft	0.00	0.02	0.07	0.14	0.24	0.14	0.19	0.05	0.02	0.20	0.13
	undefined	0.00	0.28	0.17	0.28	0.18	0.27	0.18	0.17	0.11	0.28	0.39
Upper Slope[2]	All	0.00	0.00	0.07	0.01	0.02	0.03	0.01	0.06	0.00	0.02	0.01
	hard	0.00	0.00	0.13	0.00	0.01	0.00	0.01	0.13	0.00	0.01	0.00
	mixed	0.00	0.00	NA	0.00	0.04	0.00	0.01	NA	0.00	0.04	0.00
	soft	0.00	0.00	0.07	0.01	0.02	0.03	0.01	0.06	0.00	0.02	0.01
	undefined	NA	NA	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.00	0.01	0.07	0.02	0.01	0.02	0.00	0.06	0.00	0.01	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

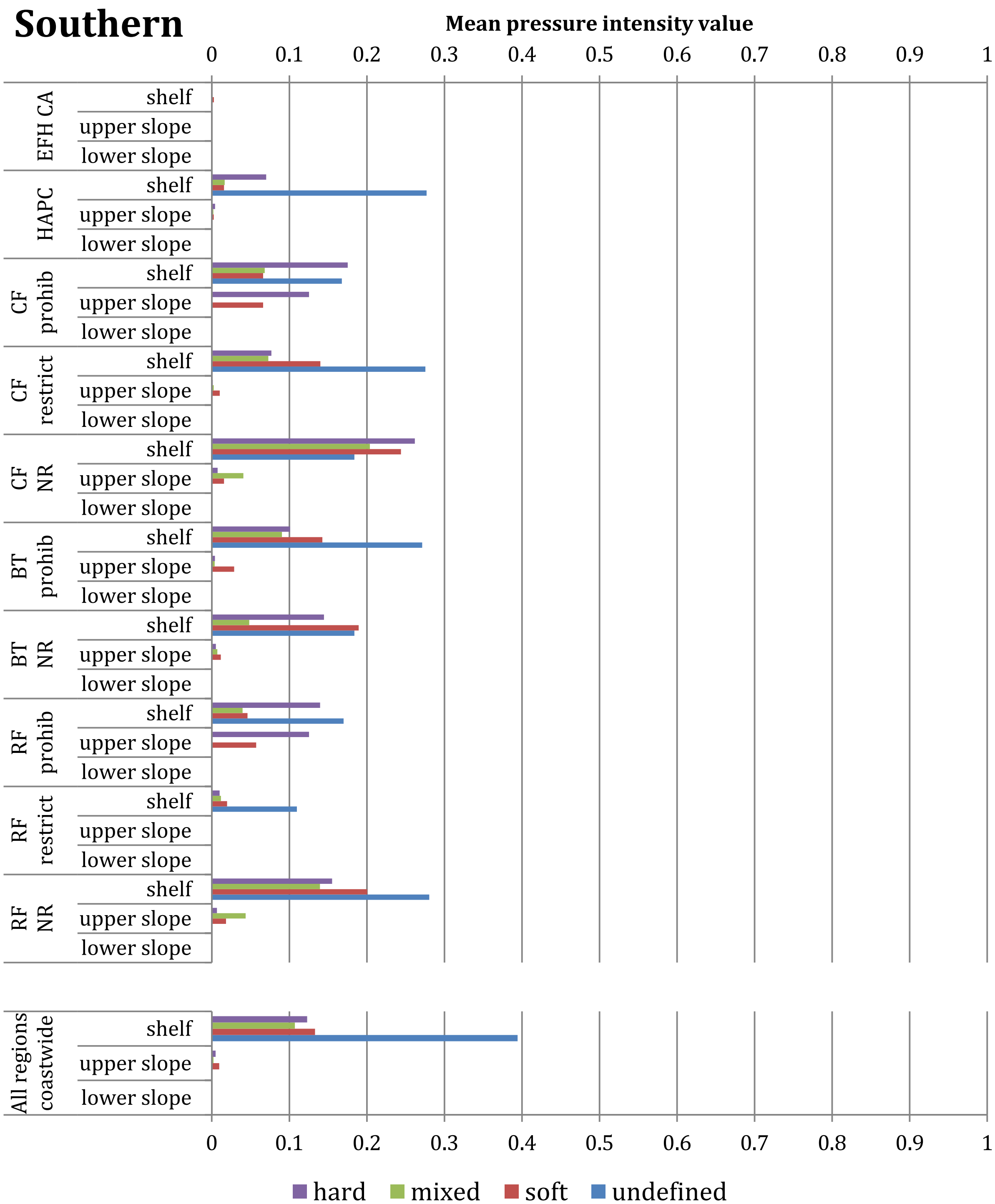


Figure A3b.23. Organic pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Southern" biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.22. Mean intensity values for organic pollution by depth zones and seabed substrate types across various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

ORGANIC POLLUTION	SALISH SEA BIOGEOGRAPHIC SUB-REGION										COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*		*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	NA	0.41	0.29	0.27	0.33	0.27	0.33	NA	0.07	0.31	0.16
	hard	NA	0.26	NA	0.13	0.26	0.13	0.26	NA	0.05	0.25	0.12
	mixed	NA	0.12	NA	0.08	0.34	0.08	0.34	NA	0.06	0.21	0.11
	soft	NA	0.09	NA	0.15	0.22	0.15	0.22	NA	0.08	0.20	0.13
	undefined	NA	0.42	0.29	0.33	0.34	0.33	0.34	NA	0.06	0.34	0.39
Upper Slope[2]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Lower Slope[3]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Grand mean	All	0.27	0.41	0.29	0.27	0.33	0.27	0.33	NA	0.07	0.31	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

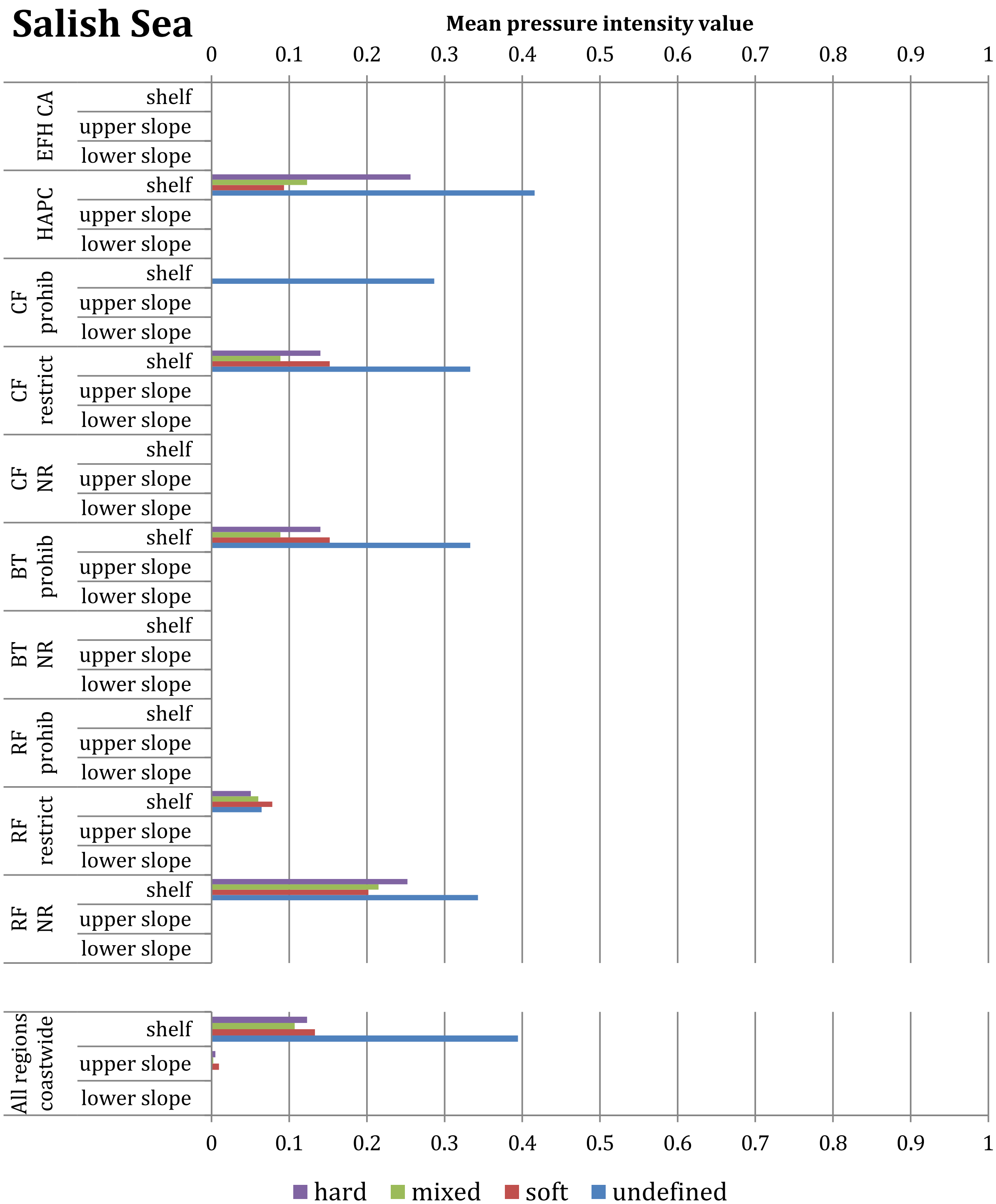


Figure A3b.24. Organic pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

3.2.4.4 Nutrient input

Elevated nutrient concentrations are a leading cause of contamination in streams, lakes, wetlands, estuaries, and ground water of the United States (USEPA 2002). Nutrients (primarily nitrogen and phosphorus) are chemical elements that are essential to plant and animal nutrition; in marine waters, either phosphorus of nitrogen can limit plant growth. However, in high concentrations they can be considered water contaminants (USEPA 1999a).

Excess nutrients in a body of water can have many detrimental effects on drinking water supplies, recreational use, aquatic life use, and fisheries, and there are multiple indirect effects of nutrient enrichment of surface waters on human health. However, excessive nutrients are more often a cause of concern because of their role in accelerating eutrophication, which produces a wide range of other impacts on aquatic ecosystems and fisheries. Severely eutrophic conditions may adversely affect aquatic systems in a number of ways, including: algae blooms; declines in submerged aquatic vegetation (SAV) populations through reduced light transmittance, epiphytic growth, and increased disease susceptibility; mass mortality of fish and invertebrates through poor water quality (e.g., via oxygen depletion and elevated ammonia levels); and alterations in long-term natural community dynamics (Dubrovsky et al. 2010). Algal toxins harmful to animal and human health can be produced from blooms of some cyanobacteria species. High algal biomass also is associated with hypoxia (low dissolved-oxygen concentrations), which can contribute to the release of toxic metals from bed sediments, increased availability of toxic substances like ammonia and hydrogen sulfide, and fish kills. In recent years, nitrate and other nutrients discharged from the Mississippi River Basin have been linked to a large zone of hypoxia in the Gulf of Mexico along the Louisiana-Texas coast (Sprague et al. 2009).

Nonpoint sources of nutrients which affect stream and groundwater concentrations include fertilizer use, livestock manure, and atmospheric deposition (Ruddy et al. 2006). Within some coastal regions of the U.S. (e.g., mid-Atlantic states), much of the excess nutrients originates from point sources, such as sewage treatment plants, whereas failing septic systems often contribute to non-point source pollution and are a negative consequence of urban development (Johnson et al. 2008). However, nutrient loading can be a complex indicator to interpret, as a variety of hydro-geomorphic features (basin slope, basin area, mean annual precipitation, stream flow, and soil type) may also interact with possible nutrient sources to complicate estimates of nutrient concentration and loading. As well, there often are multiple and possibly counteracting anthropogenic factors influencing nutrient source and transport in a watershed, and without detailed knowledge of all important factors in each watershed, it may be difficult to discern the specific cause(s) of a trend in concentration (Sprague et al. 2009). Best land-use practices are known to reduce nutrient loading. Protocols for establishing total maximum daily load (TMDL) values of nutrients have been developed for specific bodies of water throughout the country (USEPA 1999a); however, we uncovered few examples in the literature of TMDLs for marine systems on the Pacific coast of the US.

Despite some of the previous cautions, nutrient loading in freshwater systems is generally a well understood indicator with a long history of reporting, as evidenced by requirements under the Clean Water Act, intensive nationwide monitoring programs at the federal, state, and local level, and a variety of national and regional trend reports by USGS (Ruddy et al. 2006, Wise et al. 2007, Sprague et al. 2009, Dubrovsky et al. 2010, Kratzer et al. 2011).

For specific details on the creation of each pressure data layer, see Halpern et al. (2008, 2009). Briefly, nutrient input was calculated from nitrogen input from farming and atmospheric deposition. County-level nitrogen application data and atmospheric deposition data were summed independently across watersheds and plumed into coastal waters using a plume model (Halpern et al. 2008). Values were normalized and summed to create a single layer of nitrogen input.

Nutrient input intensity values were very similar to organic pollution: values were highest in the Salish Sea (Figs. A3b.25-26, Table A3b.23) and in shelf habitat (Figs. A3b.25-27; Tables A3b.23-24). Habitat within the northern sub-region was exposed to the lowest values of nutrient input, particularly in shelf habitat. Nutrient input was generally higher in HAPCs and in areas prohibited to commercial and recreational fishing (Fig. A3b.27, Table A3b.24); however, this was likely because these management areas were in nearshore habitats that were more exposed to land-based pressures and had little to do with EFH-related management boundaries. These coastwide patterns were generally reflected within each biogeographic sub-region (Figs. A3b.28-31, Tables A3b.25-28).

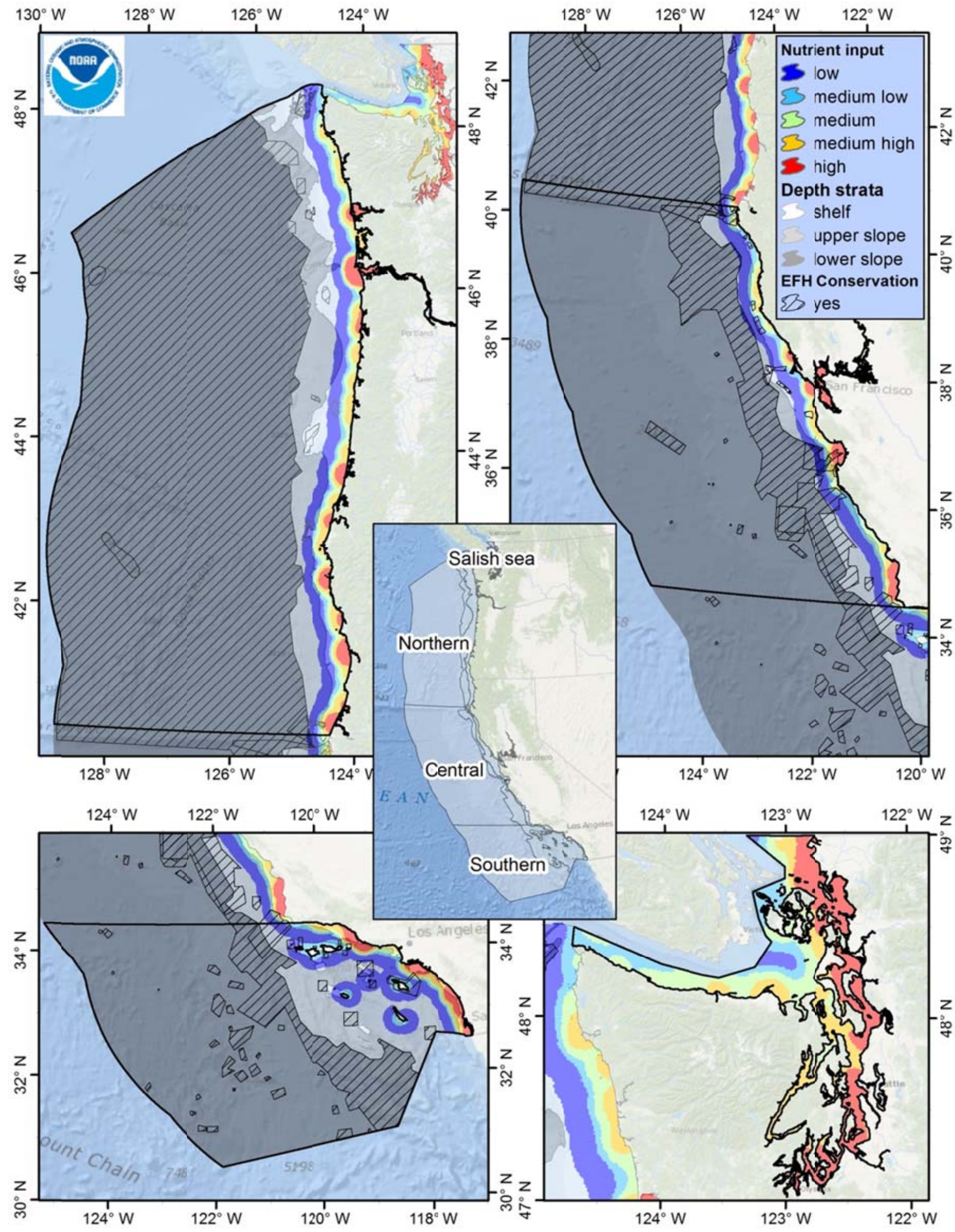


Figure A3b.25. Distribution of nutrient input intensity values among biogeographic regions, depth strata and essential fish habitat (EFH) conservation areas. Nutrient input data is from Halpern et al. 2009.

Table A3b.23. Mean intensity values for nutrient input by depth zones and seabed substrate types across 4 biogeographic regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1.

NUTRIENT INPUT						
Depth Zone	*Substrate*	*Northern*	*Central*	*Southern*	*Salish Sea*	*Coastwide*
Shelf[1]	All	0.12	0.19	0.17	0.24	0.18
	hard	0.06	0.20	0.14	0.15	0.15
	mixed	0.06	0.20	0.09	0.11	0.13
	soft	0.11	0.16	0.18	0.16	0.16
	undefined	0.70	0.58	0.27	0.29	0.24
Upper Slope[2]	All	0.00	0.01	0.02	NA	0.06
	hard	0.00	0.01	0.01	NA	0.05
	mixed	0.00	0.02	0.01	NA	0.03
	soft	0.00	0.01	0.03	NA	0.06
	undefined	NA	0.00	0.00	NA	0.01
Lower Slope[3]	All	0.00	0.00	0.00	NA	0.00
	hard	0.00	0.00	0.00	NA	0.01
	mixed	0.00	0.00	0.00	NA	0.00
	soft	0.00	0.00	0.00	NA	0.01
	undefined	0.00	0.00	0.00	NA	0.00
Grand mean	All	0.01	0.01	0.01	0.24	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

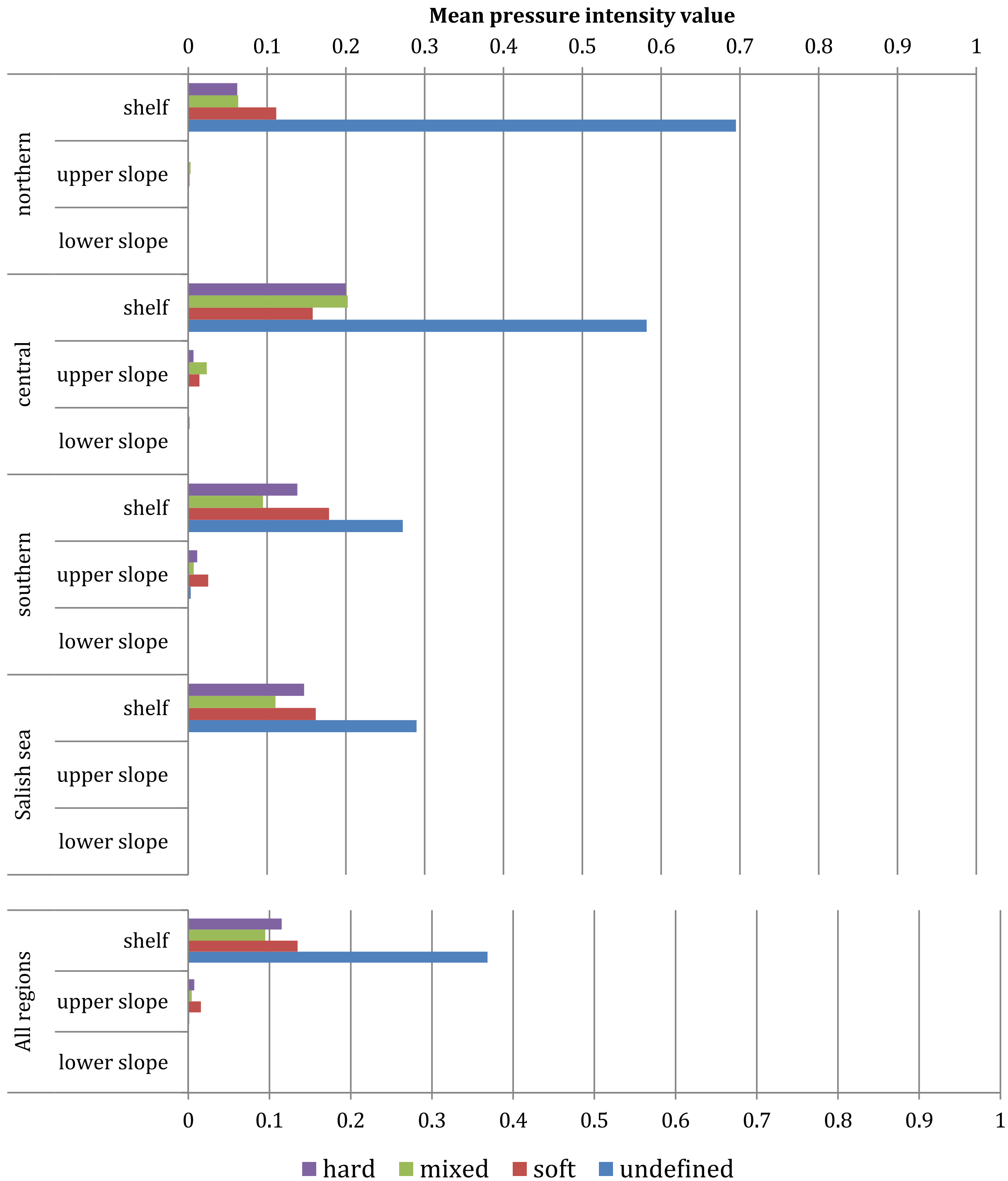


Figure A3b.26. Nutrient input. Mean pressure intensity values among seabed substrate types by depth zones across 4 biogeographic sub-regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound).

Table A3b.24. Mean intensity values for nutrient input by depth zones and seabed substrate types across various management boundaries. Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

NUTRIENT INPUT												
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawling*		*Recreational fishing*			*Coastwide*
Depth Zone	**Substrate**			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	**All**	**0.07**	**0.24**	**0.15**	**0.18**	**0.13**	**0.21**	**0.11**	**0.14**	**0.08**	**0.17**	**0.15**
	hard	0.06	0.09	0.19	0.12	0.10	0.13	0.09	0.18	0.10	0.12	0.11
	mixed	0.02	0.09	0.18	0.07	0.15	0.10	0.08	0.19	0.03	0.14	0.09
	soft	0.08	0.17	0.14	0.15	0.12	0.19	0.11	0.13	0.08	0.15	0.13
	undefined	0.10	0.45	0.31	0.35	0.66	0.35	0.66	0.09	0.15	0.38	0.37
Upper Slope[2]	**All**	**0.01**	**0.01**	**0.09**	**0.02**	**0.01**	**0.03**	**0.01**	**0.08**	**0.00**	**0.02**	**0.01**
	hard	0.01	0.01	0.10	0.01	0.01	0.01	0.00	0.11	0.00	0.01	0.01
	mixed	0.00	0.01	0.30	0.00	0.00	0.00	0.00	NA	0.00	0.01	0.00
	soft	0.01	0.03	0.09	0.02	0.01	0.03	0.01	0.08	0.00	0.02	0.02
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Lower Slope[3]	**All**	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**0.00**
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	**All**	**0.00**	**0.08**	**0.14**	**0.02**	**0.01**	**0.02**	**0.01**	**0.13**	**0.03**	**0.01**	**0.01**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

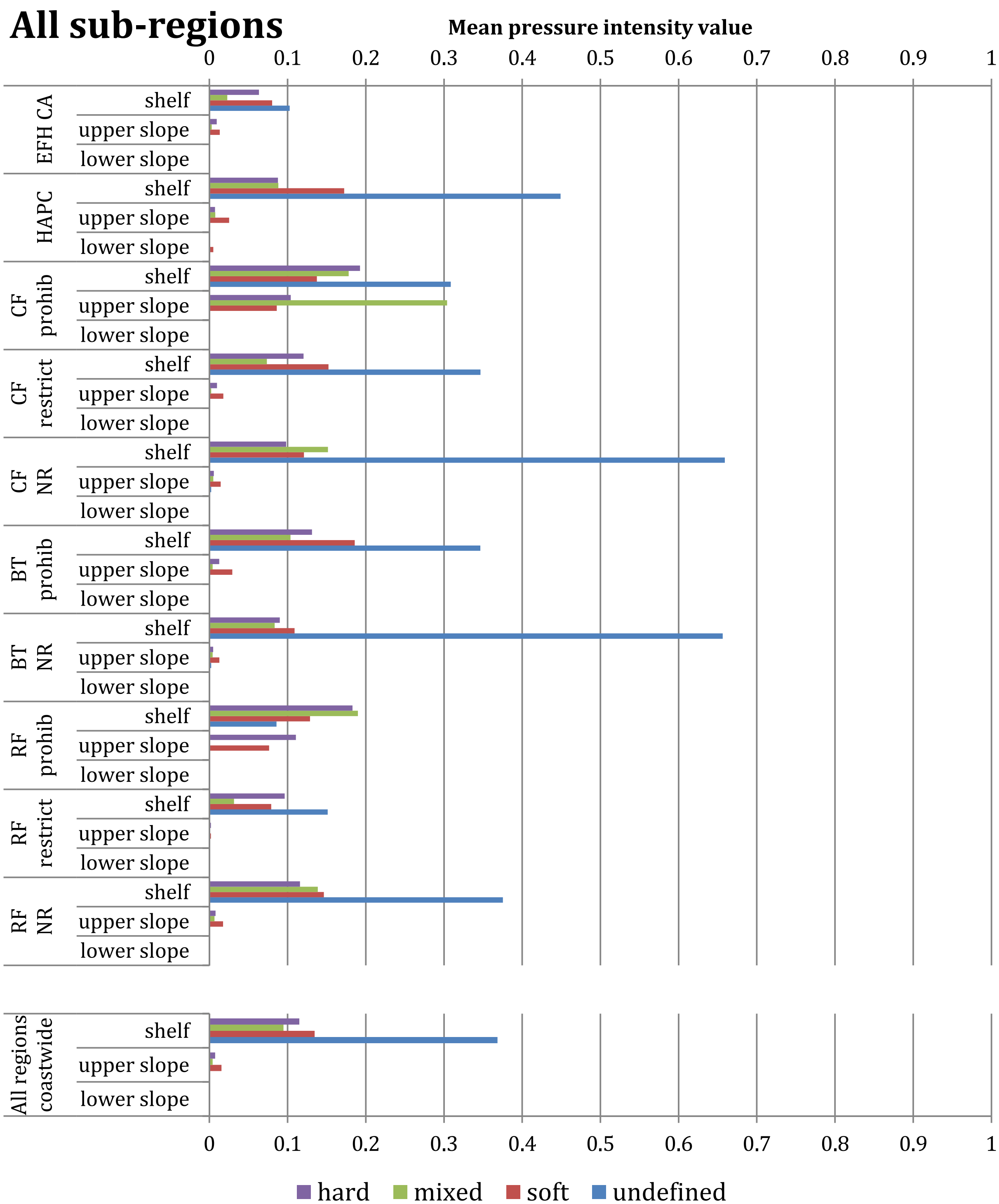


Figure A3b.27. Nutrient input. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries across all biogeographic regions. EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.25. Mean intensity values for nutrient input by depth zones and seabed substrate types across various management boundaries in the "Northern" biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

NUTRIENT INPUT	NORTHERN BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.00	0.20	0.44	0.10	0.12	0.16	0.11	0.44	0.06	0.13	0.15
	hard	0.00	0.04	NA	0.04	0.08	0.04	0.08	NA	0.08	0.06	0.11
	mixed	0.00	0.07	NA	0.02	0.15	0.03	0.08	NA	0.01	0.11	0.09
	soft	0.01	0.21	0.44	0.11	0.11	0.18	0.10	0.44	0.07	0.12	0.13
	undefined	NA	0.78	NA	0.76	0.69	0.78	0.69	NA	0.10	0.70	0.37
Upper Slope[2]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.01
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.01
	mixed	0.00	0.01	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.02
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.00	0.08	0.44	0.00	0.06	0.00	0.05	0.44	0.05	0.01	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

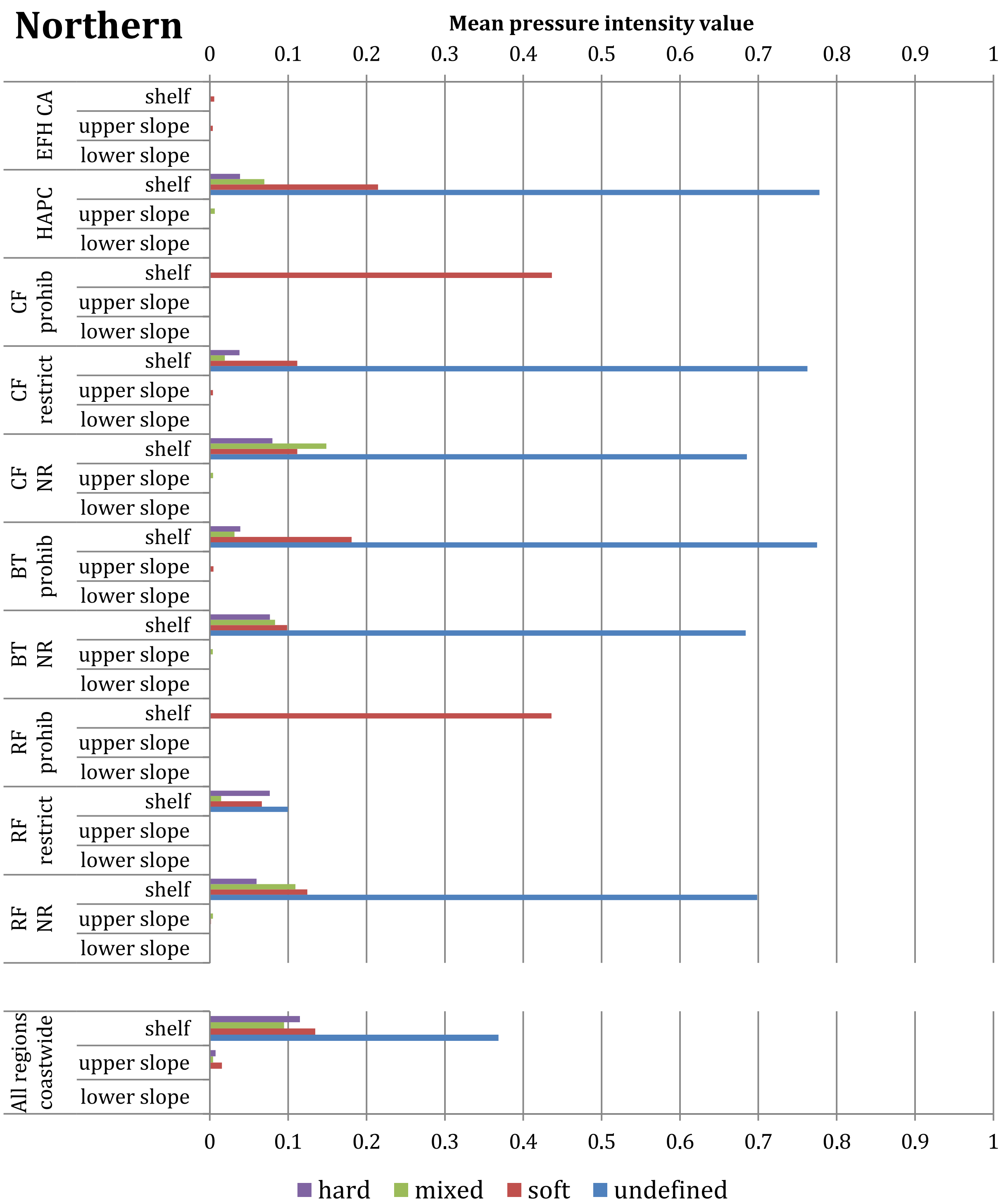


Figure A3b.28. Nutrient input. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Northern" biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.26. Mean intensity values for nutrient input by depth zones and seabed substrate types across various management boundaries in the "Central" biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

NUTRIENT INPUT	CENTRAL BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.14	0.36	0.22	0.26	0.12	0.26	0.12	0.23	0.25	0.18	0.15
	hard	0.17	0.20	0.20	0.21	0.12	0.21	0.12	0.21	0.32	0.19	0.11
	mixed	0.10	0.20	0.23	0.20	0.17	0.20	0.18	0.25	0.25	0.19	0.09
	soft	0.14	0.22	0.22	0.22	0.12	0.22	0.12	0.23	0.24	0.15	0.13
	undefined	0.19	0.60	0.38	0.59	0.46	0.59	0.45	0.03	0.27	0.59	0.37
Upper Slope[2]	All	0.02	0.03	0.09	0.03	0.01	0.03	0.01	0.08	0.24	0.01	0.01
	hard	0.01	0.01	NA	0.01	0.00	0.01	0.00	NA	0.55	0.01	0.01
	mixed	0.13	0.12	0.30	0.02	0.01	0.04	0.01	NA	NA	0.02	0.00
	soft	0.02	0.11	0.08	0.03	0.01	0.03	0.01	0.08	0.23	0.01	0.02
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	hard	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.01	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.01	0.09	0.21	0.03	0.01	0.03	0.01	0.22	0.25	0.01	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

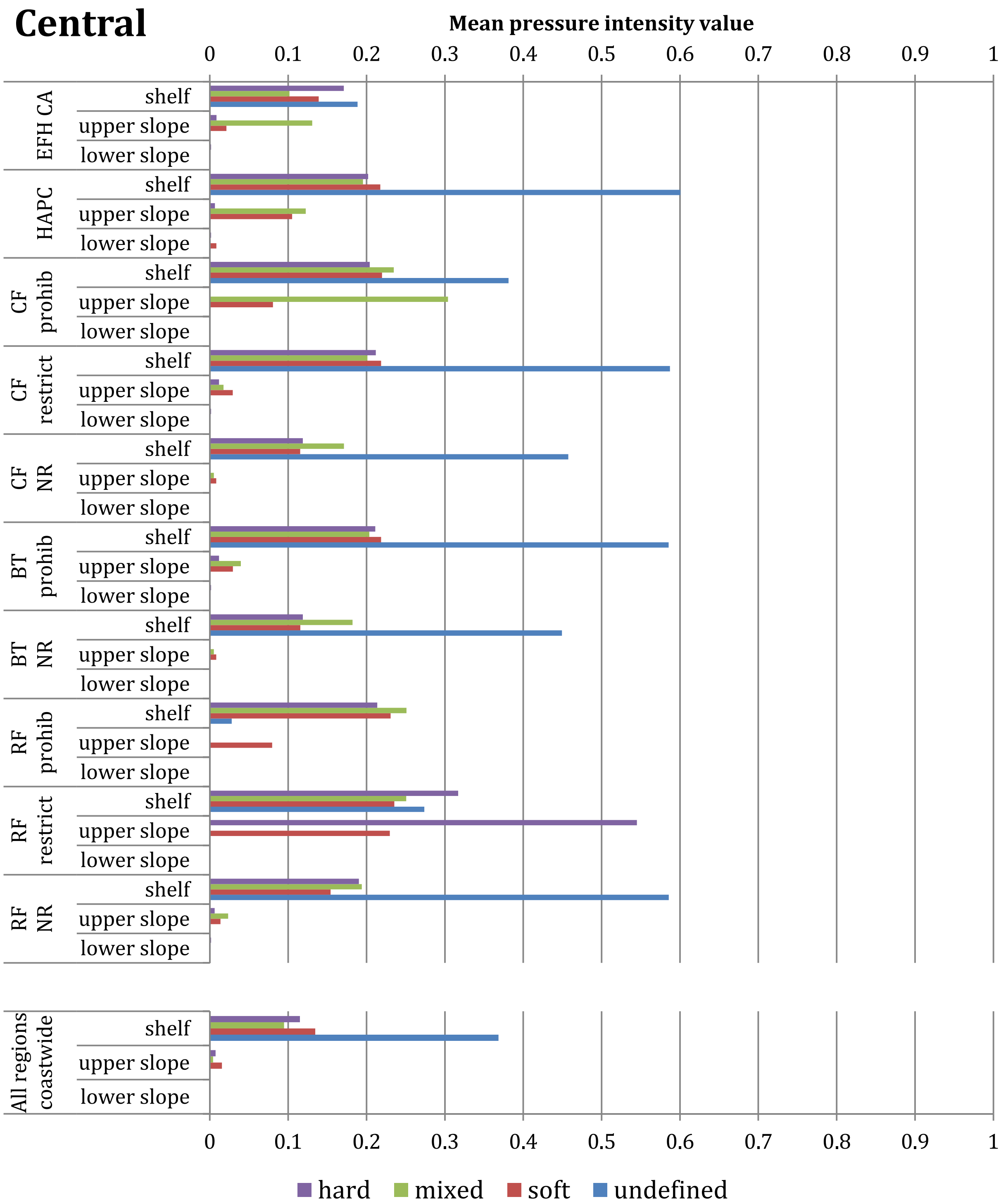


Figure A3b.29. Nutrient input. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Central" biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.27. Mean intensity values for nutrient input by depth zones and seabed substrate types across various management boundaries in the "Southern" biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

NUTRIENT INPUT		SOUTHERN BIOGEOGRAPHIC SUB-REGION										COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.03	0.06	0.09	0.15	0.29	0.16	0.22	0.07	0.04	0.22	0.15
	hard	0.01	0.10	0.18	0.10	0.31	0.13	0.17	0.14	0.02	0.19	0.11
	mixed	0.02	0.03	0.10	0.09	0.22	0.11	0.05	0.08	0.02	0.15	0.09
	soft	0.03	0.04	0.08	0.16	0.29	0.16	0.23	0.06	0.04	0.23	0.13
	undefined	0.05	0.26	0.18	0.28	0.22	0.28	0.22	0.20	0.15	0.29	0.37
Upper Slope[2]	All	0.01	0.01	0.09	0.02	0.03	0.04	0.02	0.08	0.00	0.03	0.01
	hard	0.02	0.01	0.10	0.01	0.01	0.02	0.01	0.11	0.00	0.01	0.01
	mixed	0.00	0.00	NA	0.00	0.04	0.01	0.01	NA	0.00	0.06	0.00
	soft	0.01	0.01	0.09	0.02	0.03	0.05	0.02	0.08	0.00	0.03	0.02
	undefined	NA	NA	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.00	0.01	0.09	0.02	0.01	0.02	0.01	0.07	0.01	0.01	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

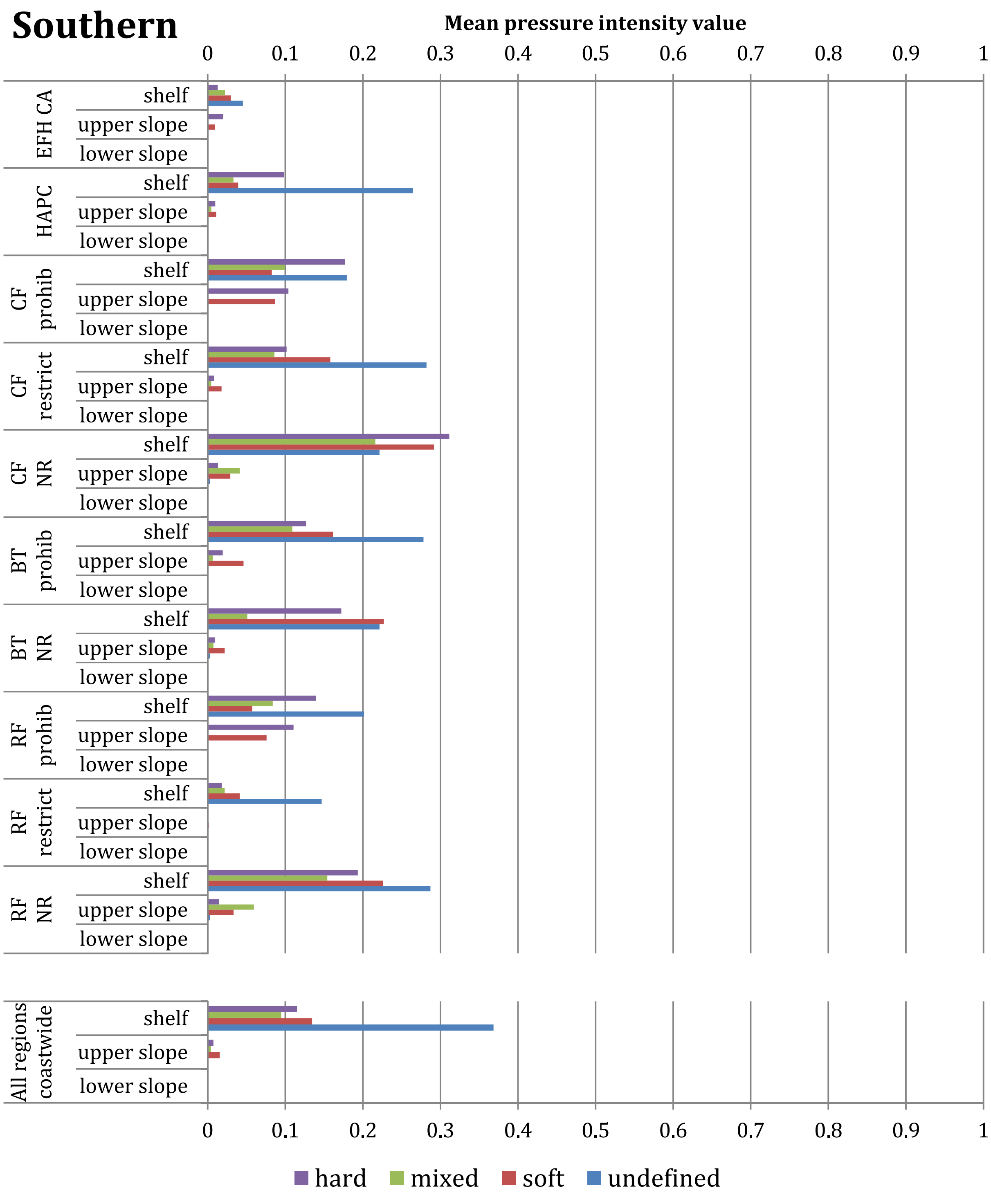


Figure A3b.30. Nutrient input. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Southern" biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.28. Mean intensity values for nutrient input by depth zones and seabed substrate types across various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

NUTRIENT INPUT	SALISH SEA BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	NA	0.34	0.22	0.24	NA	0.24	NA	NA	0.16	0.26	0.15
	hard	NA	0.14	NA	0.15	NA	0.15	NA	NA	0.15	0.14	0.11
	mixed	NA	0.08	NA	0.11	NA	0.11	NA	NA	0.10	0.17	0.09
	soft	NA	0.11	NA	0.16	NA	0.16	NA	NA	0.17	0.16	0.13
	undefined	NA	0.34	0.22	0.29	NA	0.29	NA	NA	0.15	0.29	0.37
Upper Slope[2]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.02
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Lower Slope[3]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Grand mean	All	NA	0.34	0.22	0.24	NA	0.24	NA	NA	0.16	0.26	0.01

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

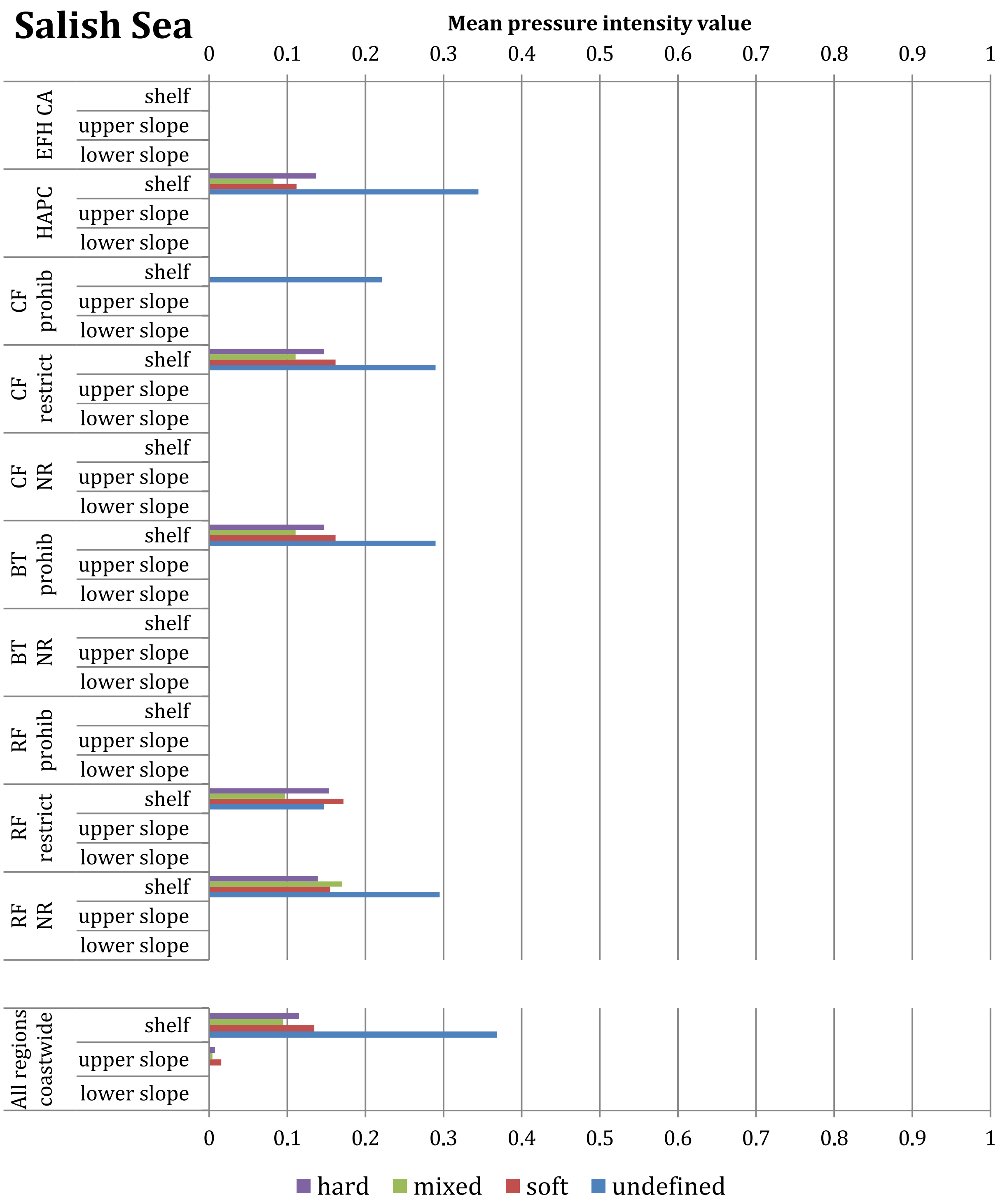


Figure A3b.31. Nutrient input. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

3.2.4.5 Sediment input (decreases and increases)

Sediment is a natural component in water bodies and the uses they support, but can also impair them in many ways (USEPA 1999b). Excessive sediments in waterways can cause direct physical harm to organisms (e.g. clogged gills), as well as impairment of aquatic feeding, rearing, spawning, and refuge habitats. As well, sediment deficits can result in stream channel scour and destruction of other habitat features. As a result, the federal Clean Water Act requires states, territories, and authorized tribes to identify and list impaired waters every two years and to develop total maximum daily loads (TMDLs) for sediment in these waters, with oversight from the U.S. Environmental Protection Agency. TMDLs establish the allowable pollutant loadings, thereby providing the basis for establishing water quality-based controls (USEPA 1999b).

Rivers are important conduits of large amounts of particulate and dissolved minerals and nutrients to the oceans, and play a key role in the global biogeochemical cycle (Dai et al. 2009). Humans are simultaneously increasing the river transport of sediment and dissolved constituents through soil erosion activities, and decreasing this flux to the coastal zone through sediment retention in reservoirs (Syvitski et al. 2005, Milliman et al. 2008). The net result is a global reduction in sediment flux by about 1.4 BT/year over pre-human loads. Rivers are globally getting dirtier and would otherwise move more sediment to the coast if not for the impact of reservoirs. The seasonal delivery of sediment to the coast affects the dynamics of nutrient fluxes to the coast and has serious implications to coastal fisheries, coral reefs, and seagrass communities (Syvitski et al. 2005). One example includes a reduction in natural dissolved silicate loads, which translates into silicon limitation in the coastal zone that discourages diatom blooms and favors nuisance and toxic phytoplankton, thereby compromising the integrity of coastal food webs (Vorosmarty and Sahagian 2000). Coastal retreat, which is directly influenced by the reduction of river-supplied sediment, has major implications for human habitat because >37% (2.1 billion people in 1994) of the world's population live within 100 km of a coastline (Syvitski et al. 2005). Dam removal restores the natural sediment transport regime and has become an increasingly adopted strategy to manage the environmental costs of these structures (Graf 1999, The Heinz Center 2002).

Changes in sediment supply can greatly influence the benthic environment of coastal estuaries, coral reefs, and seagrass communities, and are intimately tied to nutrient fluxes in these systems (Syvitski et al. 2005). Sediment delivery rates also affect harbor maintenance and pollutant burial or resuspension. Decreases in sediment input are largely the result of river damming or diversions, which directly influence the rate of coastal retreat. Dams affect the physical integrity of watersheds by fragmenting the lengths of rivers, changing their hydrologic characteristics, and altering their sediment regimes by trapping most of the sediment entering the reservoirs and disrupting the sediment budget of the downstream landscape (The Heinz Center 2002, Johnson et al. 2008). Because water released from dams is relatively free of sediment, downstream reaches of rivers may be altered by increased particle size, erosion, channel shrinkage, and deactivation of floodplains (The Heinz Center 2002). The consequence of reduced sediment also extends to long stretches of coastline where the erosive effect of waves is no longer sustained by sediment inputs from rivers (World Commission on Dams 2000). The effects to fishes of a reduced sediment regime would be indirect and primarily experienced through the long-term loss of soft-bottom habitat features and coastal landforms and/or changes to benthic habitat composition.

Increases in sediment input are largely due to land use practices that increase erosion rates (e.g., deforestation, wetland drainage, mining) or human activities in or near aquatic habitats (e.g., dredging) that re-suspend bottom sediments and create turbid conditions (Syvitski et al. 2005). Suspended sediments can elicit a variety of responses from aquatic biota; these responses may range from an active preference for turbid conditions, presumably to facilitate feeding and avoidance behaviors, to detrimental physical impacts that may result in egg abrasion, reduced bivalve pumping rates, and direct mortality (Wilber and Clarke 2001). Much of the available data on biological effects on organisms come from bioassays that measure acute responses and require high concentrations of suspended sediments to induce the measured response, usually mortality (Wilber and Clarke 2001). Although anadromous salmonids have received much attention, little is known of behavioral responses of many estuarine fishes to suspended sediment plumes. There is a high degree of species variability in response to sedimentation; reports of ‘‘no effect’’ were made at concentrations as great as 14,000 mg/L for durations of 3 d and more (oyster toadfish and spot) and mortality was observed at a concentration/duration combination of 580 mg/L for 1 d (Atlantic silversides). For both salmonid and estuarine fishes, the egg and larval stages are more sensitive to suspended sediment impacts than are the older life history stages.

For specific details on the creation of each pressure data layer, see Halpern et al. (2008, 2009). Briefly, sediment decrease and sediment increase data layers were calculated using a sediment release model (Syvitski et al. 2003) with the current location of dams and temperature (accounts for increases in precipitation correlated with rising temperatures). Increases in sediment occurred exclusively in watersheds without dams, while decreases in sediment occurred mostly in watersheds with dams.

Sediment runoff decrease intensity values were highest in the Salish Sea and lowest in the northern sub-region (Fig. A3b.32-33; Table A3b.29). Sediment decrease was highest in shelf habitat and was absent from all lower slope habitat (Fig. A3b.32-34, Tables A3b.29-30). Sediment runoff decrease was generally higher in HAPCs and in areas prohibited to commercial and recreational fishing (Fig. A3b.34, Table A3b.30); however, this was likely because these management areas were in nearshore habitats that were more exposed to land-based pressures and had little to do with EFH-related management boundaries. These coastwide patterns were generally reflected within each biogeographic sub-region (Figs. A3b.35-38, Tables A3b.31-34).

Sediment runoff increase intensity values were more evenly distributed along the West Coast than sediment runoff decreases, but the highest values were still located in the Salish Sea (Figs.

39-40, Table A3b.35). Sediment runoff increase intensity values were highest in shelf habitat, but there was some exposure to this pressure in the upper slope habitat particularly in the central and southern sub-regions, but values were still very low (Figs. 39-41, Tables A3b.35-36). Sediment runoff increase was generally higher in HAPCs and in areas prohibited to commercial and recreational fishing (Fig. A3b.41, Table A3b.36); however, this was likely because these management areas were in nearshore habitats that were more exposed to land-based pressures and had little to do with EFH-related management boundaries. These coastwide patterns were generally reflected within each biogeographic sub-region (Figs. A3b.42-45, Tables A3b.37-40).

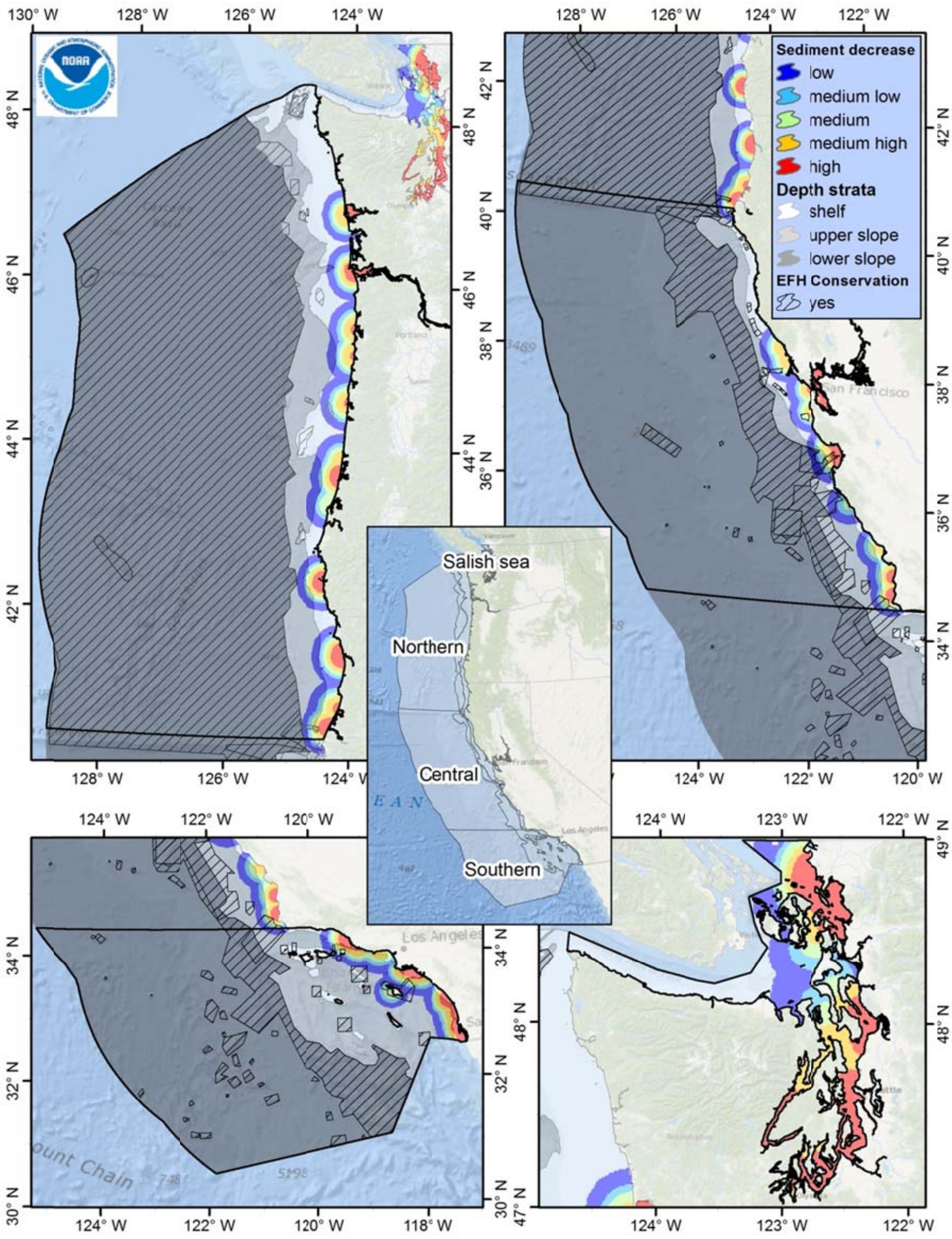


Figure A3b.32. Distribution of sediment runoff decrease intensity values among biogeographic regions, depth strata and essential fish habitat (EFH) conservation areas. Sediment decrease data is from Halpern et al. 2009.

Table A3b.29. Mean intensity values for sediment runoff decrease by depth zones and seabed substrate types across 4 biogeographic regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from the sums of 16 pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1.

SEDIMENT RUNOFF DECREASE						
Depth Zone	*Substrate*	*Northern*	*Central*	*Southern*	*Salish Sea*	*Coastwide*
Shelf[1]	All	0.16	0.25	0.24	0.32	0.21
	hard	0.06	0.27	0.20	0.10	0.14
	mixed	0.03	0.25	0.09	0.06	0.08
	soft	0.17	0.21	0.25	0.15	0.19
	undefined	0.73	0.74	0.43	0.42	0.49
Upper Slope[2]	All	0.01	0.02	0.05	NA	0.03
	hard	0.00	0.01	0.02	NA	0.01
	mixed	0.00	0.01	0.01	NA	0.00
	soft	0.01	0.03	0.05	NA	0.03
	undefined	NA	0.00	0.03	NA	0.01
Lower Slope[3]	All	0.00	0.00	0.00	NA	0.00
	hard	0.00	0.00	0.00	NA	0.00
	mixed	0.00	0.00	0.00	NA	0.00
	soft	0.00	0.00	0.00	NA	0.00
	undefined	0.00	0.00	0.00	NA	0.00
Grand mean	All	0.02	0.02	0.02	0.32	0.02

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

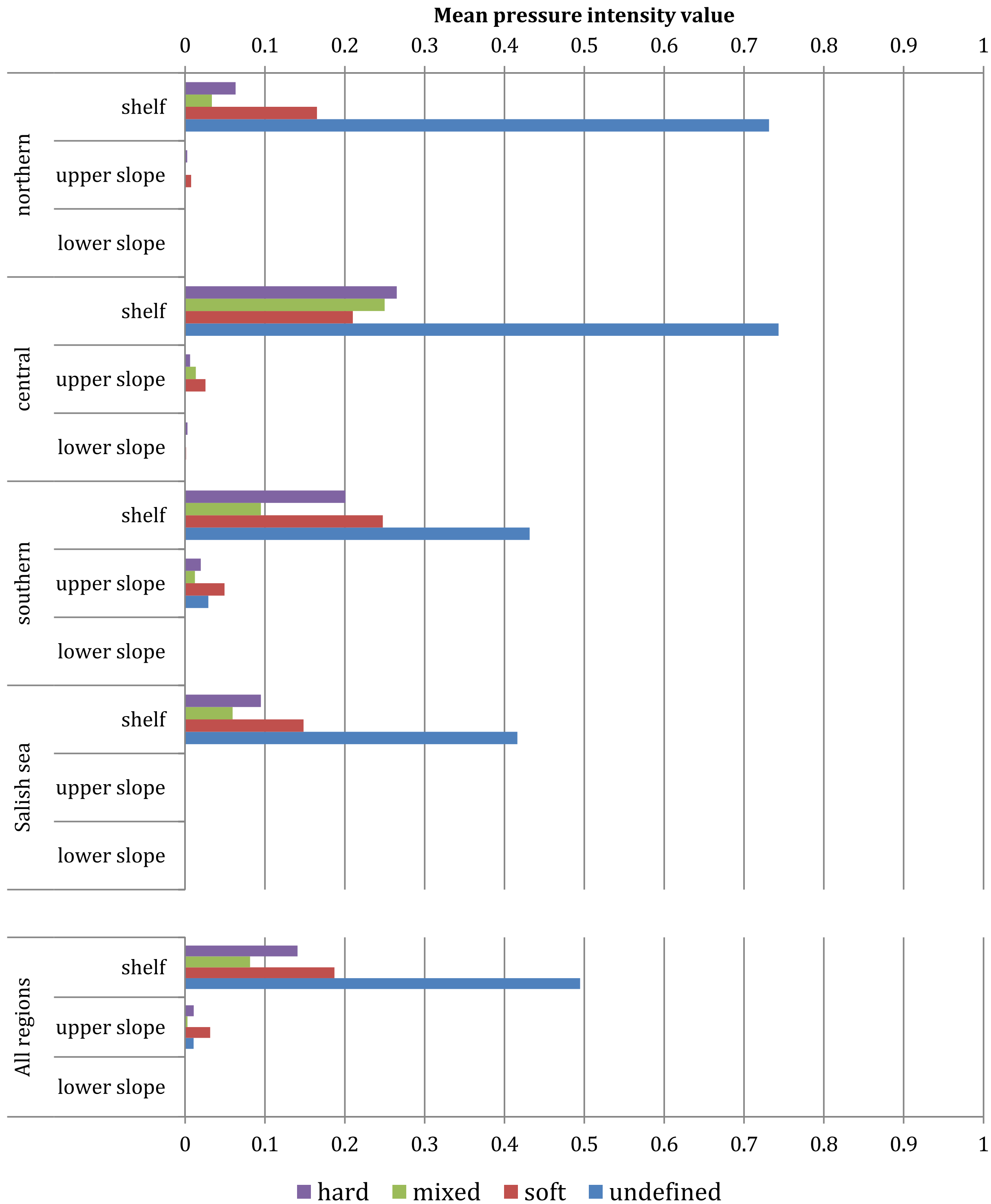


Figure A3b.33. Sediment runoff decrease. Mean pressure intensity values among seabed substrate types by depth zones across 4 biogeographic sub-regions: “Northern” (i.e., Cape Flattery, WA to Cape Mendocino, CA), “Central” (i.e., Cape Mendocino, CA to Point Conception, CA), “Southern” (i.e., Point Conception, CA to U.S.-Mexico maritime border) and “Salish Sea” (i.e., Straits of Juan de Fuca, Georgia and Puget Sound).

Table A3b.30. Mean intensity values for sediment runoff decrease by depth zones and seabed substrate types across various management boundaries. Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

SEDIMENT RUNOFF DECREASE												
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawling*		*Recreational fishing*			*Coastwide*
Depth Zone	**Substrate**			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	**All**	**0.10**	**0.31**	**0.17**	**0.22**	**0.20**	**0.26**	**0.18**	**0.14**	**0.07**	**0.24**	**0.21**
	hard	0.09	0.11	0.23	0.15	0.12	0.16	0.11	0.17	0.08	0.15	0.14
	mixed	0.03	0.06	0.19	0.08	0.07	0.11	0.04	0.15	0.03	0.12	0.08
	soft	0.11	0.17	0.16	0.17	0.20	0.21	0.17	0.14	0.07	0.21	0.19
	undefined	0.10	0.65	0.45	0.48	0.71	0.48	0.70	0.06	0.24	0.50	0.49
Upper Slope[2]	**All**	**0.02**	**0.02**	**0.20**	**0.03**	**0.03**	**0.05**	**0.03**	**0.18**	**0.00**	**0.03**	**0.03**
	hard	0.01	0.01	0.31	0.01	0.01	0.02	0.01	0.31	0.00	0.01	0.01
	mixed	0.00	0.00	0.18	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	soft	0.02	0.03	0.20	0.03	0.03	0.06	0.03	0.18	0.00	0.04	0.03
	undefined	0.00	0.00	NA	0.00	0.02	0.00	0.02	NA	NA	0.01	0.01
Lower Slope[3]	**All**	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**0.00**
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.01	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	**All**	**0.00**	**0.10**	**0.17**	**0.02**	**0.02**	**0.02**	**0.02**	**0.15**	**0.03**	**0.02**	**0.02**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

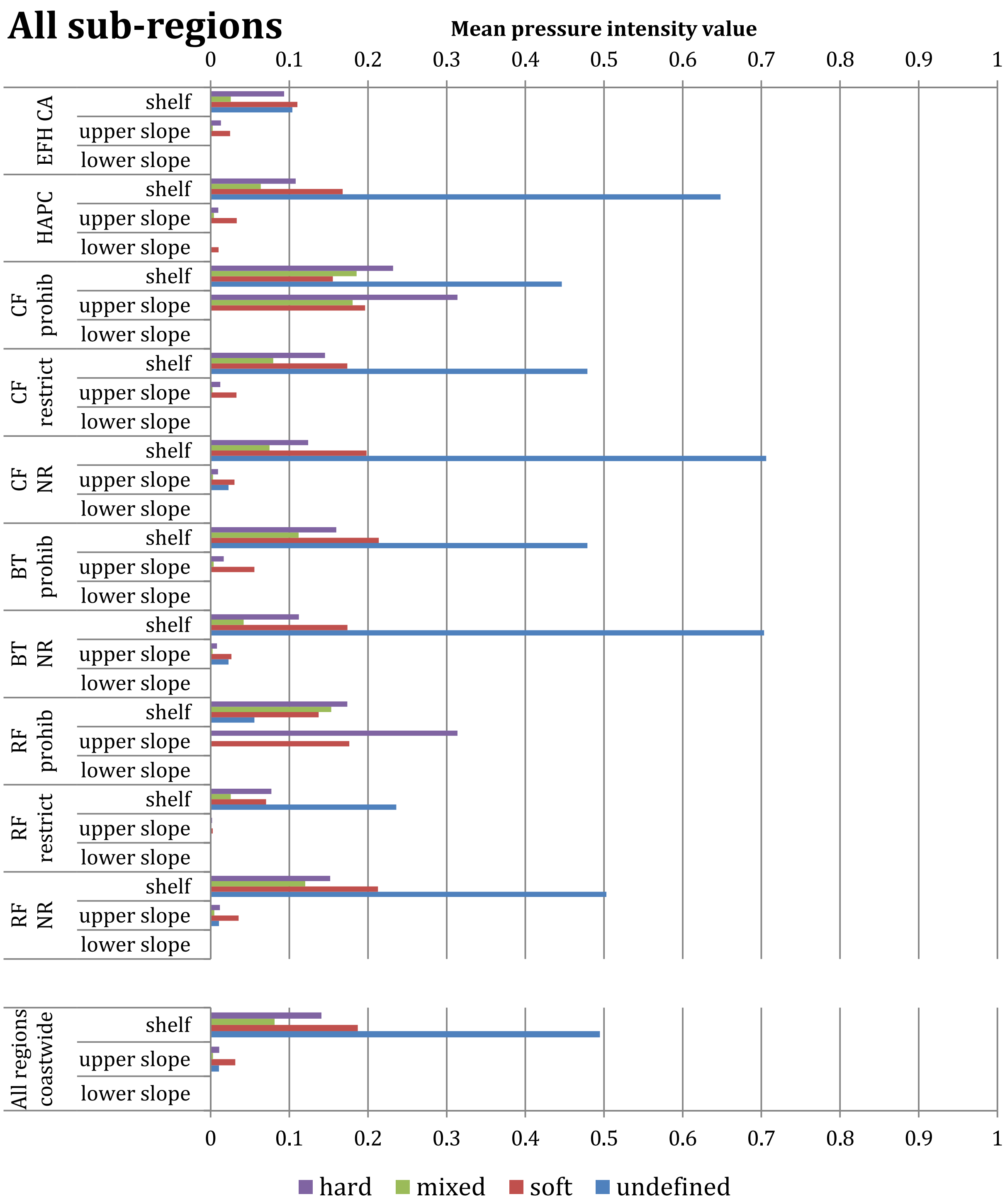


Figure A3b.34. Sediment runoff decrease. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries across all biogeographic regions. EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.31. Mean intensity values for sediment runoff decrease by depth zones and seabed substrate types across various management boundaries in the “Northern” biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where “Commercial fishing” was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

SEDIMENT DECREASE	NORTHERN BIOGEOGRAPHIC SUB-REGION										COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.01	0.16	0.68	0.11	0.19	0.17	0.16	0.68	0.04	0.20	0.21
	hard	0.01	0.03	NA	0.02	0.09	0.02	0.09	NA	0.01	0.07	0.14
	mixed	0.00	0.01	NA	0.02	0.07	0.03	0.04	NA	0.01	0.06	0.08
	soft	0.02	0.16	0.68	0.12	0.19	0.19	0.16	0.68	0.04	0.20	0.19
	undefined	NA	0.82	NA	0.77	0.73	0.79	0.73	NA	0.00	0.74	0.49
Upper Slope[2]	All	0.01	0.00	NA	0.01	0.01	0.02	0.01	NA	0.00	0.01	0.03
	hard	0.00	0.00	NA	0.01	0.00	0.01	0.00	NA	0.00	0.00	0.01
	mixed	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	soft	0.01	0.00	NA	0.02	0.01	0.02	0.01	NA	0.00	0.01	0.03
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.00	0.07	0.68	0.01	0.09	0.00	0.09	0.68	0.03	0.02	0.02

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

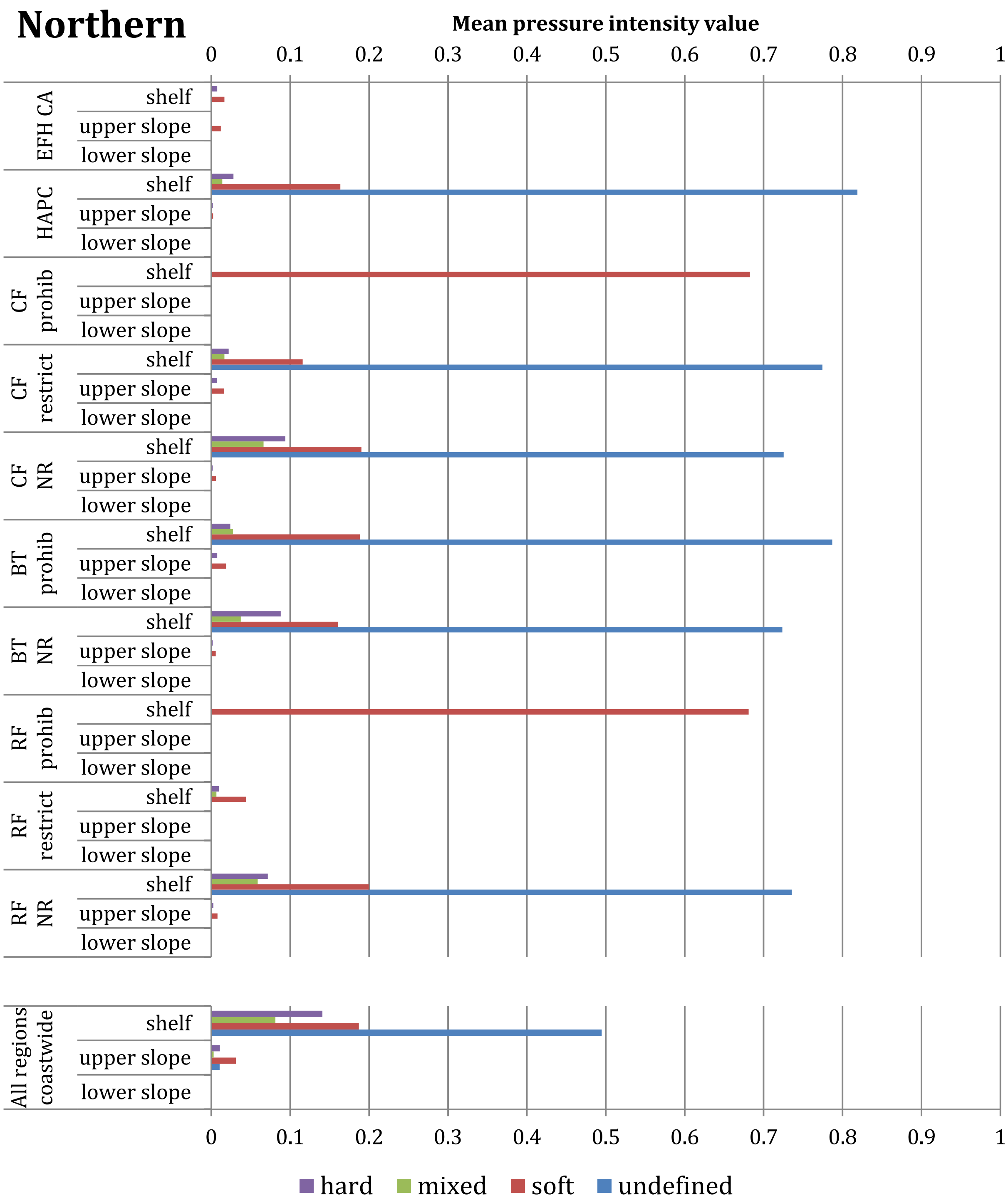


Figure A3b.35. Sediment runoff decrease. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the “Northern” biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.32. Mean intensity values for sediment runoff decrease by depth zones and seabed substrate types across various management boundaries in the "Central" biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

SEDIMENT DECREASE		**CENTRAL BIOGEOGRAPHIC SUB-REGION**										**COASTWIDE**
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.18	0.47	0.25	0.33	0.17	0.32	0.17	0.25	0.29	0.24	0.21
	hard	0.24	0.29	0.22	0.28	0.18	0.28	0.18	0.17	0.38	0.26	0.14
	mixed	0.11	0.27	0.19	0.25	0.29	0.25	0.31	0.16	0.29	0.25	0.08
	soft	0.17	0.29	0.25	0.26	0.17	0.26	0.17	0.27	0.27	0.21	0.19
	undefined	0.26	0.77	0.52	0.75	0.55	0.75	0.54	0.01	0.37	0.75	0.49
Upper Slope[2]	All	0.02	0.02	0.30	0.04	0.02	0.04	0.02	0.30	0.31	0.02	0.03
	hard	0.01	0.01	NA	0.01	0.00	0.01	0.00	NA	0.69	0.01	0.01
	mixed	0.09	0.08	0.18	0.01	0.00	0.02	0.00	NA	NA	0.01	0.00
	soft	0.03	0.10	0.30	0.05	0.02	0.05	0.02	0.30	0.30	0.02	0.03
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.01
Lower Slope[3]	All	0.00	0.01	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	hard	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.02	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.01	0.12	0.25	0.04	0.01	0.04	0.01	0.25	0.29	0.01	0.02

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

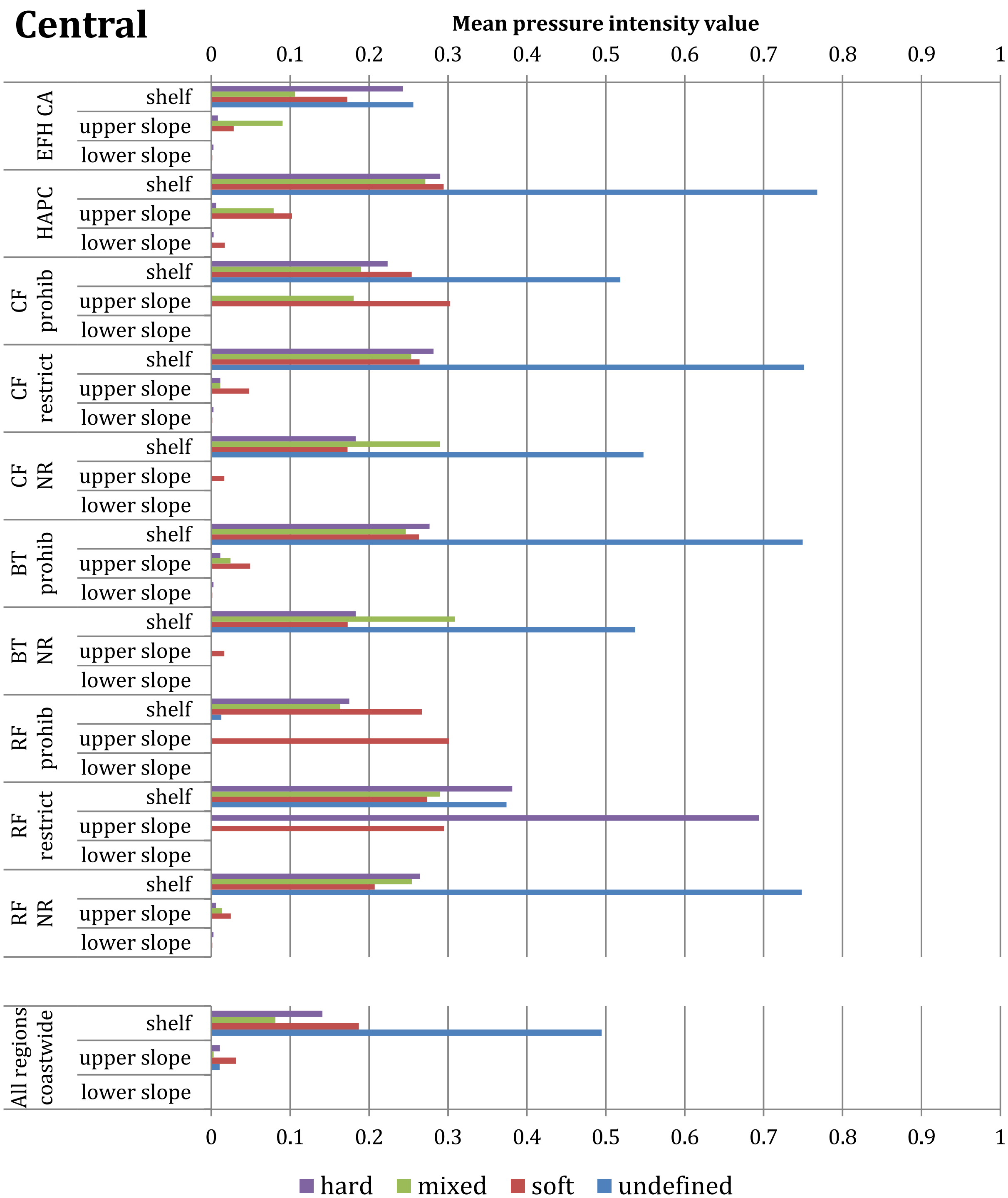


Figure A3b.36. Sediment runoff decrease. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the “Central” biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.33. Mean intensity values for sediment runoff decrease by depth zones and seabed substrate types across various management boundaries in the "Southern" biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

SEDIMENT DECREASE	SOUTHERN BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.06	0.09	0.10	0.20	0.47	0.21	0.35	0.06	0.04	0.32	0.21
	hard	0.01	0.14	0.24	0.15	0.44	0.19	0.24	0.17	0.02	0.29	0.14
	mixed	0.05	0.05	0.18	0.09	0.06	0.12	0.01	0.14	0.04	0.13	0.08
	soft	0.06	0.07	0.09	0.20	0.47	0.21	0.37	0.05	0.05	0.32	0.19
	undefined	0.00	0.47	0.15	0.44	0.42	0.43	0.42	0.14	0.22	0.46	0.49
Upper Slope[2]	All	0.03	0.02	0.18	0.03	0.06	0.08	0.04	0.16	0.00	0.06	0.03
	hard	0.05	0.02	0.31	0.01	0.02	0.04	0.02	0.31	0.00	0.03	0.01
	mixed	0.00	0.01	NA	0.01	0.10	0.01	0.02	NA	0.00	0.11	0.00
	soft	0.03	0.02	0.18	0.03	0.06	0.09	0.04	0.16	0.00	0.07	0.03
	undefined	NA	NA	NA	0.00	0.03	0.00	0.03	NA	NA	0.03	0.01
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.00	0.02	0.12	0.03	0.01	0.03	0.01	0.08	0.01	0.02	0.02

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

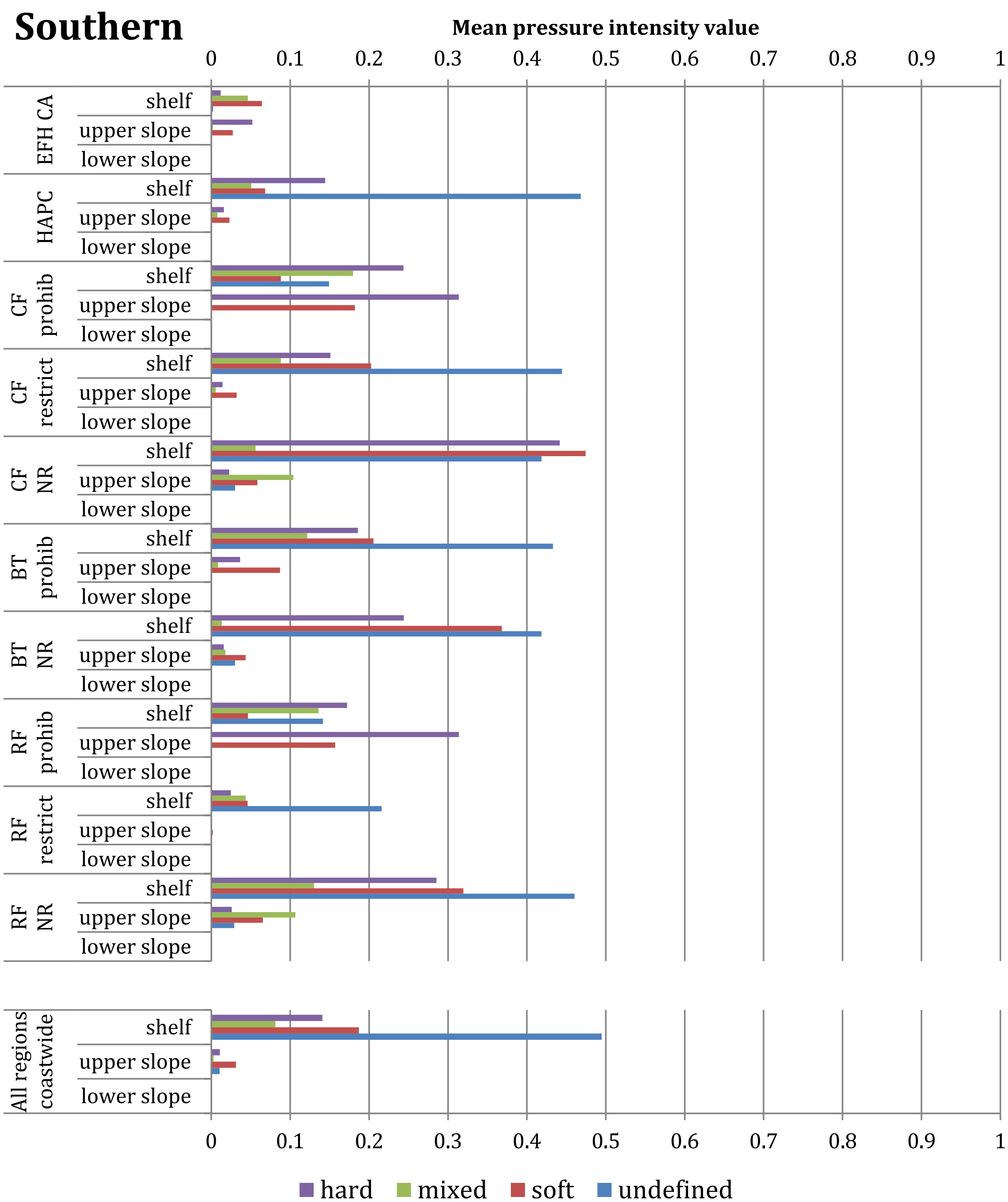


Figure A3b.37. Sediment runoff decrease. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Southern" biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.34. Mean intensity values for sediment runoff decrease by depth zones and seabed substrate types across various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

SEDIMENT DECREASE	SALISH SEA BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	NA	0.57	0.53	0.32	NA	0.32	NA	NA	0.22	0.34	0.21
	hard	NA	0.00	NA	0.10	NA	0.10	NA	NA	0.17	0.00	0.14
	mixed	NA	0.00	NA	0.06	NA	0.06	NA	NA	0.06	0.05	0.08
	soft	NA	0.12	NA	0.15	NA	0.15	NA	NA	0.23	0.09	0.19
	undefined	NA	0.58	0.53	0.42	NA	0.42	NA	NA	0.23	0.42	0.49
Upper Slope[2]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.03
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.03
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01
Lower Slope[3]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Grand mean	All	NA	0.57	0.53	0.32	NA	0.32	NA	NA	0.22	0.34	0.02

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

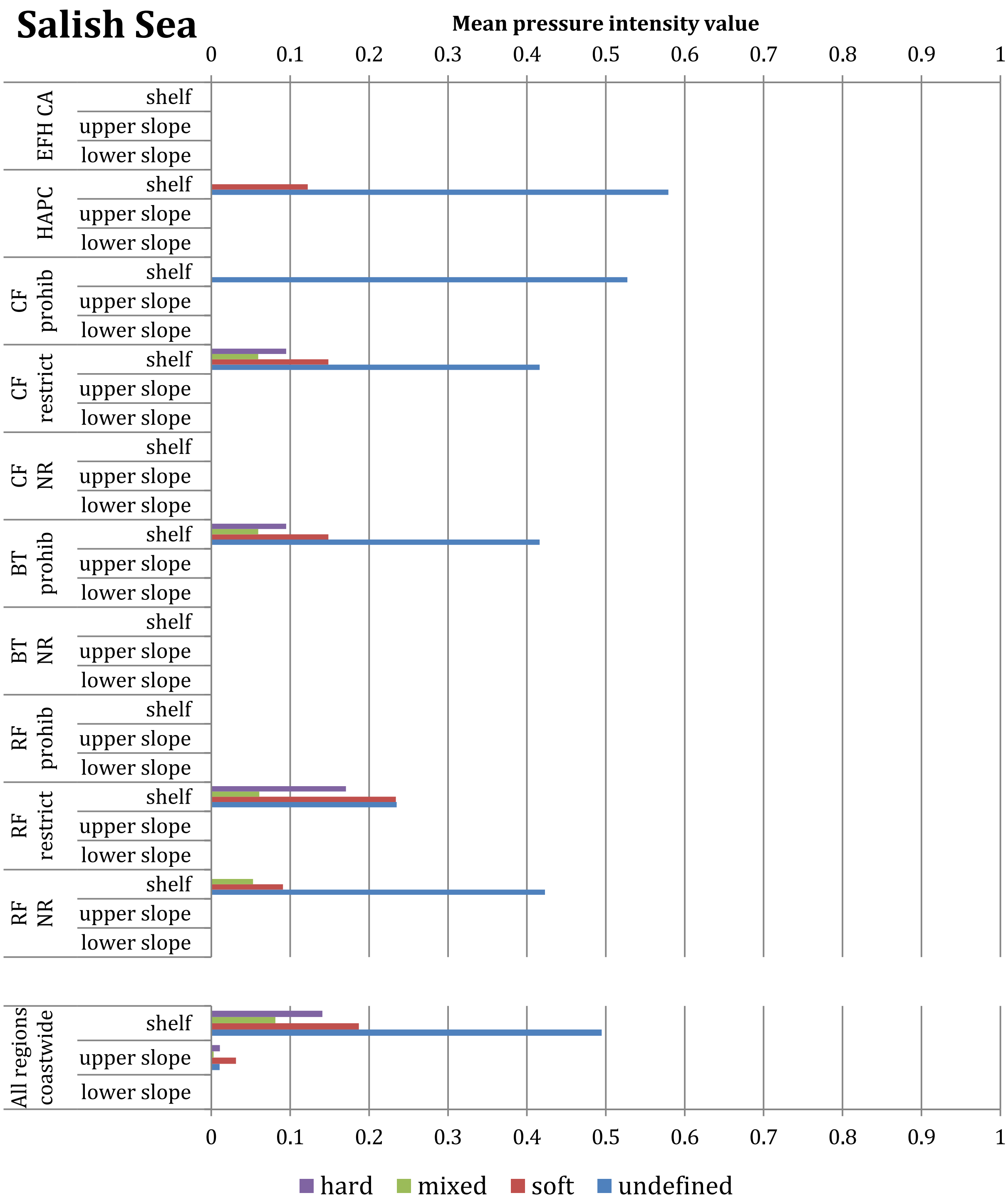


Figure A3b.38. Sediment runoff decrease. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

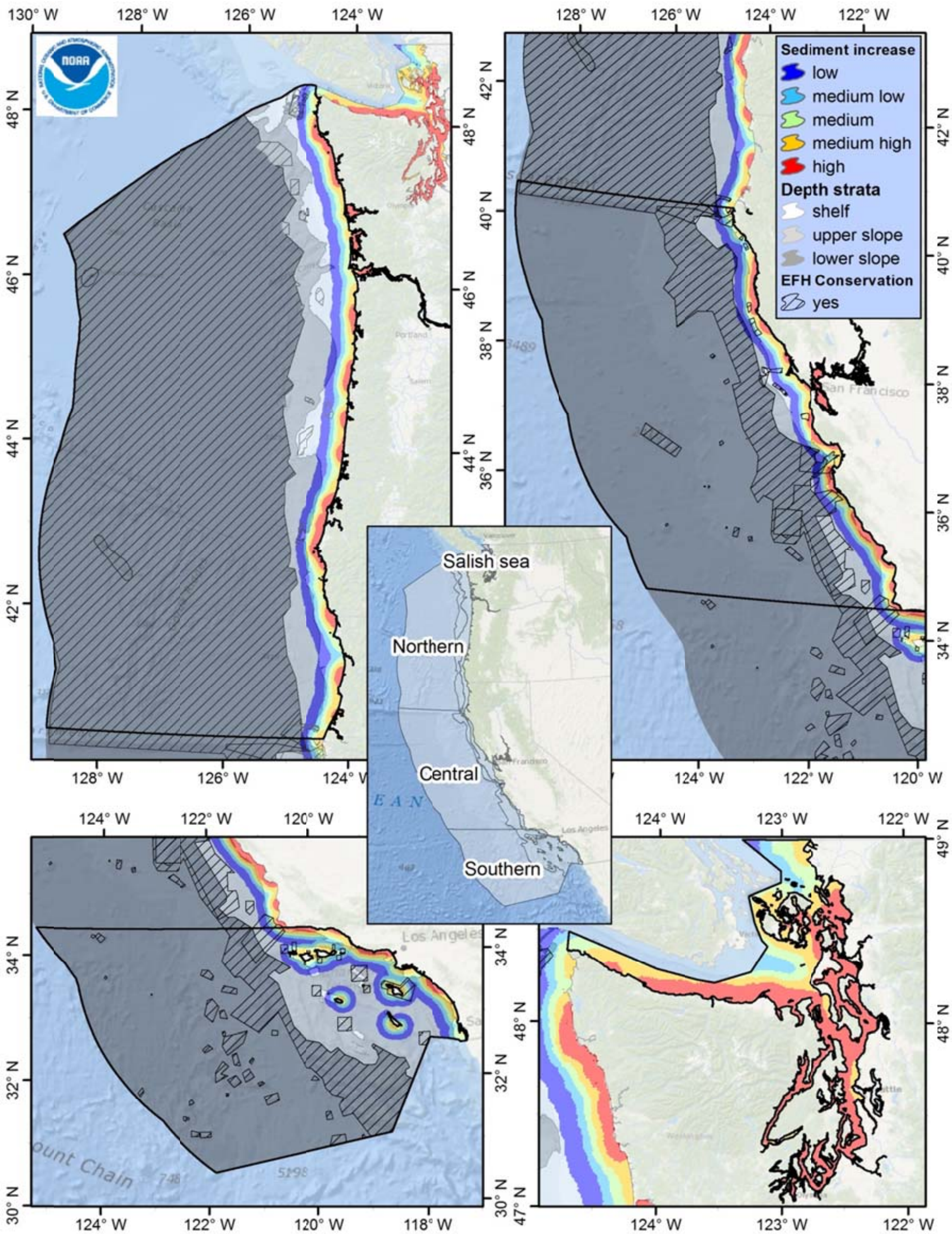


Figure A3b.39. Distribution of sediment runoff increase intensity values among biogeographic regions, depth strata and essential fish habitat (EFH) conservation areas. Sediment increase data is from Halpern et al. 2009.

Table A3b.35. Mean intensity values for sediment runoff increase by depth zones and seabed substrate types across 4 biogeographic regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1.

SEDIMENT RUNOFF INCREASE						
Depth Zone	*Substrate*	*Northern*	*Central*	*Southern*	*Salish Sea*	*Coastwide*
Shelf[1]	All	0.31	0.53	0.47	0.68	0.42
	hard	0.19	0.60	0.35	0.68	0.35
	mixed	0.21	0.63	0.38	0.52	0.33
	soft	0.31	0.50	0.48	0.65	0.40
	undefined	0.71	0.87	0.50	0.70	0.72
Upper Slope[2]	All	0.01	0.10	0.09	NA	0.07
	hard	0.00	0.02	0.07	NA	0.04
	mixed	0.02	0.10	0.03	NA	0.02
	soft	0.01	0.11	0.09	NA	0.07
	undefined	NA	0.00	0.03	NA	0.01
Lower Slope[3]	All	0.00	0.00	0.00	NA	0.00
	hard	0.00	0.00	0.00	NA	0.00
	mixed	0.00	0.01	0.00	NA	0.00
	soft	0.00	0.00	0.00	NA	0.00
	undefined	0.00	0.00	0.00	NA	0.00
Grand mean	All	0.03	0.04	0.04	0.68	0.04

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

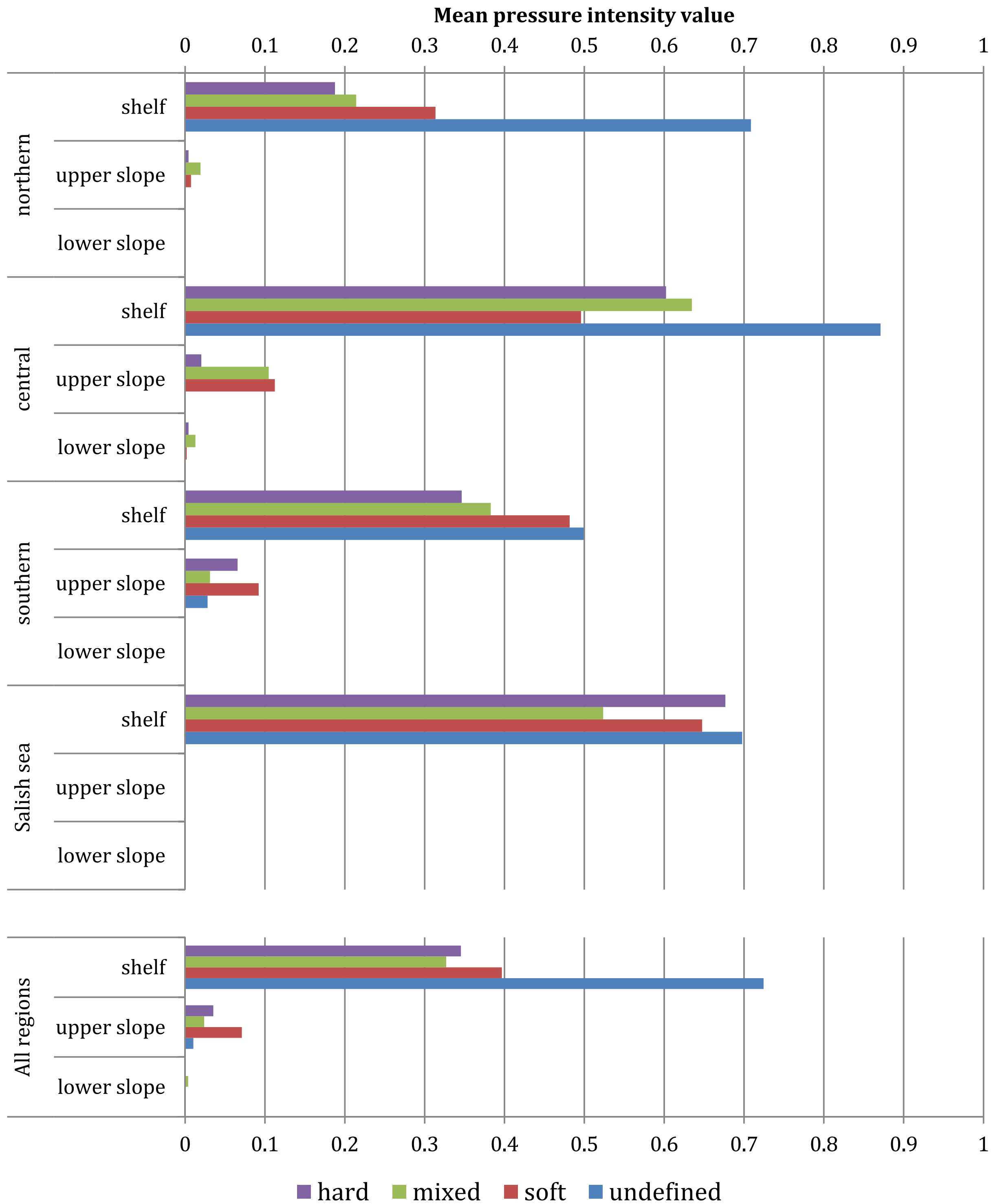


Figure A3b.40. Sediment runoff increase. Mean pressure intensity values among seabed substrate types by depth zones across 4 biogeographic sub-regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound).

Table A3b.36. Mean intensity values for sediment runoff increase by depth zones and seabed substrate types across various management boundaries. Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

SEDIMENT RUNOFF INCREASE												
		EFH CA	***HAPC***	***Commercial fishing***			***Bottom trawling***		***Recreational fishing***			***Coastwide***
Depth Zone	***Substrate***			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	**All**	**0.25**	**0.56**	**0.50**	**0.49**	**0.35**	**0.57**	**0.32**	**0.49**	**0.29**	**0.45**	**0.42**
	hard	0.16	0.26	0.56	0.39	0.26	0.42	0.24	0.55	0.36	0.33	0.35
	mixed	0.08	0.30	0.64	0.26	0.50	0.36	0.28	0.68	0.14	0.45	0.33
	soft	0.30	0.52	0.49	0.45	0.35	0.55	0.32	0.47	0.30	0.42	0.40
	undefined	0.42	0.82	0.68	0.73	0.69	0.73	0.69	0.47	0.51	0.73	0.72
Upper Slope[2]	**All**	**0.08**	**0.06**	**0.45**	**0.08**	**0.06**	**0.12**	**0.06**	**0.45**	**0.02**	**0.08**	**0.07**
	hard	0.04	0.03	0.68	0.05	0.02	0.06	0.02	0.70	0.01	0.04	0.04
	mixed	0.02	0.04	0.90	0.02	0.03	0.03	0.02	NA	0.01	0.03	0.02
	soft	0.08	0.11	0.44	0.09	0.06	0.13	0.06	0.44	0.02	0.08	0.07
	undefined	0.00	0.00	NA	0.00	0.02	0.00	0.02	NA	NA	0.01	0.01
Lower Slope[3]	**All**	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**0.00**
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	mixed	0.00	0.01	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.02	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	**All**	**0.01**	**0.19**	**0.49**	**0.04**	**0.04**	**0.04**	**0.04**	**0.48**	**0.14**	**0.04**	**0.04**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

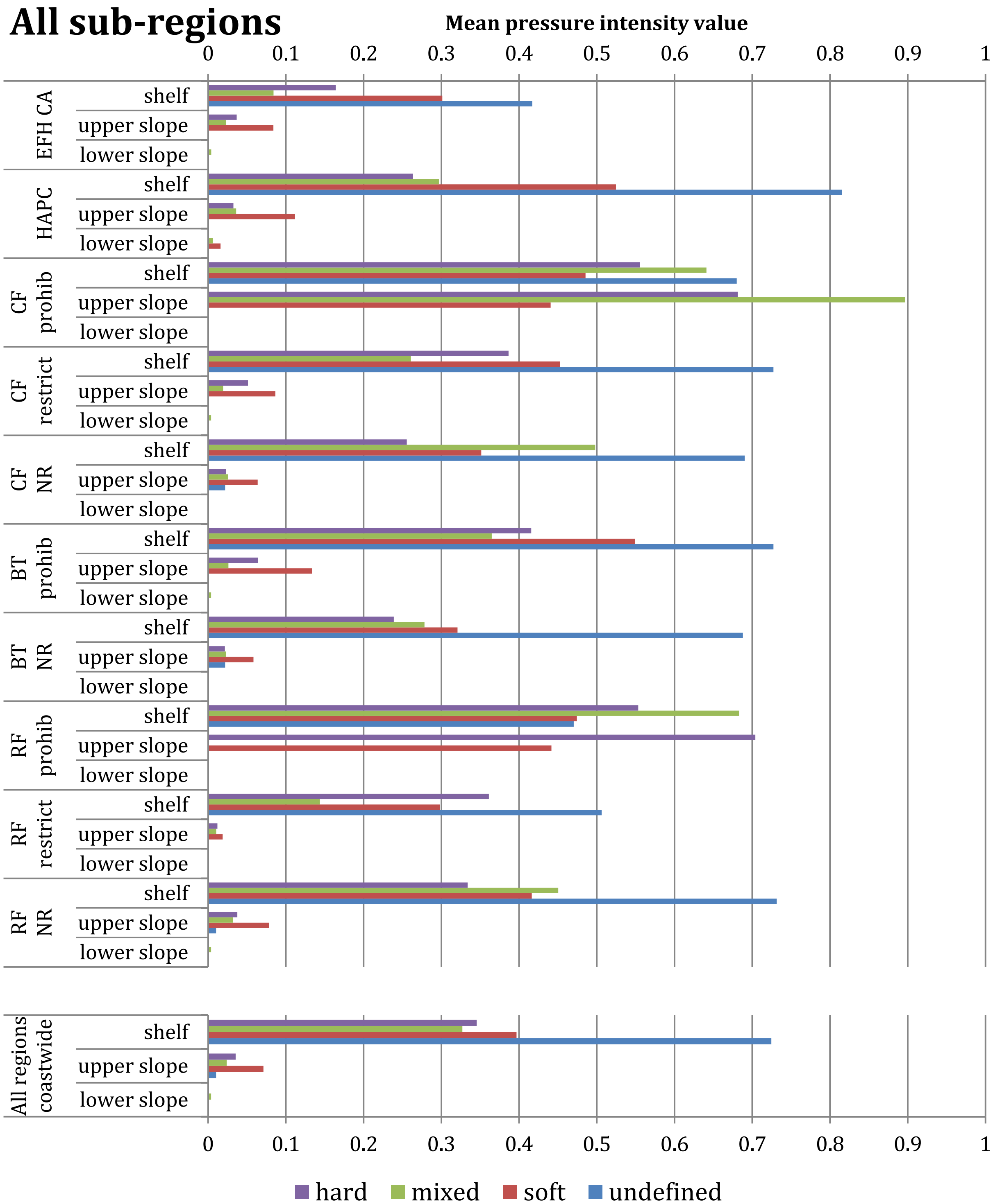


Figure A3b.41. Sediment runoff increase. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries across all biogeographic regions. EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.37. Mean intensity values for sediment runoff increase by depth zones and seabed substrate types across various management boundaries in the “Northern” biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where “Commercial fishing” was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

SEDIMENT INCREASE	NORTHERN BIOGEOGRAPHIC SUB-REGION										COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.01	0.49	0.82	0.29	0.32	0.42	0.29	0.83	0.25	0.33	0.42
	hard	0.01	0.14	NA	0.16	0.21	0.16	0.21	NA	0.39	0.16	0.35
	mixed	0.00	0.26	NA	0.08	0.48	0.12	0.28	NA	0.07	0.35	0.33
	soft	0.03	0.65	0.82	0.31	0.31	0.47	0.28	0.83	0.25	0.33	0.40
	undefined	NA	0.79	NA	0.72	0.71	0.73	0.71	NA	0.50	0.71	0.72
Upper Slope[2]	All	0.01	0.01	NA	0.02	0.01	0.02	0.01	NA	0.01	0.01	0.07
	hard	0.00	0.00	NA	0.01	0.00	0.01	0.00	NA	0.03	0.00	0.04
	mixed	0.02	0.03	NA	0.01	0.02	0.01	0.02	NA	0.02	0.02	0.02
	soft	0.01	0.01	NA	0.02	0.01	0.02	0.01	NA	0.00	0.01	0.07
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.00	0.21	0.82	0.01	0.15	0.01	0.15	0.83	0.21	0.03	0.04

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

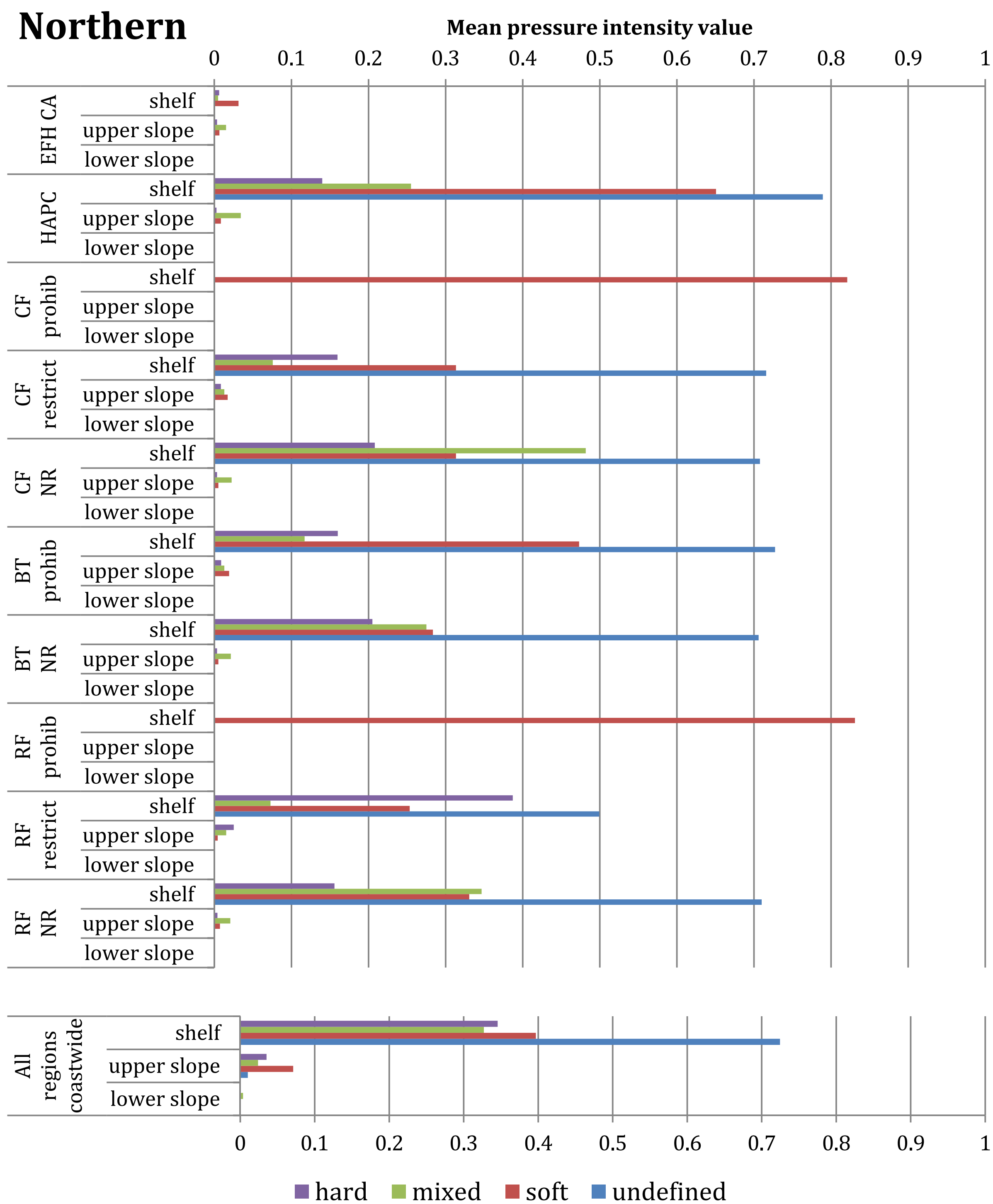


Figure A3b.42. Sediment runoff increase. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Northern" biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.38. Mean intensity values for sediment runoff increase by depth zones and seabed substrate types across various management boundaries in the "Central" biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

SEDIMENT INCREASE	CENTRAL BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		Efh Ca	*Hapc*	*Commercial Fishing*			*Bottom Trawl*		*Recreational Fishing*			*All*
Depth Zone	Substrate			Prohib	Restr	NR	Prohib	NR	Prohib	Restr	NR	
Shelf[1]	All	0.40	0.65	0.65	0.65	0.41	0.65	0.41	0.66	0.65	0.52	0.42
	hard	0.41	0.54	0.64	0.61	0.52	0.61	0.52	0.67	0.74	0.59	0.35
	mixed	0.34	0.50	0.81	0.62	0.65	0.63	0.66	0.84	0.77	0.61	0.33
	soft	0.40	0.48	0.64	0.62	0.41	0.62	0.41	0.65	0.64	0.49	0.40
	undefined	0.39	0.90	0.73	0.88	0.59	0.88	0.58	0.33	0.54	0.88	0.72
Upper Slope[2]	All	0.08	0.07	0.62	0.12	0.09	0.12	0.09	0.60	0.69	0.10	0.07
	hard	0.02	0.02	NA	0.03	0.01	0.03	0.01	NA	0.50	0.02	0.04
	mixed	0.39	0.43	0.90	0.09	0.05	0.15	0.05	NA	NA	0.10	0.02
	soft	0.10	0.30	0.60	0.15	0.10	0.15	0.10	0.60	0.70	0.11	0.07
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.01
Lower Slope[3]	All	0.00	0.01	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	hard	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	mixed	0.01	0.02	NA	0.01	NA	0.01	NA	NA	NA	0.01	0.00
	soft	0.00	0.03	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.02	0.18	0.65	0.08	0.02	0.08	0.02	0.65	0.66	0.04	0.04

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

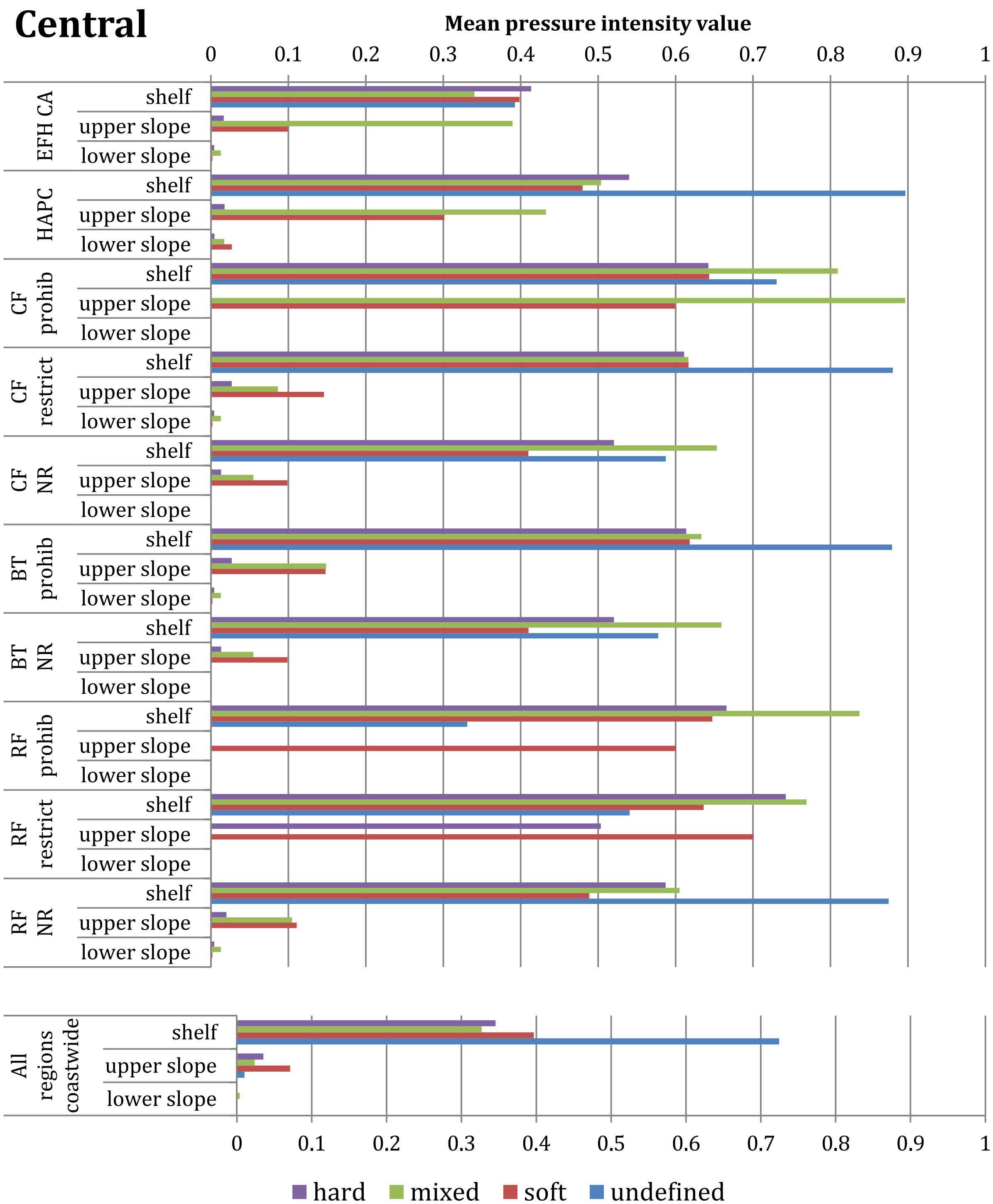


Figure A3b.43. Sediment runoff increase. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the “Central” biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.39. Mean intensity values for sediment runoff increase by depth zones and seabed substrate types across various management boundaries in the "Southern" biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

SEDIMENT INCREASE	SOUTHERN BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.27	0.27	0.39	0.46	0.54	0.49	0.41	0.36	0.24	0.55	0.42
	hard	0.12	0.28	0.44	0.31	0.50	0.37	0.28	0.39	0.07	0.47	0.35
	mixed	0.13	0.17	0.41	0.35	0.80	0.45	0.19	0.42	0.12	0.59	0.33
	soft	0.29	0.28	0.38	0.48	0.54	0.50	0.43	0.35	0.26	0.55	0.40
	undefined	0.43	0.43	0.59	0.52	0.32	0.52	0.32	0.75	0.49	0.50	0.72
Upper Slope[2]	All	0.11	0.07	0.43	0.09	0.09	0.20	0.07	0.42	0.02	0.11	0.07
	hard	0.19	0.06	0.68	0.09	0.05	0.20	0.04	0.70	0.01	0.08	0.04
	mixed	0.02	0.02	NA	0.02	0.13	0.03	0.03	NA	0.00	0.26	0.02
	soft	0.11	0.09	0.42	0.09	0.09	0.20	0.08	0.42	0.02	0.12	0.07
	undefined	NA	NA	NA	0.00	0.03	0.00	0.03	NA	NA	0.03	0.01
Lower Slope[3]	All	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	hard	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	mixed	0.00	0.00	NA	0.00	NA	0.00	NA	NA	NA	0.00	0.00
	soft	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00
	undefined	0.00	0.00	NA	0.00	0.00	0.00	0.00	NA	NA	0.00	0.00
Grand mean	All	0.02	0.06	0.40	0.07	0.02	0.08	0.02	0.38	0.04	0.03	0.04

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

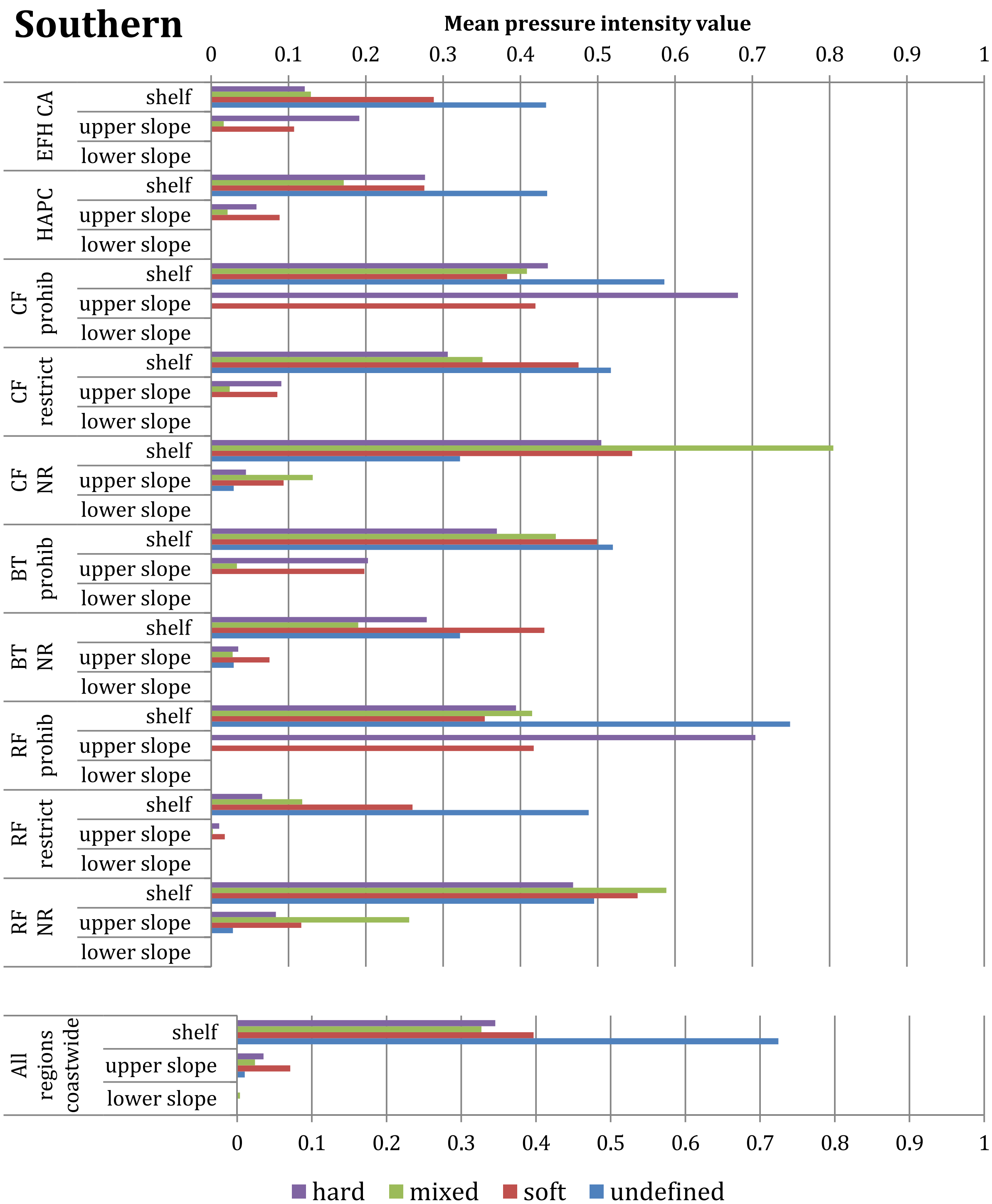


Figure A3b.44. Sediment runoff increase. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the “Southern” biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.40. Mean intensity values for sediment runoff increase by depth zones and seabed substrate types across various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

SEDIMENT INCREASE	SALISH SEA BIOGEOGRAPHIC SUB-REGION										COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*		*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	NA	0.79	0.62	0.68	NA	0.68	NA	NA	0.56	0.70	0.42
	hard	NA	0.79	NA	0.67	NA	0.67	NA	NA	0.59	0.79	0.35
	mixed	NA	0.57	NA	0.52	NA	0.52	NA	NA	0.49	0.68	0.33
	soft	NA	0.68	NA	0.65	NA	0.65	NA	NA	0.57	0.70	0.40
	undefined	NA	0.79	0.62	0.70	NA	0.70	NA	NA	0.51	0.70	0.72
Upper Slope[2]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.07
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.04
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.02
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.07
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01
Lower Slope[3]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00
Grand mean	All	NA	0.79	0.62	0.68	NA	0.68	NA	NA	0.56	0.70	0.04

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

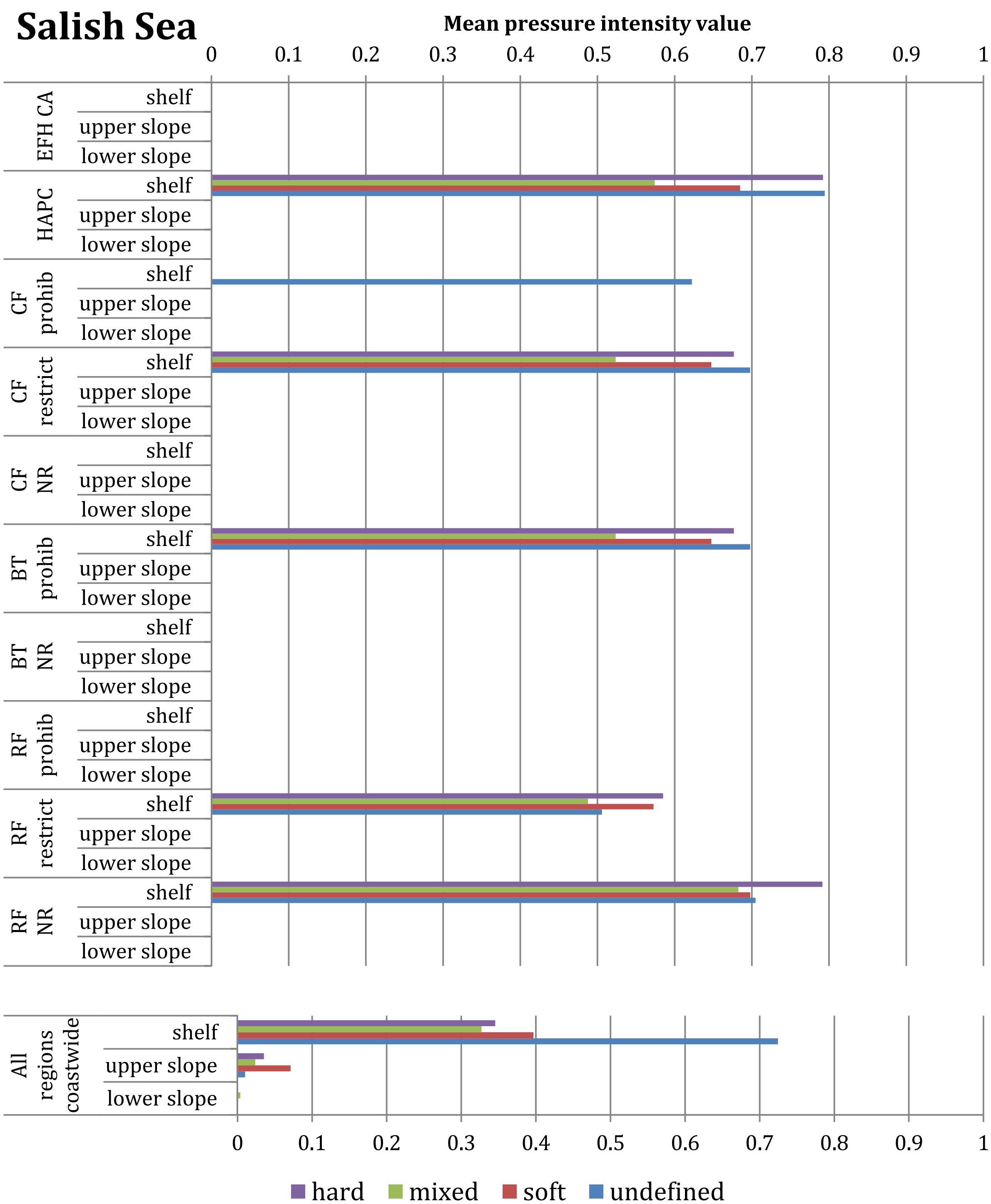


Figure A3b.45. Sediment runoff increase. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

3.2.4.6 Ocean-based pollution

The impact of ocean-based pollution is wide-spread as we include pollution from sea-going vessels and activity within ports throughout the California Current. Marine ports in the United States are major industrial centers providing jobs and steady revenue streams yet contributing significantly to pollution. Ships with huge engines running on bunker fuel without emission controls, thousands of diesel trucks per day, diesel locomotives, and other polluting equipment and activities at modern seaports cause an array of environmental impacts that can seriously affect local communities and marine and land-based ecosystems throughout a region (Bailey and Solomon 2004). As vessels transit within ports, along the coast, and along international shipping lanes, there are inevitable discharges of waste, leaks of oil and gas, loss of cargo during rough seas, and increased risk of oil spills from oil shipping vessels. Beaches close in proximity to oil shipping lanes have been observed to have high tar content related to the degree of oil pollution in the sea (Golik 1982).

The effects of oil pollution on components of the CCLME are both direct and indirect. Because seabirds and marine mammals require direct contact with the sea surface, these taxa experience high risk from floating oil (Loughlin 1994). Oiled seabirds and marine mammals lose the insulating capacity of their feathers and fur which can lead to death from hypothermia (Peterson et al. 2003). Chronic exposure to partially weathered oil is toxic to eggs of pink salmon *Oncorhynchus gorbuscha* and herring *Clupea pallasii* (Marty et al. 1997, Heintz et al. 2000). Many effects of exposure to oil and the associated polycyclic aromatic hydrocarbons (PAHs) are sublethal and have lasting effects on individual survival which may scale up to population-level responses. For example, embryos of zebrafish *Danio rerio* exposed to PAHs showed delayed changes in heart shape and reduced cardiac output (Hicken et al. 2011). Strandings of oiled seabirds have been used as an indicator of chronic oil pollution along heavily used shipping lanes in the North Sea and recent studies show declining oil-rates reflecting reduced oil spills(Camphuysen 1998, Camphuysen 2010).

In addition to the potential for pollution, other common impacts of vessel activities include vessel wake generation, anchor chain and propeller scour, vessel groundings, the introduction of invasive or nonnative species, and the discharge of contaminants and debris.

For specific details on the creation of each pressure data layer, see Halpern et al. (2008, 2009). Briefly, the ocean-based pollution data layer was calculated using vessel tracking data (from the World Meteorological Organization Voluntary Observing Ships Scheme and regional ferries) and port volume (proxy for the likelihood of pollutants in nearshore waters). These values were normalized and combined to develop a single layer for ocean-based pollution.

Ocean-based pollution intensity values were highest in the Salish Sea and lowest in the northern sub-region (Figs. A3b.46-47; Table A3b.41). Ocean-based pollution was highest in shelf habitat, most likely due to the influence of pollutants from ports on nearshore habitats (Figs. A3b.46-48, Tables A3b.41-42). Ocean-based pollution was generally higher in HAPCs and in areas prohibited to commercial and recreational fishing (Fig. A3b.48, Table A3b.42); however, this was likely because these management areas were in nearshore habitats that were more exposed to land-based pressures and had little to do with EFH-related management boundaries. These coastwide patterns were generally reflected within each biogeographic sub-region (Figs. A3b.49-52, Tables A3b.43-46).

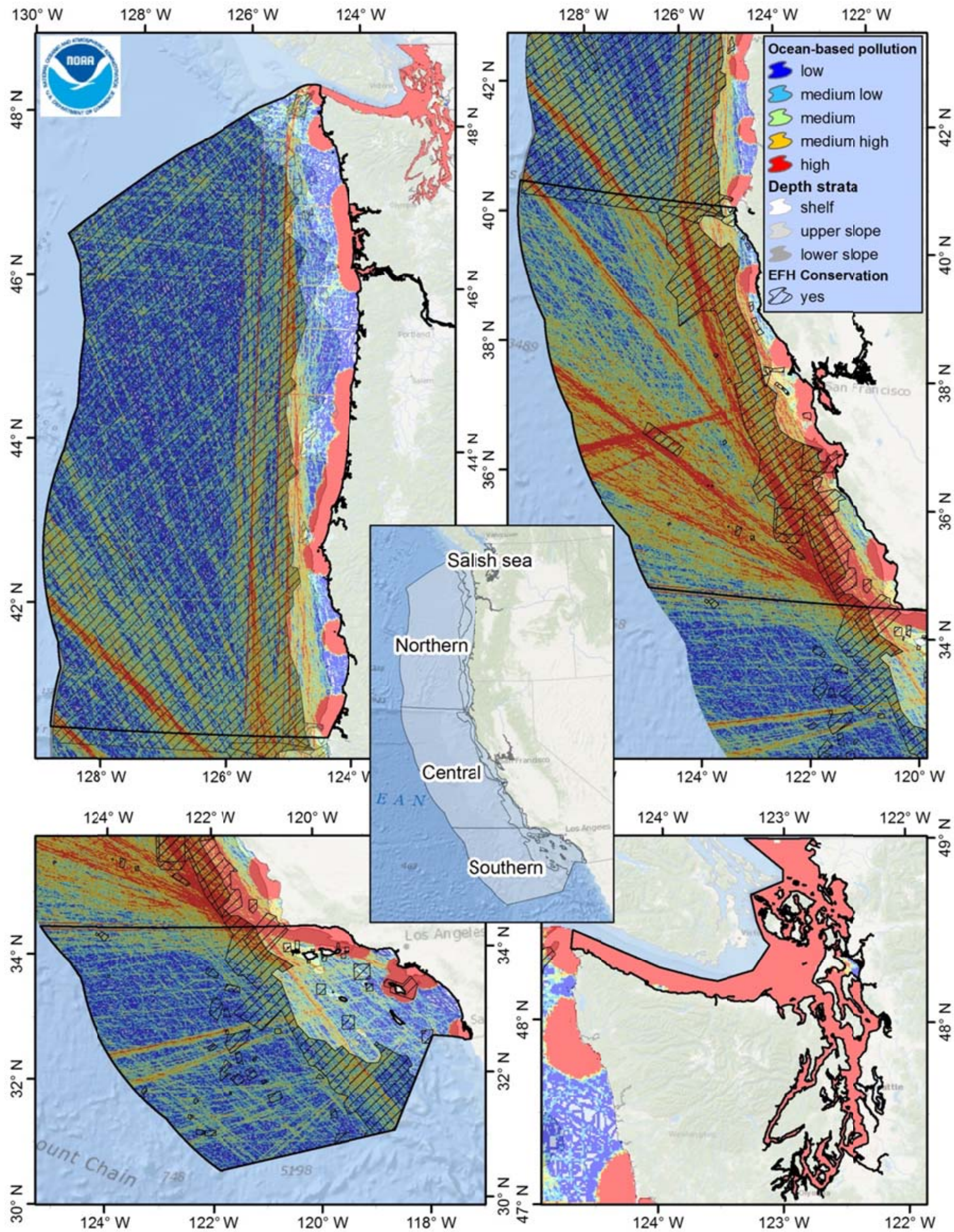


Figure A3b.46. Distribution of ocean-based pollution intensity values among biogeographic regions, depth strata and essential fish habitat (EFH) conservation areas. Ocean-based pollution data is from Halpern et al. 2009.

Table A3b.41. Mean intensity values for ocean-based pollution by depth zones and seabed substrate types across 4 biogeographic regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1.

OCEAN-BASED POLLUTION						
Depth Zone	*Substrate*	*Northern*	*Central*	*Southern*	*Salish Sea*	*Coastwide*
Shelf[1]	All	0.23	0.31	0.32	0.55	0.29
	hard	0.16	0.35	0.28	0.50	0.25
	mixed	0.23	0.32	0.33	0.61	0.28
	soft	0.23	0.28	0.32	0.54	0.26
	undefined	0.58	0.68	0.36	0.56	0.58
Upper Slope[2]	All	0.11	0.17	0.14	NA	0.14
	hard	0.12	0.17	0.13	NA	0.15
	mixed	0.12	0.18	0.09	NA	0.12
	soft	0.11	0.17	0.14	NA	0.14
	undefined	NA	0.15	0.11	NA	0.13
Lower Slope[3]	All	0.09	0.13	0.09	NA	0.10
	hard	0.12	0.15	0.09	NA	0.11
	mixed	0.15	0.17	0.10	NA	0.12
	soft	0.11	0.15	0.11	NA	0.12
	undefined	0.08	0.13	0.08	NA	0.10
Grand mean	All	0.11	0.14	0.11	0.55	0.12

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

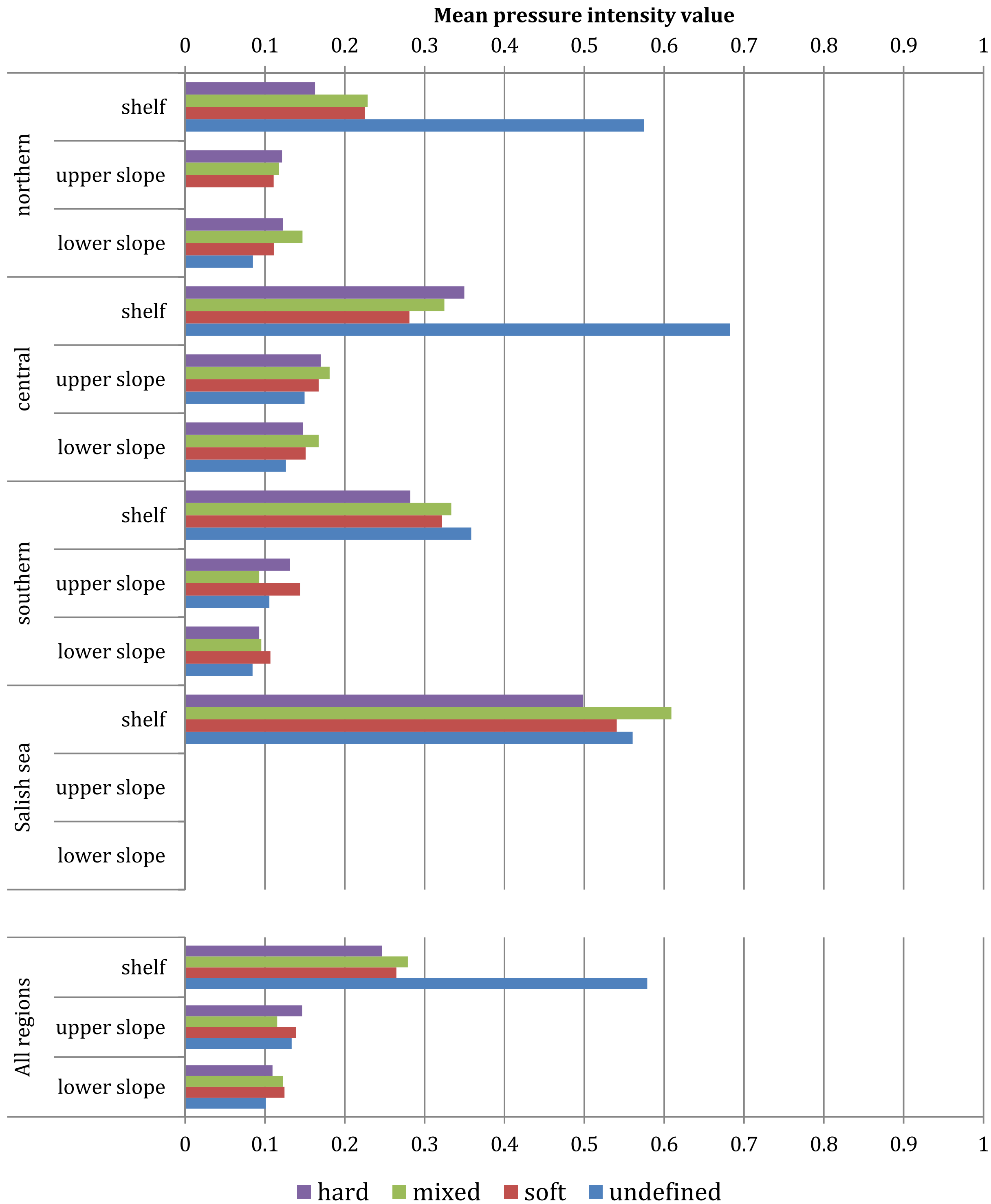


Figure A3b.47. Ocean-based pollution. Mean pressure intensity values among seabed substrate types by depth zones across 4 biogeographic sub-regions: “Northern” (i.e., Cape Flattery, WA to Cape Mendocino, CA), “Central” (i.e., Cape Mendocino, CA to Point Conception, CA), “Southern” (i.e., Point Conception, CA to U.S.-Mexico maritime border) and “Salish Sea” (i.e., Straits of Juan de Fuca, Georgia and Puget Sound).

Table A3b.42. Mean intensity values for ocean-based pollution by depth zones and seabed substrate types across various management boundaries. Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

OCEAN-BASED POLLUTION												
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawling*		*Recreational fishing*			*Coastwide*
Depth Zone	***Substrate***			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	**All**	**0.20**	**0.41**	**0.23**	**0.33**	**0.26**	**0.37**	**0.24**	**0.23**	**0.20**	**0.31**	**0.29**
	hard	0.19	0.21	0.27	0.27	0.21	0.28	0.20	0.30	0.26	0.24	0.25
	mixed	0.14	0.27	0.25	0.25	0.38	0.29	0.26	0.30	0.22	0.33	0.28
	soft	0.21	0.35	0.22	0.28	0.25	0.32	0.23	0.22	0.19	0.28	0.26
	undefined	0.29	0.61	0.43	0.58	0.55	0.58	0.55	0.16	0.50	0.58	0.58
Upper Slope[2]	**All**	**0.17**	**0.15**	**0.29**	**0.15**	**0.14**	**0.18**	**0.13**	**0.29**	**0.09**	**0.15**	**0.14**
	hard	0.18	0.15	0.09	0.16	0.14	0.18	0.13	0.09	0.10	0.15	0.15
	mixed	0.11	0.13	0.47	0.11	0.12	0.12	0.12		0.11	0.12	0.12
	soft	0.17	0.16	0.29	0.15	0.14	0.18	0.13	0.29	0.09	0.15	0.14
	undefined	0.15	0.15		0.15	0.12	0.15	0.12			0.13	0.13
Lower Slope[3]	**All**	**0.10**	**0.12**		**0.10**	**0.11**	**0.10**	**0.11**		**0.10**	**0.10**	**0.10**
	hard	0.11	0.11		0.11	0.12	0.11	0.12		0.09	0.11	0.11
	mixed	0.12	0.12		0.12		0.12				0.12	0.12
	soft	0.13	0.15		0.13	0.11	0.13	0.11		0.11	0.12	0.12
	undefined	0.09	0.12		0.09	0.11	0.09	0.11			0.10	0.10
Grand mean	All	0.10	0.22	0.24	0.12	0.12	0.12	0.12	0.24	0.14	0.12	0.12

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

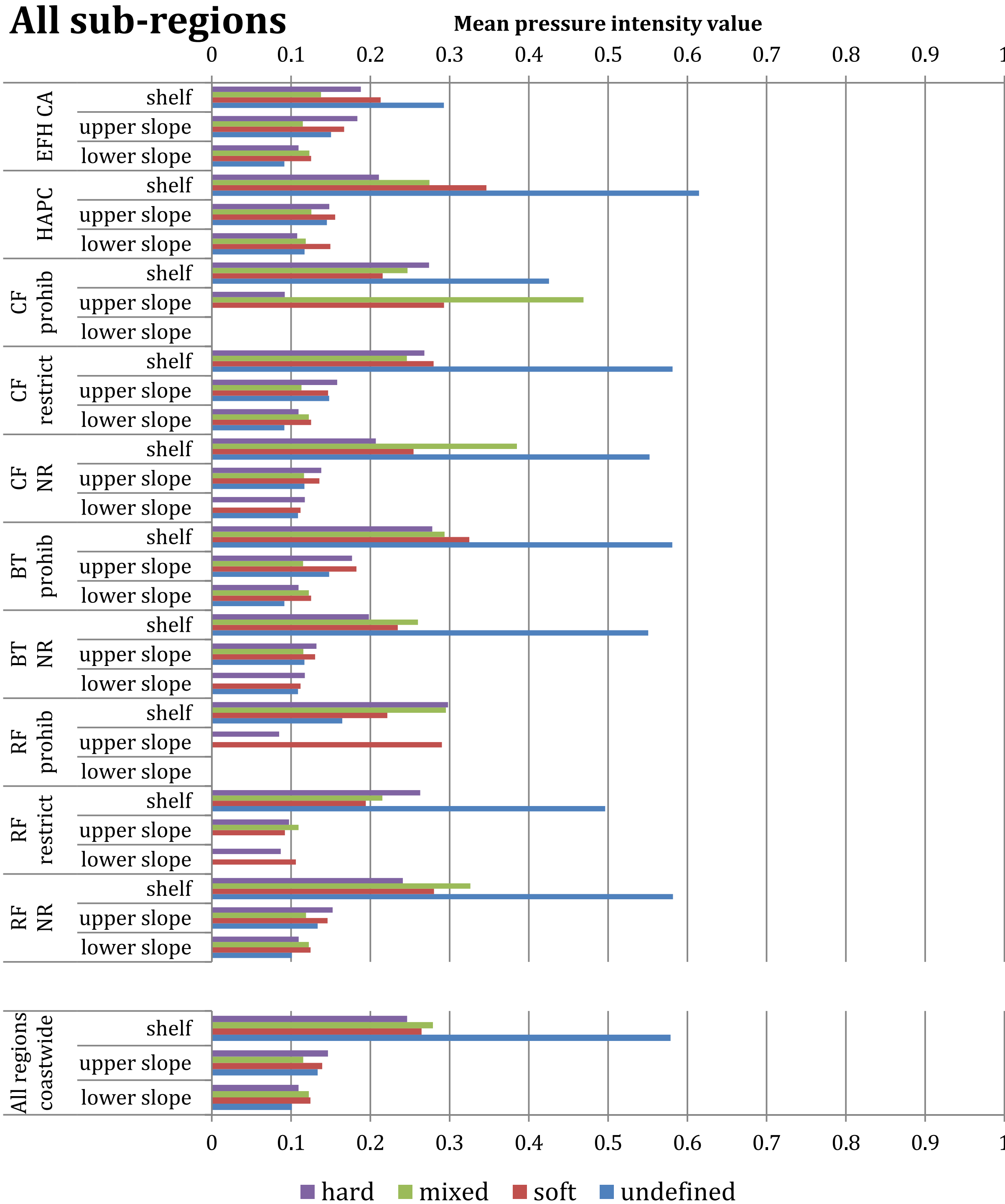


Figure A3b.48. Ocean-based pollution. Mean pressure intensity values among seabed substrate types depth zones in various management boundaries across all biogeographic regions. EFH CA = essential habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fish is restricted; NR = no restrictions on type of fishing.

Table A3b.43. Mean intensity values for ocean-based pollution by depth zones and seabed substrate types across various management boundaries in the "Northern" biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

OCEAN-BASED POLLUTION	NORTHERN BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.11	0.34	0.60	0.20	0.24	0.27	0.22	0.62	0.15	0.25	0.29
	hard	0.10	0.15	NA	0.15	0.17	0.15	0.17	NA	0.20	0.16	0.25
	mixed	0.11	0.27	NA	0.15	0.37	0.18	0.26	NA	0.16	0.29	0.28
	soft	0.12	0.40	0.60	0.21	0.23	0.29	0.21	0.62	0.15	0.25	0.26
	undefined	NA	0.64	NA	0.66	0.56	0.67	0.56	NA	0.35	0.58	0.58
Upper Slope[2]	All	0.11	0.13	NA	0.11	0.11	0.11	0.11	NA	0.10	0.11	0.14
	hard	0.13	0.12	NA	0.13	0.12	0.13	0.12	NA	0.12	0.12	0.15
	mixed	0.12	0.14	NA	0.12	0.11	0.12	0.12	NA	0.13	0.11	0.12
	soft	0.11	0.13	NA	0.11	0.11	0.11	0.11	NA	0.09	0.11	0.14
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.13
Lower Slope[3]	All	0.09	0.11	NA	0.09	0.10	0.09	0.10	NA	NA	0.09	0.10
	hard	0.12	0.12	NA	0.12	0.13	0.12	0.13	NA	NA	0.12	0.11
	mixed	0.15	0.15	NA	0.15	NA	0.15	NA	NA	NA	0.15	0.12
	soft	0.11	0.12	NA	0.11	0.12	0.11	0.12	NA	NA	0.11	0.12
	undefined	0.08	0.09	NA	0.08	0.09	0.08	0.09	NA	NA	0.08	0.10
Grand mean	All	0.09	0.21	0.60	0.09	0.17	0.09	0.17	0.62	0.14	0.10	0.12

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

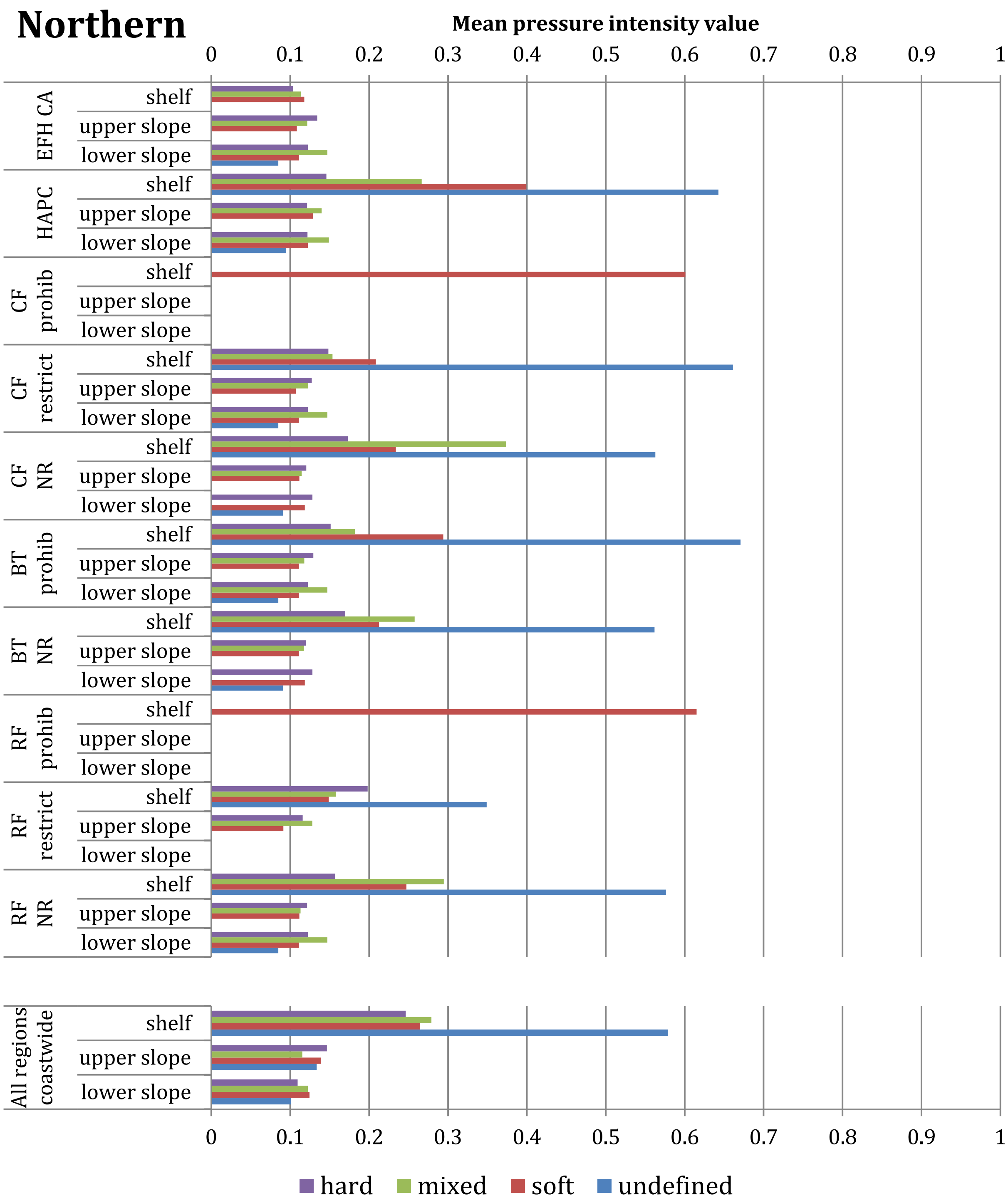


Figure A3b.49. Ocean-based pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the “Northern” biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.44. Mean intensity values for ocean-based pollution by depth zones and seabed substrate types across various management boundaries in the "Central" biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

OCEAN-BASED POLLUTION	CENTRAL BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.24	0.47	0.22	0.37	0.27	0.36	0.27	0.23	0.39	0.31	0.29
	hard	0.33	0.35	0.30	0.37	0.27	0.36	0.27	0.34	0.47	0.34	0.25
	mixed	0.21	0.31	0.22	0.33	0.45	0.32	0.45	0.31	0.40	0.32	0.28
	soft	0.22	0.32	0.20	0.31	0.26	0.30	0.26	0.21	0.38	0.28	0.26
	undefined	0.37	0.71	0.47	0.69	0.48	0.69	0.48	0.09	0.34	0.69	0.58
Upper Slope[2]	All	0.17	0.19	0.11	0.18	0.16	0.18	0.16	0.09	0.32	0.17	0.14
	hard	0.17	0.17	NA	0.17	0.17	0.17	0.17	NA	0.61	0.17	0.15
	mixed	0.29	0.26	0.47	0.16	0.18	0.19	0.18	NA	NA	0.18	0.12
	soft	0.17	0.26	0.09	0.18	0.16	0.18	0.16	0.09	0.31	0.17	0.14
	undefined	0.15	0.15	NA	0.15	0.15	0.15	0.15	NA	NA	0.15	0.13
Lower Slope[3]	All	0.14	0.15	NA	0.14	0.12	0.14	0.12	NA	NA	0.13	0.10
	hard	0.15	0.15	NA	0.15	NA	0.15	NA	NA	NA	0.15	0.11
	mixed	0.17	0.16	NA	0.17	NA	0.17	NA	NA	NA	0.17	0.12
	soft	0.15	0.17	NA	0.15	0.16	0.15	0.16	NA	NA	0.15	0.12
	undefined	0.14	0.14	NA	0.14	0.12	0.14	0.12	NA	NA	0.13	0.10
Grand mean	All	0.15	0.24	0.22	0.17	0.13	0.17	0.13	0.23	0.38	0.14	0.12

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

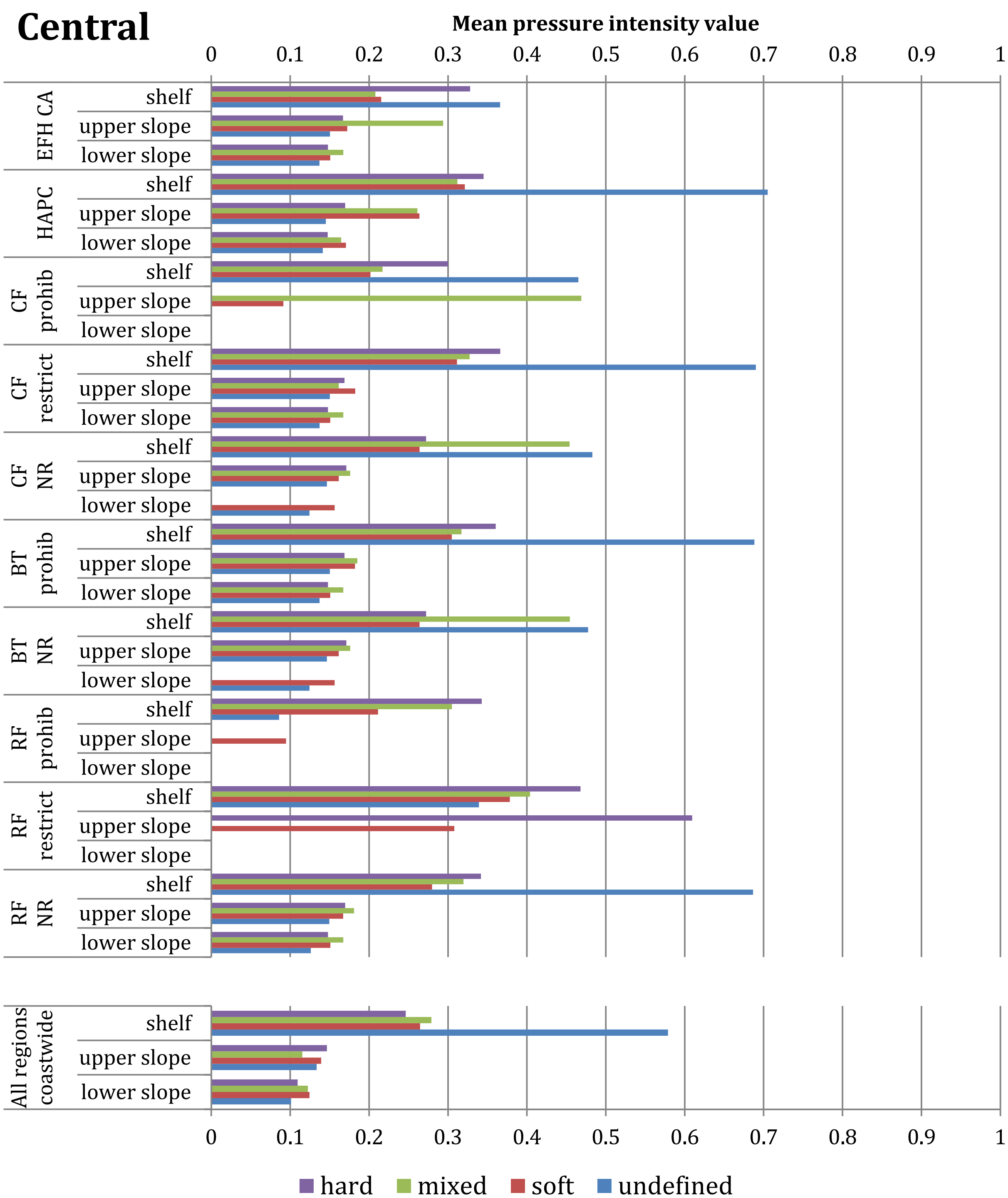


Figure A3b.50. Ocean-based pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the “Central” biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.45. Mean intensity values for ocean-based pollution by depth zones and seabed substrate types across various management boundaries in the "Southern" biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

OCEAN-BASED POLLUTION		SOUTHERN BIOGEOGRAPHIC SUB-REGION										COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	0.24	0.25	0.22	0.28	0.50	0.29	0.40	0.23	0.15	0.38	0.29
	hard	0.14	0.24	0.24	0.24	0.56	0.25	0.36	0.24	0.13	0.36	0.25
	mixed	0.17	0.20	0.29	0.32	0.65	0.37	0.23	0.28	0.17	0.47	0.28
	soft	0.26	0.25	0.22	0.28	0.50	0.29	0.41	0.23	0.15	0.38	0.26
	undefined	0.24	0.41	0.29	0.36	0.35	0.36	0.35	0.32	0.33	0.36	0.58
Upper Slope[2]	All	0.19	0.13	0.31	0.15	0.14	0.23	0.13	0.31	0.09	0.16	0.14
	hard	0.32	0.13	0.09	0.15	0.12	0.22	0.11	0.09	0.10	0.14	0.15
	mixed	0.10	0.09	NA	0.09	0.12	0.10	0.08	NA	0.08	0.19	0.12
	soft	0.19	0.13	0.32	0.15	0.14	0.23	0.13	0.32	0.09	0.16	0.14
	undefined	NA	NA	NA	0.06	0.11	0.06	0.11	NA	NA	0.11	0.13
Lower Slope[3]	All	0.10	0.09	NA	0.10	0.08	0.10	0.08	NA	0.10	0.09	0.10
	hard	0.09	0.09	NA	0.09	0.08	0.09	0.08	NA	0.09	0.09	0.11
	mixed	0.09	0.09	NA	0.10	NA	0.10	NA	NA	NA	0.10	0.12
	soft	0.11	0.10	NA	0.11	0.10	0.11	0.10	NA	0.11	0.11	0.12
	undefined	0.09	0.08	NA	0.09	0.08	0.09	0.08	NA	NA	0.08	0.10
Grand mean	All	0.11	0.13	0.25	0.13	0.10	0.14	0.10	0.25	0.10	0.11	0.12

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

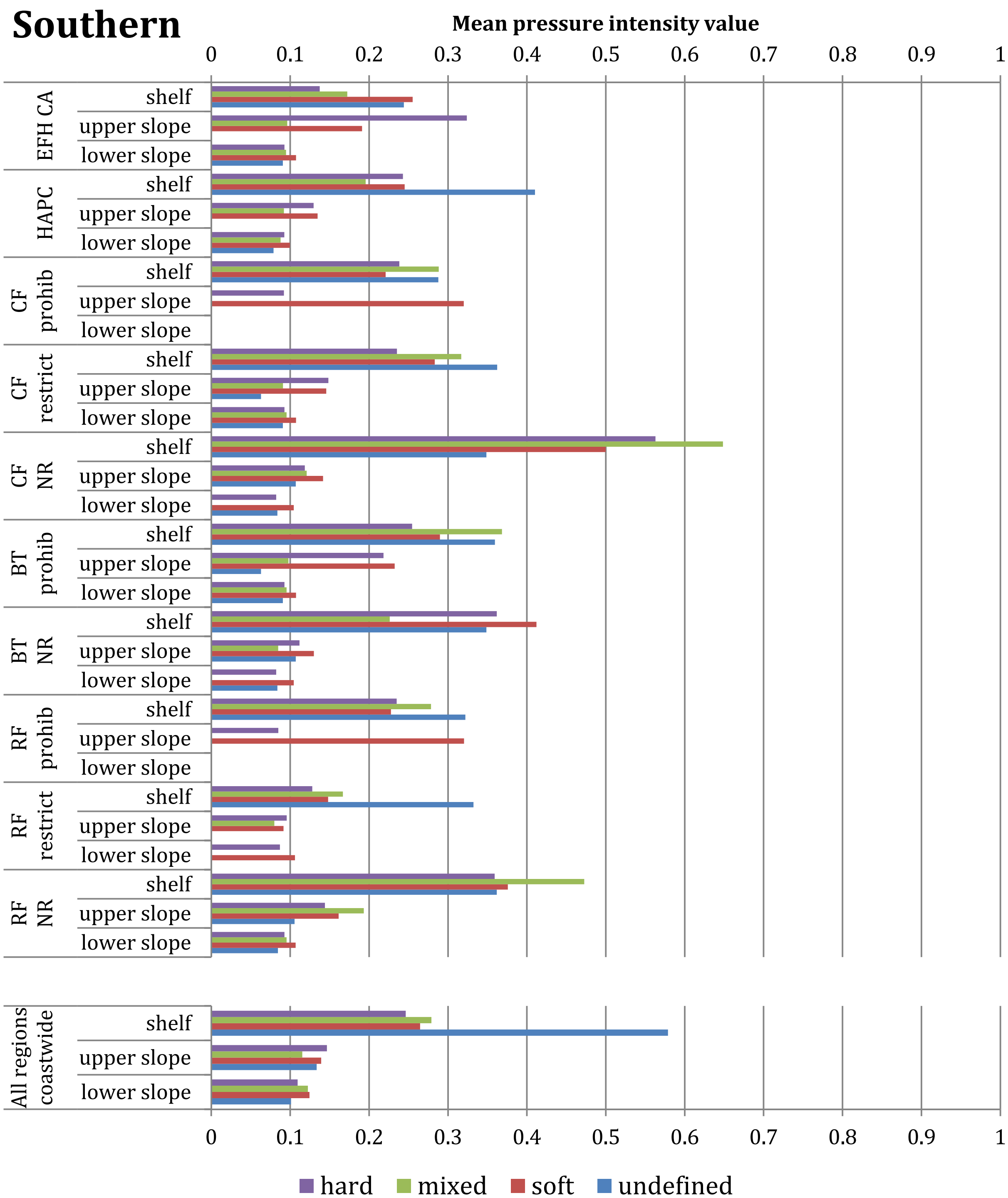


Figure A3b.51. Ocean-based pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the “Southern” biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.46. Mean intensity values for ocean-based pollution by depth zones and seabed substrate types across various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone and ranged from 0 to 1. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

OCEAN-BASED POLLUTION		SALISH SEA BIOGEOGRAPHIC SUB-REGION										COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	NA	0.58	0.44	0.55	NA	0.55	NA	NA	0.56	0.55	0.29
	hard	NA	0.36	NA	0.50	NA	0.50	NA	NA	0.58	0.40	0.25
	mixed	NA	0.64	NA	0.61	NA	0.61	NA	NA	0.61	0.58	0.28
	soft	NA	0.52	NA	0.54	NA	0.54	NA	NA	0.56	0.53	0.26
	undefined	NA	0.58	0.44	0.56	NA	0.56	NA	NA	0.52	0.56	0.58
Upper Slope[2]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.14
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.15
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.12
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.14
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.13
Lower Slope[3]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.10
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.11
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.12
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.12
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.10
Grand mean	All	NA	0.58	0.44	0.55	NA	0.55	NA	NA	0.56	0.55	0.12

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

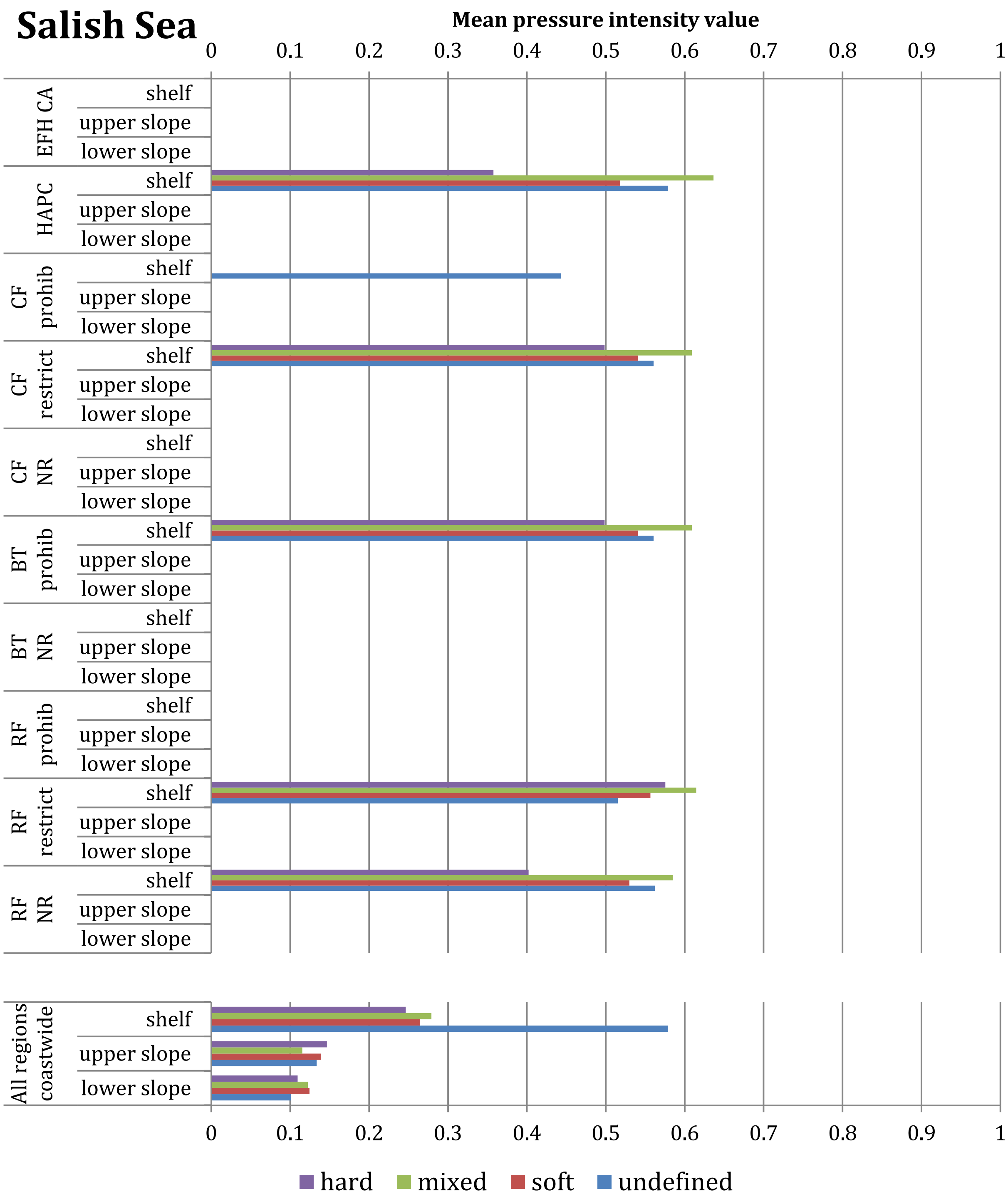


Figure A3b.52. Ocean-based pollution. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

3.2.4.7 Combined pressures

Importantly, the pressures identified above do not act upon groundfish EFH individually, but collectively. Pressures from terrestrial-based pollution, shipping, offshore energy development, fisheries and coastal development exert cumulative effects on the ecosystem and should be managed in a holistic way (Vinebrooke et al. 2004, Crain et al. 2008, Halpern et al. 2008, Curtin and Prellezo 2010, Stelzenmüller et al. 2010). However, quantifying the cumulative effects of these pressures is a difficult task. Previous studies developing cumulative impact metrics have used qualitative risk metrics (Stelzenmüller et al. 2010) or expert-based scoring systems (Halpern et al. 2008, 2009, Teck et al. 2010) that weight the relative importance of each pressure prior to summing scores across pressures. However, qualitative risk and expert-based scoring systems have been heavily criticized for two reasons. First, the weighting of pressures qualitatively or by expert surveys may be heavily influenced by a range of heuristic and cognitive biases that may lead to arbitrary or misleading results (Hubbard 2009). Second, our understanding of whether the effects of multiple pressures are additive, synergistic, or antagonistic is relatively poor (Darling and Côté 2008, Hoegh-Guldberg and Bruno 2010). Several studies have suggested that multiple pressures interact on various ecosystem components in non-additive ways, either causing effects greater than (synergistic) or less than (antagonistic) that explained by the sum of individual pressures (Sala and Knowlton 2006, Darling and Côté 2008, Griffith et al. 2012, Sunda and Cai 2012). Thus, linear combinations of weighted pressures will not account for these interactions. Because of these unknowns and time constraints, we did not try to calculate cumulative effects values of non-fisheries pressures on groundfish EFH; instead, we used a simplified approach which simply summed the pressure intensity values of all 16 non-fisheries pressures (Table A3b.1) for each 1 km^2 cell within the U.S. EEZ to calculate a "combined pressures" data layer. The values for each individual pressure layer range between 0 and 1, so the maximum value for this layer was 16. This data layer simply shows the additive sum of all overlapping pressures within each cell; it is not intended to describe the cumulative impacts of all pressures present in each cell.

The distribution of combined pressures showed the distinct influence of land-based pollution pressures in nearshore habitats and the exposure of offshore habitats to ocean-based pollution and commercial shipping activity (Fig. A3b.53). Overall, mean intensity values were highest in the Salish Sea biogeographic sub-region and in the shelf depth strata (Figs. A3b.2a, A3b.53-55, Tables A3b.47-48). The Salish Sea was most exposed because the vast majority of the region was exposed to highly populated areas and had only shelf habitat, which was the most exposed depth stratum. The northern sub-region was the next most-greatly exposed region, but this varied among depth strata (Table A3b.47). For example, pressure intensity values were highest in lower slope habitat in the north, but pressures were higher in the southern sub-region in shelf and upper slope habitat. High values in the lower slope of the northern sub-region were most likely the result of high atmospheric pollution values (see *'Atmospheric pollution'*), whereas multiple land-based pressures (see *Individual pressures)* were responsible for high values in the shelf and upper-slope in the southern sub-region. Within each depth stratum, pressure intensity values varied across habitat types, but showed no clear trend.

Differences in pressure intensity values among management boundaries were more difficult to determine, but it seemed that HAPCs and areas that were prohibited to commercial and recreational fishing had higher pressure intensity values than other EFH-related management areas (Fig. A3b.2b, A3b.55, Table A3b.48). This result was likely due to HAPCs and many prohibited fishing areas being located nearshore or inside bays where pressure intensity values were relatively high because of numerous land-based pressures. These coastwide patterns were generally reflected within biogeographic sub-regions (Figs. A3b.56-59, Tables A3b.49-52).

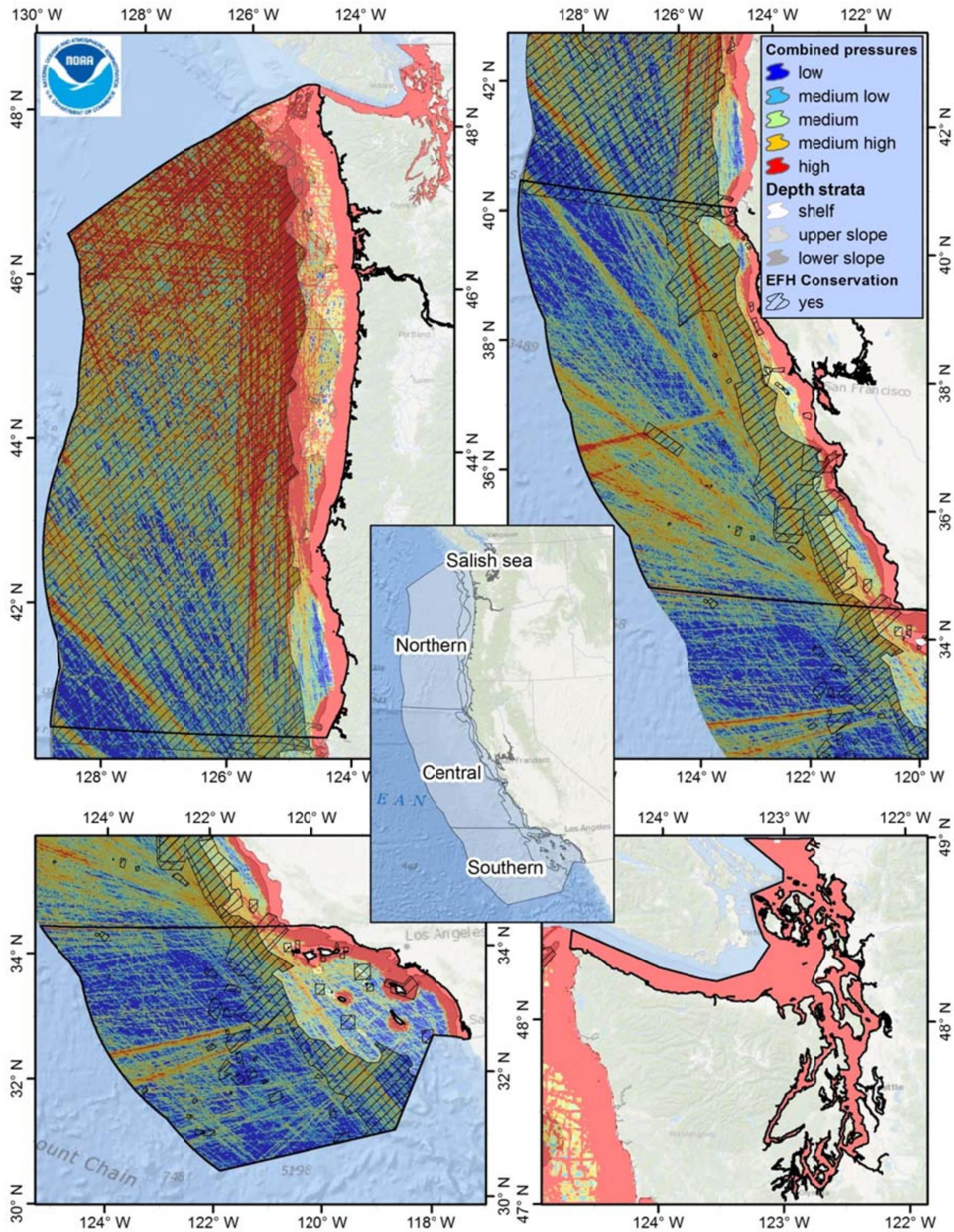


Figure A3b.53. Distribution of combined pressure intensity values among biogeographic regions, depth strata and essential fish habitat (EFH) conservation areas. Combined pressure data is the sum of 16 non-fisheries pressures identified in Table A3b.1. Data for each pressure was derived from Halpern et al. 2009.

Table A3b.47. Mean intensity values for atmospheric pollution by depth zones and seabed substrate types across 4 biogeographic sub-regions: "Northern" (i.e., Cape Flattery, WA to Cape Mendocino, CA), "Central" (i.e., Cape Mendocino, CA to Point Conception, CA), "Southern" (i.e., Point Conception, CA to U.S.-Mexico maritime border) and "Salish Sea" (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from the sums of 16 pressure intensity values (data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone which ranged from 0 to 1.

COMBINED PRESSURES						
Depth Zone	*Substrate*	*Northern*	*Central*	*Southern*	*Salish Sea*	*Coastwide*
Shelf[1]	All	2.20	2.71	2.92	4.31	2.63
	hard	1.76	3.00	2.57	3.57	2.30
	mixed	1.98	3.04	2.41	3.55	2.31
	soft	2.18	2.45	2.93	3.64	2.40
	undefined	5.85	6.27	4.71	4.67	5.03
Upper Slope[2]	All	1.22	1.22	1.28	NA	1.25
	hard	1.28	1.15	1.17	NA	1.18
	mixed	1.34	1.37	0.98	NA	1.29
	soft	1.21	1.23	1.29	NA	1.25
	undefined	NA	1.05	1.00	NA	1.03
Lower Slope[3]	All	1.08	0.98	0.88	NA	1.00
	hard	1.26	1.05	0.90	NA	1.03
	mixed	1.10	1.09	0.91	NA	0.99
	soft	1.26	1.06	0.95	NA	1.10
	undefined	1.06	0.97	0.87	NA	0.98
Grand mean	All	1.22	1.10	1.04	4.31	1.15

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

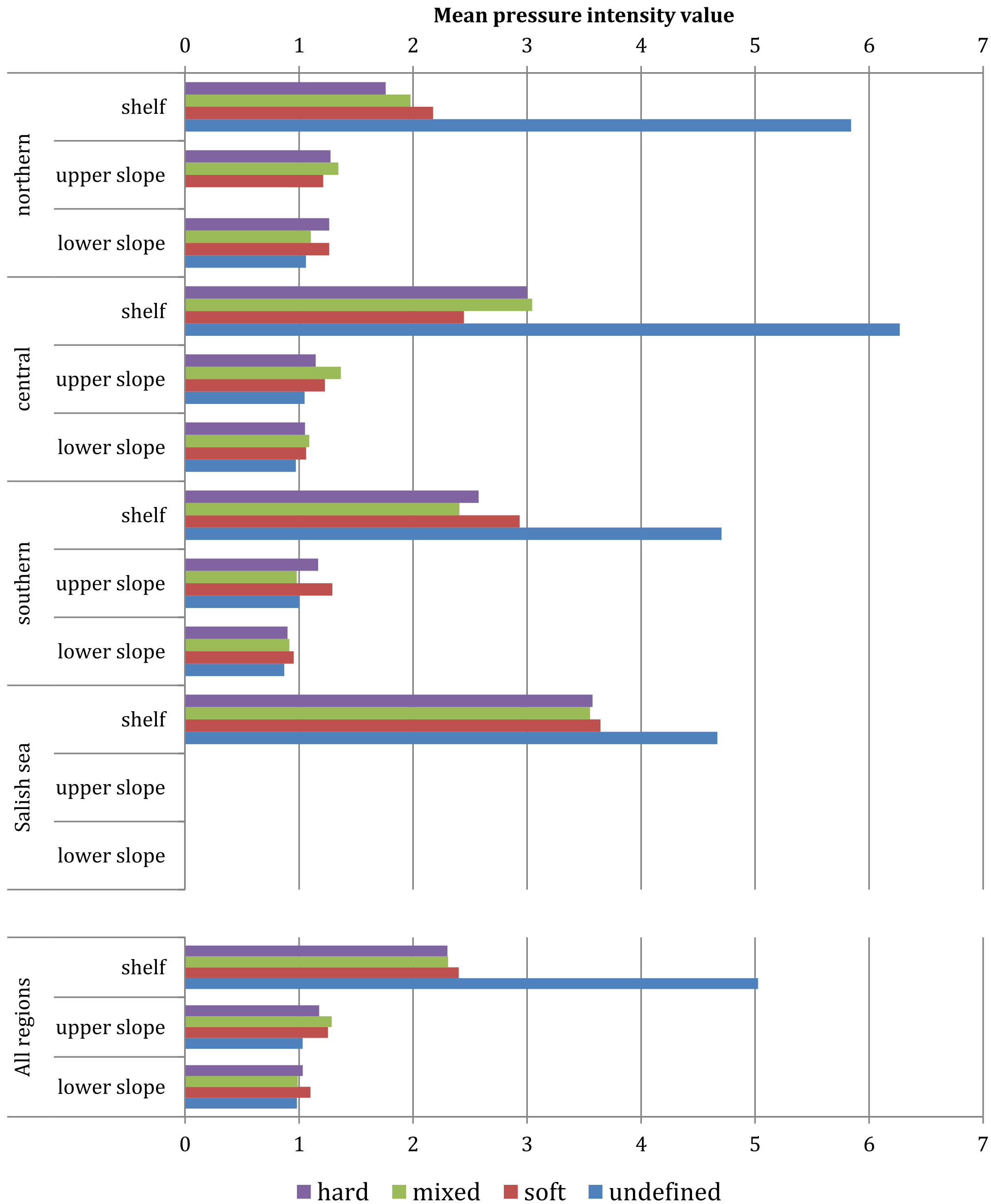


Figure A3b.54. Combined non-fisheries pressures. Mean pressure intensity values among seabed substrate types by depth zones across 4 biogeographic sub-regions: “Northern” (i.e., Cape Flattery, WA to Cape Mendocino, CA), “Central” (i.e., Cape Mendocino, CA to Point Conception, CA), “Southern” (i.e., Point Conception, CA to U.S.-Mexico maritime border) and “Salish Sea” (i.e., Straits of Juan de Fuca, Georgia and Puget Sound).

Table A3b.48. Mean intensity values for combined pressures by depth zones and seabed substrate types across various management boundaries. Mean intensity values were calculated from the sum of 16 non-fisheries pressures' intensity values (Table A3b.1; data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" was prohibited, so they have the same mean intensity values. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing; NA = no habitat present in this category. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions.

COMBINED PRESSURES												
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawling*		*Recreational fishing*			*Coastwide*
Depth Zone	**Substrate**			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	**All**	**1.78**	**3.61**	**2.50**	**3.01**	**2.27**	**3.31**	**2.17**	**2.40**	**2.05**	**2.76**	**2.63**
	hard	1.67	2.00	3.12	2.41	2.04	2.52	1.97	2.94	2.25	2.28	2.30
	mixed	1.52	2.19	2.83	2.17	2.69	2.46	2.11	2.88	1.89	2.60	2.31
	soft	1.86	2.87	2.38	2.63	2.23	2.93	2.14	2.31	2.02	2.48	2.40
	undefined	2.66	5.69	4.39	4.97	5.75	4.97	5.73	2.48	3.43	5.08	5.03
Upper Slope[2]	**All**	**1.31**	**1.23**	**2.42**	**1.28**	**1.23**	**1.45**	**1.20**	**2.35**	**1.01**	**1.28**	**1.25**
	hard	1.22	1.16	2.53	1.18	1.17	1.24	1.14	2.52	0.98	1.20	1.18
	mixed	1.28	1.32	4.22	1.29	1.28	1.31	1.27	NA	1.28	1.29	1.29
	soft	1.33	1.32	2.40	1.29	1.24	1.49	1.21	2.34	1.00	1.29	1.25
	undefined	1.04	1.05	NA	1.03	1.03	1.03	1.03	NA	NA	1.03	1.03
Lower Slope[3]	**All**	**1.06**	**1.05**	**NA**	**1.06**	**0.93**	**1.06**	**0.93**	**NA**	**0.97**	**0.99**	**1.00**
	hard	1.03	1.00	NA	1.03	1.13	1.03	1.13	NA	0.89	1.03	1.03
	mixed	0.99	0.96	NA	0.99	NA	0.99	NA	NA	NA	0.99	0.99
	soft	1.11	1.16	NA	1.11	0.95	1.11	0.95	NA	0.98	1.10	1.10
	undefined	1.05	1.05	NA	1.05	0.93	1.05	0.93	NA	NA	0.98	0.98
Grand mean	**All**	**1.08**	**1.89**	**2.49**	**1.23**	**1.08**	**1.23**	**1.09**	**2.39**	**1.46**	**1.14**	**1.15**

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

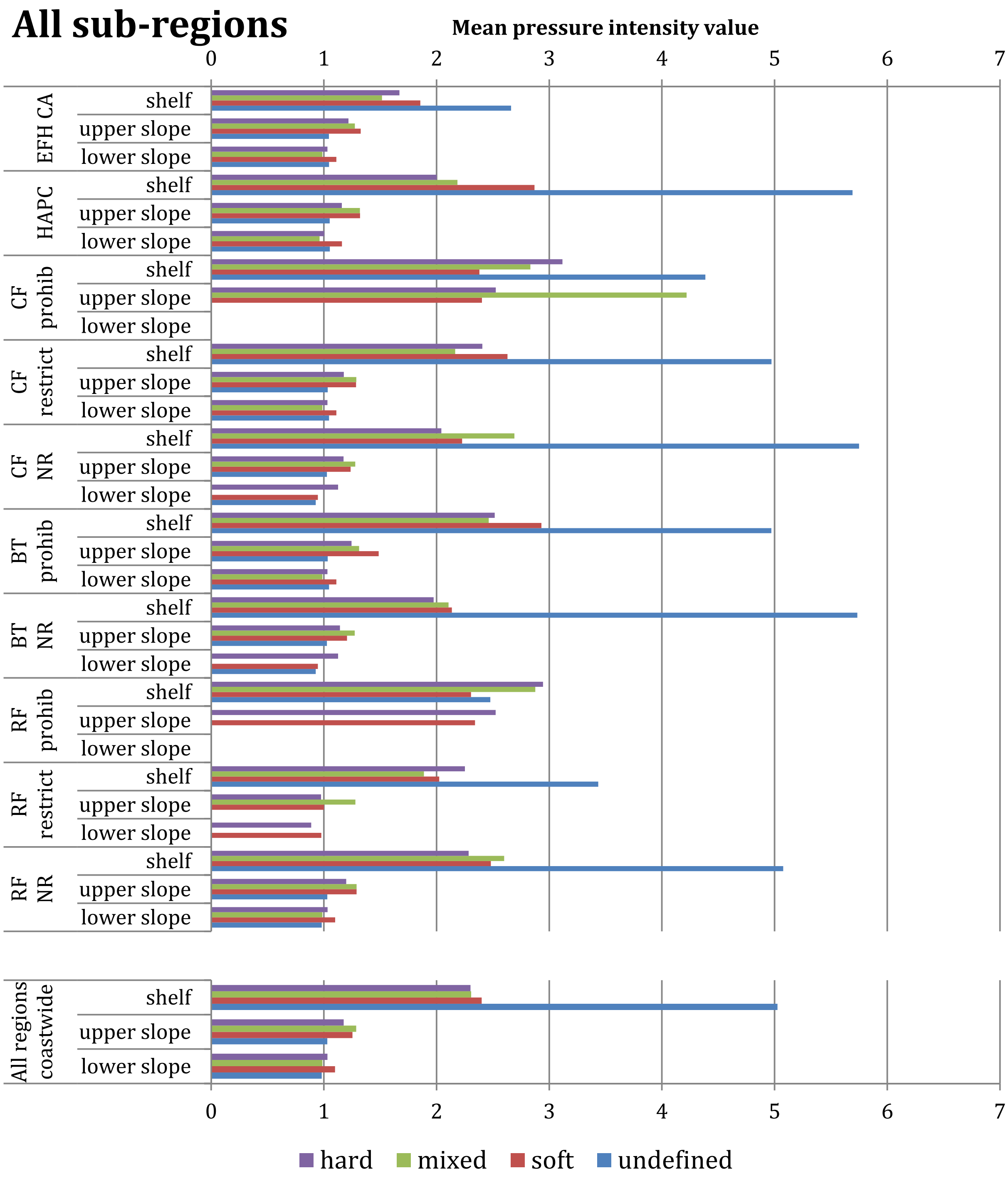


Figure A3b.55. Combined non-fisheries pressures. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries across all biogeographic regions. EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.49. Combined pressure mean intensity values by depth zones and seabed substrate types across various management boundaries in the "Northern" biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). Mean intensity values were calculated from the sum of 16 non-fisheries pressures' intensity values (Table A3b.1; data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone. Values for each pressure ranged from 0 to 1. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" is prohibited, so these management areas all have the same mean intensity values. NA = no habitat present in this category.

COMBINED PRESSURES	**NORTHERN BIOGEOGRAPHIC SUB-REGION**											**COASTWIDE**
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	1.32	2.98	5.00	2.15	2.22	2.60	2.11	5.08	1.87	2.29	2.63
	hard	1.23	1.57	NA	1.62	1.86	1.63	1.85	NA	2.13	1.70	2.30
	mixed	1.39	2.06	NA	1.63	2.64	1.76	2.12	NA	1.67	2.26	2.31
	soft	1.36	3.34	5.00	2.20	2.16	2.76	2.07	5.08	1.88	2.26	2.40
	undefined	NA	6.40	NA	5.98	5.84	6.06	5.83	NA	2.90	5.87	5.03
Upper Slope[2]	All	1.39	1.34	NA	1.32	1.20	1.32	1.20	NA	1.41	1.21	1.25
	hard	1.32	1.28	NA	1.30	1.27	1.31	1.27	NA	1.48	1.27	1.18
	mixed	1.47	1.49	NA	1.48	1.28	1.46	1.31	NA	1.53	1.27	1.29
	soft	1.39	1.34	NA	1.31	1.19	1.31	1.20	NA	1.37	1.21	1.25
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.03
Lower Slope[3]	All	1.08	1.21	NA	1.08	1.10	1.08	1.10	NA	NA	1.08	1.00
	hard	1.26	1.25	NA	1.26	1.22	1.26	1.22	NA	NA	1.26	1.03
	mixed	1.10	1.11	NA	1.10	NA	1.10	NA	NA	NA	1.10	0.99
	soft	1.26	1.28	NA	1.26	1.33	1.26	1.33	NA	NA	1.26	1.10
	undefined	1.06	1.09	NA	1.06	0.93	1.06	0.93	NA	NA	1.06	0.98
Grand mean	All	1.09	1.98	5.00	1.14	1.67	1.12	1.67	5.08	1.80	1.20	1.15

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

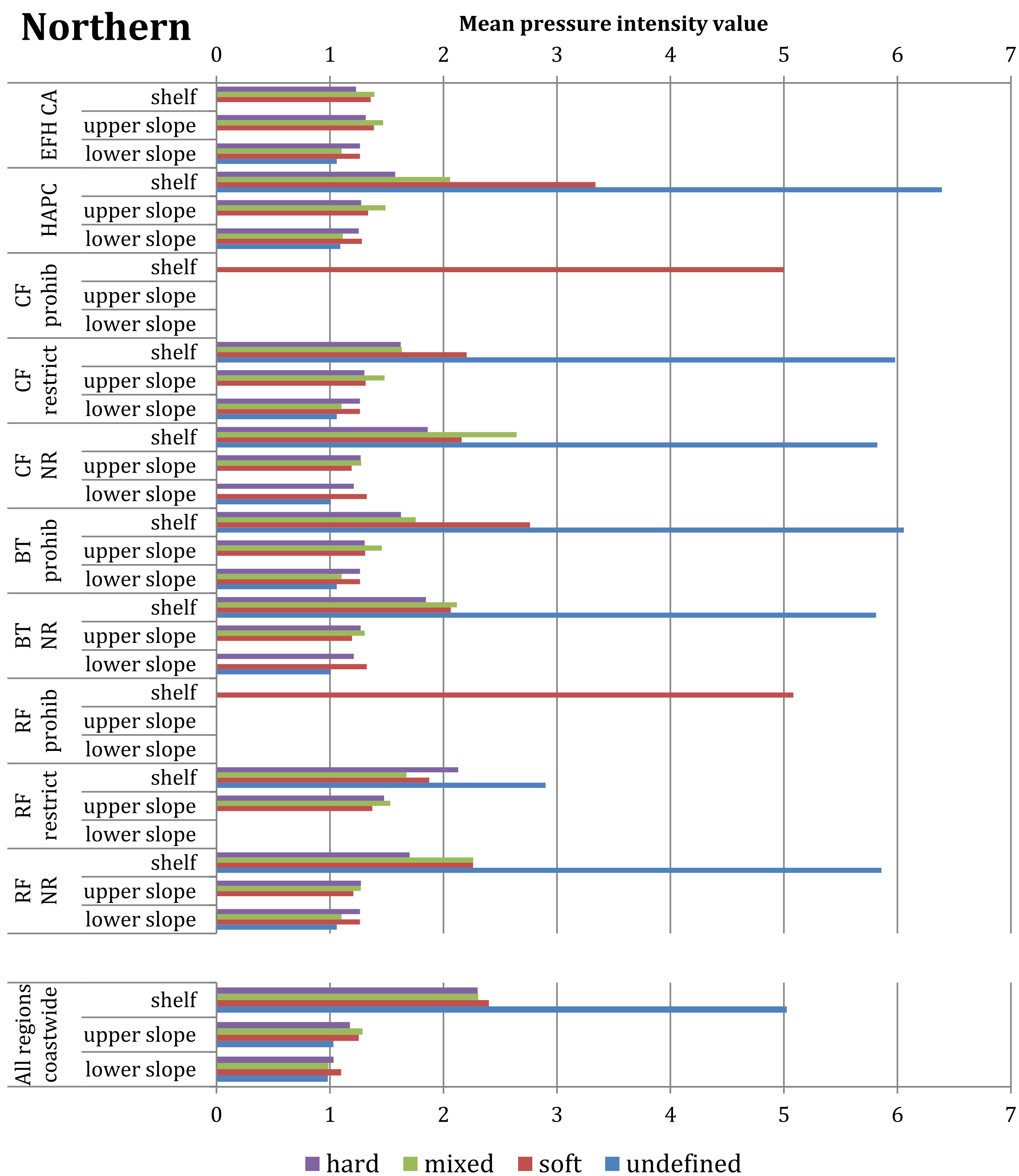


Figure A3b.56. Combined non-fisheries pressures. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Northern" biogeographic region (i.e., Cape Flattery, WA to Cape Mendocino, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.50. Combined pressure mean intensity values by depth zones and seabed substrate types across various management boundaries in the "Central" biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). Mean intensity values were calculated from the sum of 16 non-fisheries pressures' intensity values (Table A3b.1; data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone. Values for each pressure ranged from 0 to 1. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" is prohibited, so these management areas all have the same mean intensity values. NA = no habitat present in this category.

COMBINED PRESSURES	CENTRAL BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	2.13	4.17	2.96	3.37	2.14	3.34	2.14	2.94	2.69	2.71	2.63
	hard	2.45	2.91	3.29	3.08	2.26	3.10	2.26	3.26	2.92	3.00	2.30
	mixed	1.99	2.91	3.20	3.03	3.01	3.04	3.09	3.28	2.98	3.04	2.31
	soft	2.06	2.83	2.83	2.91	2.12	2.90	2.12	2.87	2.42	2.45	2.40
	undefined	3.06	6.42	4.64	6.31	5.55	6.30	5.47	1.59	6.31	6.27	5.03
Upper Slope[2]	All	1.22	1.28	2.04	1.31	1.18	1.31	1.18	1.88	1.21	1.22	1.25
	hard	1.12	1.14	NA	1.15	1.14	1.15	1.14	NA	1.14	1.15	1.18
	mixed	2.31	2.20	4.22	1.24	1.25	1.47	1.25	NA	1.37	1.37	1.29
	soft	1.26	1.88	1.89	1.35	1.18	1.35	1.18	1.88	1.22	1.23	1.25
	undefined	1.04	1.05	NA	1.04	1.08	1.04	1.08	NA	1.05	1.05	1.03
Lower Slope[3]	All	1.04	1.07	NA	1.04	0.96	1.04	0.96	NA	0.98	1.04	1.00
	hard	1.05	1.05	NA	1.05	NA	1.05	NA	NA	1.05	1.05	1.03
	mixed	1.09	1.08	NA	1.09	NA	1.09	NA	NA	1.09	1.09	0.99
	soft	1.06	1.11	NA	1.06	1.09	1.06	1.09	NA	1.06	1.06	1.10
	undefined	1.02	1.03	NA	1.02	0.96	1.02	0.96	NA	0.97	1.02	0.98
Grand mean	All	1.08	1.88	2.91	1.30	1.03	1.31	1.03	2.88	1.09	1.36	1.15

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

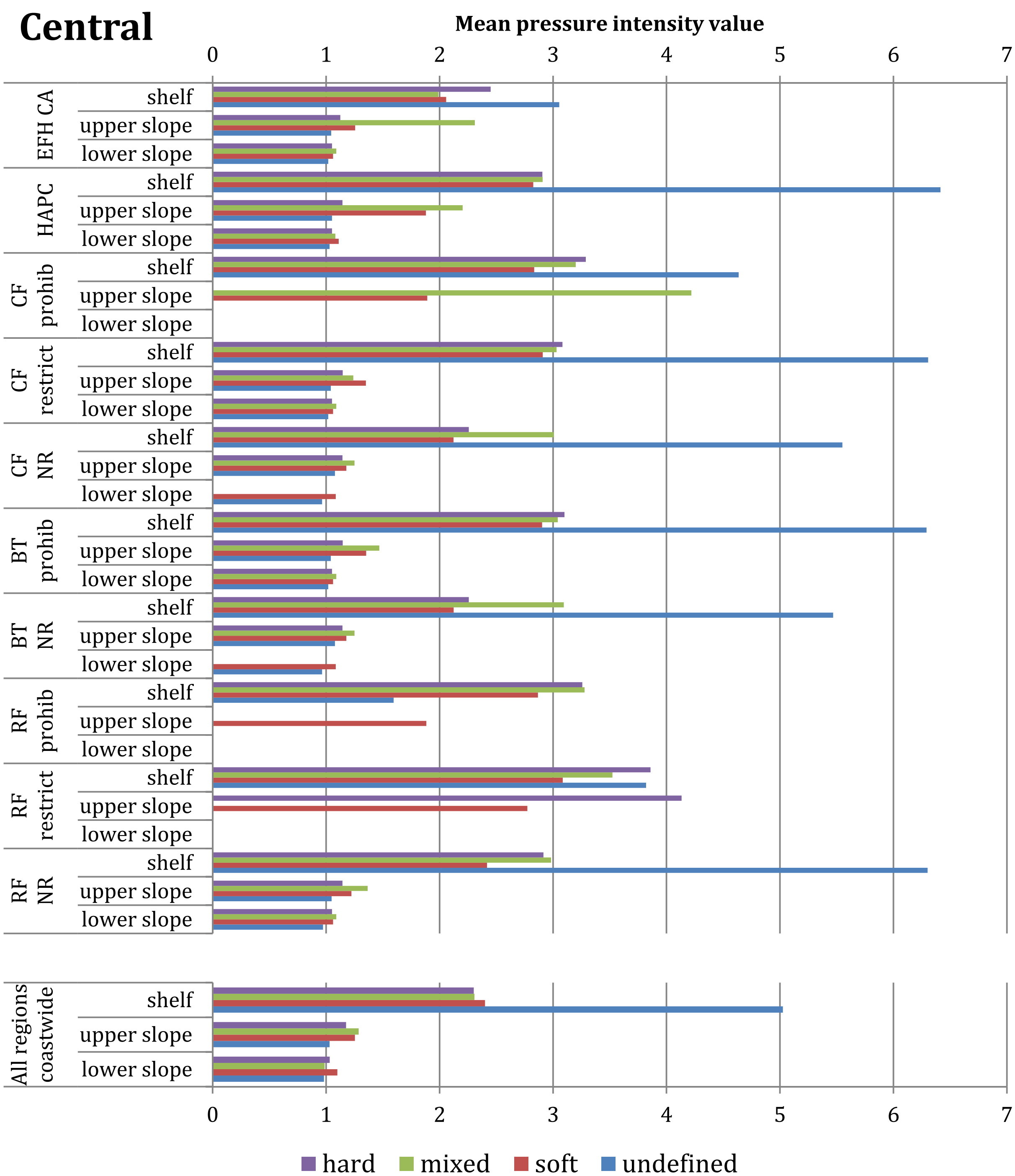


Figure A3b.57. Combined non-fisheries pressures. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the “Central” biogeographic region (i.e., Cape Mendocino, CA to Point Conception, CA). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.51. Combined pressure mean intensity values by depth zones and seabed substrate types across various management boundaries in the “Southern” biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). Mean intensity values were calculated from the sum of 16 non-fisheries pressures’ intensity values (Table A3b.1; data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone. Values for each pressure ranged from 0 to 1. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where “Commercial fishing” is prohibited, so these management areas all have the same mean intensity values. NA = no habitat present in this category.

COMBINED PRESSURES	SOUTHERN BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	1.74	1.95	2.15	2.76	3.87	2.84	3.16	1.97	3.40	2.92	2.63
	hard	1.20	2.13	2.88	2.25	4.15	2.51	2.75	2.50	3.21	2.57	2.30
	mixed	1.38	1.53	2.33	2.32	3.73	2.67	1.61	2.18	3.25	2.41	2.31
	soft	1.80	1.82	2.07	2.78	3.86	2.83	3.23	1.91	3.39	2.93	2.40
	undefined	2.40	4.86	4.06	4.87	3.58	4.84	3.58	4.24	4.87	4.71	5.03
Upper Slope[2]	All	1.38	1.16	2.47	1.25	1.30	1.71	1.22	2.41	1.39	1.28	1.25
	hard	1.79	1.15	2.53	1.20	1.14	1.54	1.08	2.52	1.24	1.17	1.18
	mixed	0.94	0.95	NA	0.95	1.45	0.99	0.97	NA	1.75	0.98	1.29
	soft	1.37	1.18	2.47	1.25	1.31	1.74	1.22	2.41	1.40	1.29	1.25
	undefined	NA	NA	NA	0.76	1.01	0.76	1.01	NA	1.00	1.00	1.03
Lower Slope[3]	All	0.92	0.90	NA	0.92	0.87	0.92	0.87	NA	0.88	0.92	1.00
	hard	0.90	0.90	NA	0.90	0.85	0.90	0.85	NA	0.90	0.90	1.03
	mixed	0.91	0.88	NA	0.91	NA	0.91	NA	NA	0.91	0.91	0.99
	soft	0.96	0.93	NA	0.96	0.92	0.96	0.92	NA	0.95	0.96	1.10
	undefined	0.89	0.85	NA	0.89	0.87	0.89	0.87	NA	0.87	0.89	0.98
Grand mean	All	0.99	1.14	2.23	1.19	0.98	1.25	0.98	2.08	1.04	1.27	1.15

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

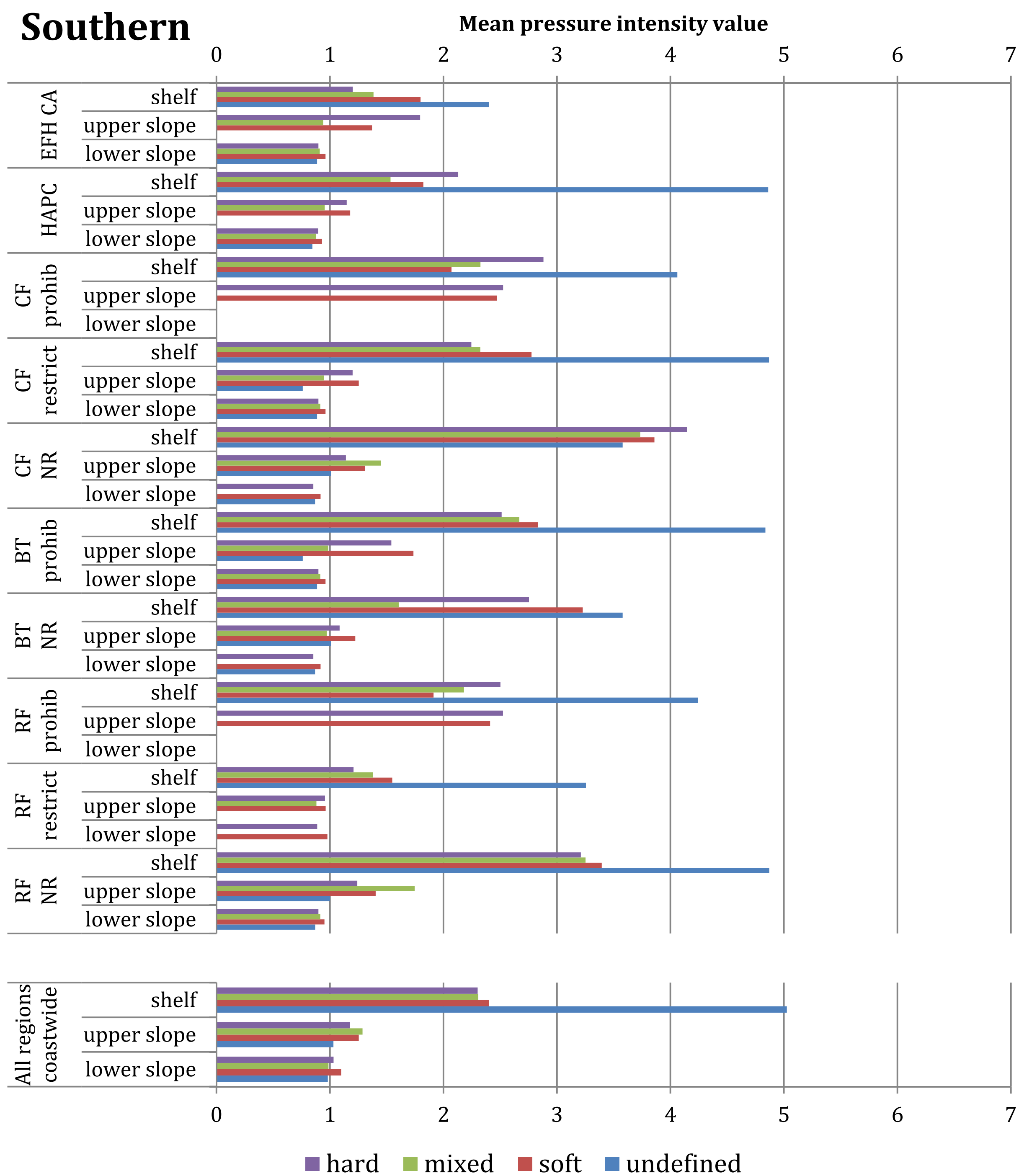


Figure A3b.58. Combined non-fisheries pressures. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Southern" biogeographic region (i.e., Point Conception, CA to U.S.-Mexico maritime border). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

Table A3b.52. Combined pressure mean intensity values by depth zones and seabed substrate types across various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). Mean intensity values were calculated from the sum of 16 non-fisheries pressures' intensity values (Table A3b.1; data from Halpern et al. 2009) assigned to 1 km^2 cells across the entire U.S. Exclusive Economic Zone. Values for each pressure ranged from 0 to 1. EFH CA = essential fish habitat conservation areas; HAPC = habitat areas of particular concern; Prohib = type of fishing is prohibited; Restr = type of fishing is restricted; NR = no restrictions for this type of fishing. Fishing restrictions included areas within EFH CA, rockfish conservation areas and state territorial sea restrictions. Fixed gear fishing (e.g., pots and longlines) and mid-water trawling were prohibited where "Commercial fishing" is prohibited, so these management areas all have the same mean intensity values. NA = no habitat present in this category.

COMBINED PRESSURES	SALISH SEA BIOGEOGRAPHIC SUB-REGION											COASTWIDE
		EFH CA	*HAPC*	*Commercial fishing*			*Bottom trawl*		*Recreational fishing*			*ALL*
Depth Zone	*Substrate*			*Prohib*	*Restr*	*NR*	*Prohib*	*NR*	*Prohib*	*Restr*	*NR*	
Shelf[1]	All	NA	5.28	3.96	4.31	NA	4.31	NA	NA	3.50	4.48	2.63
	hard	NA	3.65	NA	3.57	NA	3.57	NA	NA	3.51	3.65	2.30
	mixed	NA	3.61	NA	3.55	NA	3.55	NA	NA	3.46	3.95	2.31
	soft	NA	3.98	NA	3.64	NA	3.64	NA	NA	3.52	3.73	2.40
	undefined	NA	5.32	3.96	4.67	NA	4.67	NA	NA	3.44	4.71	5.03
Upper Slope[2]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.25
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.18
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.29
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.25
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.03
Lower Slope[3]	All	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.00
	hard	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.03
	mixed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.99
	soft	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.10
	undefined	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.98
Grand mean	All	NA	5.28	3.96	4.31	NA	4.31	NA	NA	3.50	4.48	1.15

[1] Continental shelf (i.e., coastline to continental shelf break), as defined by regional habitat layers.
[2] Upper continental slope (i.e., shelf break – 700 ftm EFH shoreward boundary). 700 ftm is generally recognized as the seaward extent of the groundfish fishery.
[3] Lower continental slope (i.e., 700 ftm EFH shoreward boundary – EEZ seaward boundary).

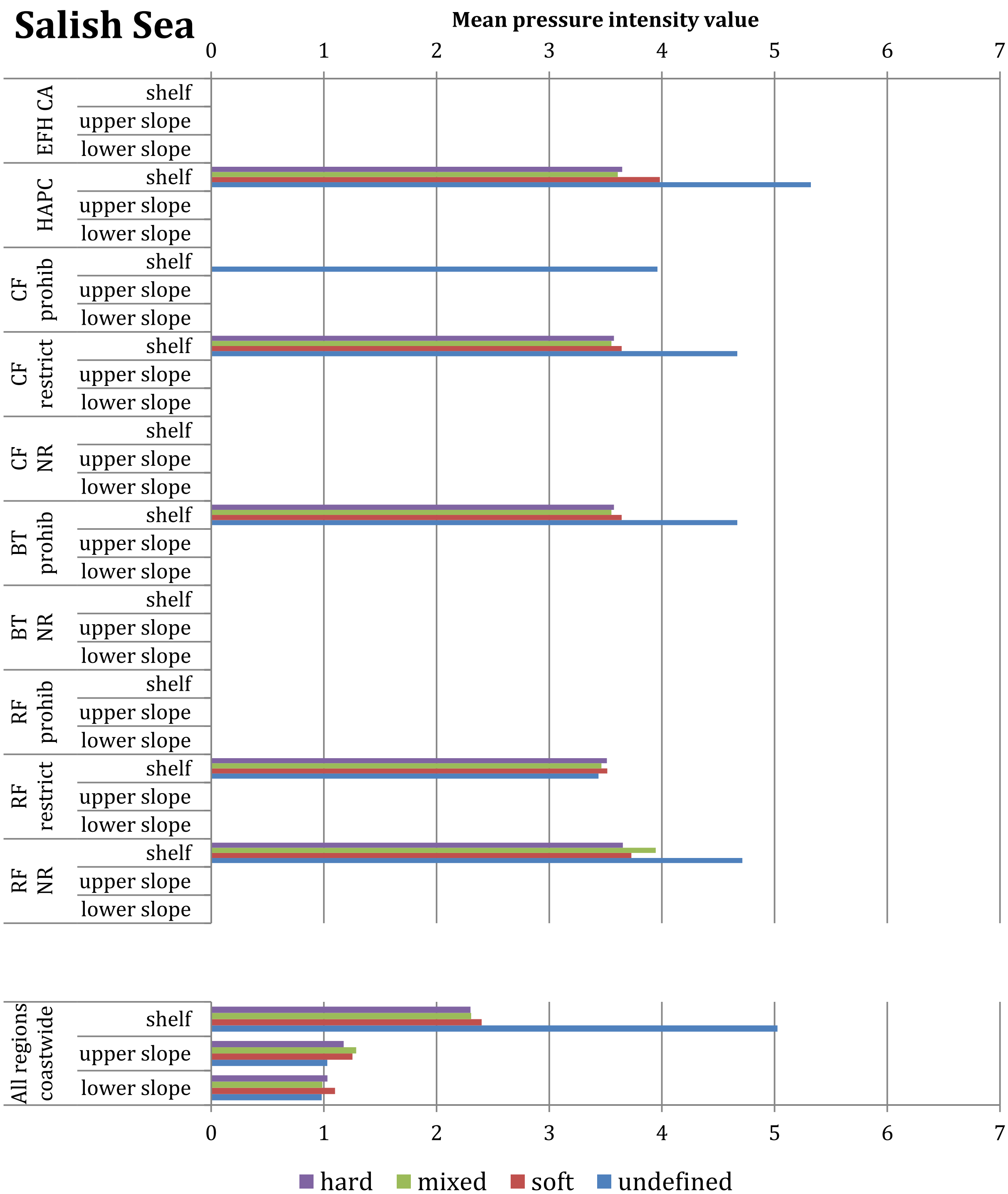


Figure A3b.59. Combined non-fisheries pressures. Mean pressure intensity values among seabed substrate types by depth zones in various management boundaries in the "Salish Sea" biogeographic region (i.e., Straits of Juan de Fuca, Georgia and Puget Sound). EFH CA = essential fish habitat conservation areas, HAPC = habitat areas of particular concern; CF = commercial fishing; BT = bottom trawling; RF = recreational fishing; prohib = type of fishing is prohibited; restrict = type of fishing is restricted; NR = no restrictions on type of fishing.

3.3 EMERGING PRESSURES

There are several pressures that will begin to exert larger influence across groundfish EFH in the near future. Natural gas terminals and associated activities, development of tidal, wave and offshore wind energy production, offshore mining activities, desalination plants, and other hydrokinetic projects will all affect groundfish EFH. There are currently preliminary permits for wave energy projects off the coast of Oregon, tidal energy projects in San Francisco Bay and other hydrokinetic projects in southern California (Fig. A3b.60), but these projects have not been deployed as of the time this report was written, so they were not included in our ‘combined’ pressures calculation.

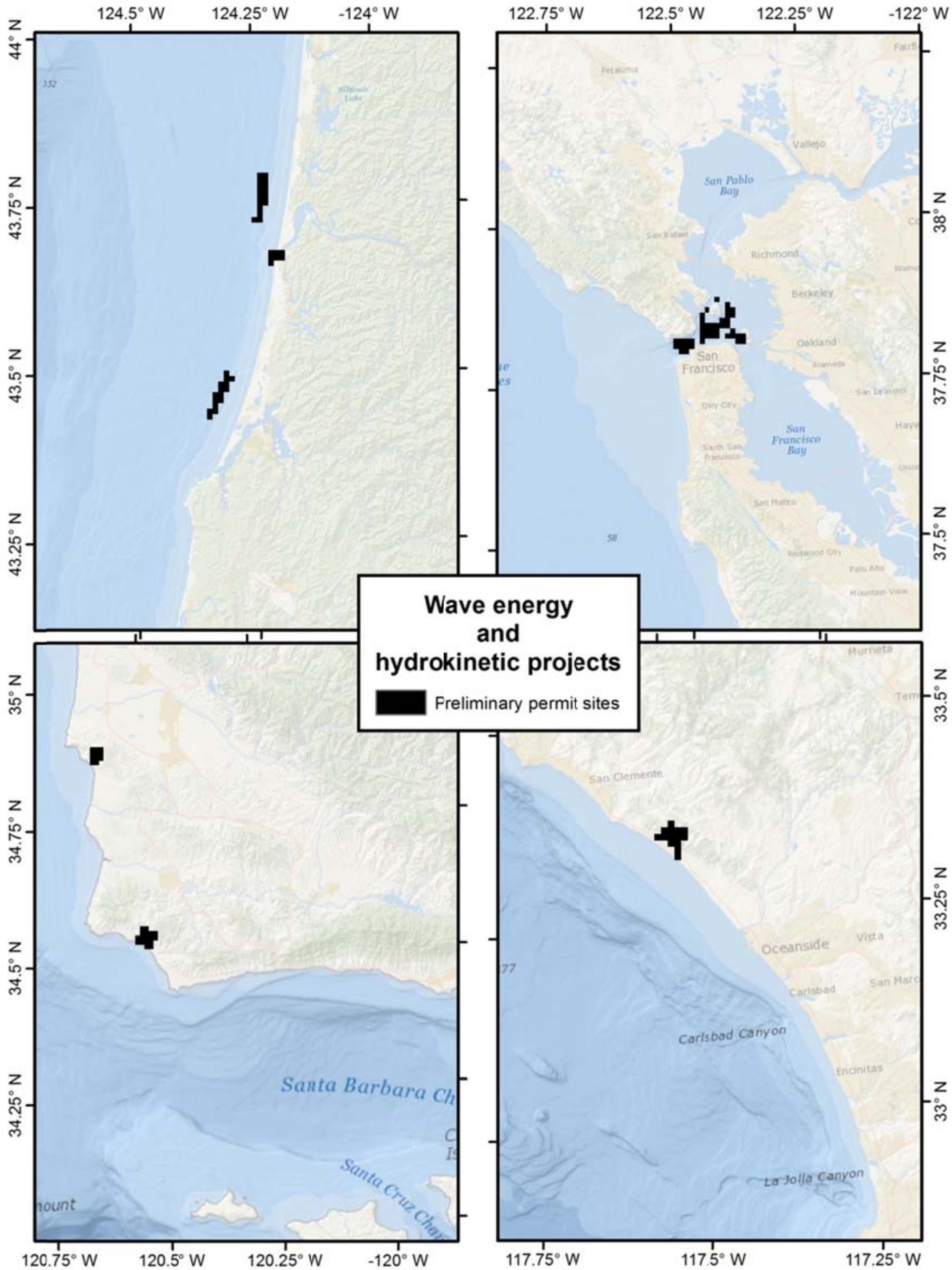


Figure A3b.60. Location of preliminary permits for wave energy and hydrokinetic projects along the U.S. West Coast.

3.4 CLIMATE CHANGE PRESSURES

Fully-developed analyses of the effects of climate change on groundfish essential fish habitat are beyond the scope of the current synthesis. Below, we outline two examples of how environmental pressures related to climate change could be incorporated into the EFH management framework.

3.4.1 Ocean acidification

In general, atmospheric carbon dioxide (CO_2) levels have been increasing at historically high rates since the industrial revolution. Rising atmospheric CO_2 is tempered by oceanic uptake where surface waters exchange gases at equilibrium with the atmosphere which has resulted in greater CO_2 uptake by the oceans (Feely et al. 2004, Doney et al. 2009). Increases in CO_2 uptake by the oceans results in lower pH values for seawater through a series of chemical reactions involving carbonate (CO_3^{2-}) ions. As the pH of seawater decreases (i.e. more acidic), calcifying organisms, such as corals and other shell-forming organisms, have decreased calcification and growth rates (Kleypas et al. 2006, Fine and Tchernov 2007, Fabry et al. 2008). Many of these affected taxa form biogenic habitat (e.g. corals) or are the basis of the food web (pteropods and coccolithophores) for a variety of zooplankton, larvae and fish predators, including groundfish in the North Pacific.

In order to determine what habitats on the U.S. West Coast may be most susceptible to ocean acidification, we used the ocean acidification (OA) data layer from Halpern et al. (Fig. 4b.61; Halpern et al. 2009) and two biogenic habitat layers. First, Guinotte & Davies (2012) have developed predictive models that identify areas with the highest probability of harboring deep-sea corals (Fig. A3b.62). Second, we used the map of direct observations of biogenic habitat described in Chapter 2. For both biogenic habitat data sets, we multiplied the OA intensity value by the corresponding habitat suitability probability value or the number of observations in each cell. This product results in an exposure intensity index that shows where the threat of OA is likely to be of greatest concern to biogenic habitats. For example, areas with high OA values and high habitat suitability values will have the highest exposure intensity values, while areas with low OA values and low habitat suitability values will have the lowest exposure intensity values.

Both data sets (Figs. 4b.63-64) show relatively high exposure intensity values in the northern region off the coast of Washington, particularly in the Olympic National Sanctuary. There also seems to be correspondence between the two data sets showing pockets of high exposure values in southern California. However, there appears to be differences among the two maps in Monterey Bay, CA. The exposure index is mostly in the medium high quintile using the habitat suitability values, while the exposure index is mostly in the two lowest quintiles using the direct observation data. OA values are consistently low across this region (Fig. A3b.61), so the difference arises because the suitability values are relatively high in Monterey Bay compared to the rest of the coast, while the numbers of direct observations in Monterey Bay are lower compared to areas with the highest numbers of direct observations along the coast.

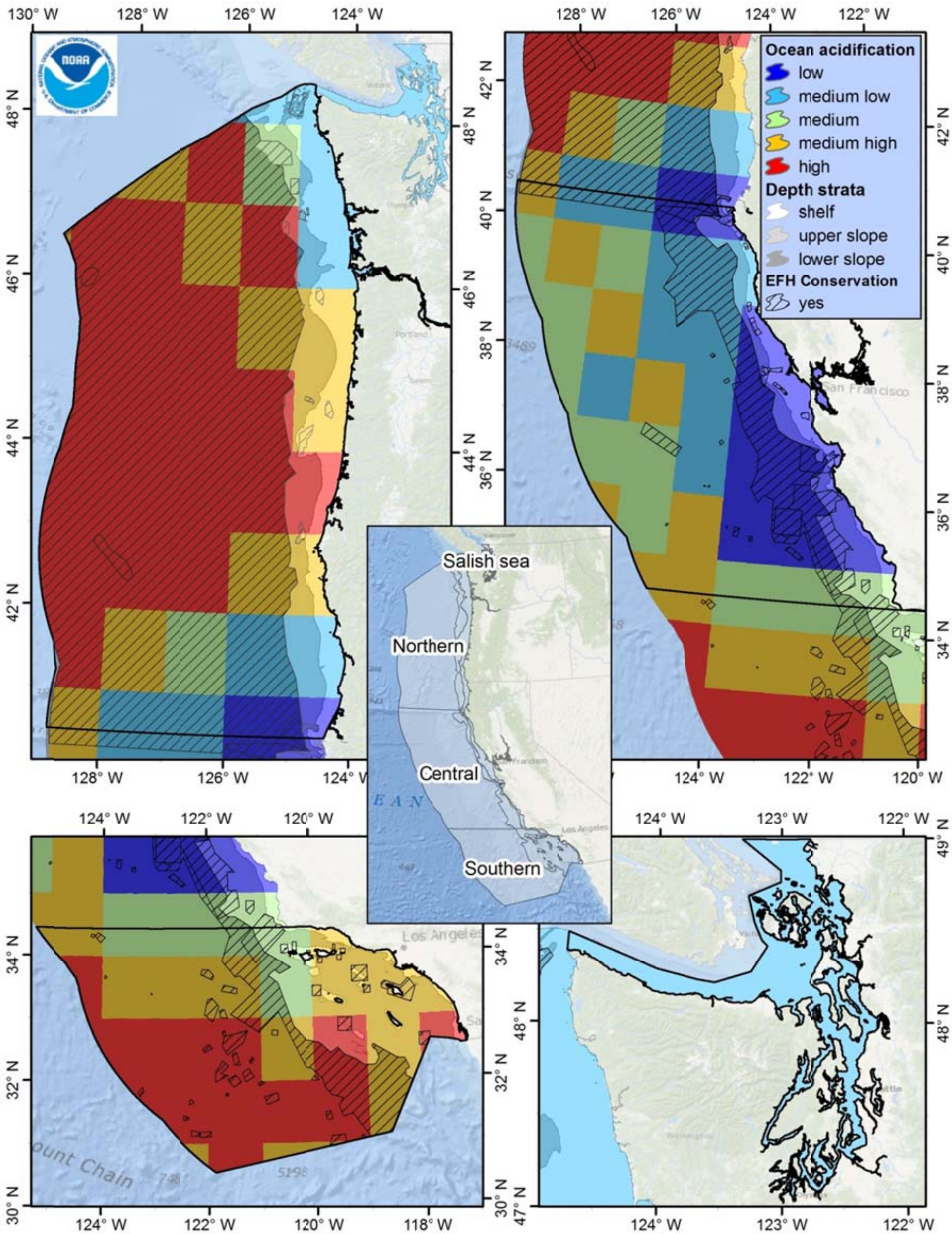


Figure A3b.61. Distribution of ocean acidification pressure intensity values among biogeographic regions, depth strata and essential fish habitat (EFH) conservation areas. Data for each pressure is from Halpern et al. 2009.

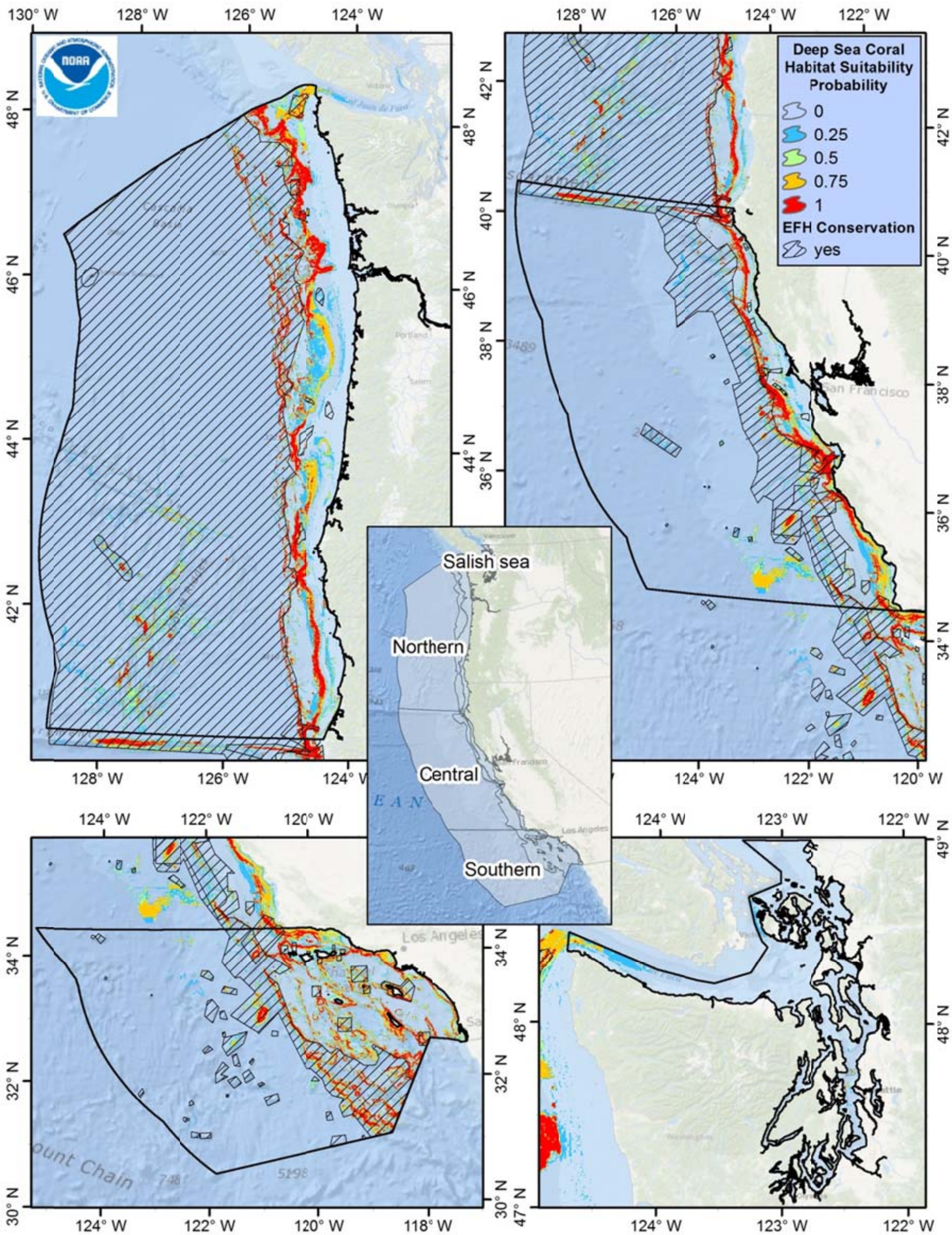


Figure A3b.62. Habitat suitability probabilities for deep sea corals. Data is from Guinotte & Davies (2012).

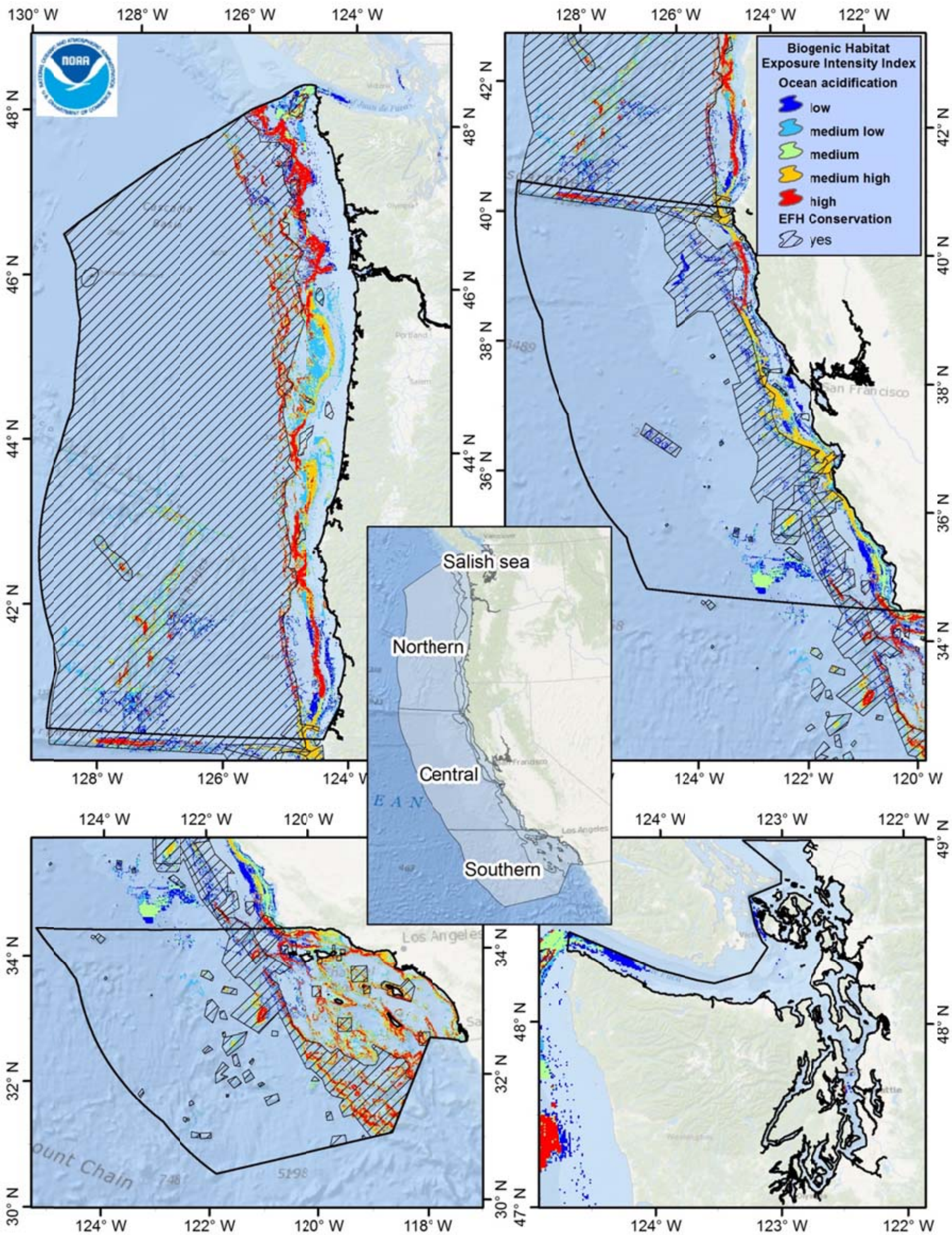


Figure A3b.63. Exposure intensity index of biogenic habitats using the habitat suitability probabilities for coral habitats described in Appendix 1. Regions with the highest exposure intensities are areas where biogenic habitat is most likely to occur and where ocean acidification is predicted to be highest. Essential Fish Habitat (EFH) conservation areas are overlaid.

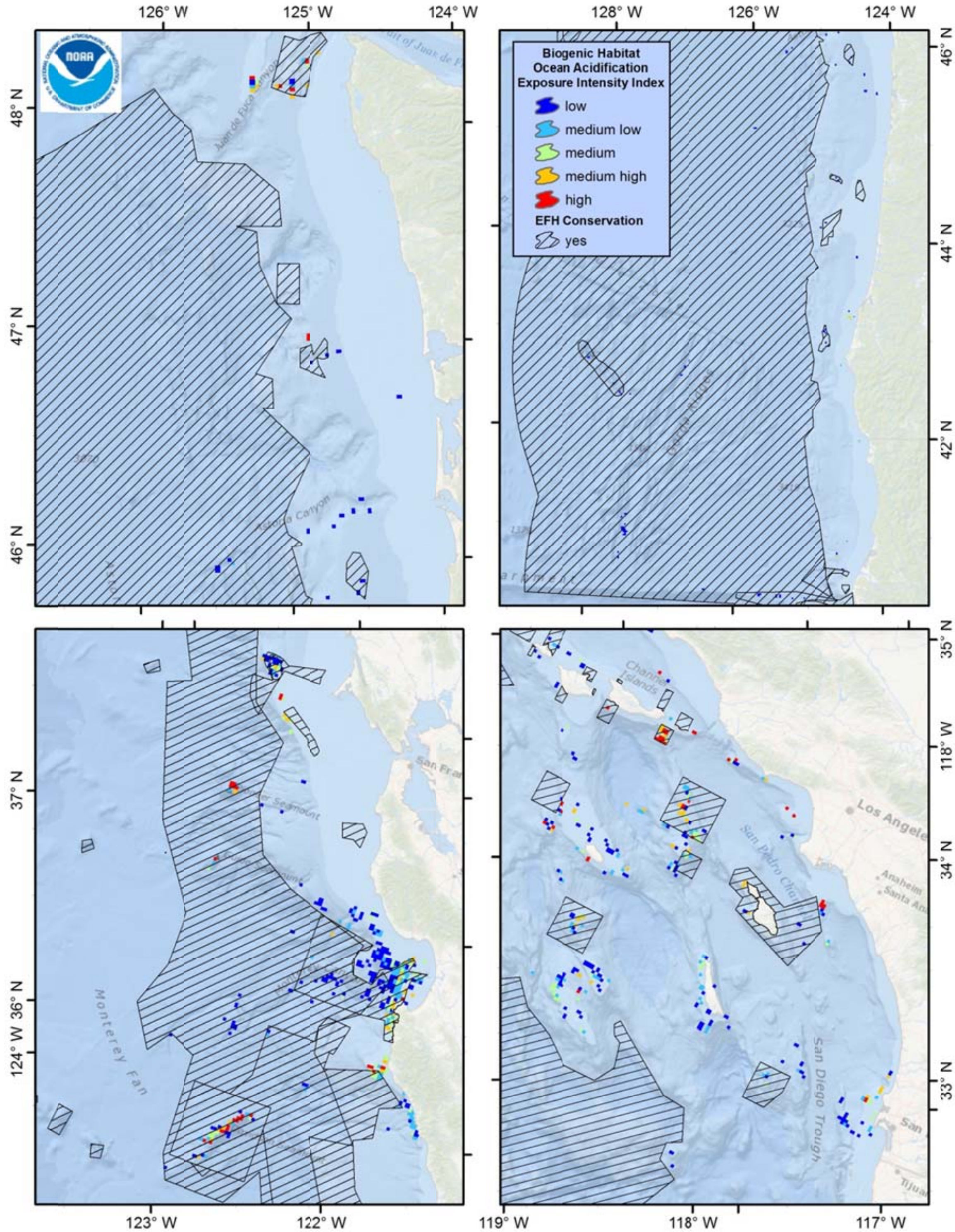


Figure A3b.64. Exposure intensity index of biogenic habitats using the database of coral and sponge occurrences described in Appendix 1. Locations with the highest exposure intensities are areas where large numbers of corals and sponges have been observed and where ocean acidification is predicted to be greatest. Essential Fish Habitat (EFH) conservation areas are overlaid. Note the entire coast is not shown to focus on areas where coral and sponge have been observed.

3.4.2 Sea-surface Temperature Anomalies

In general, global datasets show a rise in sea-surface temperatures since the 1970's (Hurrell and Trenberth 1999) and an increase in the ocean heat content since the 1950's (Levitus et al. 2005, Domingues et al. 2008). Rises in sea-surface temperature and ocean heat content have been linked with increases of greenhouse gases in the Earth's atmosphere (Levitus et al. 2001). With increasing ocean temperatures, marine species will have to adapt and they may do this in several ways. Some may simply be able to adjust their thermal tolerances (Young and Cech Jr 1996) if the changes occur slowly enough; however, this may come at a cost because energy allocation towards growth and reproduction declines at temperatures near the range extremes (Miller et al. 1988, Sogard and Olla 2002). Other species will likely exhibit behavioral thermoregulation, in that they will move to preferred temperatures or will have to move because their prey sources have moved. For example, the numbers and abundance of tropical species showing up in temperate habitats are slowly increasing because of increases in bottom water temperatures (1 – 6°C) over a 15-year period (Parker Jr and Dixon 1998). Moreover, two-thirds of the North Sea demersal fish assemblage has responded to increases in sea temperature by shifting their mean latitude or depth or both over a 25-year period (Perry et al. 2005).

In order to determine what areas of each species' distribution may be most at risk to temperature changes, we used the sea-surface temperature anomaly (SST) data layer from Halpern et al. (Halpern et al. 2009) and the across-year mean combined probability maps for each of the six groundfish species developed in Chapter 3. Each species distribution data layer was multiplied by the SST data layer. This product results in an exposure intensity index that shows where the threat of SST is likely to be of greatest concern to each species. For example, areas with high SST values and high probability values will have the highest exposure intensity values, while areas with low SST values and low probability values will have the lowest exposure intensity values.

Sea-surface temperature anomaly data shows relatively higher values in the northern biogeographic sub-region (Fig. A3b.65) and as a result, each species shows high exposure intensity values in the northern sub-region where the species is most likely to occur, regardless of whether the species is most likely to be found in offshore (longspine thornyhead: Fig. A3b.68; and sablefish: Fig. A3b.70), mid-depths (darkblotched: Fig. A3b.66; greenstriped: Fig. A3b.67; and yelloweye rockfish: Fig. A3b.71) or nearshore (petrale sole: Fig. A3b.69) waters.

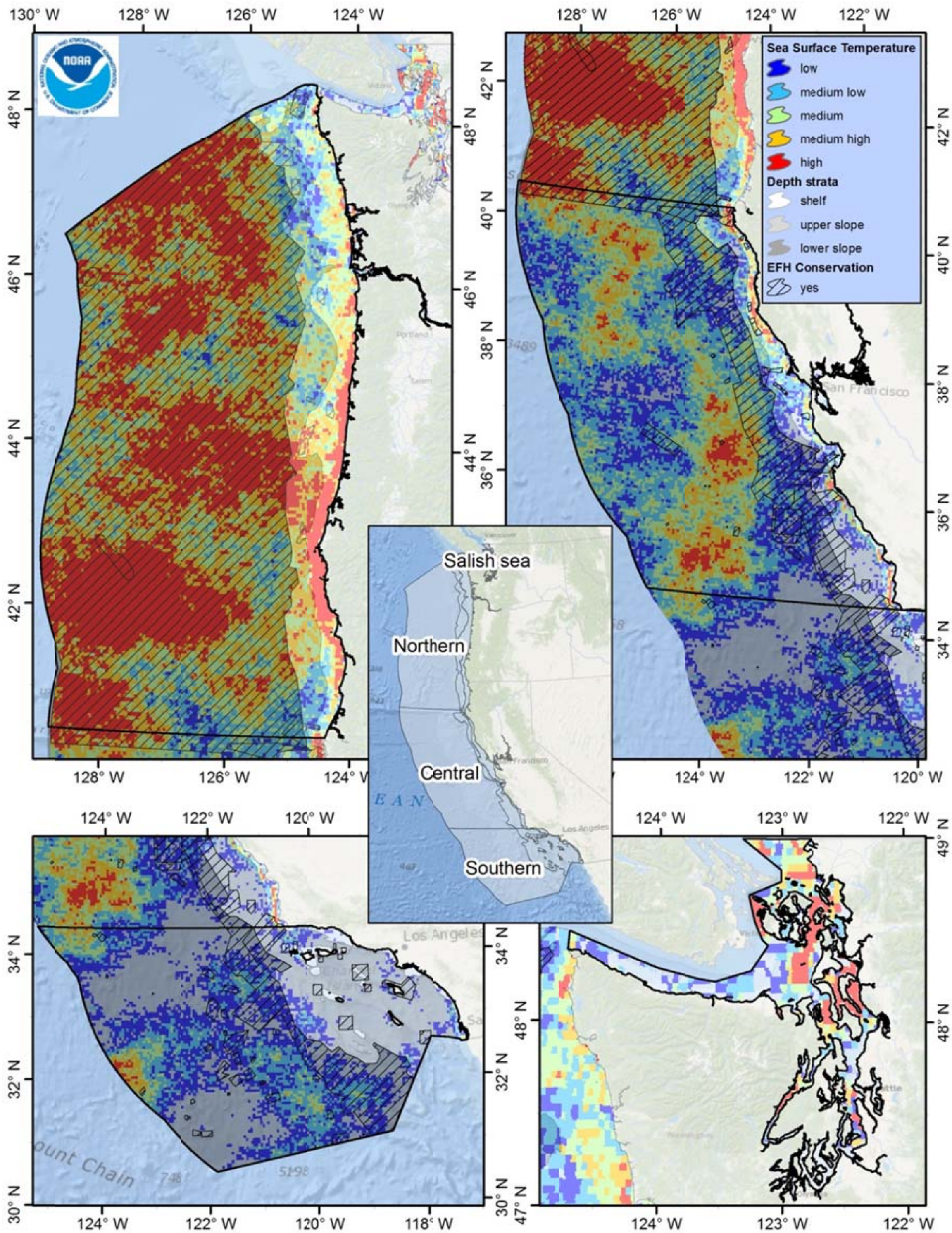


Figure A3b.65. Distribution of sea-surface temperature anomalies pressure intensity values among biogeographic regions, depth strata and essential fish habitat (EFH) conservation areas. Data for each pressure is from Halpern et al. 2009.

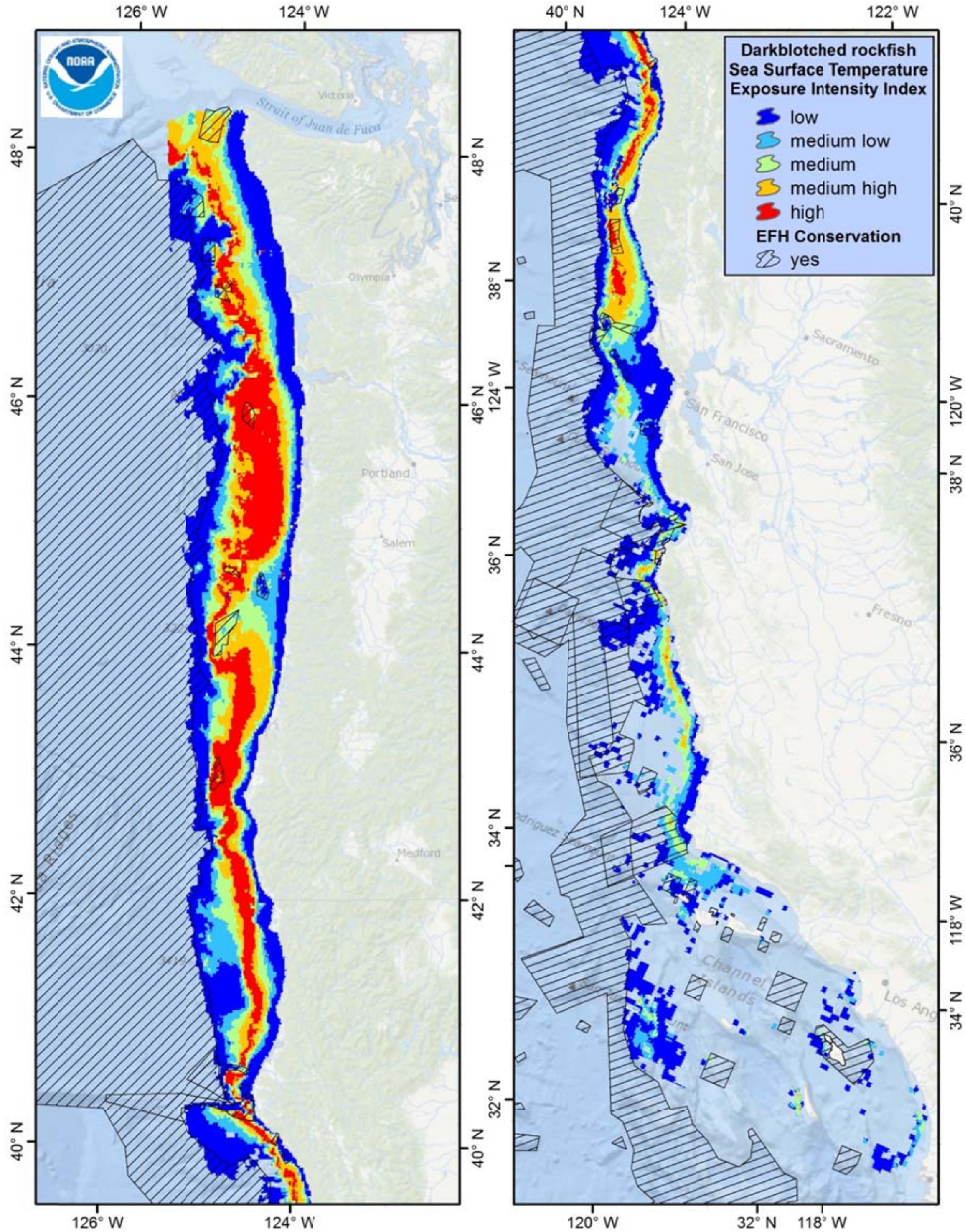


Figure A3b.66. Sea-surface temperature exposure intensity index for darkblotched rockfish *Sebastes crameri*. Exposure intensity values represent the product of the probability of species occurrence (see individual species-habitat maps in Appendix 2) and the sea-surface temperature anomaly pressure (see Halpern et al. 2008, 2009) data layers. Exposure intensity values were classified and shown by quintiles (20% of the data in each color). Essential Fish Habitat (EFH) conservation areas are overlaid.

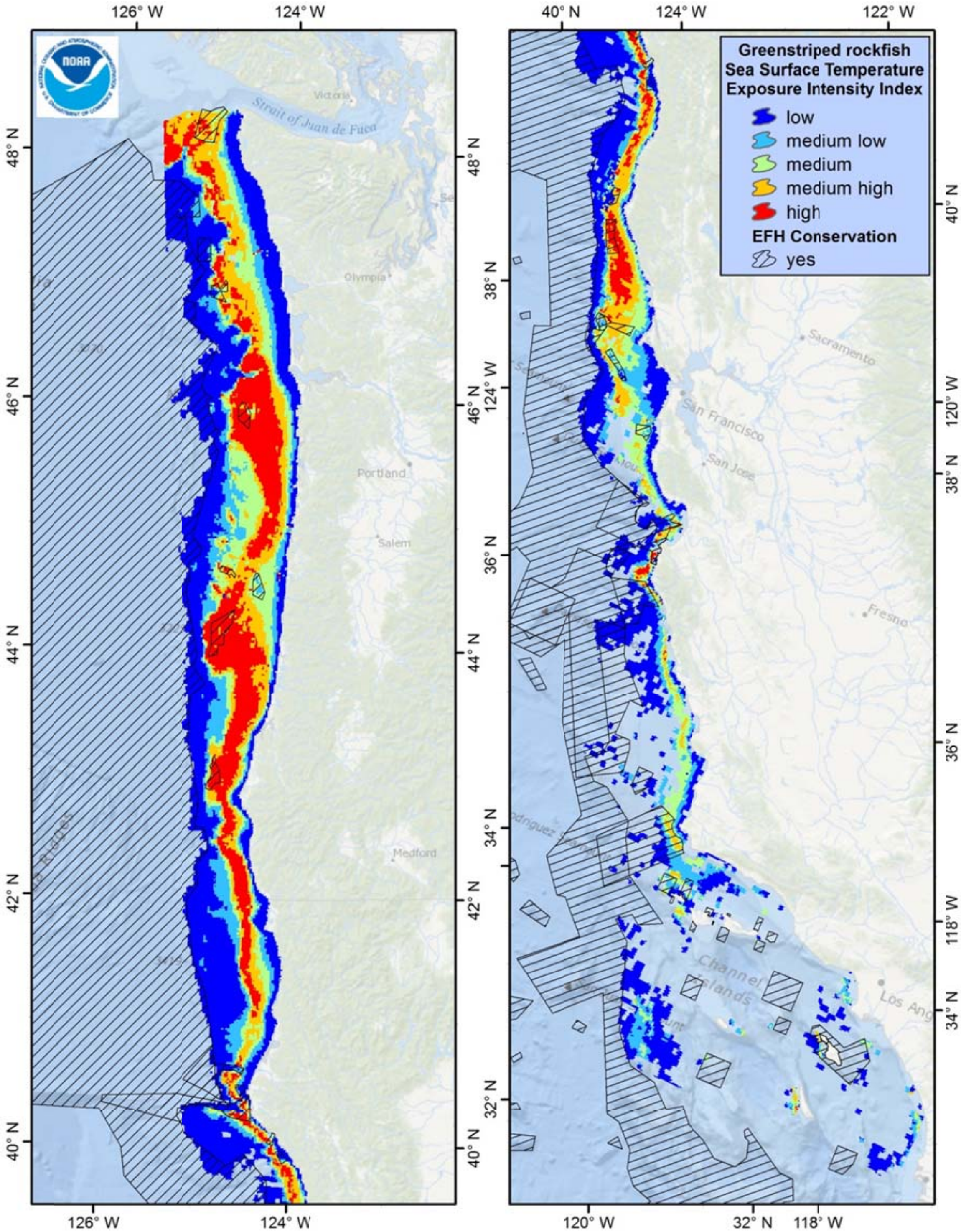


Figure A3b.67. Sea-surface temperature exposure intensity index for greenstriped rockfish *Sebastes elongatus*. Exposure intensity values represent the product of the probability of species occurrence (see individual species-habitat maps in Appendix 2) and the sea-surface temperature anomaly pressure (see Halpern et al. 2008, 2009) data layers. Exposure intensity values were classified and shown by quintiles (20% of the data in each color). Essential Fish Habitat (EFH) conservation areas are overlaid.

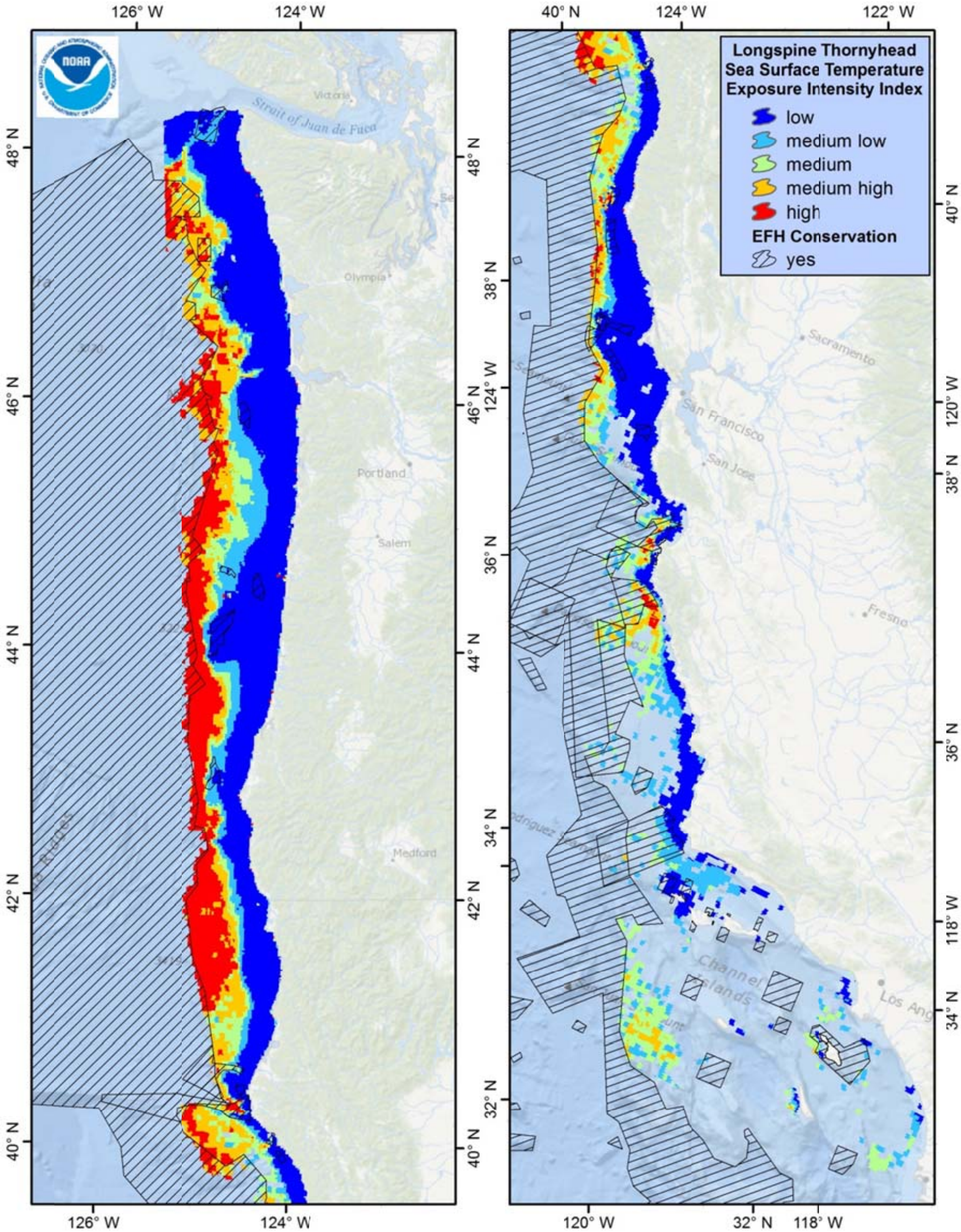


Figure A3b.68. Sea-surface temperature exposure intensity index for longspine thornyhead *Sebastolobus altivelis*. Exposure intensity values represent the product of the probability of species occurrence (see individual species-habitat maps in Appendix 2) and the sea-surface temperature anomaly pressure (see Halpern et al. 2008, 2009) data layers. Exposure intensity values were classified and shown by quintiles (20% of the data in each color). Essential Fish Habitat (EFH) conservation areas are overlaid.

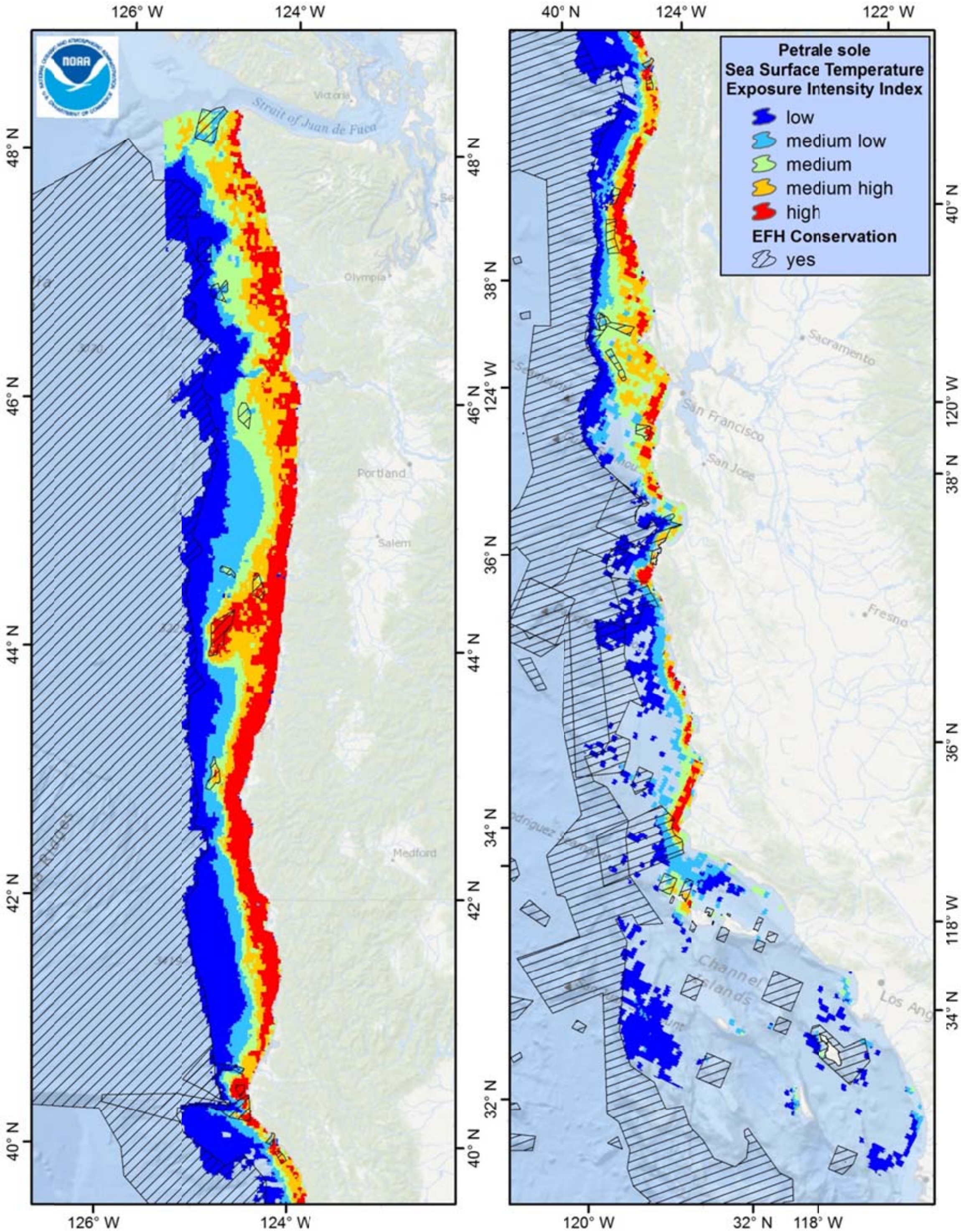


Figure A3b.69. Sea-surface temperature exposure intensity index for petrale sole *Eopsetta jordani*. Exposure intensity values represent the product of the probability of species occurrence (see individual species-habitat maps in Appendix 2) and the sea-surface temperature anomaly pressure (see Halpern et al. 2008, 2009) data layers. Exposure intensity values were classified and shown by quintiles (20% of the data in each color). Essential Fish Habitat (EFH) conservation areas are overlaid.

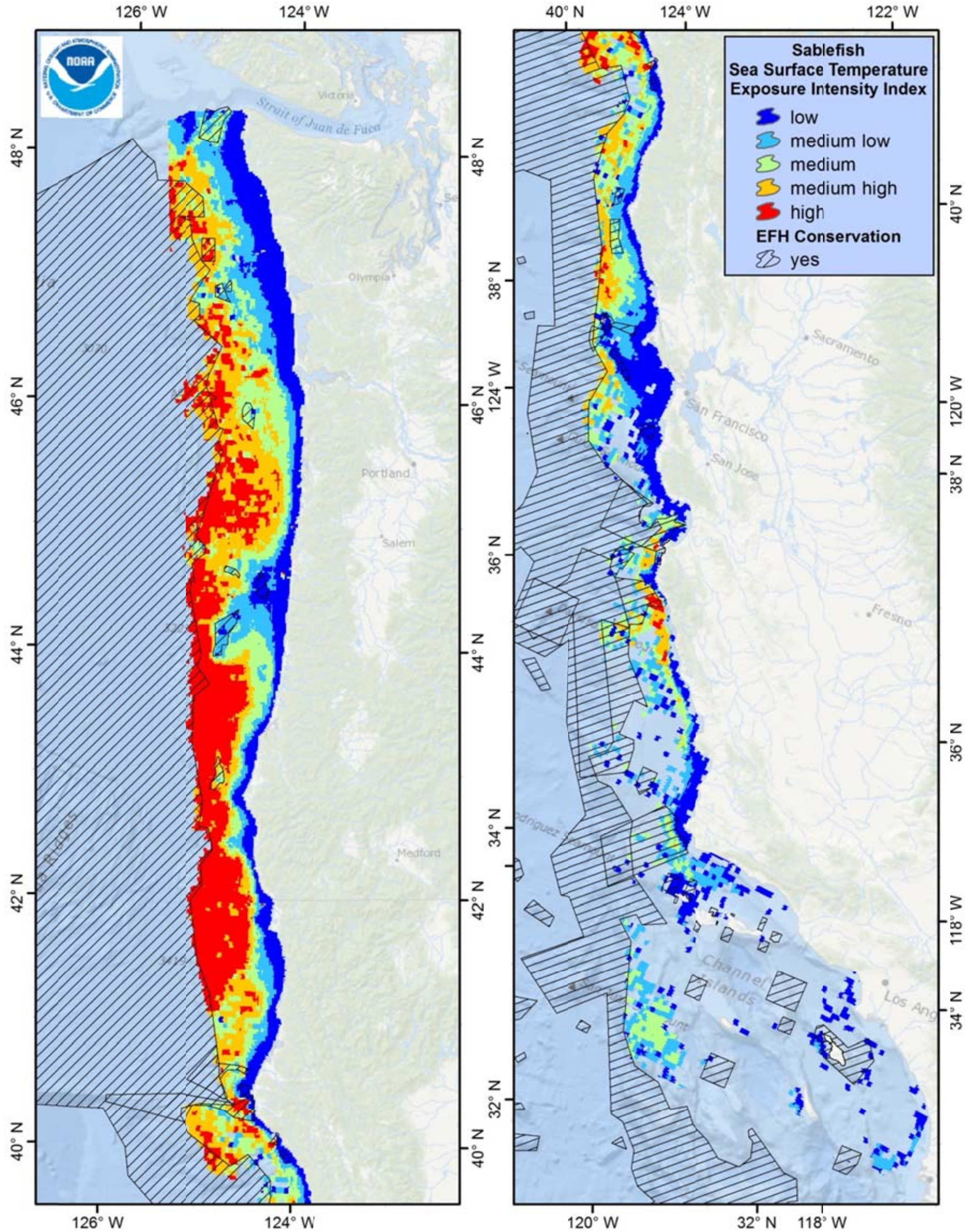


Figure A3b.70. Sea-surface temperature exposure intensity index for sablefish *Anoplopoma fimbria*. Exposure intensity values represent the product of the probability of species occurrence (see individual species-habitat maps in Appendix 2) and the sea-surface temperature anomaly pressure (see Halpern et al. 2008, 2009) data layers. Exposure intensity values were classified and shown by quintiles (20% of the data in each color). Essential Fish Habitat (EFH) conservation areas are overlaid.

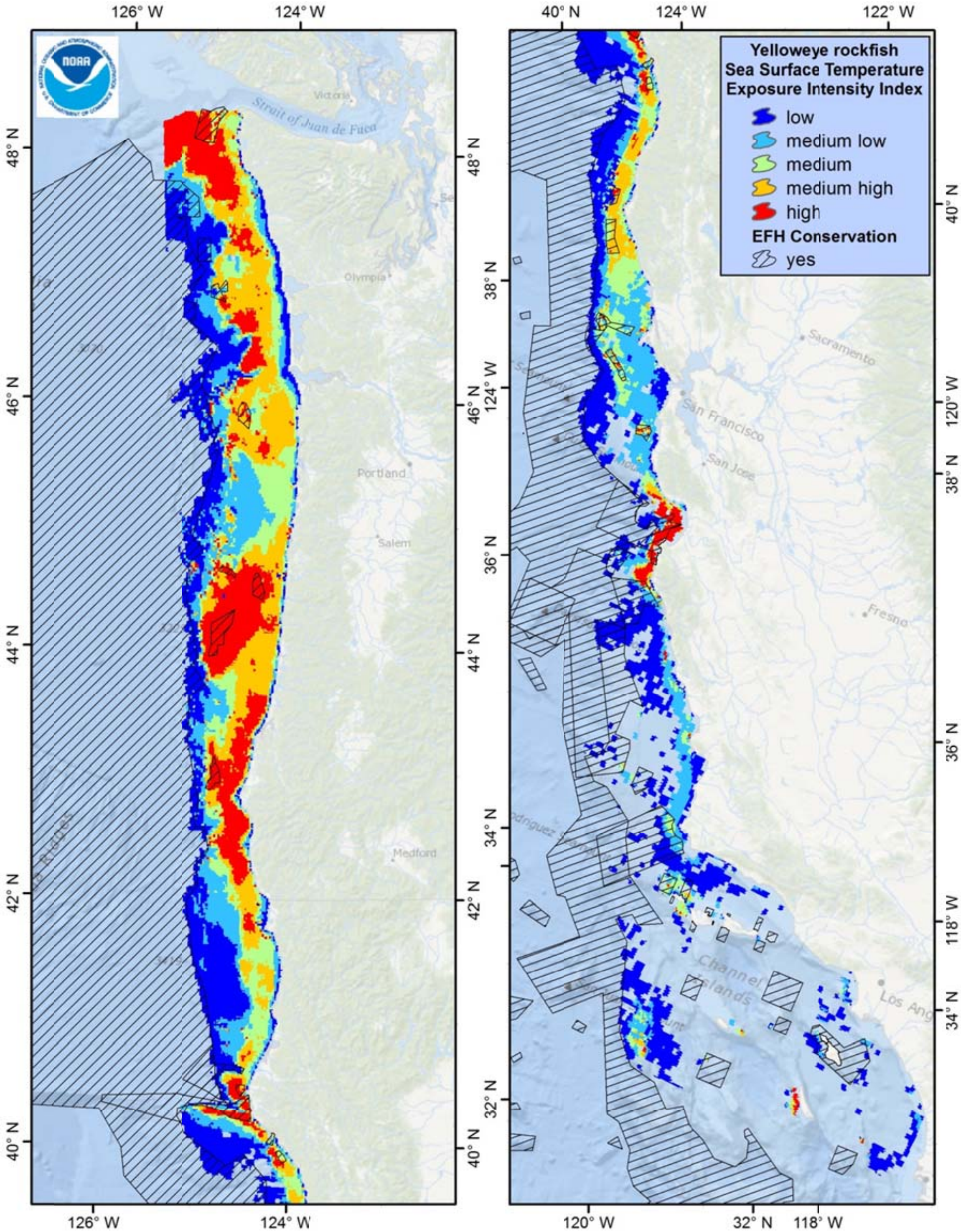


Figure A3b.71. Sea-surface temperature exposure intensity index for yelloweye rockfish *Sebastes ruberrimus*. Exposure intensity values represent the product of the probability of species occurrence (see individual species-habitat maps in Appendix 2) and the sea-surface temperature anomaly pressure (see Halpern et al. 2008, 2009) data layers. Exposure intensity values were classified and shown by quintiles (20% of the data in each color). Essential Fish Habitat (EFH) conservation areas are overlaid.

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4.0 METHODS FOR EXAMINING PREDATOR/PREY RELATIONSHIPS

References used to Evaluate Diet Composition of Select Groundfish Species

Petrale Sole (*Eopsetta jordani*)

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Dover Sole *(Microstomus pacificus)*

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Sablefish (*Anoplopoma fimbria*)

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Lingcod (*Ophiodon elongatus*)

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Greenstriped Rockfish (*Sebastes elongatus*)

Allen, M. J. 1982. Functional structure of soft-bottom fish communities of the southern California shelf. Ph.D. Thesis. University of California, San Diego.

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Rosethorn Rockfish (*Sebastes helvomaculatus*)

Shaw, F. R. 1999. Life history traits of four species of rockfish (genus *Sebastes*). M.S. Thesis. University of Washington.

York, K. J. 2005. Resource partitioning in an assemblage of deep-water, demersal rockfish (*Sebastes* spp.) on the northeast Pacific continental shelf. Masters Thesis. Washington State University.

Sharpchin Rockfish (*Sebastes zacentrus*)

Shaw, F. R. 1999. Life history traits of four species of rockfish (genus *Sebastes*). M.S. Thesis. University of Washington.

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Darkblotched Rockfish (*Sebastes crameri*)

Brodeur, R.D. and Pearcy, W.G. 1984. Food habits and dietary overlap of some shelf rockfishes (genus *Sebastes*) from the northeastern Pacific Ocean. Fishery Bulletin 82: 269-273.

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Yelloweye Rockfish (*Sebastes ruberrimus*)

Steiner, R. E. 1978. Food habits and species composition of neritic reef fishes off Depoe Bay, Oregon. M.S. Thesis. Oregon State University.

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Longspine Thornyhead (*Sebastolobus altivelis*)

Buckley, T. W., Tyler, G.E., Smith, D.M., and Livingston, P.A. 1999. Food habits of some commercially important groundfish off the coasts of California, Oregon, Washington, and British Columbia. NOAA Technical Memorandum NMFS-AFSC-102.

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4.1 INFORMATION USED TO EVALUATE DIET COMPOSITION OF SELECT GROUNDFISH SPECIES

PETRALE SOLE. Author(s) and year of publication, number of stomachs with prey (*n*), sampling year, sampling method, study region, size range (SL = standard length), maturity (after Love 2011), sampling depth, and metric used in diet composition calculations (% W = percent weight; %IRI = percent index of relative importance) for petrale sole (*Eopsetta jordani*). U = unknown.

Study	*n*	Year	Method	Study Region	Size Range (cm)	Maturity	Depth (m)	Diet Metric
Morejohn et al. 1978	10	1978	Trolling, set lines, trawls	Central CA	U	U	37 - 73	%IRI
Morejohn et al. 1978	4	1978	Trolling, set lines, trawls	Southern CA	U	U	55 - 73	%IRI
Wakefield 1984	29	1979	Trawl	OR	10 - 32 SL	Juvenile - Adult	73	%W

DOVER SOLE. Author(s) and year of publication, number of stomachs with prey (*n*), sampling year(s), sampling method, study region, size range (SL = standard length; FL = fork length), maturity (after Love 2011), sampling depth, and metric used in diet composition calculations (% W = percent weight) for Dover sole *(Microstomus pacificus*). U = unknown.

Study	*n*	Year(s)	Method	Study Region	Size Range (cm)	Maturity	Depth (m)	Diet Metric
Pearcy and Hancock 1978	326	1968 - 1970	Beam trawl	OR	5 - 45 SL	Juvenile - Adult	74 - 195	%W
Gabriel and Pearcy 1981	202	1976	Beam trawl	OR	11 - 42 SL	Juvenile - Adult	119	%W
Gabriel and Pearcy 1981	202	1976	Beam trawl	OR	11 - 42 SL	Juvenile - Adult	426	%W
Allen 1982	23	1973 - 1977	Trawl	Southern CA	U	U	88 - 182	%W
Manzanilla and Cross 1982	38	1980	Trawl	Santa Monica Bay, CA	U	U	60	%W
Wakefield 1984	24	1979	Trawl	OR	10 - 22 SL	Juvenile - Adult	73	%W
Buckley et al. 1999	262	1989	Trawl	Point Conception, CA - Cape Blanco, OR	15 - 54 FL	Juvenile - Adult	55 - 364	%W
Buckley et al. 1999	261	1989	Trawl	Cape Blanco, OR - Vancouver Island, Canada	15 - 54 FL	Juvenile - Adult	55 - 364	%W
Buckley et al. 1999	116	1991	Trawl	Point Conception, CA - Cape Blanco, OR	25 - 54 FL	Juvenile - Adult	366 - 1279	%W
Buckley et al. 1999	131	1992	Trawl	Cape Blanco, OR - Vancouver Island, Canada	20 - 54 FL	Juvenile - Adult	183 - 1279	%W

SABLEFISH. Author(s) and year of publication, number of stomachs with prey (*n*), sampling year(s), sampling method, study region, size range (FL = fork length; SL = standard length), maturity (after Love 2011), sampling depth, and metric used in diet composition calculations (% W = percent weight; %V = percent volume) for sablefish (*Anoplopoma fimbria*). U = unknown. * = mean length (+ SD).

Study	*n*	Year(s)	Method	Study Region	Size Range (cm)	Maturity	Depth (m)	Diet Metric
Conway 1967	556	1965 - 1966	Set lines, purse seine	Southern CA - Northern Baja	5 - 75 FL	Juvenile - Adult	Surface waters, 366 - 549	%W
Allen 1982	12	1972 - 1973	Trawl	Southern CA	U	U	30 - 190	%V
Laidig et al. 1997	1868	1987 - 1992	Trawl	OR - CA	25 - 75 FL	Juvenile - Adult	183 - 1280	%V
Cailliet et al. 1988	19	1973 - 1974	Traps, otter trawl, gill nets, angling	Monterey Bay, CA	20 - 30 SL	Juvenile	92 - 915	%V
Cailliet et al. 1988	295	1973 - 1974	Traps, otter trawl, gill nets, angling	Monterey Bay, CA	31 - 91 SL	Juvenile - Adult	92 - 549	%W
Buckley et al. 1999	129	1989	Trawl	Point Conception, CA - Cape Blanco, OR	20 - 59 FL	Juvenile - Adult	55 - 364	%W
Buckley et al. 1999	129	1989	Trawl	Cape Blanco, OR - Vancouver Island, Canada	20 - > 70 FL	Juvenile - Adult	55 - 364	%W
Buckley et al. 1999	88	1991	Trawl	Point Conception, CA - Cape Blanco, OR	40 - > 70 FL	Juvenile - Adult	366 - 1279	%W
Buckley et al. 1999	76	1992	Trawl	Cape Blanco, OR - Vancouver Island, Canada	40 - 69 FL	Juvenile - Adult	183 - 1279	%W
Miller and Brodeur 2007	6	2000	Trawl	OR - Northern CA	16 (± 2) FL*	Juvenile	< 18	%W
Miller and Brodeur 2007	15	2002	Trawl	OR - Northern CA	18 (± 9) FL*	Juvenile	< 18	%W

LINGCOD. Author(s) and year of publication, number of stomachs with prey (*n*), sampling year(s), sampling method, study region, size range (FL = fork length; SL = standard length; TL = total length), maturity (after Miller and Brodeur, 2007; Love 2011), sampling depth, and metric used in diet composition calculations (% W = percent weight) for lingcod *Ophiodon elongatus*). * = mean length (± SD).

Study	*n*	Year(s)	Method	Study Region	Size Range (cm)	Maturity	Depth (m)	Diet Metric
Steiner 1978	68	1976 - 1977	Angling	OR	40 - 115 FL	Juvenile - Adult	10 - 50	%W
Wakefield 1984	4	1979	Trawl	OR	22 - 65 SL	Juvenile - Adult	73	%W
Beaudreau and Essington 2007	13	2004 - 2005	Beach seine	San Juan Archipelago, WA	10 - 20 TL	Juvenile	< 5	%W
Beaudreau and Essington 2007	385	2004 - 2005	Angling	San Juan Archipelago, WA	31 - 110 TL	Juvenile - Adult	9 - 55	%W
Miller and Brodeur 2007	10	2000	Trawl	OR - Northern CA	7 (± 4) FL*	Juvenile	< 18	%W
Miller and Brodeur 2007	1	2002	Trawl	OR - Northern CA	6 FL*	Juvenile	< 18	%W

GREEENSTRIPED ROCKFISH. Author and year of publication, number of stomachs with prey (*n*), sampling years, sampling method, study region, size range (TL = total length; FL = fork length), maturity (after Love 2011), sampling depth, and metric used in diet composition calculations (%V = percent volume; %W = percent weight) for greenstriped rockfish (*Sebastes elongatus*). U = unknown. * = mean length (+ SD).

Study	***n***	**Years**	**Method**	**Study Region**	**Size Range (cm)**	**Maturity**	**Depth (m)**	**Diet Metric**
Allen 1982	12	1965-1980	Trawl	Southern CA	4 - 31 TL	Juvenile - Adult	90 - 274	%V
Shaw 1999	47	1986	Trawl	CA to WA	21 - 35 TL	Juvenile - Adult	< 500	%W
York 2005	51	2003-2004	Trawl	Central CA - Canadian Border	27 (+ 5) FL*	Juvenile - Adult	U	%W

ROSETHORN ROCKFISH. Author and year of publication, number of stomachs with prey (*n*), sampling year(s), sampling method, study region, size range (TL = total length; FL = fork length), maturity (after Love 2011), sampling depth, and metric used in diet composition calculations (%W = percent weight; %V = percent volume) for rosethorn rockfish (*Sebastes helvomaculatus*). U = unknown. * = mean length (+ SD).

Study	***n***	**Years**	**Method**	**Study Region**	**Size Range (cm)**	**Maturity**	**Depth (m)**	**Diet Metric**
Shaw 1999	8	1986	Trawl	CA to WA	20 - 30 TL	Juvenile - Adult	< 500	%W
York 2005	60	2003 - 2004	Trawl	Central CA - Canadian Border	26 (+ 3) FL*	Juvenile - Adult	U	%V

SHARPCHIN ROCKFISH. Author and year of publication, number of stomachs with prey (*n*), sampling year(s), sampling method, study region, size range (FL = fork length), maturity (after Love 2011), sampling depth, and metric used in diet composition calculations (% W = percent weight) for sharpchin rockfish *(Sebastes zacentrus*). U = unknown. * = mean length (+ SD).

Study	***n***	**Year(s)**	**Method**	**Study Region**	**Size Range (cm)**	**Maturity**	**Depth (m)**	**Diet Metric**
Shaw 1999	8	1986	Trawl	OR	U	U	25 - 444	%W
York 2005	36	2003 - 2004	Trawl	Central CA - Canadian Border	27 (+ 4) FL*	Juvenile - Adult	U	%W

DARKBLOTCHED ROCKFISH. Authors and year of publication, number of stomachs with prey (*n*), sampling year, sampling method, study region, size range (TL = total length; FL = fork length), maturity (after Miller and Brodeur 2007), sampling depth, and metric used in diet composition calculations (% W = percent weight) for darkblotched rockfish (*Sebastes crameri*). * = mean length (+ SD).

Study	*n*	Year	Method	Study Region	Size Range (cm)	Maturity	Depth (m)	Diet Metric
Brodeur and Pearcy 1984	20	1980	Trawl	Northern CA to Vancouver Island, BC	33 (+ 8) TL*	Juvenile - Adult	55 - 366	%W
Miller and Brodeur 2007	7	2000	Trawl	OR to Northern CA	5 (+ 0.4) FL*	Juvenile	< 18 m	%W
Miller and Brodeur 2007	11	2002	Trawl	OR to Northern CA	3 (+ 0.2) FL*	Juvenile	< 18 m	%W

YELLOWEYE ROCKFISH. Author and year of publication, number of stomachs with prey (*n*), sampling years, sampling method, study region, size range (FL = fork length), maturity (after Love 2011), sampling depth, and metric used in diet composition calculations (% W = percent weight) for yelloweye rockfish (*Sebastes ruberrimus*). U= unknown. * = mean length (+ SD).

Study	*n*	Year	Method	Study Region	Size Range (cm)	Maturity	Depth (m)	Diet Metric
Steiner 1978	28	1976 - 1977	Angling	OR	U	U	10 - 30	%W
York 2005	9	2003 - 2004	Trawl	Central CA - Canadian Border	35 (+ 19) FL*	Juvenile - Adult	U	%W

LONGSPINE THORNYHEAD. Author(s) and year of publication, number of stomachs with prey (*n*), sampling year(s), sampling method, study region, size range (FL = fork length; SL = standard length), maturity (after Love 2011), sampling depth, and metric used in diet composition calculations (% W = percent weight; %V = percent volume) for longspine thornyhead *(Sebastolobus altivelis*).

Study	*n*	Year	Method	Study Region	Size Range (cm)	Maturity	Depth (m)	Diet Metric
Buckley et al. 1999	168	1991	Trawl	Point Conception, CA - Cape Blanco, OR	5 - 34 FL	Juvenile - Adult	366 - 1279	%W
Buckley et al. 1999	113	1992	Trawl	Cape Blanco, OR - Vancouver Island, Canada	5 - 34 FL	Juvenile - Adult	366 - 1279	%W
Laidig, unpublished data; Field 2004	959	1988 - 1990	Trawl	OR - CA	6-32 SL	Juvenile - Adult	183 - 1280	%V

PACIFIC HAKE. Author(s) and year of publication, number of stomachs with prey (*n*), sampling years, sampling method, study region, size range (TL = total length; TL* = presumed total length; FL = fork length, SL = standard length), maturity, (after Love 2011, Gustafson et al. 2000), sampling depth, and metric used in diet composition calculations (% V = percent volume; %IRI = percent index of relative importance, %W = perecent weight) for the Pacific hake (*Merluccius productus*). U = unknown. * = mean length.

Study	*n*	Year(s)	Method(s)	Study Region	Size Range (cm)	Maturity	Depth (m)	Diet Metric
Gotshall 1969	449	1964 - 1965	Trawl	Northern CA	10 - 82 TL	Juvenile - Adult	≤ 338	%V
Morejohn et al. 1978	13	1978	Trolling, set lines, trawls	Central CA	U	U	37 - 73	%IRI
Morejohn et al. 1978	4	1978	Trolling, set lines, trawls	Southern CA	U	U	55 - 73	%IRI
Livingston 1983	202	1967	Trawl	OR	49* TL*	U	< 100	%W
Livingston 1983	1,228	1967	Trawl	WA	50* TL*	U	< 100	%W
Livingston 1983	40	1980	Trawl	CA	< 20 TL*	Juvenile	77 - 298	%W
Livingston 1983	16	1980	Trawl	OR	35 - 45 TL*	Juvenile - Adult	77 - 298	%W
Livingston 1983	17	1980	Trawl	OR	45 - 55 TL*	Adult	77 - 298	%W
Livingston 1983	20	1980	Trawl	OR	≥ 55 TL*	Adult	77 - 298	%W
Livingston 1983	70	1980	Trawl	WA - Vancouver Island, BC	45 - 55 TL*	Adult	77 - 298	%W
Livingston 1983	41	1980	Trawl	WA - Vancouver Island, BC	≥ 55 TL*	Adult	77 - 298	%W
Rexstad and Pikitch 1986	4	1983	Trawl	Cape Blanco, OR - Cape Flattery, WA	30 - 34 TL*	Juvenile - Adult	< 200	%W
Rexstad and Pikitch 1986	94	1983	Trawl	Cape Blanco, OR - Cape Flattery, WA	35 - 39 TL*	Juvenile - Adult	< 200	%W
Rexstad and Pikitch 1986	69	1983	Trawl	Cape Blanco, OR - Cape Flattery, WA	40 - 44 TL*	Juvenile - Adult	< 200	%W
Rexstad and Pikitch 1986	77	1983	Trawl	Cape Blanco, OR - Cape Flattery, WA	45 - 49 TL*	Adult	< 200	%W
Rexstad and Pikitch 1986	82	1983	Trawl	Cape Blanco, OR - Cape Flattery, WA	50 - 54 TL*	Adult	< 200	%W
Rexstad and Pikitch 1986	21	1983	Trawl	Cape Blanco, OR - Cape Flattery, WA	≥ 55 TL*	Adult	< 200	%W
Brodeur et al. 1987	28	1981	Purse Seine	Cape Blanco, OR - Cape Flattery, WA	43 - 60 FL	Adult	15 - 65	%W
Brodeur et al. 1987	58	1982	Purse Seine	Cape Blanco, OR - Cape Flattery, WA	31 - 63 FL	Juvenile - Adult	15 - 65	%W
Brodeur et al. 1987	10	1983	Purse Seine	Cape Blanco, OR - Cape Flattery, WA	46 - 62 FL	Adult	15 - 65	%W
Brodeur et al. 1987	60	1984	Purse Seine	Cape Blanco, OR - Cape Flattery, WA	37 - 59 FL	Juvenile - Adult	15 - 65	%W
Buckley and Livingston 1997	1	1989	Trawl	Cape Blanco, OR - Vancouver Island, Canada	20 - 29 FL	Juvenile	55 - 366	%W
Buckley and Livingston 1997	3	1989	Trawl	Cape Blanco, OR - Vancouver Island, Canada	30 - 39 FL	Juvenile - Adult	55 - 366	%W
Buckley and Livingston 1997	495	1989	Trawl	Cape Blanco, OR - Vancouver Island, Canada	40 - 49 FL	Juvenile - Adult	55 - 366	%W
Buckley and Livingston 1997	180	1989	Trawl	Cape Blanco, OR - Vancouver Island, Canada	50 - 59 FL	Adult	55 - 366	%W
Buckley and Livingston 1997	15	1989	Trawl	Cape Blanco, OR - Vancouver Island, Canada	≥ 60 FL	Adult	55 - 366	%W
Buckley and Livingston 1997	58	1989	Trawl	Point Conception, CA - Cape Blanco, OR	10 - 19 FL	Juvenile	55 - 366	%W
Buckley and Livingston 1997	29	1989	Trawl	Point Conception, CA - Cape Blanco, OR	20 - 29 FL	Juvenile	55 - 366	%W
Buckley and Livingston 1997	38	1989	Trawl	Point Conception, CA - Cape Blanco, OR	30 - 39 FL	Juvenile - Adult	55 - 366	%W
Buckley and Livingston 1997	146	1989	Trawl	Point Conception, CA - Cape Blanco, OR	40 - 49 FL	Adult	55 - 366	%W
Buckley and Livingston 1997	30	1989	Trawl	Point Conception, CA - Cape Blanco, OR	50 - 59 FL	Adult	55 - 366	%W
Buckley and Livingston 1997	1	1989	Trawl	Point Conception, CA - Cape Blanco, OR	≥ 60 FL	Adult	55 - 366	%W
Buckley and Livingston 1997	10	1991	Trawl	Point Conception, CA - Cape Blanco, OR	10 - 19 FL	Juvenile	183 - 1280	%W
Buckley and Livingston 1997	58	1991	Trawl	Point Conception, CA - Cape Blanco, OR	20 - 29 FL	Juvenile	183 - 1280	%W
Buckley and Livingston 1997	26	1991	Trawl	Point Conception, CA - Cape Blanco, OR	30 - 39 FL	Juvenile - Adult	183 - 1280	%W
Buckley and Livingston 1997	28	1991	Trawl	Point Conception, CA - Cape Blanco, OR	40 - 49 FL	Adult	183 - 1280	%W
Buckley and Livingston 1997	7	1991	Trawl	Point Conception, CA - Cape Blanco, OR	50 - 59 FL	Adult	183 - 1280	%W
Buckley and Livingston 1997	2	1991	Trawl	Point Conception, CA - Cape Blanco, OR	≥ 60 FL	Adult	183 - 1280	%W
Buckley and Livingston 1997	1	1992	Trawl	Cape Blanco, OR - Vancouver Island, Canada	30 - 39 FL	Juvenile - Adult	183 - 1280	%W
Buckley and Livingston 1997	70	1992	Trawl	Cape Blanco, OR - Vancouver Island, Canada	40 - 49 FL	Juvenile - Adult	183 - 1280	%W
Buckley and Livingston 1997	3	1992	Trawl	Cape Blanco, OR - Vancouver Island, Canada	50 - 59 FL	Adult	183 - 1280	%W
Buckley et al. 1999	62	1987	Trawl	Central CA	3 - 10 FL	Juvenile	U	%W
Buckley et al. 1999	302	1988	Trawl	Central CA	3 - 13 FL	Juvenile	U	%W
Buckley et al. 1999	302	1989	Trawl	Point Conception, CA - Cape Blanco, OR	10 - 60+ FL	Juvenile - Adult	55 - 364	%W
Buckley et al. 1999	694	1989	Trawl	Cape Blanco, OR - Vancouver Island, Canada	20 - 60+ FL	Juvenile - Adult	55 - 364	%W
Buckley et al. 1999	131	1991	Trawl	Point Conception, CA - Cape Blanco, OR	10 - 60+ FL	Juvenile - Adult	183 - 913	%W
Buckley et al. 1999	74	1992	Trawl	Cape Blanco, OR - Vancouver Island, Canada	30 - 59 FL	Juvenile - Adult	183 - 913	%W

Grover et al. 2002	151	1995	Trawl	Central CA	1 - 8 SL	Juvenile	30	%V
Grover et al. 2002	250	1997	Trawl	Central CA	1 - 8 SL	Juvenile	30	%V
Grover et al. 2002	240	1998	Trawl	Central CA	1 - 8 SL	Juvenile	30	%V
Grover et al. 2002	253	1999	Trawl	Central CA	1 - 8 SL	Juvenile	30	%V
Miller and Brodeur 2007	72	2002	Trawl	Northern CA - OR	5* FL	Juvenile	$\leq$ 18	%W

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5.0 RELEVANT MARINE PROTECTED AREAS

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Various map figures resented in this appendix (Figure A5.1 map plates) and elsewhere within this report and associated appendices depict the spatial distribution of selected federal and state marine protected areas (MPA). The source of these GIS layers is the MPA Inventory (vers. 3, Mar 2012); a collaboration between NOAA's MPA Center and the Department of the Interior. MPAs included in the Pacific Fishery Management Council (PFMC) region were designated between 1909 and 2012, with 150 MPAs designated since implementation of Amendment 19 regulations (Table A5.1). These include Pacific coast groundfish EFH conservations areas (n=51), California State MPAs designated as part of the Marine Life Protection Act (n=94), and non-trawl and recreational Rockfish Conservation Areas (n=5). In addition to those MPAs included in the National MPA Inventory, 3 additional areas were added since all three prohibit the use of bottom trawls. These include the state territorial seas of Washington and California, and the NMFS trawl rockfish conservation area (RCA) between the 100- and 150-ftm RCA boundaries. See Table A5.2 for a complete list of MPAs included in the inventory for the PFMC region.

In order to explore physical and biogenic habitats in the context of various protected areas, MPAs were further categorized by gear prohibitions, if applicable. For example, MPAs designated as "no-take" or where commercial fishing is "prohibited" in fact prohibit the use of any of the three main gear types (bottom trawl, midwater trawl, fixed gears). In contrast, MPAs classified as "restricted" to commercial fishing typically prohibit the use of only one gear type (usually bottom trawl) while allowing the use of fixed gears. Unfortunately, not all MPAs were designated with specific gear prohibitions in mind. For example, state conservations areas off California were often designed to protect selected fish and invertebrate species, while allowing take of a limited set of organisms (e.g., pelagic finfish, lobster). These are often classified as having commercial fishing "restricted." Despite this distinction, most of the state territorial sea of California (including these conservation areas) is closed to bottom trawling.

In addition to MPAs in the inventory where either commercial fishing is prohibited or bottom trawling is prohibited, the trawl rockfish conservation area (RCA) also prohibits the use of bottom trawls within certain depth ranges. The RCA is a type of time-area closure, with the shoreward and seaward boundaries being adjusted, sometimes monthly, as a result of varying levels of bycatch of overfished species. Despite this dynamic type of closure, an area between the 100- and 150-fathom RCA lines has been closed consistently since the inception of the RCA in 2002. Consequently, we incorporated this area into our regional layer of bottom trawl closures.

References

NMPAC (National Marine Protected Areas Center). 2012. Marine Protected Areas Inventory, vers. 3, Mar 2012.

Table A5.1. Summary of federal and state MPAs depicted in map figures, categorized by level of fishing restriction and time period of designation. "Before" means MPA was designated prior to 2006 and "After" between 2006 and 2012. Data Source: National Marine Protected Areas Center, Marine Protected Areas Inventory, vers. 3, Mar 2012.

	# MPAs	
FISHING RESTRICTION	**BEFORE**	**AFTER**
Commercial and Recreational Fishing Prohibited	33	48
Commercial Fishing Prohibited	0	1
Commercial Fishing Prohibited and Recreational Fishing Restricted	10	14
Commercial Fishing Restricted	7	54
Commercial and Recreational Fishing Restricted	39	28
Commercial Fishing Restricted and Recreational Fishing Prohibited	3	1
Recreational Fishing Prohibited	0	1
Recreational Fishing Restricted	11	3
Restrictions Unknown	2	0
No Site Restrictions	3	0
Total	**108**	**150**

Table A5.2. List of marine protected areas (MPAs) with relevant attributes including year established, level of government designation, type of fishing restriction, and temporal nature. Values in the "MPA ID" column correspond to labels in the map figures. MPA type and agency abbreviations are listed in Tables 3 and 4, respectively. Data Source: National Marine Protected Areas Center, Marine Protected Areas Inventory, vers. 3, Mar 2012. In addition to those MPAs included in the National MPA Inventory, 3 additional areas were added since all three prohibit or restrict bottom trawling. These include the state territorial seas of Washington and California, and the NMFS trawl rockfish conservation area (RCA) between the 100- and 150-ftm RCA boundaries.

MPA ID	MPA Name	Year Est.	Agency ABBR	Govt. Level	Fishing Restriction	Permanence	Constancy
CA100	MacKerricher SMCA	1970	CDPR	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA102	Russian Gulch SMCA	1970	CDPR	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA104	Van Damme SMCA	1970	CDPR	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA136	Richardson Rock SMR	2003	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA137	Judith Rock SMR	2003	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA138	Harris Point SMR	2003	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA139	Skunk Point SMR	2003	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA140	Carrington Point SMR	2003	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA141	South Point SMR	2003	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA142	Gull Island SMR	2003	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA143	Scorpion SMR	2003	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA144	Santa Barbara Island SMR	2003	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA145	Anacapa Island SMR	2003	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA146	Anacapa Island SMCA	2003	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA147	Painted Cave SMCA	2003	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA151	Anacapa Island SC (B)	2005	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Seasonal
CA201	A±o Nuevo SMCA	2007	CDFG	State	Commercial Fishing Restricted and Recreational Fishing Prohibited	Permanent	Year-round
CA202	Greyhound Rock SMCA	2007	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA203	Natural Bridges SMR	2007	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA204	Elkhorn Slough SMR	1980	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA205	Elkhorn Slough SMCA	2007	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA206	Moro Cojo Slough SMR	2007	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA207	Soquel Canyon SMCA	2007	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA208	Portugese Ledge SMCA	2007	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round

MPA ID	MPA Name	Year Est.	Agency ABBR	Govt. Level	Fishing Restriction	Permanence	Constancy
CA209	Edward F. Ricketts SMCA	2007	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA210	Lovers Point SMR	2007	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA211	Pacific Grove MG SMCA	2007	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA212	Asilomar SMR	2007	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA213	Carmel Pinnacles SMR	2007	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA214	Carmel Bay SMCA	1976	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA215	Point Lobos SMR	1973	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA216	Point Lobos SMCA	2007	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA217	Point Sur SMR	2007	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA218	Point Sur SMCA	2007	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA219	Big Creek SMR	1994	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA220	Big Creek SMCA	2007	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA221	Piedras Blancas SMR	2007	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA222	Piedras Blancas SMCA	2007	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA223	Cambria SMCA	2007	CDFG	State	Commercial Fishing Prohibited	Permanent	Year-round
CA224	White Rock SMCA	2007	CDFG	State	Commercial Fishing Restricted	Permanent	Year-round
CA225	Morro Bay SMRMA	2007	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA226	Morro Bay SMR	2007	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA227	Point Buchon SMR	2007	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA228	Point Buchon SMCA	2007	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA229	Vandenberg SMR	1994	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA230	Anacapa SC (A)	2005	CDFG	State	Commercial Fishing Restricted	Permanent	Year-round
CA231	Footprint SMR	2007	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA233	Point Arena SMR	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA234	Point Arena SMCA	2010	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA235	Sea Lion Cove SMCA	2010	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA236	Saunders Reef SMCA	2010	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA237	Del Mar Landing SMR	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA238	Stewarts Point SMR	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round

MPA ID	MPA Name	Year Est.	Agency ABBR	Govt. Level	Fishing Restriction	Permanence	Constancy
CA239	Salt Point SMCA	2010	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA240	Gerstle Cove SMR	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA241	Russian River SMR	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA242	Russian River SMCA	2010	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA243	Bodega Head SMR	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA244	Bodega Head SMCA	2010	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA245	Estero Americano SMRMA	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA246	Estero de San Antonio SMRMA	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA247	Drakes Estero SMCA	2010	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA248	Estero de Limantour SMR	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA249	Point Reyes SMR	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA250	Point Reyes SMCA	2010	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA251	Duxbury SMCA	2010	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA252	Southeast Farallon Island SMR	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA253	Southeast Farallon Island SMCA	2010	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA254	Montara SMR	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA255	Pillar Point SMCA	2010	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA256	Point Reyes Headlands SC	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA257	Point Resistance SC	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA258	Double Point/Stormy Stack SC	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA259	Egg Rock (Devils Slide) SC	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA260	North Farallon Islands SC	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA261	Southeast Farallon SC (A)	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA262	North Farallon Islands SMR	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA263	Southeast Farallon SC (B)	2010	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Seasonal
CA264	Stewarts Point SMCA	2010	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA265	Point Conception SMR	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round

MPA ID	MPA Name	Year Est.	Agency ABBR	Govt. Level	Fishing Restriction	Permanence	Constancy
CA266	Kashtayit SMCA	2012	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA267	Naples SMCA	2012	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA268	Campus Point SMCA	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA269	Goleta Slough SMCA	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA270	Begg Rock (San Nicolas Island Quad) SMR	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA271	Point Dume SMCA	2012	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA272	Point Dume SMR	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA273	Point Vicente SMCA	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA274	Abalone Cove SMCA	2012	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA275	Bolsa Bay SMCA	2012	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA276	Bolsa Chica Basin SMCA	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA277	Arrow Point to Lion Head Point (Catalina Island) SMCA	2012	CDFG	State	Recreational Fishing Prohibited	Permanent	Year-round
CA278	Blue Cavern (Catalina Island) SMCA	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA279	Bird Rock (Catalina Island) SMCA	2012	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA280	Long Point (Catalina Island) SMR	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA281	Casino Point (Catalina Island) SMCA	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA282	Lover's Cove (Catalina Island) SMCA	2012	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA283	Farnsworth Onshore (Catalina Island) SMCA	2012	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA284	Farnsworth Offshore (Catalina Island) SMCA	2012	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA285	Cat Harbor (Catalina Island) SMCA	2012	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA286	Upper Newport Bay SMCA	2012	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round

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CA287	Crystal Cove SMCA	2012	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA288	Laguna Beach SMR	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA289	Laguna Beach SMCA	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA290	Dana Point SMCA	2012	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA291	Batiquitos Lagoon SMCA	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA292	Swami's SMCA	2012	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA293	San Elijo Lagoon SMCA	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA294	San Diego-Scripps Coastal SMCA	2012	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA295	Matlahuayl SMR	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA296	South La Jolla SMR	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA297	South La Jolla SMCA	2012	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA298	Famosa Slough SMCA	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA299	Cabrillo SMR	2012	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA300	Tijuana River Mouth SMCA	2012	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA301	San Dieguito Lagoon SMCA	2012	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA38	Albany Mudflats SMP	1986	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA40	Bair Island SMP	1986	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA45	Corte Madera Marsh SMP	1976	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA48	Fagan Marsh SMP	1979	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA49	Farnsworth Bank SMCA	1972	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
CA52	Marin Islands SMP	1993	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA53	Peytonia Slough SMP	1976	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round

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CA54	Redwood Shores SMP	1976	CDFG	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
CA67	Punta Gorda SMR	1994	CDFG	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
CA90	Lover's Cove SMCA	1974	CDFG	State	Commercial Fishing Restricted and Recreational Fishing Prohibited	Permanent	Year-round
CA92	Point Cabrillo SMCA	1975	CDFG	State	Commercial Fishing Restricted and Recreational Fishing Prohibited	Permanent	Year-round
CA94	Robert W. Crown SMCA	1980	CDFG	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
NER21	South Slough NERR	1974	ODSL & NOAA	Partnership	Commercial Fishing Restricted	Permanent	Year-round
NER22	Tijuana River NERR	1982	CDPR & NOAA	Partnership	Commercial and Recreational Fishing Restricted	Permanent	Year-round
NMF235	North Coast Commercial YRCA	2007	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF236	Salmon Troll YRCA	2007	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF237	South Coast Recreational YRCA	2007	NMFS	Federal	Recreational Fishing Restricted	Permanent	Year-round
NMF238	Westport Offshore Recreational YRCA	2009	NMFS	Federal	Recreational Fishing Restricted	Permanent	Year-round
NMF239	Stonewall Bank YRCA	2007	NMFS	Federal	Recreational Fishing Restricted	Permanent	Year-round
NMF35	Columbia River Salmon CZ	1992	NMFS	Federal	Commercial and Recreational Fishing Restricted	Permanent	Year-round
NMF36	Klamath River Salmon CZ	1992	NMFS	Federal	Commercial and Recreational Fishing Restricted	Permanent	Year-round
NMF74	North Coast Recreational Yelloweye RCA	2003	NMFS	Federal	Recreational Fishing Restricted	Permanent	Year-round
NMF80	Western and Eastern CCAs	2001	NMFS	Federal	Commercial and Recreational Fishing Restricted	Permanent	Year-round
NMF900	Biogenic 1 EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF901	Biogenic 2 EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF902	Biogenic 3 EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF903	Gray's Canyon EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF904	Olympic 2 EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF905	Astoria Canyon EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF906	Bandon High Spot EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF907	Daisy Bank/Nelson Island EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round

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NMF908	Deepwater off Coos Bay EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF909	Heceta Bank EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF910	Nahelem Bank/Shale Pile EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF911	Newport Rockpile/Stonewall Bank EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF912	Rogue Canyon EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF913	Siletz Deepwater EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF914	Big Sur/Port San Luis EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF915	Blunt's Reef EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF916	Catalina Island EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF917	Cherry Bank EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF918	Cordell Bank/Biogenic Area EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF919	CCA East EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF920	Delgada Canyon EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF921	East San Lucia Bank EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF922	Eel River Canyon EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF923	Farallon Islands/Fanny Shoal EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF924	Half Moon Bay EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF925	Hidden Reef/Kidney Bank EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF926	Mendocino Ridge EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF927	Monterey Bay/Canyon EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF928	Point Arena North EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF929	Point Arena South EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF930	Point Conception EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF931	Point Sur Deep EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF932	Potato Bank EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF933	Tolo Bank EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF934	President Jackson Seamount EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round

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NMF935	Thompson Seamount EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF936	Anacapa Island EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF938	Carrington Point EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF939	Cordell Bank (50 fm (91m) isobath) EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF940	Davidson Seamount EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF941	Footprint EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF942	Gull Island EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF943	Harris Point EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF944	Judith Rock EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF945	Painted Cave EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF946	Richardson Rock EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF947	Santa Barbara Island EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF948	Scorpion EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF949	Skunk Point EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF950	South Point EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMF951	Seaward of the 700 fm - EFH CA	2006	NMFS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMS1	Channel Islands NMS	1980	NMS	Federal	Commercial Fishing Restricted	Permanent	Year-round
NMS11	Monterey Bay NMS	1992	NMS	Federal	No Site Restrictions	Permanent	Year-round
NMS13	Olympic Coast NMS	1994	NMS	Federal	Commercial and Recreational Fishing Restricted	Permanent	Year-round
NMS2	Cordell Bank NMS	1989	NMS	Federal	No Site Restrictions	Permanent	Year-round
NMS8	Gulf of the Farallones NMS	1981	NMS	Federal	No Site Restrictions	Permanent	Year-round
NPS12	Channel Islands NP	1938	NPS	Federal	Commercial and Recreational Fishing Restricted	Permanent	Year-round
NPS19	Golden Gate NRA	1972	NPS	Federal	Commercial and Recreational Fishing Restricted	Permanent	Year-round
NPS27	Olympic NP	1909	NPS	Federal	Commercial and Recreational Fishing Restricted	Permanent	Year-round
NPS30	Point Reyes NS	1962	NPS	Federal	Commercial and Recreational Fishing Restricted	Permanent	Year-round
NPS31	Redwood NP	1968	NPS	Partnership	Commercial and Recreational Fishing Restricted	Permanent	Year-round
NPS54	Ebey's Landing NHR	1978	NPS	Federal	Commercial Fishing Restricted	Permanent	Year-round
OR25	Haystack Rock MG	1990	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR26	Cape Kiwanda MG	1997	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round

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OR27	Otter Rock MG	1962	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR28	Yaquina Head MG	1988	OBLM	Partnership	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR30	Cape Perpetua MG	1977	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR31	Harris Beach MG	1997	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR32	Netarts Bay Shellfish Pres.	1960	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR33	Yaquina Bay Shellfish Pres.	1970	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR35	Pirate Cove RR	1996	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR36	Gregory Point RR	1996	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR37	Boiler Bay RR	1997	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR38	Neptune SP RR	1997	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR39	Cape Arago RR	1997	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR40	Brookings RR	1997	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
OR41	Whale Cove Habitat Refuge	1978	ODFW	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
OR515	Yachats MG	1997	ODFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
WA102	Brackett's Landing Shoreline Sanct. Cons. Area	1970	WDFW	Partnership	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA19	Dabob Bay NAP	1987	WDNR	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA33	Zella M. Schultz/Protection Island Seabird Sanct.	1975	WDFW	Partnership	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA34	Argyle Lagoon SJI Marine Pres.	1990	WDFW	State	Commercial Fishing Restricted and Recreational Fishing Prohibited	Permanent	Year-round
WA44	False Bay SJI Marine Pres.	1990	WDFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
WA47	Friday Harbor SJI Marine Pres.	1990	WDFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
WA50	Haro Strait SMFA	1972	WDFW	State	Restrictions Unknown	Permanent	Year-round
WA506	Woodard Bay NRCA	1987	WDNR	State	Recreational Fishing Restricted	Permanent	Year-round
WA507	Sund Rock Cons. Area	1994	WDFW	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA508	Titlow Beach Marine Pres.	1994	WMPDT	Partnership	Commercial and Recreational Fishing Restricted	Permanent	Year-round
WA509	Octopus Hole Cons. Area	1998	WDFW	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA510	Orchard Rocks Cons. Area	1998	WDFW	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA511	South 239th Street Park Cons. Area	1998	WDFW	Partnership	Commercial and Recreational Fishing Prohibited	Permanent	Year-round

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WA512	City of Des Moines Park Cons. Area	1998	WDFW	Partnership	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA513	Waketickeh Creek Cons. Area	2000	WDFW	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA514	Saltar's Point Beach Cons. Area	2000	WDFW	Partnership	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA515	Zee's Reef Marine Pres.	2002	WDFW	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
WA516	Admiralty Head Marine Pres.	2002	WDFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
WA517	Keystone Cons. Area	2002	WDFW	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA518	Colvos Passage Marine Pres.	2000	WDFW	State	Commercial Fishing Prohibited and Recreational Fishing Restricted	Permanent	Year-round
WA522	Blake Island Underwater Park	1970	WSPRC	State	Recreational Fishing Restricted	Permanent	Year-round
WA524	Fort Worden Underwater Park	1977	WSPRC	State	Recreational Fishing Restricted	Permanent	Year-round
WA525	Deception Pass Underwater Park	1970	WSPRC	State	Recreational Fishing Restricted	Permanent	Year-round
WA526	Fort Casey Underwater Park	1970	WSPRC	State	Recreational Fishing Restricted	Permanent	Year-round
WA527	Fort Ward Underwater Park	1970	WSPRC	State	Recreational Fishing Restricted	Permanent	Year-round
WA528	Kopachuck Underwater Park	1971	WSPRC	State	Recreational Fishing Restricted	Permanent	Year-round
WA529	Saltwater Underwater Park	1970	WSPRC	State	Recreational Fishing Restricted	Permanent	Year-round
WA530	Tolmie Underwater Park	1971	WSPRC	State	Recreational Fishing Restricted	Permanent	Year-round
WA531	Kennedy Creek NAP	1990	WDNR	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA532	Skookum Inlet NAP	1986	WDNR	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA533	San Juan County/Cypress Island MBP	1923	UW-FHL	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
WA534	Elk River NRCA		WDNR	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
WA536	Chehalis River Surge Plain NAP	1989	WDNR	State	Recreational Fishing Restricted	Permanent	Year-round
WA537	North Bay NAP	1988	WDNR	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA540	Bone River NAP	1987	WDNR	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA541	Niawiakum River NAP	1987	WDNR	State	Commercial and Recreational Fishing Prohibited	Permanent	Year-round
WA69	San Juan Channel and Upright Channel SMFA	1972	WDFW	State	Restrictions Unknown	Permanent	Year-round
WA72	Shaw Island SJI Marine Pres.	1990	WDFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round

MPA ID	MPA Name	Year Est.	Agency ABBR	Govt. Level	Fishing Restriction	Permanence	Constancy
WA87	Yellow and Low Islands SJI Marine Pres.	1990	WDFW	State	Commercial and Recreational Fishing Restricted	Permanent	Year-round
NA	Washington State Territorial Sea		WDFW & NMFS	Partnership	Commercial Fishing Restricted	Unknown	Year-round
NA	California State Territorial Sea		CDFG & NMFS	Partnership	Commercial Fishing Restricted	Unknown	Year-round
NA	Trawl RCA - 100-150 ftm closure*	2002	NMFS	Federal	Commercial Fishing Restricted	Unknown	Year-round

*Trawl Rockfish Conservation Area boundaries defined in 50 CFR 660.130 (2012).

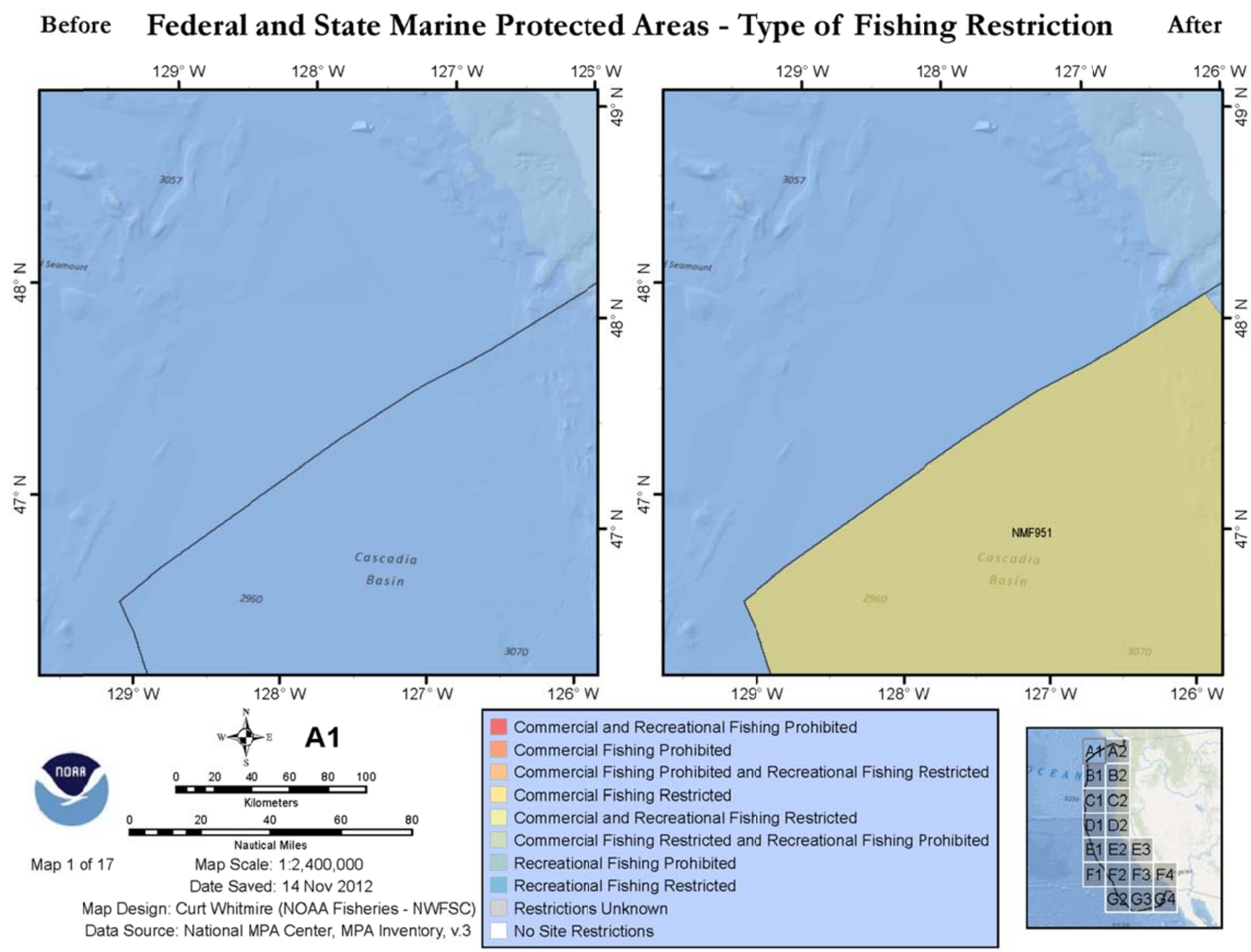
Table A5.3. Acronyms for MPA types listed as part of the "MPA Name" column in Table 2.

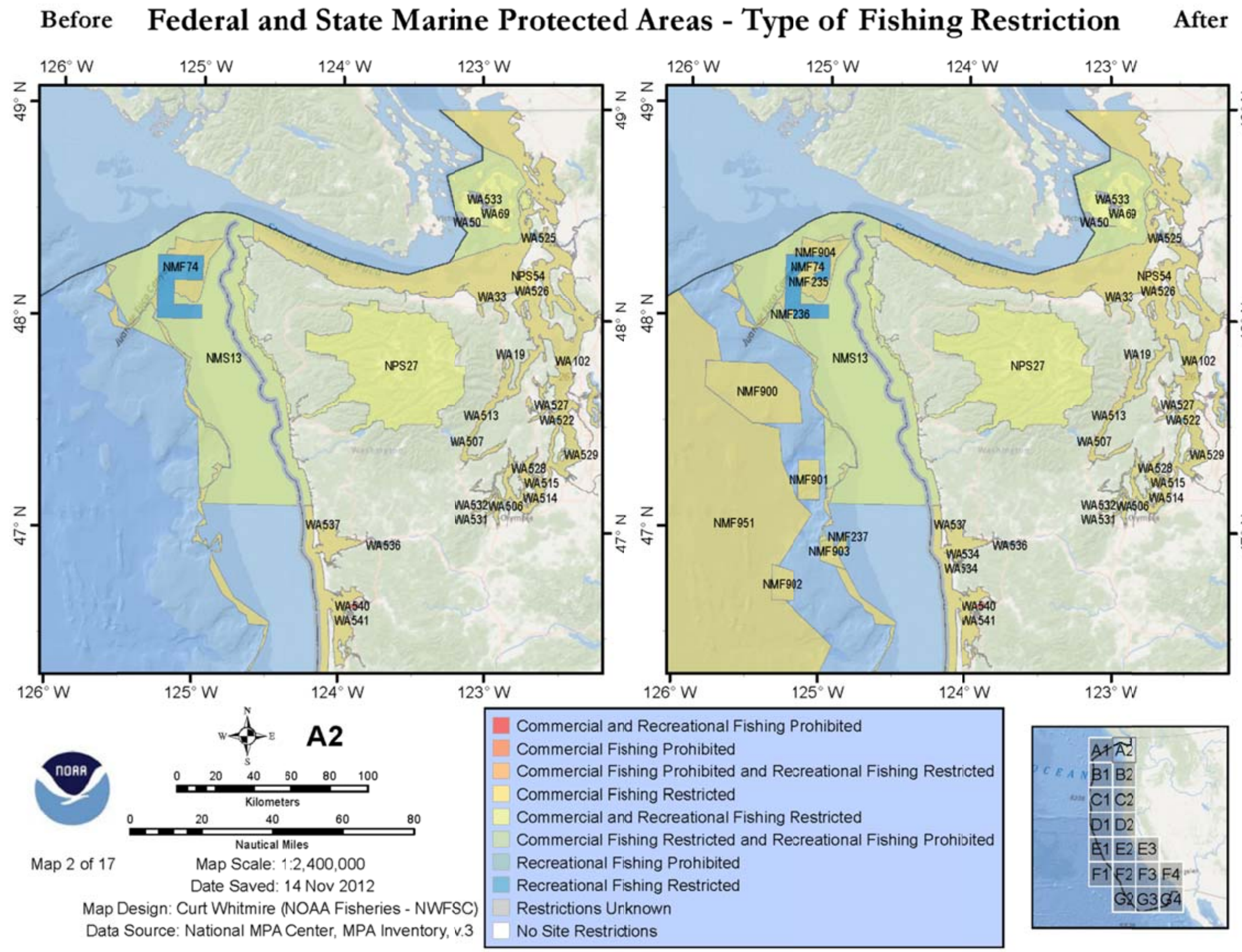
Acronym	MPA Type	# MPAs
CCAs	Cowcod Conservation Areas	1
Cons. Area	Conservation Area	8
CZ	Conservation Zone	2
EFH CA	Essential Fish Habitat Conservation Area	51
	Habitat Refuge	1
MBP	Marine Biological Preserve	1
MG	Marine Garden	7
Marine Pres.	Marine Preserve	4
NAP	Natural Area Preserve	7
NERR	National Estuarine Research Reserve	2
NHR	National Historical Reserve	1
NMS	National Marine Sanctuary	5
NP	National Park	3
NRA	National Recreation Area	1
NRCA	Natural Resources Conservation Area	2
NS	National Seashore	1
Shellfish Pres.	Shellfish Preserve	2
RCA	Rockfish Conservation Area	2
RR	Research Reserve	6
Sanct.	Sanctuary	1
Sanct. Cons. Area	Sanctuary Conservation Area	1
SC	Special Closure	9
SJI Marine Pres.	San Juan Islands Marine Preserve	5
SMCA	State Marine Conservation Area	65
SMFA	Special Management Fishery Area	2
SMP	State Marine Park	7
SMR	State Marine Reserve	44
SMRMA	State Marine Recreational Management Area	3
	State Territorial Sea	2
	Underwater Park	8
YRCA	Yelloweye Rockfish Conservation Area	5
	Total	259

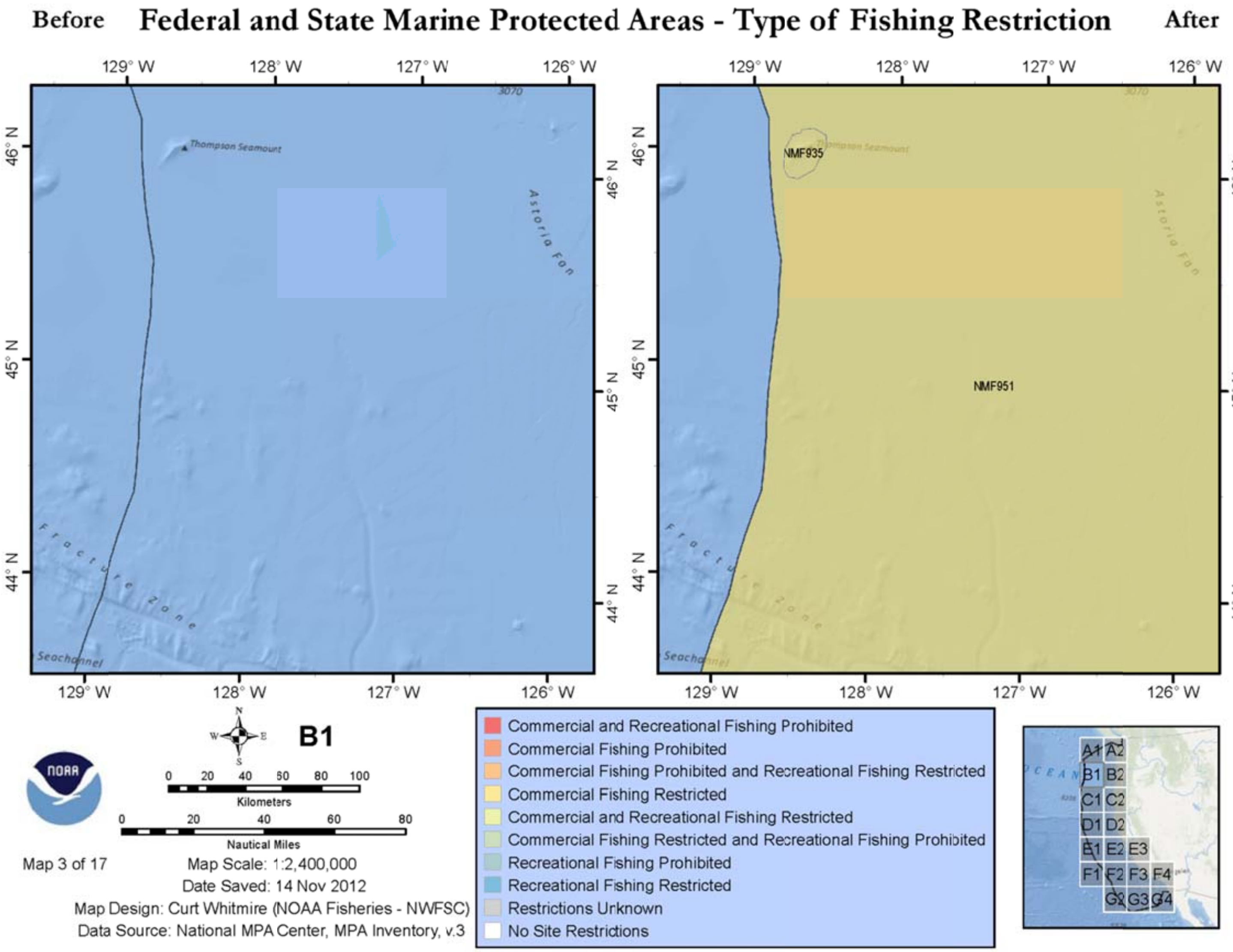
Table A5.4. Abbreviations for federal and state management agencies responsible for designation of MPAs, and listed under the "Agency ABBR" column in Table 2.

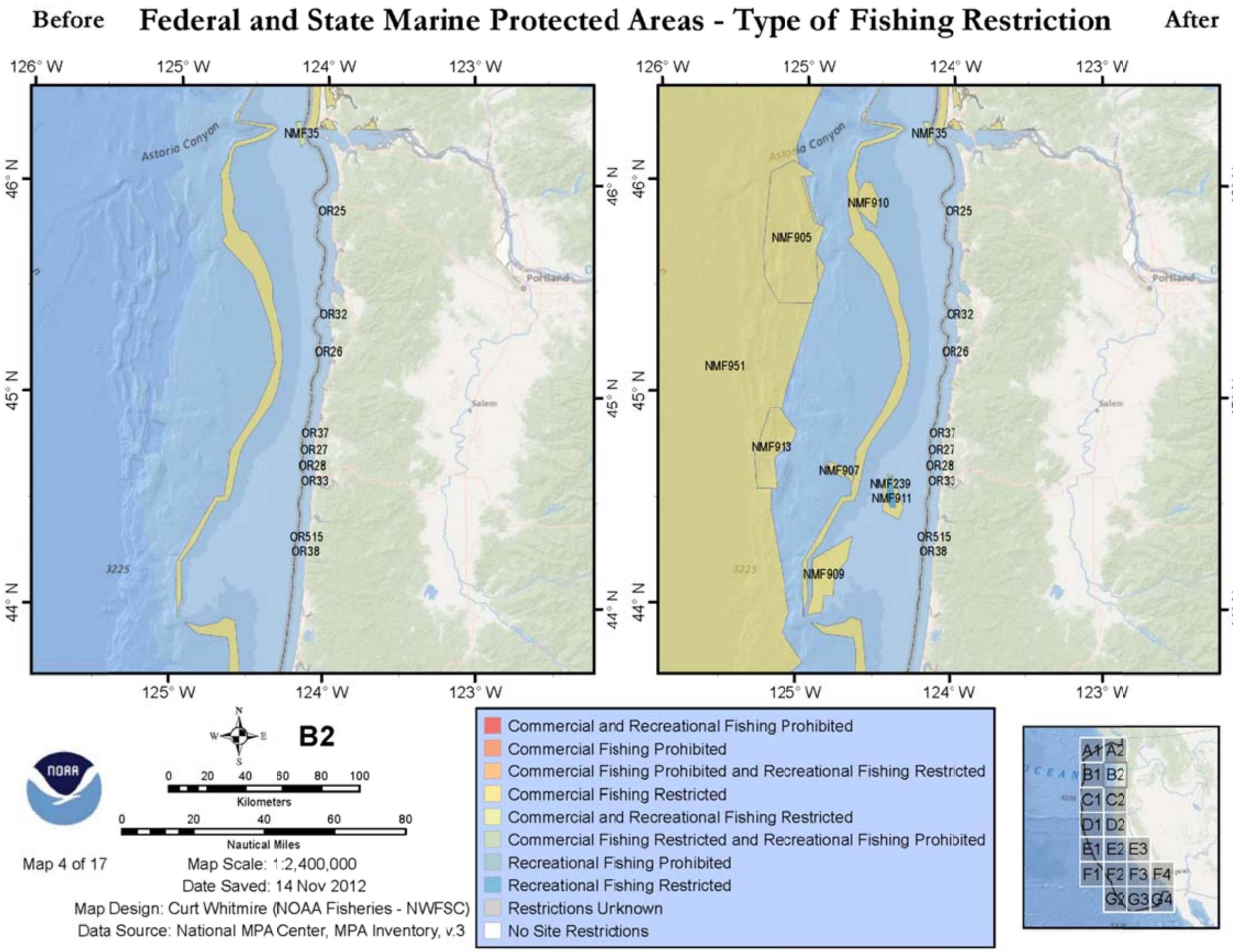
Agency ABBR	Management Agency	# MPAs
CDFG	California Department of Fish and Game	125
CDFG & NMFS	California Department of Fish and Game & National Marine Fisheries Service	1
CDPR	California Department of Parks and Recreation	3
CDPR & NOAA	California Department of Parks and Recreation & National Oceanic and Atmospheric Administration	1
NMFS	National Marine Fisheries Service	61
NMS	National Marine Sanctuaries	5
NPS	National Park Service	6
OBLM	Oregon Bureau of Land Management	1
ODFW	Oregon Department of Fish and Wildlife	15
ODSL & NOAA	Oregon Department of State Lands & National Oceanic and Atmospheric Administration	1
UW-FHL	University of Washington Friday Harbor Laboratories	1
WDFW	Washington Department of Fish and Wildlife	20
WDFW & NMFS	Washington Department of Fish and Wildlife & National Marine Fisheries Service	1
WDNR	Washington Department of Natural Resources	9
WMPDT	Washington Metropolitan Park District of Tacoma	1
WSPRC	Washington State Parks & Recreation Commission	8
	Total	259

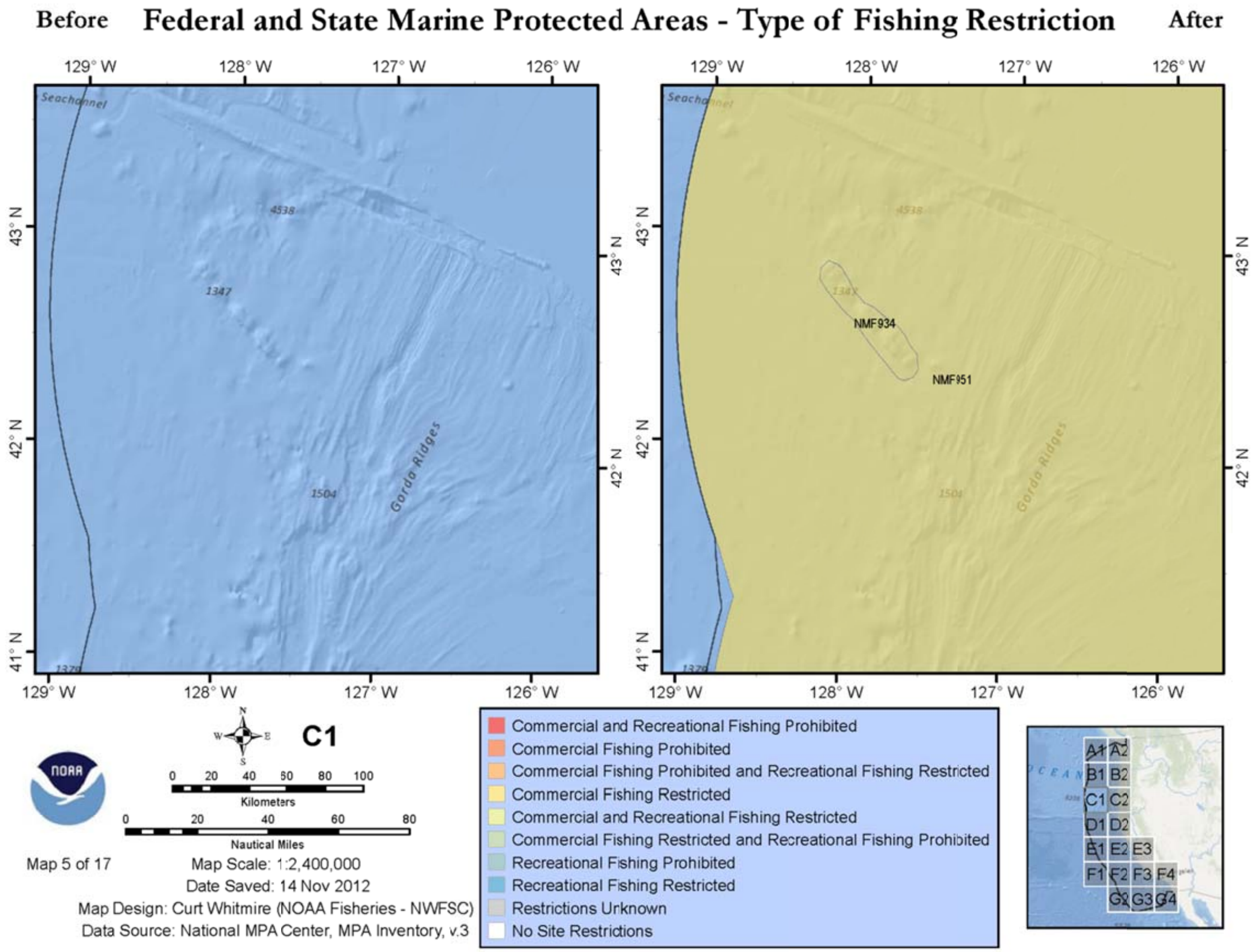
Figure A5.1. Map views showing the spatial distribution of various federal and state marine protected areas. Data Source: NMPAC, 2012 and 50 CFR 660.130 (2012).

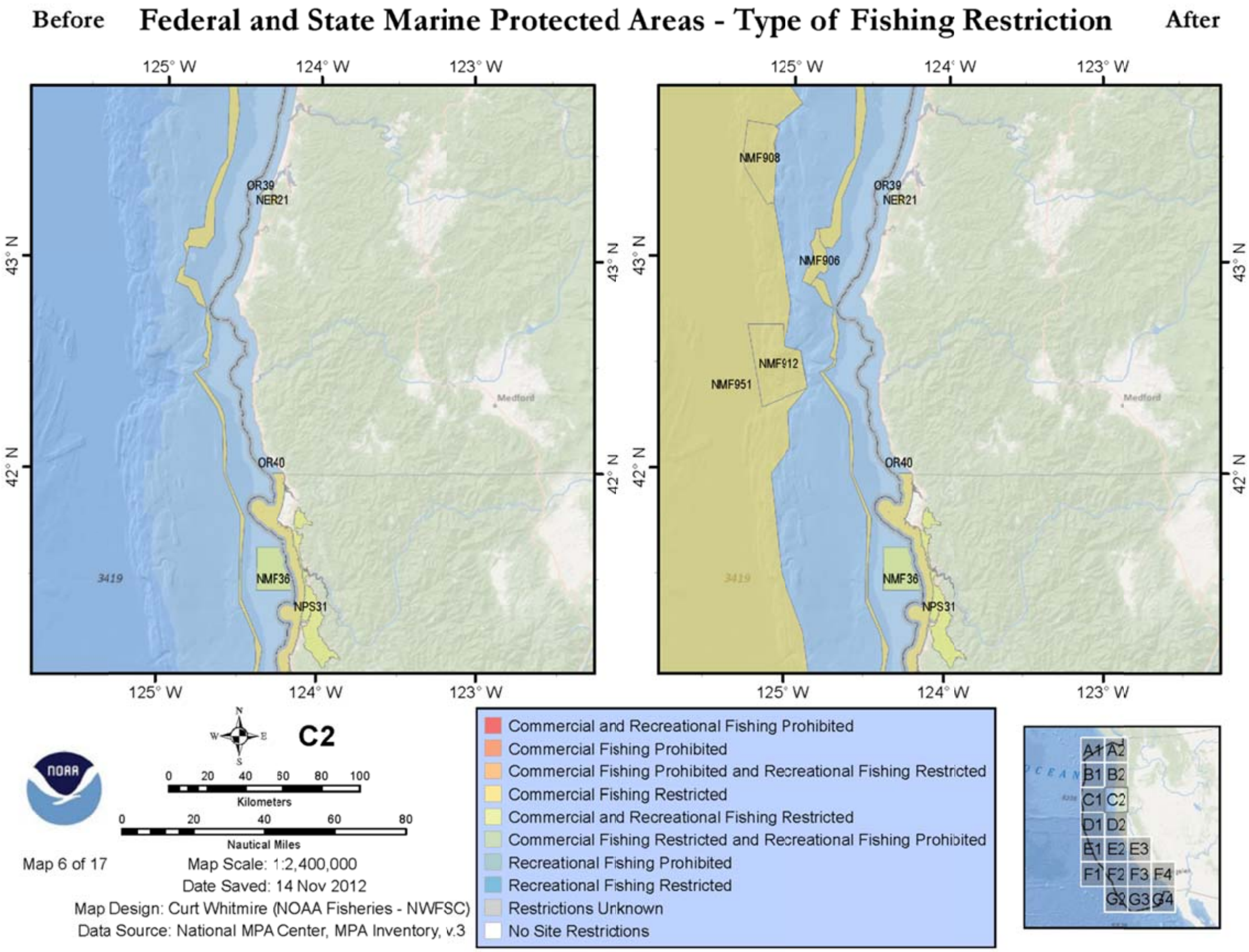


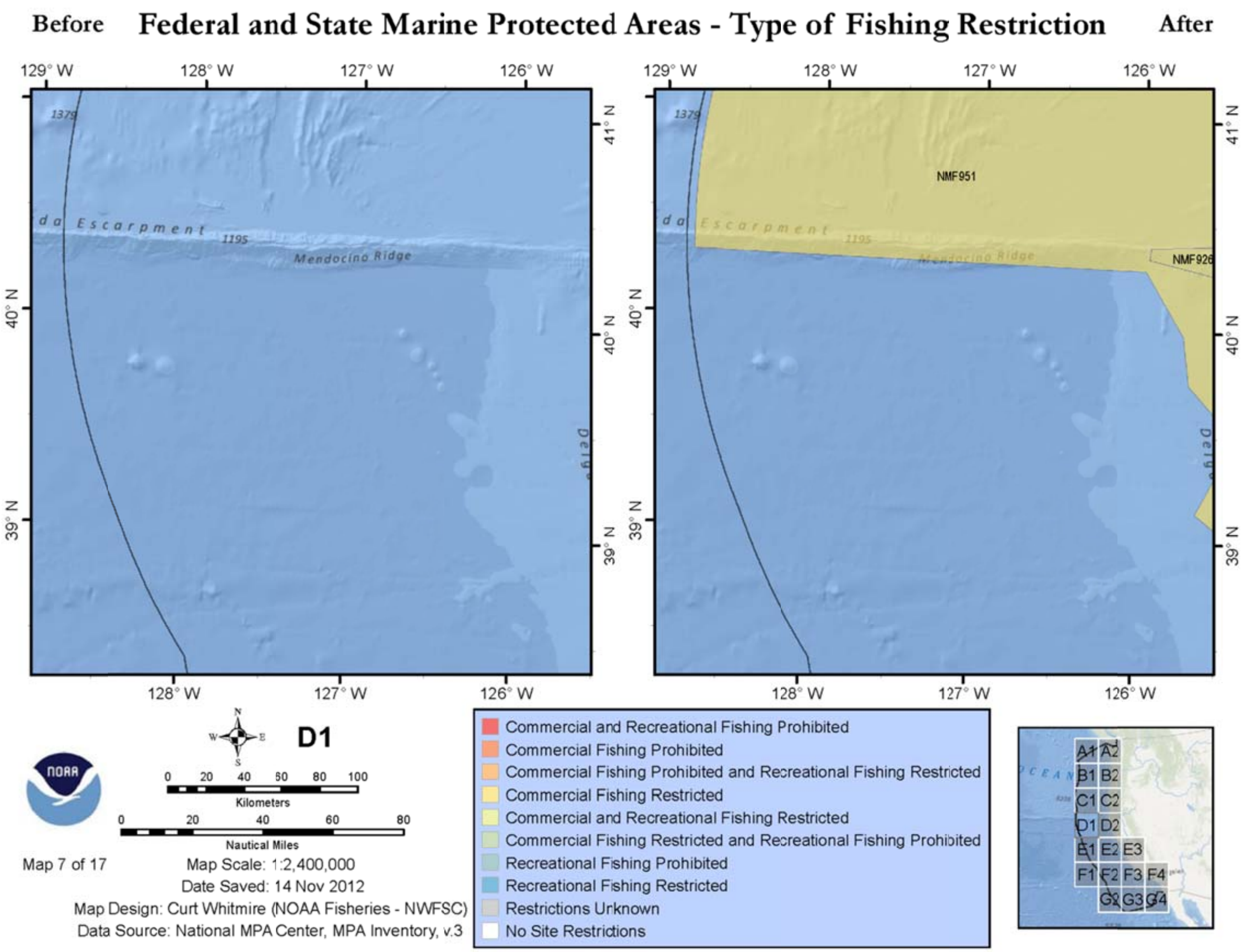

Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
126° W
125° W
124° W
123° W
49° N
48° N
47° N
NMF74
NMS13
NPS27
NPS54
WA533
WA69
WA50
WA525
WA526
WA33
WA19
WA102
WA527
WA522
WA513
WA507
WA529
WA528
WA515
WA514
WA532
WA506
WA531
WA537
WA536
WA540
WA541
NMF904
NMF235
NMF236
NMF900
NMF901
NMF951
NMF237
NMF903
NMF902
WA534
A2
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map 2 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

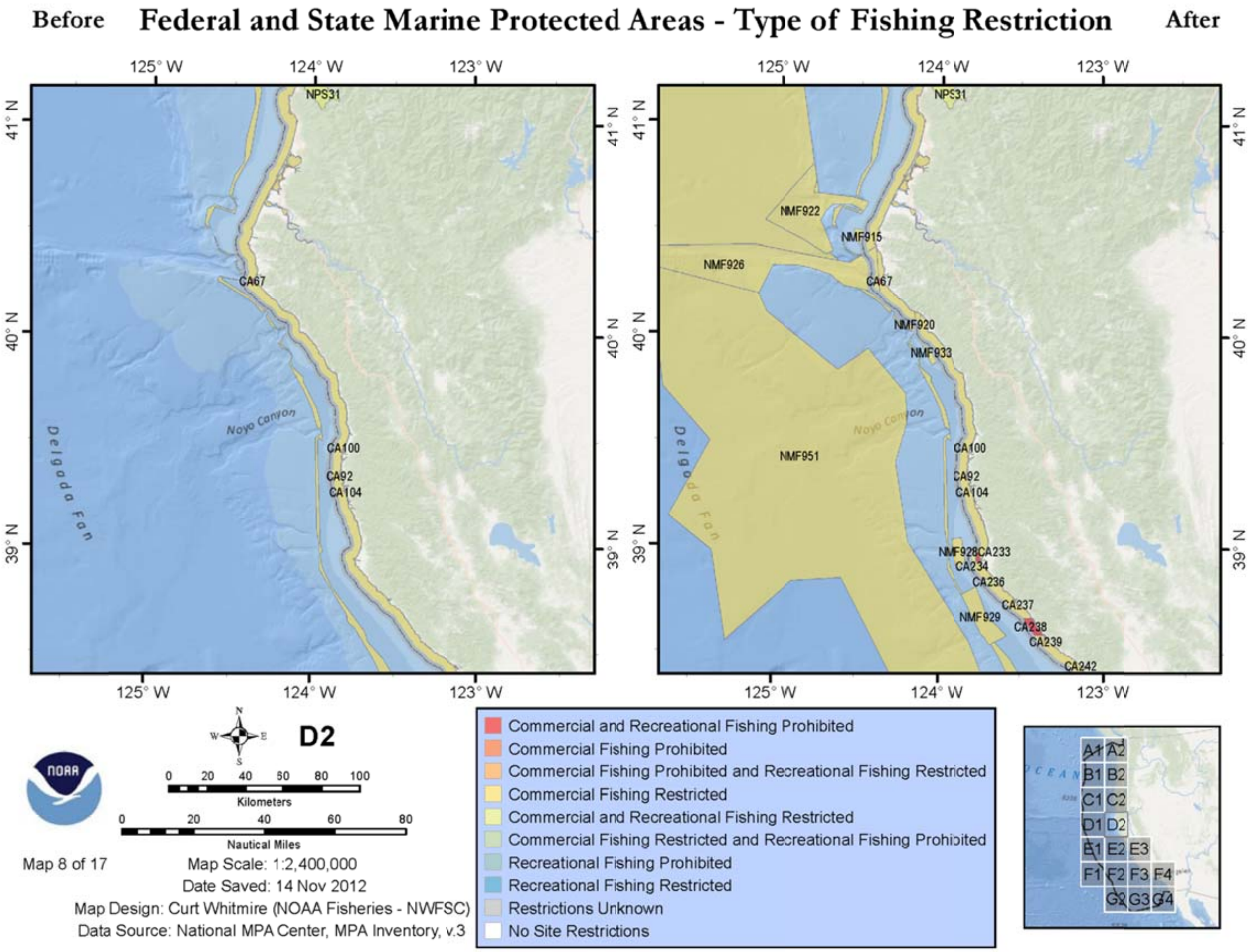

Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
129° W
128° W
127° W
126° W
46° N
45° N
44° N
Thompson Seamount
Astoria Fan
Fracture Zone
Seachannel
NMF935
NMF951
B1
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map 3 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

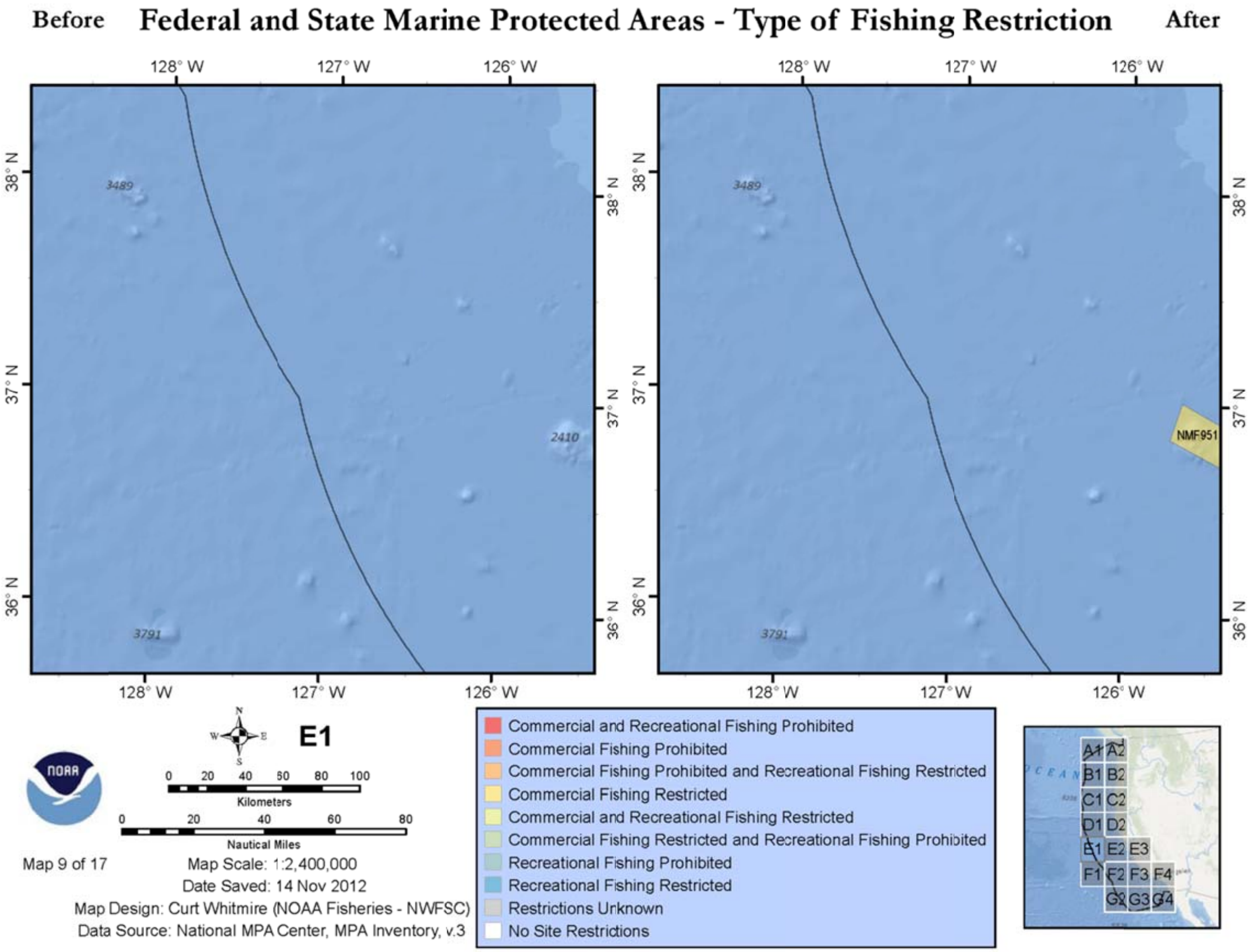

Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
126° W
125° W
124° W
123° W
46° N
45° N
44° N
Astoria Canyon
NMF35
OR25
OR32
OR26
OR37
OR27
OR28
OR33
OR515
OR38
NMF910
NMF905
NMF951
NMF913
NMF907
NMF239
NMF911
NMF909
Portland
Salem
3225
B2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map 4 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

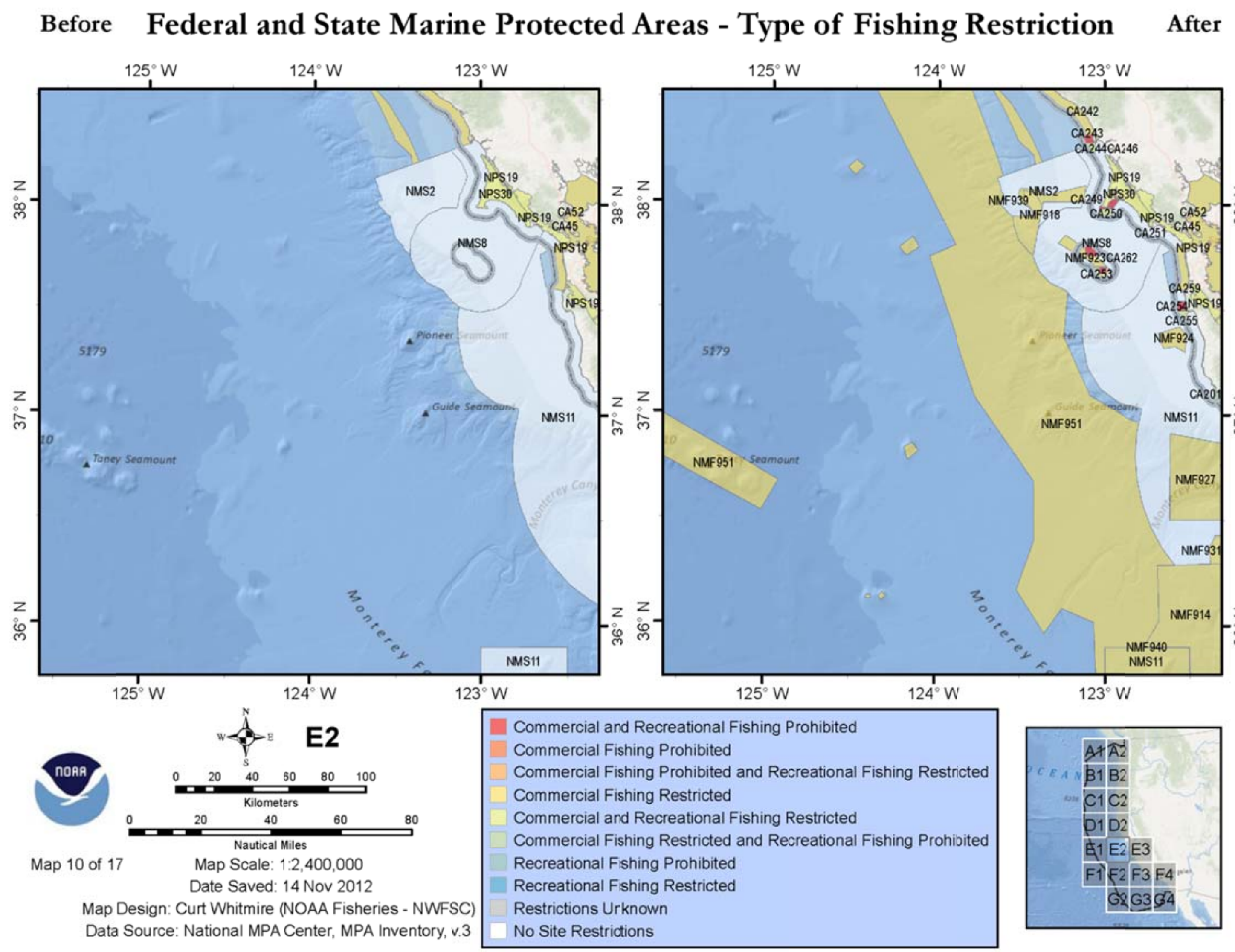

Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
129° W
128° W
127° W
126° W
43° N
42° N
41° N
Seachannel
4538
1347
1504
Gorda Ridges
1379
NMF934
NMF951
C1
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map 5 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

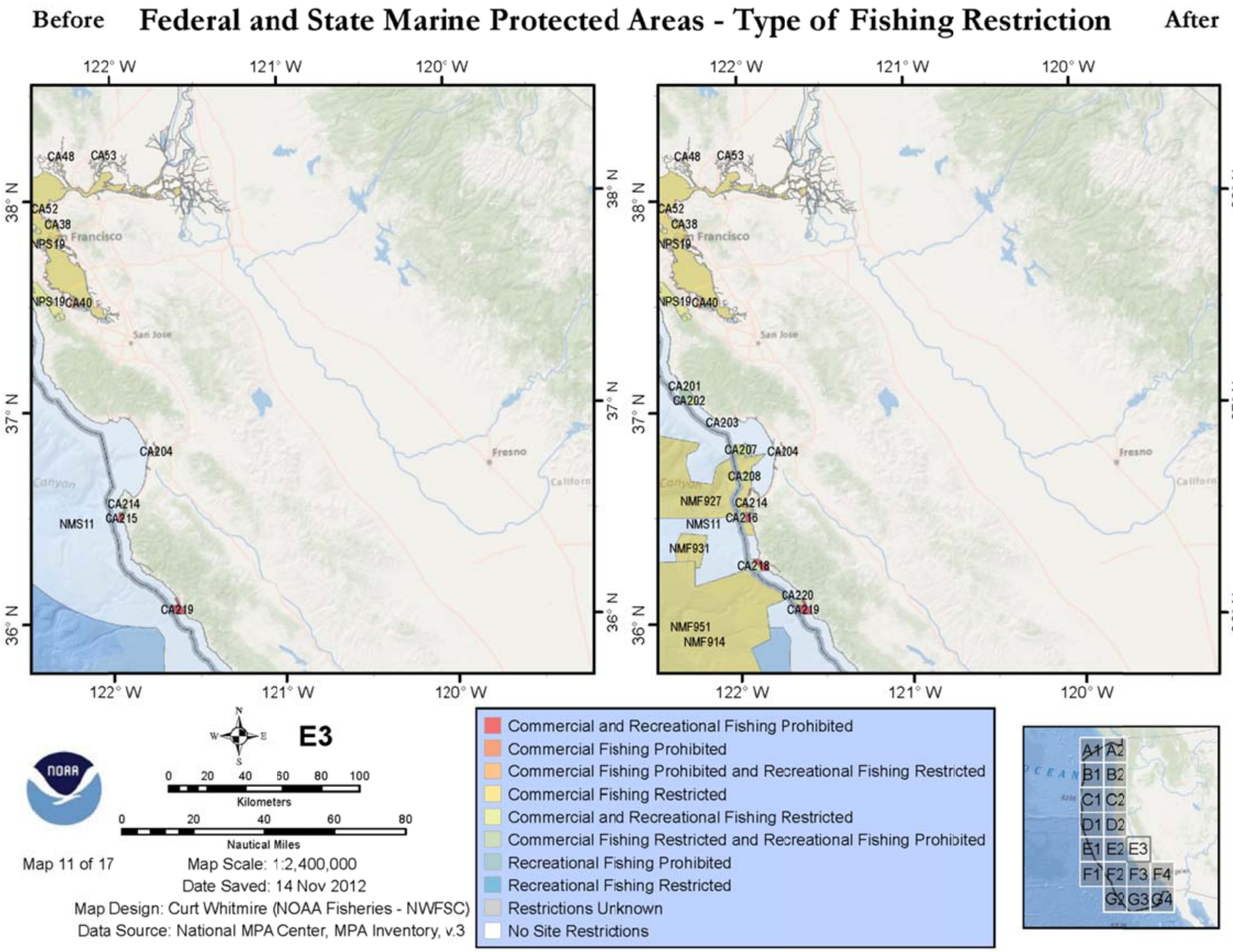

Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
125° W
124° W
123° W
43° N
42° N
OR39
NER21
OR40
NMF36
NPS31
NMF908
NMF906
NMF912
NMF951
Medford
3419
C2
Kilometers
Nautical Miles
Map 6 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

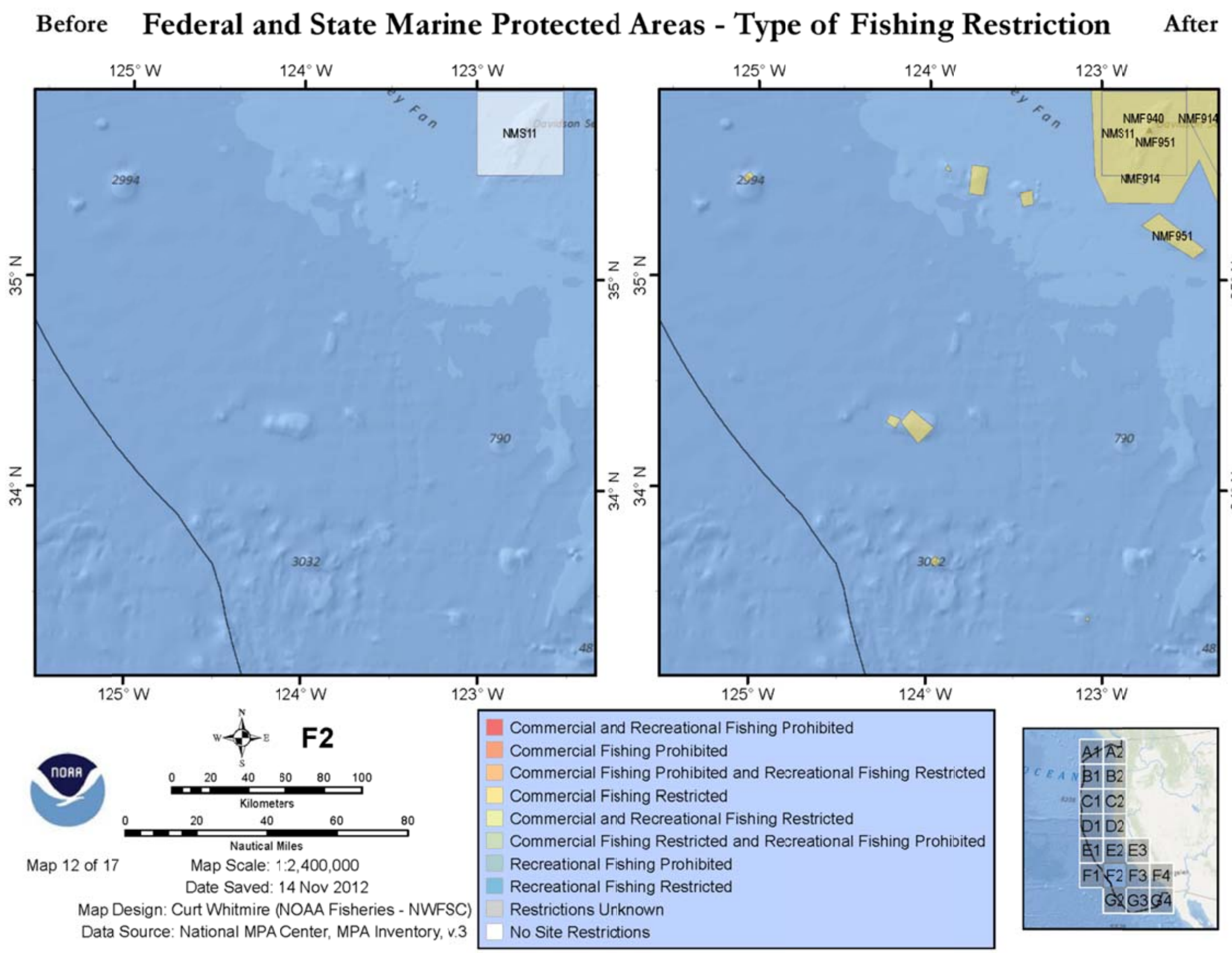

Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
129° W
128° W
127° W
126° W
41° N
40° N
39° N
1379
1195
Escarpment
Mendocino Ridge
NMF951
NMF926
D1
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map 7 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4


Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
125° W
124° W
123° W
41° N
40° N
39° N
NPS31
CA67
Noyo Canyon
Delgada Fan
CA100
CA92
CA104
NMF922
NMF915
NMF926
NMF920
NMF933
NMF951
NMF928
CA233
CA234
CA236
CA237
NMF929
CA238
CA239
CA242
D2
Kilometers
Nautical Miles
Map 8 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

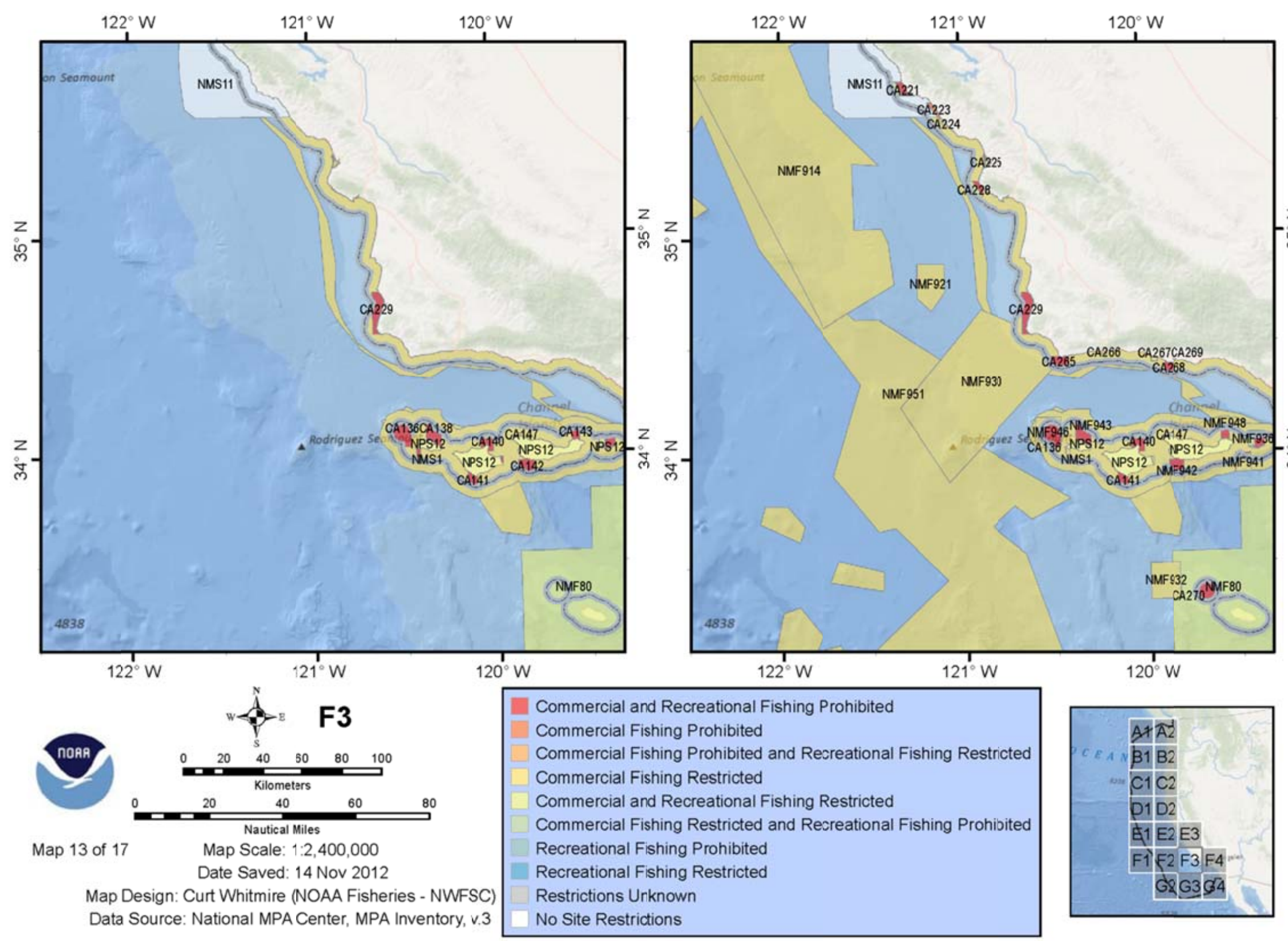

Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
128° W
127° W
126° W
38° N
37° N
36° N
3489
2410
3791
NMF951
E1
Kilometers
Nautical Miles
Map 9 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4


Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
NMS2
NPS19
NPS30
CA52
CA45
NMS8
NMS11
Pioneer Seamount
Guide Seamount
Taney Seamount
5179
Monterey
NMF951
NMF939
NMF918
NMF923
NMF924
NMF927
NMF931
NMF914
NMF940
CA242
CA243
CA244
CA246
CA249
CA250
CA251
CA262
CA253
CA259
CA254
CA255
CA201
125° W
124° W
123° W
38° N
37° N
36° N
E2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map 10 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

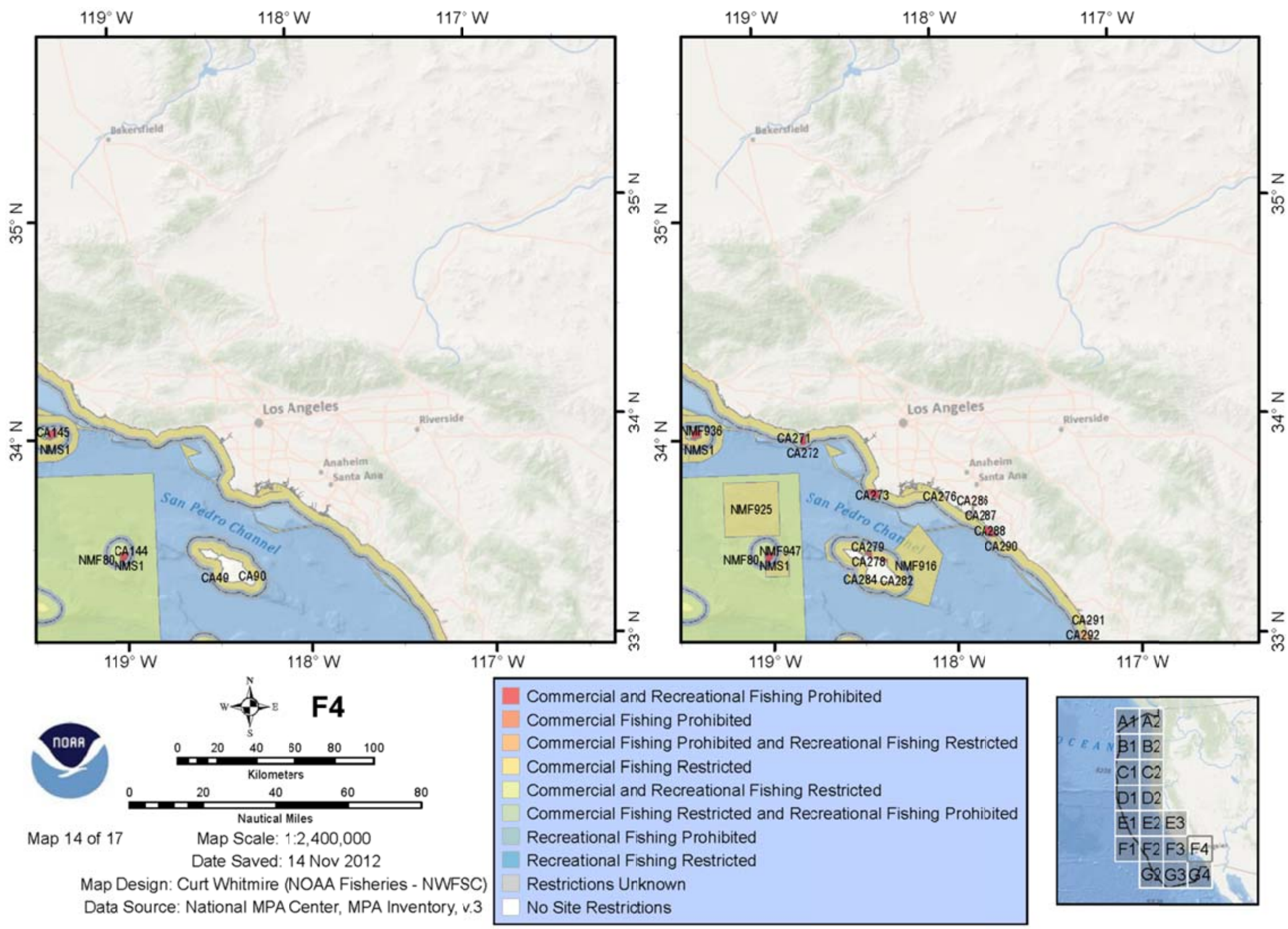

Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
122° W
121° W
120° W
38° N
37° N
36° N
CA48
CA53
CA52
CA38
NPS19
NPS19
CA40
San Jose
CA201
CA202
CA203
CA204
CA207
CA208
NMF927
CA214
CA215
CA216
NMS11
NMF931
CA218
CA219
CA220
NMF951
NMF914
Fresno
E3
Kilometers
Nautical Miles
Map 11 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

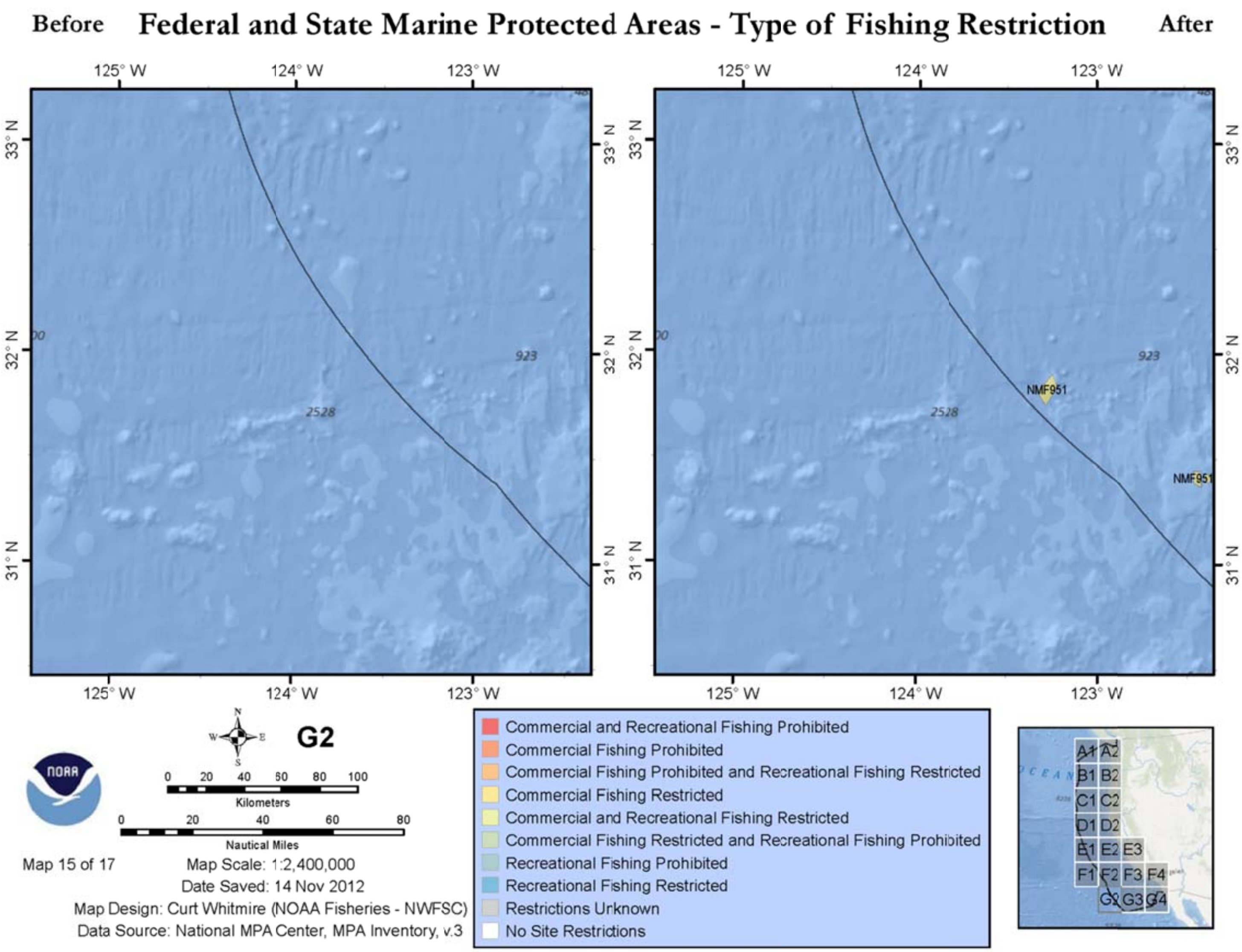

Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
125° W
124° W
123° W
35° N
34° N
NMS11
2994
790
3032
48
NMF940
NMF914
NMF951
F2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map 12 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

Before **Federal and State Marine Protected Areas - Type of Fishing Restriction** After

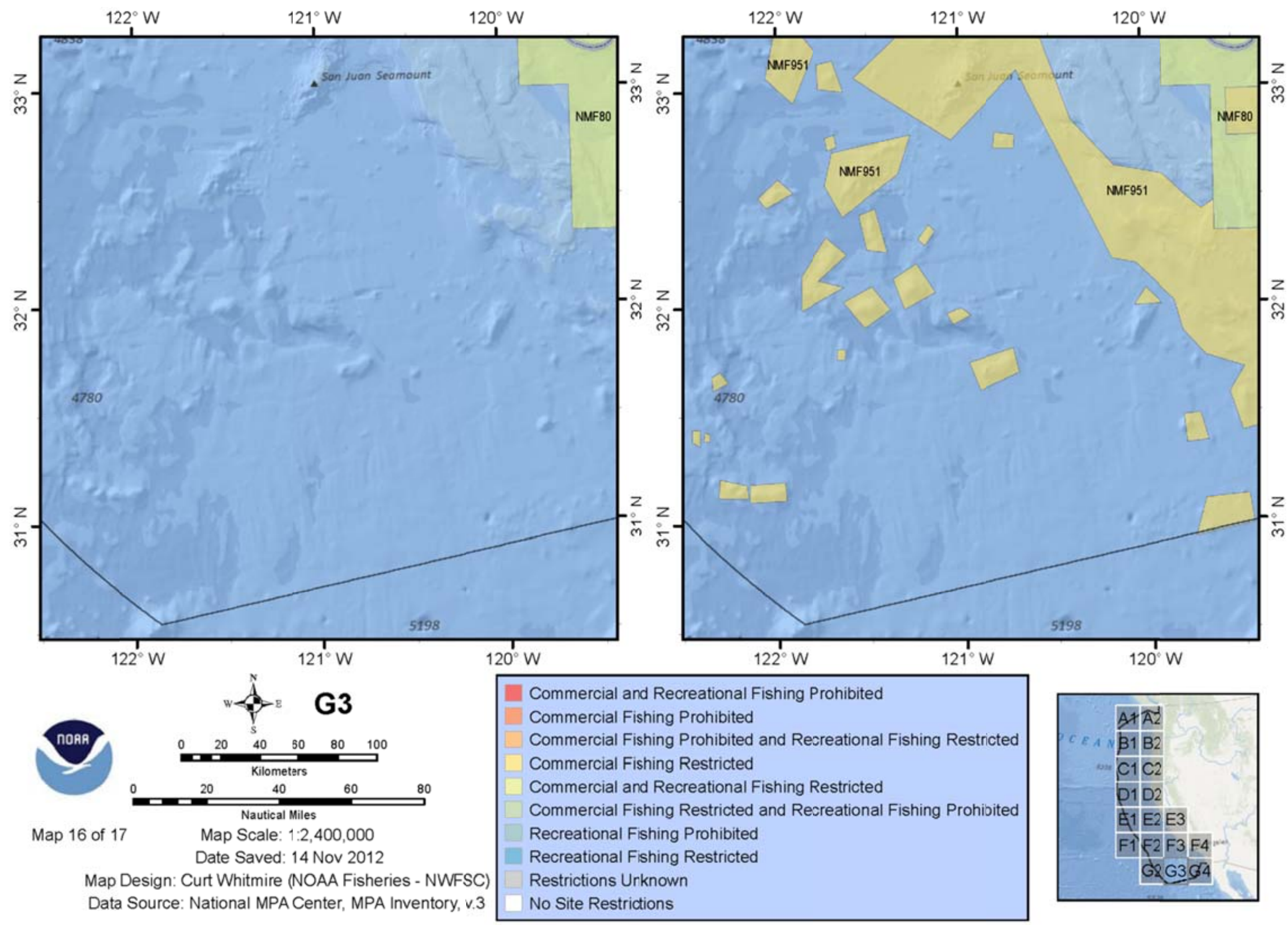


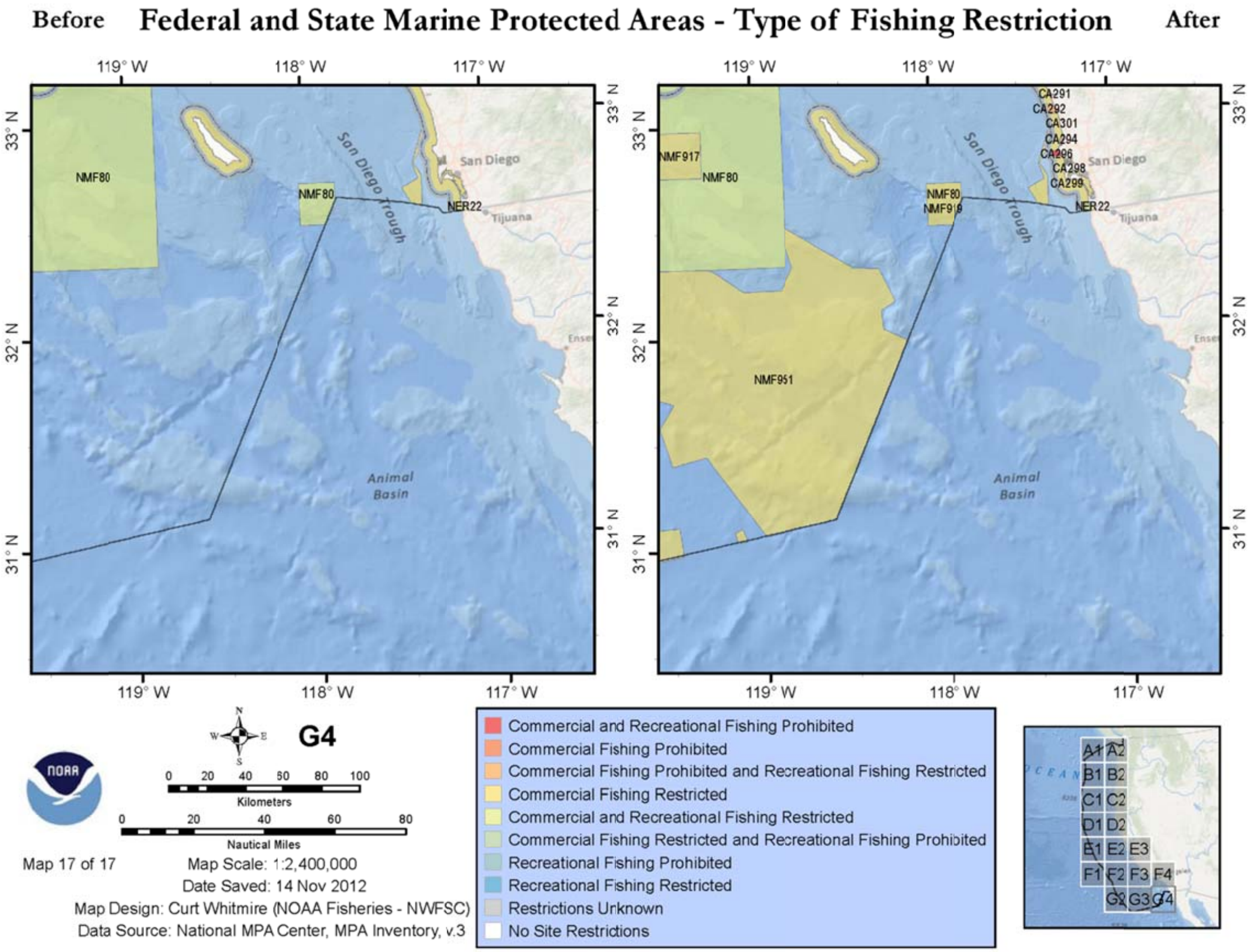
Before **Federal and State Marine Protected Areas - Type of Fishing Restriction** After




Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
125° W
124° W
123° W
33° N
32° N
31° N
923
2528
NMF951
G2
Kilometers
Nautical Miles
Map 15 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

Before **Federal and State Marine Protected Areas - Type of Fishing Restriction** After




Before
Federal and State Marine Protected Areas - Type of Fishing Restriction
After
119° W
118° W
117° W
33° N
32° N
31° N
NMF80
NER22
San Diego
Tijuana
San Diego Trough
Animal Basin
NMF917
NMF919
NMF951
CA291
CA292
CA301
CA294
CA296
CA298
CA299
G4
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map 17 of 17
Map Scale: 1:2,400,000
Date Saved: 14 Nov 2012
Map Design: Curt Whitmire (NOAA Fisheries - NWFSC)
Data Source: National MPA Center, MPA Inventory, v.3
Commercial and Recreational Fishing Prohibited
Commercial Fishing Prohibited
Commercial Fishing Prohibited and Recreational Fishing Restricted
Commercial Fishing Restricted
Commercial and Recreational Fishing Restricted
Commercial Fishing Restricted and Recreational Fishing Prohibited
Recreational Fishing Prohibited
Recreational Fishing Restricted
Restrictions Unknown
No Site Restrictions
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

User Guide and Conclusions:
Groundfish Essential Fish Habitat Synthesis Report

Because the amount of information in the *Phase 1 Essential Fish Habitat Report* (Phase I Report) and its companion, *Groundfish Essential Fish Habitat Synthesis Report* (Synthesis Report), may be daunting, we present some approaches for using the Synthesis Report in both developing and evaluating future proposals to change Essential Fish Habitat (EFH) boundaries.

The NMFS Synthesis Report is not a comprehensive EFH analysis, but rather provides summaries and some interpretation of newly available information that supplements previous EFH work and can be used by stakeholders to assess and propose changes to existing spatial management boundaries. The report is intended to set the stage for proposals to articulate any perceived need for changes and to lay the groundwork for Groundfish EFH Request for Proposals. We provide five types of analyses or summarizations: a) the spatial distribution of physical and biogenic habitats of the West Coast across bioregions, depth zones, and areas with different regulatory protections; b) the association of representative species with habitat characteristics including depth, temperature and substrate; c) the distribution of fishing and non-fishing threats across habitat types; d) analyses of the overlap of high likelihood of species occurrence and threats to habitat; and e) a summary of the diets of select groundfishes.

All documents, as well as the underlying data layers for the Synthesis Report, are available online:

- Phase I Report: www.pcouncil.org/groundfish/background/document-library/pacific-coast-groundfish-5-year-review-of-efh/
- Synthesis Report: www.pcouncil.org/wp-content/uploads/D6b_NMFS_SYNTH_ELECTRIC_ONLY_APR2013BB.pdf
- Synthesis data layers and data developed during Phase 1: http://efh-catalog.coas.oregonstate.edu/synthesis
- Groundfish EFH Environmental Impact Statement (2006): www.nwr.noaa.gov/publications/nepa/groundfish/final_groundfish_efh_eis.html.

1. User Guide

Below are suggestions for using the Synthesis Report with respect to EFH consideration.

- **Read this document, look closely at both the Phase 1 Report and Synthesis Report, and consider information from the original groundfish EFH EIS.**

  A primary purpose of the Synthesis Report is to provide summarized data that are useful to the development of proposals for changes to EFH and/or regulatory measures to minimize adverse effects to EFH. We have worked to lay out our analyses sequentially; they should form the foundation of proposals. For topics that are not considered in this report, the Phase 1 Report and the initial EIS contain useful information.

- **Look at the distribution of habitats in areas with and without protections.**

  Different types of habitats (by depth, by substrate type, by biogeographic region) are differentially subject to fishing regulations and other protections. A logical argument for any change in EFH or related spatially-driven protections includes an articulation of the relative amount of different types of protected and unprotected habitat.

- **Assess protections relevant to individual species.**

  We focused on 6 ecologically distinct groundfish species that were selected to be generally representative of the west coast groundfish complex. Our analyses reveal that virtually all the marine habitat along the US West Coast is likely to have a high probability of occurrence for the subadult through adult stage of at least one of these species. [Note that since species are not distributed randomly, we use the probability of occurrence based on habitat characteristics as a proxy for habitat preferences.] Moreover, the value of all areas will likely increase as additional life stages and species are more quantitatively considered. Because species are distributed across habitat types, any difference in protections among habitat types will have varying impacts on species, depending on their affinity to particular habitats. In some cases, such as when a species is subject to very little fishing pressure or other non-fishing stressors, this variance may be acceptable, at least to some stakeholders. Alternately, stakeholders may feel that protections for habitats where certain species are likely to be found are insufficient. Examining: a) the habitat characteristics associated with particular groundfish species; and b) the protections for habitats of those types (as described above) provides a first cut at whether particular species are likely to be affected by the differences in habitat protections.

- **Identify areas of low and high impacts from fishing and other stressors.**

  Current levels of impact from both fishing and other threats to habitat can affect the degree of risk or protection that is tolerable to stakeholders or the Council. For example, areas or habitats that are relatively unaffected by human activities may be in little need of additional EFH-related protection; however, if such areas are important for some species, they might be protected now to prevent future degradation. Some habitats or areas subject to both high fishing pressures and high levels of other impacts could be considered for regulations to improve the overall quality of the habitat.

- **Assess the correspondence of threats with habitats among species.**

  Ultimately, it is the combination of habitat type, the probability of seeing a species in that habitat, and the threats to which a habitat is subjected, that should inform decisions about changes to existing EFH protections. Protecting areas in which there is a low probability of occurrence for a particular species will have little impact on the long-term persistence and productivity of a species. Thus, probability of occurrence, and associations of species with habitat characteristics can be used to prioritize areas for species of particular concern. The combination of current ecological importance and fishing pressure allows stakeholders to evaluate how much 'important' habitat has fishing protection. The inclusion of non-fisheries stressors allows consideration of the suitability of areas for protection. For example, managers may choose to protect areas of the highest quality by prioritizing areas subject to low levels of pollution over areas with high levels of these threats. Or, they may determine that non-fishing threats are so great in some areas that reductions in fishing pressure might be needed to maintain the health of the species. Our 'occurrence by exposure' graphs provide a means of gauging how much total habitat is and is not protected where there is a high probability of finding a species.

- **Consider the major prey species of groundfish only when proposing prey-based changes to EFH.**

  The definition of EFH includes waters and substrate necessary to fish for feeding, and the presence of prey makes waters and substrate function as feeding habitat. Therefore, activities, both fishing and non-fishing, that reduce the availability of a major prey species, either through direct harm or capture or through adverse impacts to the prey species' habitat, may be considered adverse effects on EFH if such activities reduce the quality of EFH. While abundant prey can be an important component of EFH, the prey species themselves cannot be designated as EFH. In addition, EFH cannot be designated for prey species that are not managed by the Council.

In this synthesis, we reviewed the available quantitative data for a representative subset of groundfish species and identified their major prey species, with greater taxonomic resolution than in the 2005 EFH designation process. Proposals that address prey abundance and availability (i.e., the quality of the foraging habitat) should focus on these major prey types, at this taxonomic resolution.

2. Conclusions

Below are some noteworthy conclusions that can be drawn from the data.

- *Areas in which there is a high probability of occurrence vary among species; all areas are likely important when the entire assemblage of 91 groundfishes is considered.* Overall, habitat areas important for each of the six representative species do not necessarily coincide; thus together, they cover virtually all locations along the coast. Identifying single areas that are important for all species is unlikely, and defining spatial management boundaries may involve prioritization and trade-offs. [Both models in this report rely heavily on bottom trawl survey data, although one also included visual survey data.]
- *Areas with fishing protections vary geographically*. A large proportion of all habitat along the US West Coast is included in EFH conservation areas. However, the bottom trawl closure of seabed seaward of 700 ftm accounts for the majority of the conservation area; ~10% of the upper slope and shelf areas have such protections.
- *Fishing effort is disproportionate geographically.* Fishing pressure from federally observed groundfish fisheries is highest in the Northern region, and is heavily concentrated on the upper slope and shelf over soft habitats along the entire coast.
- *Patterns of fishing pressure have remained moderately stable over the previous decade, but have likely varied over longer time periods*. Areas designated as EFH conservation areas tend to be areas that had relatively low fishing pressure from the groundfish fishery for several years before Amendment 19 was implemented, which established EFH boundaries and conservation areas in 2006, and continue to have relatively low fishing pressure. However, many of those areas may have received greater fishing pressure before the 2000 trawl footrope restriction and the implementation of Rockfish Conservation Areas. There does appear to be some displacement of trawling activity from the RCAs to areas more seaward.
- *EFH conservation areas protect some groundfish species from fishing more than others.* The proportion of habitat where there is a high probability of occurrence for one of six representative groundfish species that is also included within an EFH conservation area varies widely among species. Those species that occur in rocky or deeper areas (yelloweye rockfish, sablefish, and longspine thornyhead)

have a relatively higher proportion of their 'high probability' habitat included within the EFH conservation areas than fish that are generally found in shallower or softer habitats (petrale sole, greenstriped rockfish, darkblotched rockfish)..

- *Fishing pressure was high in high-probability habitat for adults of some groundfish species but not others.* Species vary in the coincidence of habitat suitability and fishing pressure from the groundfish fishery. Sablefish has the highest proportion of areas that are heavily targeted by the fishery and also have a high probability of occurrence. Petrale sole has high probability of occurrence and high fishing pressure near the mouth of the Columbia River (Washington/Oregon border) and near San Francisco, California, but areas of lower fishery pressure (from federally observed fisheries) near shore. The estimated threat to yelloweye rockfish is generally low since yelloweye have a high probability of occurrence only in areas with a low exposure to bottom trawl fishing.

- *Habitat areas of particular concern (HAPCs) are more exposed to high non-fisheries pressures than other areas.* On average, HAPCs and non-HAPC areas are similar in the total level of non-fisheries threat experienced. However, both cumulatively and with respect to individual threats, HAPCs have a greater proportion of areas exposed to 'high' non-fisheries threats than were present in non-HAPC areas. This is largely due to HAPCs in shelf areas exposed to land-based threats, and their selection to address non-fishing impacts.

- *The level of taxonomic diversity of prey was significantly improved for 11 groundfish species over the level of information presented in the Phase 1 Report.* However, quantitative information on diet composition is limited for most of the other 80 species in the groundfish FMP. Additional studies are needed to establish trophic linkages for these species throughout the California Current system.

- *Current EFH conservation areas protect many deep-sea coral and sponge habitats, but additional areas remain open to some or all bottom contact gears*. There are numerous sites outside EFH conservation areas where corals and sponges have been observed in relative high abundance; the known distribution of corals and sponges is heavily influenced by how they are sampled.

- *Diet composition differed substantially among these 11 groundfish species.* Such information should not be combined among species for subsequent analysis.

- *Other sources of data are important*. Our analyses did not consider young-of-the-year juveniles or biogenic habitat other than corals and sponges. Information in the 2005 compilation of information for groundfish EFH designation is therefore still relevant. Similarly, the HSP designations made in that effort may be useful for considering habitats potentially important for all life stages.

- *Next steps for future habitat-related analyses include (but are not limited to)*: 1) determining the coincidence of non-fishing pressures and high-probability habitats, 2) quantifying key prey species for remaining 80 species of FMP groundfishes; 3) evaluating habitat associations for key prey species, 4) further evaluating the association between groundfishes and biogenic habitats; and 5) incorporating community metrics (such as diversity) into habitat association models. In addition, impacts of climate change are expected to cause shifts in the locations of preferred habitats for different species due to changes in temperature, dissolved oxygen, or acidity, and future reviews of EFH should evaluate the potential need to change EFH designations to accommodate such habitat shifts.

3. Errata

The Synthesis Report includes an older version of Figure 4b.2. Below is the correct figure.

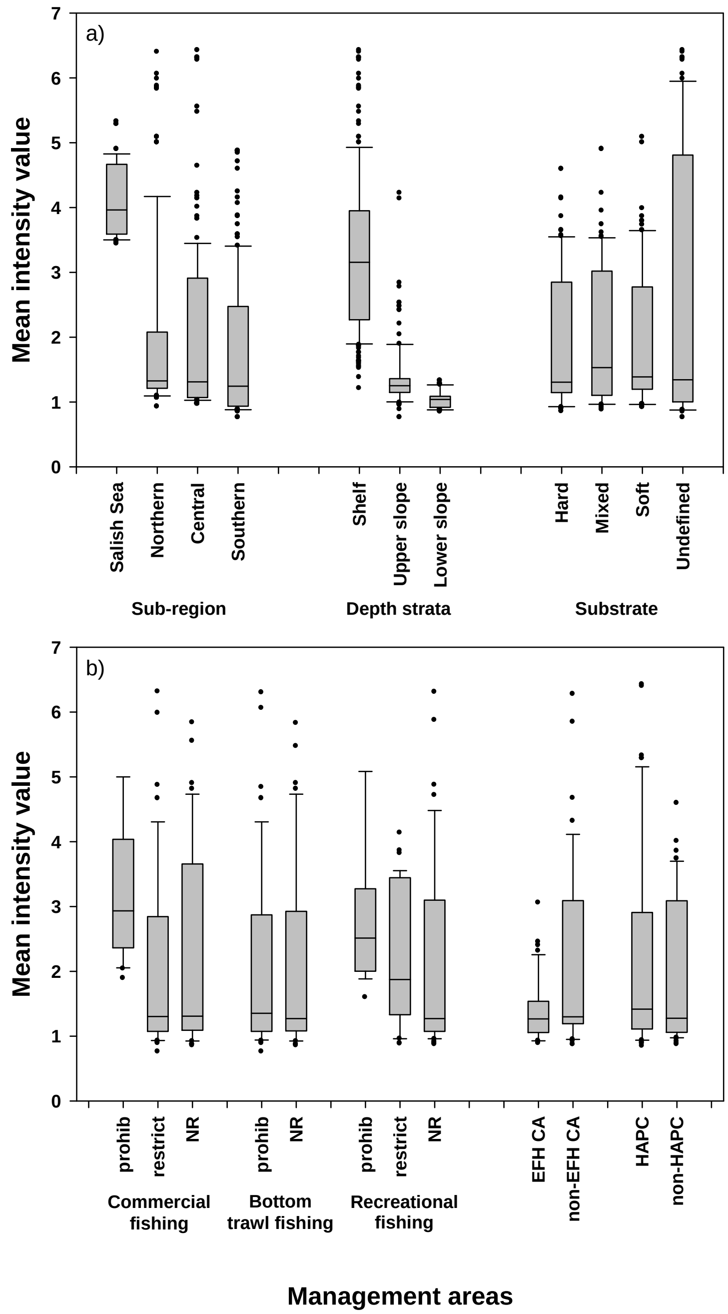


Figure 4b.2. Mean intensity values of combined pressures across a) sub-regions, depth strata, substrate, and b) management areas. The shaded box indicates the 25th to 75th percentile, the line within the box marks the median, the whiskers indicate the 10th and 90th percentiles, and the dots indicate all outliers. prohib: type of fishing is prohibited; restrict: type of fishing is restricted; NR: type of fishing has no restrictions; EFH CA: essential fish habitat conservation areas for West Coast groundfish; HAPC: habitat areas of particular concern. Fishing restrictions include areas within EFH CA, rockfish conservation areas (RCAs), and state territorial sea restrictions.

Agenda Item D.6.c
Supplemental EFHRC Report
April 2013

Essential Fish Habitat Review Committee (EFHRC) REPORT ON
GROUNDFISH ESSENTIAL FISH HABITAT REPORT AND REQUEST FOR PROPOSALS

The Essential Fish Habitat Review Committee (EFHRC) reviewed the draft National Marine Fisheries Service (NMFS) report entitled "Groundfish Essential Fish Habitat Synthesis Report" (Agenda Item D.6.b, NMFS Synthesis Report) and the associated appendices (Agenda Item D.6.b, Supplemental NMFS Report 2). The EFHRC commends the NMFS Team for a tremendous effort in compiling the Synthesis Report, and appreciates the willingness to accommodate suggestions.

The EFHRC offers the following comments:

1 The NMFS Synthesis Report and Appendices (Agenda Item D.6.b, Supplemental NMFS Report 2) contains a significant amount of information that complements the Phase 1 Report (September 2012 Agenda Item H.6.b, EFHRC Report 1) and the data available on the online data catalogue (http://efh-catalog.coas.oregonstate.edu/overview/). Together, these provide a sufficient basis for anyone wishing to submit a proposal for changes to groundfish essential fish habitat (EFH). The EFHRC endorses the NMFS Synthesis Report, with the following changes that were developed in collaboration with the report's authors. With these changes, the concerns of the EFHRC will have been addressed:

    a Replace the descriptor "ecological importance" with "probability of occurrence" and/or "occupancy."
    b Add language describing the differences between the document's analysis of habitat occupancy and the 2005 Habitat Suitability Probability (HSP) analysis (*see below).
    c Minor editorial changes.

2 The EFHRC suggests that once the described changes have been made to the report, the Council should issue the request for proposals (RFP) with at least a 90-day open period. This means that proposals would be due in late July 2013. The EFHRC will begin initial proposal review thereafter.

3 The EFHRC would like to convene for two days at the September 2013 Council meeting to continue review of proposals, and to provide the Council with an initial summary of the number, scope, and general content of proposals. Final action should remain scheduled for the November 2013 Council meeting.

4 The EFHRC reiterates the research priorities contained in its September 2012 Supplemental Report (September 2012 Agenda Item H.6.b, Supplemental EFHRC Report 2). The draft NMFS Synthesis Report addressed and was responsive to many of the "Information and Research Needs" identified by the EFHRC in September 2012 (September 2013 Agenda Item H.6.b, Supplemental EFHRC Report 2). However, there remain some outstanding issues that

the EFHRC recommends remain a top priority for completion during Phase 2, concurrent with the proposal process:

a Include an assessment of physical and biogenic substrate types inside and outside EFH conservation areas based on the data available in 2005 to contrast with the assessments based on 2011 data.

b Qualitative comparison of high and low areas using HSP and probability of occurrence models for the six groundfish species assessed.

c Update analysis of midwater trawl habitat impacts based on new fleet-based estimates of bottom contact frequency and duration.

d Re-assess the role of corals and sponges as habitat for groundfish based on an updated literature review.

e Update the HUD database.

5 In considering the NMFS Synthesis report and the relevance of the new information in the Phase 1 report, the EFHRC highlights the following key conclusions:

a Hard seabed habitat types are less abundant, or rare, in comparison to soft seabed though the relative proportions of each type within depth strata are fairly consistent across biogeographic subregions. There is a significantly new understanding of hard substrate shape and distribution in federal waters inside and outside EFH conservation areas in Northern Washington and throughout Oregon. However, the 2005 understanding of hard substrate distribution in federal waters off California is essentially unchanged (with the exception of the Gulf of the Farallon Islands region).

b Much of the new information on biogenic habitat is in the form of a large database of records of deep-sea corals and sponges. There are numerous sites outside EFH conservations areas where corals and sponges have been observed in higher relative numbers off all three states.

c The level of bottom trawl fishing effort within closed areas is fairly consistent both pre- and post- EFH conservation areas, indicating that those closures resulted in minimal disruption of bottom trawl fishery dynamics.

d Midwater trawl fishing is permissible within all Amendment 19 EFH conservation areas since it was assumed to have no contact with the seafloor. Annually, midwater trawling occurs over 8-31% of EFH conservation areas where bottom trawling is prohibited, and bottom contact is estimated by the fleet to occur on up to 25% of tows predominantly in soft sediment habitats, as referenced in the Phase 1 Report.

e There is new quantitative and species specific prey information for 11 groundfish species enabling assessments of “major prey” for those species.

*This language should be added to the Introduction of the NMFS Synthesis Report:

> This report provides summaries and characterizations of information developed during Phase I of the EFH 5-year review (2012). It is not intended as a full EFH analysis, but rather, to provide supporting and contextual information for those making proposals or evaluating proposals in Phase II. There are a variety of aspects that are not addressed in this work, including the importance of juvenile habitat and the association of groundfish with biogenic habitat. Thus, information previously developed to support the 2005 EFH EIS is still relevant.

In this document, we provide an analysis of habitat associations for six representative species, using the NWFSC trawl survey data as a primary input, coupled with a range of environmental parameters. It also incorporates some information from visual surveys in rocky areas. Because it uses these recent data, this analysis reflects current distributions of these species and characteristics of the habitats they currently occupy, and projects those associations in areas that have not been sampled. It is an empirically based assessment of the likelihood of finding a species at a particular location under current conditions.

For the 2005 EFH EIS, an analysis termed the HSP that also produced distributional maps was conducted. That analysis was based on habitat mapping, the Habitat Use Database (a multidimensional relational database of species and life stages related to substrate types), the literature, and was moderated by expert opinion. It presents a depiction of potential distribution, or idealized distribution, independent of current conditions – it estimates the intrinsic potential for a particular habitat to support each species. When using these analyses to support or evaluate proposals, stakeholders, managers and scientists should keep the different approaches in mind.

PFMC
04/08/13

GROUNDFISH ADVISORY SUBPANEL REPORT ON ESSENTIAL FISH HABITAT AND REQUESTS FOR PROPOSALS

The Groundfish Advisory Subpanel (GAP) heard a presentation from Dr. Michelle McClure, Dr. Waldo Wakefield and Dr. Ole Shelton on the Essential Fish Habitat and Synthesis and completion of Phase I. The GAP appreciates their significant work, as well as that of the Essential Fish Habitat Review Committee (EFHRC), and National Marine Fisheries Service, to develop information for the Council to consider possible changes to current EFH designations. Of particular interest to the GAP was the EFH website developed by Mr. Chris Romsos [http://efh-catalog.coas.oregonstate.edu/overview/].

In the event the Council decides to issue a Request for Proposal (RFP), it is the intention of the GAP to actively participate in the evaluation of any proposals submitted regarding EFH.

It is the GAP's understanding that this matter is currently scheduled for the November 2013 Council meeting, with possible subsequent action in March 2014.

In order to have ample opportunity to examine proposals for their technical sufficiency, as well as their biological, ecological and social implications, the GAP strongly recommends that all submissions received by the Council in response to the RFP be made available publically prior to the September 2013 Council meeting.

The GAP wants to begin its review of the proposals at the September Council meeting and continue its review in November, for what we hope will be sufficient opportunity to provide comment in advance of any action the Council may take.

PFMC
04/08/13

GROUNDFISH MANAGEMENT TEAM REPORT ON ESSENTIAL FISH HABITAT SYNTHESIS REPORT AND REQUEST FOR PROPOSALS

The Groundfish Management Team (GMT) appreciated receiving a presentation from Drs. Michele McClure, Waldo Wakefield, and Ole Shelton from the National Marine Fisheries Service (NMFS) Northwest Fisheries Science Center (NWFSC) on the Essential Fish Habitat (EFH) Synthesis Report. That report provides an impressive summary of the available information in a concise and understandable format. We expect the data provided will be useful to the Council in considering proposed changes to EFH designations and/or management measures.

While it is beneficial to have the available new information distilled in this way, the GMT highlights that there are important limitations to the analyses that should be recognized. For instance, there is relatively little information available for all life history stages or indeed most of the stocks within the Fishery Management Plan. Moreover, the information on presence/absence comes primarily from the NWFSC trawl survey that occurs in the summer, meaning that habitat use from other seasons is likely underrepresented. Likewise, the trawl survey does not sample all available habitats, as shown by the yelloweye rockfish distribution maps, and the difference the visual survey data makes to the predictive modeling. This underscores the importance of visual surveys in understanding the habitat needs of some rockfishes. The visual surveys used in the Synthesis Report have covered only a limited part of non-trawlable habitat on the coast.

Nonetheless, the summary of areas and habitat types protected as well as fishing pressure for those areas and habitats is useful. It appears that the Council and NMFS were largely successful at “freezing” the trawl footprint, and pressure has not changed much since 2006. The GMT notes, however, that information from the rationalized trawl fishery is not yet available and may have quite a different pattern from what was seen under bimonthly cumulative limits.

Lastly, we think that some of the metrics produced for this EFH review (e.g. prey species and cumulative fishery pressure analysis) could be helpful indicators for the Tier 1 Environmental Impact Statement and follow-ups to it if resources allow for regular updating.

PFMC
04/07/13

HABITAT COMMITTEE COMMENTS ON GROUNDFISH ESSENTIAL FISH HABITAT SYNTHESIS REPORT AND REQUEST FOR PROPOSALS

NMFS Groundfish Essential Fish Habitat (EFH) Synthesis Report

The Habitat Committee (HC) received a presentation from Michele McClure and Waldo Wakefield (NMFS FRAM) and Ole Shelton (Habitat Conservation Program), on the NMFS EFH Synthesis Report. The HC appreciates NMFS' efforts in synthesizing the EFH Phase 1 data into more digestible and comparable data summaries. The presentation was a brief overview of the results of the complex analyses that went into the synthesis. The biogenic habitat analysis was not highlighted in the presentation, however more information on the methods and results of the biogenic habitat analysis is available in Appendix 1 and now posted to the Council website.*

This information, in addition to the biogenic habitat data summaries from the Phase 1 report, will be useful for anyone wanting to delve further into these analyses of biogenic habitat and support the development of EFH proposals. The HC recommends that the Council adopt the NMFS Synthesis report as a supplemental document to the EFH Phase 1 Review Report.

Groundfish EFH Request for Proposals to Modify Essential Fish Habitat

The HC has reviewed the modified request for proposals, and feels this version is ready for public distribution. However, before the actual release, the Council should ensure that all relevant documents (reports, appendices, etc.) and all datasets used in the EFH Report and NMFS Synthesis Report be made available to the public on the Catalog site and/or Council site.

For instance, the data available in the national database prepared under the auspices of NOAA's Deep-Sea Coral Research and Technology Program (NOAA 2011) as referenced in the EFH Review Phase 1 Report should be made available for proposal development. The HC recommends that these data be uploaded to the EFH Review data catalog website at this time http://efh-catalog.coas.oregonstate.edu/bio/.

* http://tinyurl.com/brdr8s5

PFMC
03/08/13

Agenda Item D.6.c
Supplemental SSC Report
April 2013

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON THE GROUNDFISH ESSENTIAL FISH HABITAT SYNTHESIS REPORT AND REQUEST FOR PROPOSALS

Drs. Michelle McClure, Waldo Wakefield and Ole Shelton (NWFSC) briefed the SSC regarding the Groundfish Essential Fish Habitat Synthesis Report. The report provides a useful synthesis of available information regarding groundfish habitat distributions, species-habitat associations, fishing and non-fishing stressors, fishing pressure, and prey species for Pacific groundfish.

The SSC considers the information contained in the Synthesis Report to be sufficient for purposes of initiating a request for proposals (RFP). However, the SSC has two concerns. First, non-fishing stressors are represented by 16 human activities summarized into a single indicator. Given the diversity of these stressors (e.g., pollution, beach use, commercial shipping activity), the SSC recommends that those stressors specifically relevant to groundfish be analyzed individually in the report and not combined. Second, the SSC is unable to comment on the methods underlying the Report, as the Appendices (which provide documentation of these methods) were not available for review until this meeting.

For purposes of evaluating proposals received under the RFP, it may be helpful to consider the objectives of the Council with regard to essential fish habitat (EFH) and the effectiveness of existing EFH conservation areas in meeting those objectives.

While EFH designation *per se* does not affect fishing activity, it can serve as a basis for future regulatory action. Maps depicting the distribution of catch and ex-vessel value by location and species would be a useful starting point for analyzing the socioeconomic effects of regulatory actions that may occur as a result of changes in EFH designation. While it may not be feasible to develop maps in time for the RFP, it would be useful to have such maps available if and when EFH regulatory actions are considered by the Council.

PFMC

04/07/13

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March 19, 2013

Mr. Dan Wolford, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, OR 97220-1384

RE: **Agenda Item D.6, Groundfish Essential Fish Habitat**

Dear Mr. Wolford and Council members:

As part of this April 2013 briefing book, Oceana is happy to submit a new report, *Important Ecological Areas Seafloor Habitat Expedition off the Southern Oregon Coast* (see Agenda Item D.6.d Public Comment 2). This report synthesizes and summarizes in a publically-available format the data we extracted from high definition seafloor habitat footage taken during Oceana's June 2011 research cruise off southern Oregon. During the course of that expedition, we executed 17 dives at depths ranging from 28 to 228 meters and we collected 13.5 hours of video of seafloor habitats and managed fish species.

While this public report is new, we previously submitted information and data on this research to the Pacific Fishery Management Council and National Marine Fisheries Service (NMFS). Information about the research was included in the Essential Fish Habitat (EFH) Review Committee's Phase I Report,[1] which we submitted in response to the agency's July 2011 data request. We subsequently provided all of the data included in this report in Geographic Information System (GIS) format to NMFS and Council staff at the September 2012 PFMC meeting with the understanding that it would be included in this 5-year review. We have also worked with NMFS staff to ensure that it will be incorporated into the NMFS EFH synthesis that will be presented at the April 2013 Council meeting. Last, we provided this data to NOAA's Deep Sea Coral Research and Technology Program for inclusion in the National Deep-Sea Coral and Sponge Geodatabase.

This research represents the first *in situ* observations of the habitats and fish species in the Cape Arago region and the first observations at the Coquille Bank EFH Conservation Area since the area was designated in 2005. The Oregon Department of Fish and Wildlife has previously surveyed the Orford Reef area and Hixon and Tissot (2007) reported on the effects of bottom trawling in soft sediment habitat areas immediately adjacent to the Coquille Bank EFH conservation area. In our research, we documented corals at 15 of the 17 dives and sponges at 16 of 17 dives, significantly adding to the direct observations of coral and sponge locations in this region. Some of the reefs we surveyed previously had no records of corals or sponges. We documented 13 different managed groundfish species and overall we saw 2,299 individual fishes

[1] PFMC September 2012., Agenda Item H.6.b, EFHRC Report, at 136

including widow rockfish, canary rockfish, yelloweye rockfish, lingcod and other managed and unmanaged fish species.

The areas we surveyed are biologically diverse, contain sensitive habitat features, and they are clearly essential fish habitat for managed fish species. Some of these areas are likely important nursery habitats for overfished species like yelloweye and canary rockfish. Importantly, the areas studied in this report represent key areas of interest where new data now exists that was not available in the initial round of EFH deliberations. We will continue to pay close attention to these areas as we develop our proposals in response to the Council’s upcoming Request for Proposals for modifications to existing EFH management. In the meantime, please don’t hesitate to contact me or my colleague Geoff Shester about any questions you may have regarding this report.

Thank you for your time and consideration.

Sincerely,

Ben Enticknap
Pacific Campaign Manager and Senior Scientist

References:

Enticknap, B., G. Shester, M. Gorny, and M. Kelley. 2013. Important Ecological Areas Seafloor Habitat Expedition off the Southern Oregon Coast. Oceana Pacific. March 2013. See: PFMC Agenda Item D.6.c Public Comment 2, April 2013

Hixon, M.A., and B.N. Tissot. 2007. Comparison of trawled vs untrawled mud seafloor assemblages of fishes and macroinvertebrates at Coquille Bank, Oregon. Journal of Experimental Marine Biology and Ecology. 344: 23-34.

OCEANA Protecting the World's Oceans

Agenda Item D.6.d
Public Comment 2
April 2013

IMPORTANT ECOLOGICAL AREAS
SEAFLOOR HABITAT EXPEDITION

Off the Southern Oregon Coast

Ben Enticknap
Geoff Shester
Matthias Gorny
Megan Kelley

OCEANA PACIFIC MARCH 2013

CONTENTS

"Only the ocean remains as the last great unexplored portion of our globe; so it is to the sea that [we] must turn to meet the last great challenge of exploration this side of outer space."

H.B. Stewart, Deep Challenge (1966)

The authors would like to give special recognition to Susan Murray, Deputy Vice President, Pacific, for her leadership and her commitment to identifying and protecting Important Ecological Areas in the Northeast Pacific and Arctic Oceans. Oceana staff Jon Warrenchuk, Whit Sheard and Cayleigh Allen provided able assistance at sea, and Mike Levine, Mike Hirshfield, Jim Simon, Eric Bilsky, and Lianne Holzer assisted with expedition planning. We thank James Lindholm and personnel at the California State University Monterey Bay for assistance with video analysis methods and species identifications. A special thanks to our internal scientific reviewers Jon Warrenchuk, Chris Krenz and Mike Hirshfield, plus our external reviewers Dave Fox, Jeff Short, and Brian Tissot, who provided valuable technical review of the methods and results. We thank Captain Bob Pedro of the R/V Miss Linda and his crew for providing a safe platform for our surveys and for his uncanny ability to stay on position.

This work was funded in part by the David and Lucile Packard Foundation and the Meyer Memorial Trust.

Graphic Designer: Jenny Jones

Cover Photo: Rosy rockfish, crinoids, and sponge at Coquille Bank
Left Insert Page: Inshore Cape Arago: lingcod
This Page: Inshore Cape Arago Reef: gorgonian coral

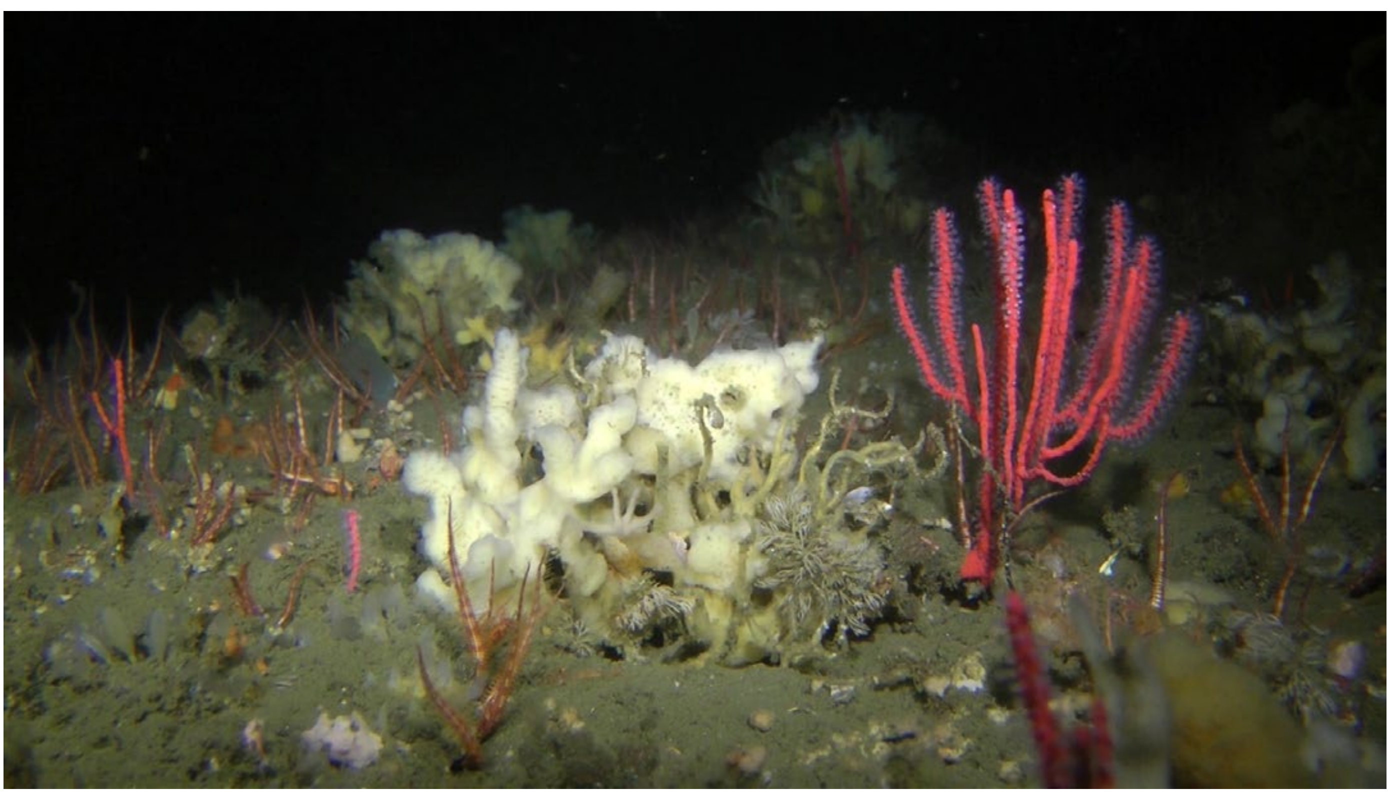
ABSTRACT

IMPORTANT ECOLOGICAL AREAS

In June 2011 Oceana conducted a five day research expedition in the Pacific Ocean waters off southern Oregon to document and characterize seafloor habitats and their associated biological communities, and to help inform and advance the long-term conservation and management of Important Ecological Areas. Using a Remotely Operated Vehicle (ROV) mounted with a high definition camera, we recorded 13.5 hours of video of the seafloor during the course of 17 dives, across six geographic study areas and in depths ranging from 28 to 228 meters. This study characterizes and compares the physical and biological structure at each area and the associated fish species identified through a combination of continuous and interval video analysis.

Areas surveyed off Cape Arago southwest of Coos Bay, and inshore and offshore Coquille Reef west of Bandon had never before been surveyed with underwater cameras. Our findings represent the first *in situ* observations of these unique habitats. We documented three orders of cold-water corals at 15 of 17 dives and sponges at 16 of 17 dives, significantly adding to the direct observations of coral and sponge locations in this region of the Pacific Ocean. We also documented many other invertebrates such as crinoids, anemones, tunicates and bryozoans that add to the biogenic structure of these areas. The physical structure of the habitats surveyed ranged from high relief hard rocky reef to low relief soft sediments.

Overall, we observed 2,299 individual fish, 900 of which we identified as federally managed fish species, principally rockfishes belonging to the genus *Sebastes*. In total, these fish represented 18 different fish species/species groups, 13 of which are federally managed species. The most abundant species observed was widow rockfish (*S. entomelas*), all of these fish were seen during the course of one dive in the offshore Cape Arago area. We documented overfished canary rockfish (*S. pinniger*) and yelloweye rockfish (*S. ruberrimus*) at all three inshore reefs surveyed and in the offshore Cape Arago area.



Offshore Cape Arago: a diverse seafloor including corals, sponges, and brittle stars

The nearshore and offshore reefs and banks surveyed both in state and federal waters are biologically diverse, contain sensitive structure forming invertebrates, and are clearly essential fish habitat for managed fish species. The Coquille Bank area is currently closed to bottom trawling but the other areas surveyed warrant consideration as conservation areas as part of the National Marine Fisheries Service and Pacific Fishery Management Council five-year review of groundfish essential fish habitat designations and protections. These areas should also be considered for designation and protection as Important Ecological Areas (IEAs) in any future state or federal marine spatial planning and marine protected area processes. IEAs like these are geographic areas that have distinguishing ecological characteristics such as high productivity or biological diversity, are important for maintaining habitat heterogeneity or the viability of a species, or contribute disproportionately to an ecosystem's health, including its function, structure, or resilience (Ayers et al. 2010, CEQ 2010).

Oceana scientists Ben Enticknap and Geoff Shester deploying the ROV

Offshore Coquille Bank: shrimp

INTRODUCTION

The Pacific Ocean off Oregon is part of the California Current Large Marine Ecosystem, which is known for strong seasonal upwelling with areas of high productivity, and which supports a wide variety of fish, seabirds and large marine mammals. Yet relatively little is known about the biological communities in some of the richest and most diverse habitat areas–the living seafloor. Globally, an estimated 98% of all marine species live in or on the seafloor (Thurman and Burton, 2001). Rocky reefs and living structure-forming invertebrates like corals and sponges create a foundation for marine biodiversity. These habitats are also spatially limited, sensitive, and vulnerable to degradation.

Seafloor habitats are especially vulnerable to fishing impacts, principally the impacts of bottom trawling. Bottom trawls, with weighted nets and large steel doors, are dragged along the seafloor off the U.S. West Coast to catch groundfish species and ocean shrimp. At the same time, however, they catch an abundance of other marine life as bycatch; damage communities of corals, sponges and other habitat forming invertebrates; as well as alter the physical structure of seafloor habitats (e.g. Puig et al. 2012, Hannah et al. 2009, Hixon and Tissot 2007, Auster and Langton 1999). Bottom trawling has been widely shown to reduce habitat complexity, productivity and alter ecological communities (NRC 2002).

There have been significant efforts in recent years to map and characterize seafloor habitats off the Oregon coast (Goldfinger 2010, Weeks and Merems 2004, Merems 2003), identify Important Ecological Areas (Oceana 2010), and protect marine habitats in both federal and state waters off Oregon (NMFS 2006, ODFW 2012, Shester and Warrenchuk 2007). These efforts are due to the growing understanding of the importance of seafloor habitats to biological diversity and their importance as essential fish habitat for managed fish species. In 2006 the Pacific Fishery Management Council and National Marine Fisheries Service closed select areas to bottom trawling in federal waters off Oregon and froze the bottom trawl footprint so that waters greater than 1,280 meters depth (700 fathoms) are closed to this gear (Figure 10). Various Important Ecological Areas within the footprint remain unprotected. Similarly, the State of Oregon recently completed a decade long process to build a limited network of marine reserves and protected areas, yet there is a major gap in that network for the southern Oregon coast. The Pacific Fishery Management Council is now conducting a 5-year review of its groundfish essential fish habitat (EFH) designation and conservation measures.

Here we describe and characterize the seafloor habitats and associated biological communities at six areas off the southern Oregon Coast. One offshore area, Coquille Bank, is within a designated EFH conservation area that is closed to bottom trawling and all others are outside of any marine protected areas. We collected 13.5 hours of high definition video during 17 dives with a Remotely Operated Vehicle (ROV). The analysis of that video and the findings presented here are useful for managers and policymakers to identify important, sensitive and unique habitats and protect them through spatial management measures.

Inshore Cape Arago: Juvenile yelloweye rockfish, boulder and sponge

Inshore Cape Arago: gorgonian coral

This expedition was part of a larger effort by Oceana to identify, map and characterize Important Ecological Areas (IEAs) in the California Current Large Marine Ecosystem. Other regions we surveyed to date include Monterey Bay, California (Shester et al. 2012) and the San Juan Islands in Puget Sound, Washington. IEAs are geographically delineated areas which by themselves or in a network have distinguishing ecological characteristics, are important for maintaining habitat heterogeneity or the viability of a species, or contribute disproportionately to an ecosystem's health, including its productivity, biodiversity, function, structure, or resilience. Examples of IEAs include migration routes, subsistence areas, sensitive seafloor habitats, breeding and spawning areas, foraging areas, and areas of high primary productivity. The goal of the IEA approach is to preserve the health, productivity, biodiversity and resilience of marine ecosystems while providing for ecologically sustainable fisheries and other economic endeavors, traditional subsistence uses, and viable marine-dependent communities (Ayers et al. 2010).

STUDY GOAL AND OBJECTIVES

The overall goal of this study is to identify and document Important Ecological Areas off the southern Oregon coast to help inform the long-term conservation and management of marine habitats and biodiversity in this region of the Northeast Pacific. The objectives of this research are to:

1. **survey and characterize the distribution and relative abundance of coral and sponge communities at sites where occurrences have not been documented,**
2. **quantify associations of federally managed groundfish species with physical and biological habitat features,**
3. **characterize habitats in areas open and closed to bottom trawling, and**
4. **add additional observations of corals and sponges to the National Oceanic Atmospheric Administration (NOAA) database on the occurrence of these biogenic habitat features.**

Offshore Cape Arago: Canary rockfish

Offshore Cape Arago: branching sponge with shrimp

METHODS

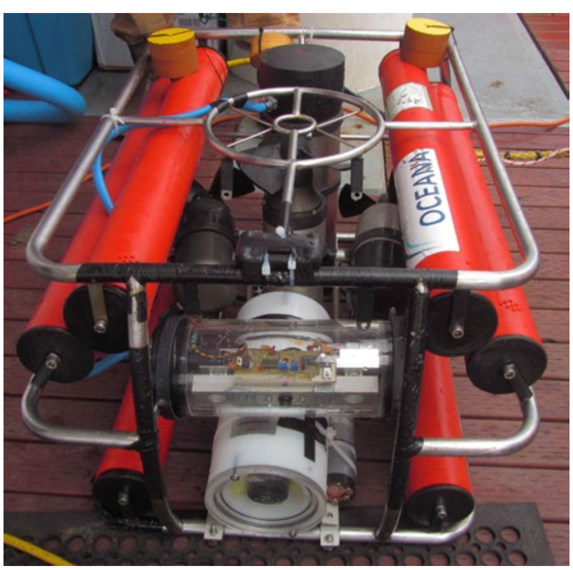
ROV Survey

Aboard the R/V Miss Linda, we conducted 17 ROV dives off the coast of southern Oregon at depths ranging from 28 to 228 meters. We targeted areas at different depth ranges and distances from shore suspected to have hard substrate based on Geographic Information System (GIS) analyses using surficial geologic habitat data (OSU 2008), preliminary habitat classification maps generated with multibeam/ backscatter surveys (now finalized, see OSU ATSML 2011) or locations identified by NOAA trawl surveys as too complex for research trawls (Zimmerman 2003).
The 17 dives were completed within six geographic areas:

1. Inshore Cape Arago (the Cape Arago-Seven Devils Reef) (dives 1, 13, and 14);
2. Offshore Cape Arago (dives 2, 3, 8, 15, 16, and 17);
3. Inshore Coquille Reef (dive 5);
4. Offshore Coquille Reef (dives 6 and 7);
5. Orford Reef (dive 4); and
6. Coquille Bank (aka Bandon High Spot) (dives 9, 10, 11, and 12).

For the purpose of this study, the areas were delineated based on commonly known geographic features (e.g. Orford Reef, Coquille Bank, Cape Arago-Seven Devils) and the inshore/ offshore areas were delineated by the three nautical mile Oregon Territorial Sea boundary.

We collected 13.5 hours of high definition video of the seafloor using a Mariscope FO-II ROV equipped with 2 cameras, 4 lights, and a single sizing laser set at 15 cm from the center of the video screen. One camera was connected by an optical umbilical cable to the surface, feeding the ROV operator and scientists aboard the research vessel real time data used for navigating the ROV. The second camera, a high definition camera mounted under the ROV, recorded the seafloor in 1080p high definition at 30 frames per second. This camera was mounted facing forward inside a waterproof housing oriented horizontally with the plane of the bottom of the ROV. We alternated between using a Cannon VIXIA HF21 and a Panasonic HDC-HS700 that were exchanged periodically between dives so that the video files could be downloaded and secured without delaying any ROV dives, and to minimize the risk of losing data in the event of a technical malfunction. The high definition video was used for all video analysis.



The team's Mariscope-FOII ROV was deployed to capture high-definition underwater footage

TABLE 1. Coordinates at the start of each dive and depth range (meters).

Dive	Latitude	Longitude	Depth Range (meters)
1	43.24045	-124.43915	40
2	43.24822	-124.50383	72
3	43.22597	-124.49865	55
4	42.75603	-124.61458	63-69
5	43.14405	-124.47712	39
6	43.14583	-124.56882	96-98
7	43.13808	-124.60670	118
8	43.22133	-124.56517	80-82
9	43.02567	-124.80933	126-128
10	43.01682	-124.85030	205-210
11	43.98783	-124.81342	127-129
12	43.07847	-124.85647	226-228
13	43.23267	-124.43650	28-34
14	43.24802	-124.44815	38-41
15	43.24930	-124.48390	60
16	43.25367	-124.52750	10-81
17	43.29483	-124.52400	99-100

FIGURE 1. **Dive locations depicted by red points, dive number, and corresponding study area groupings.**

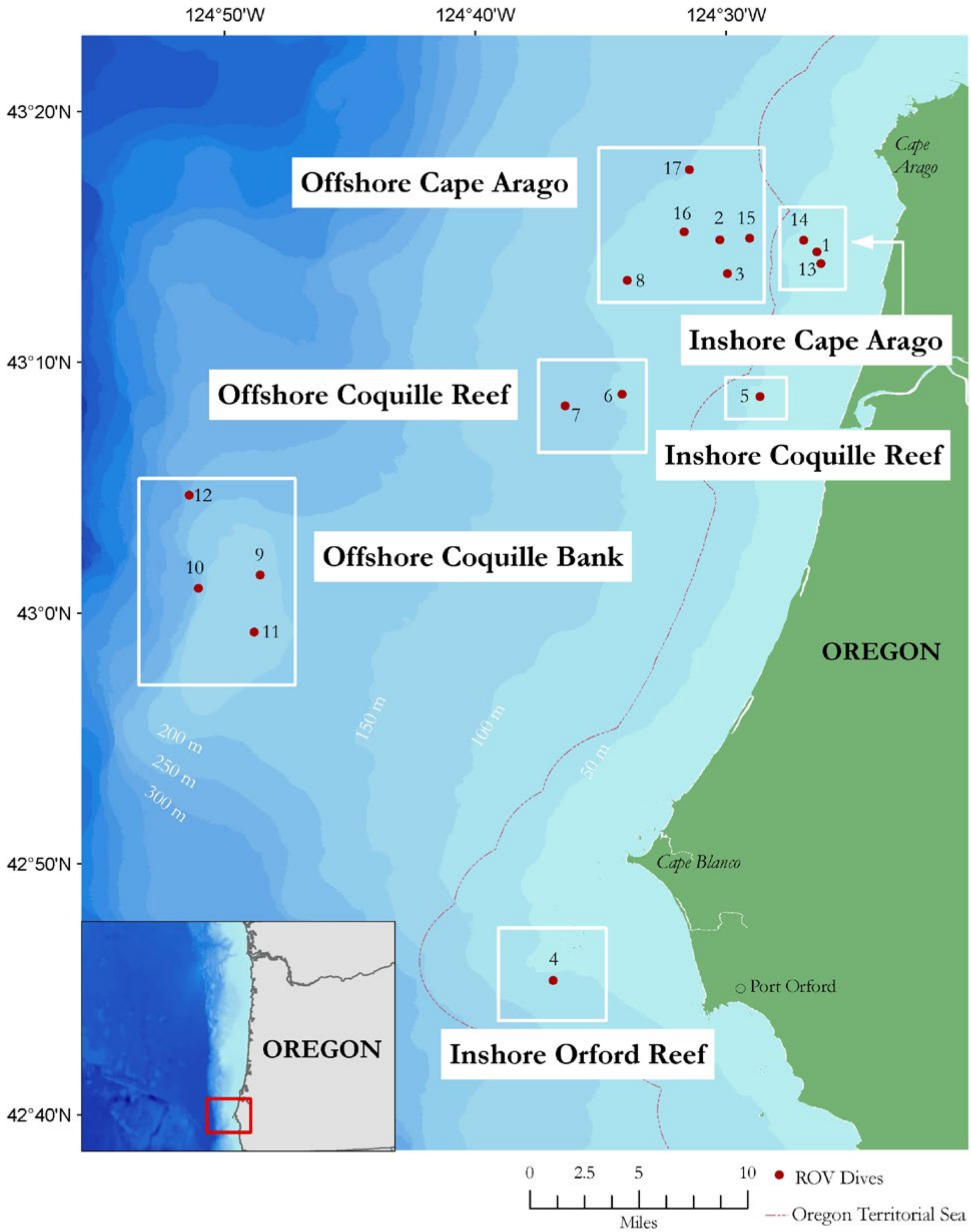
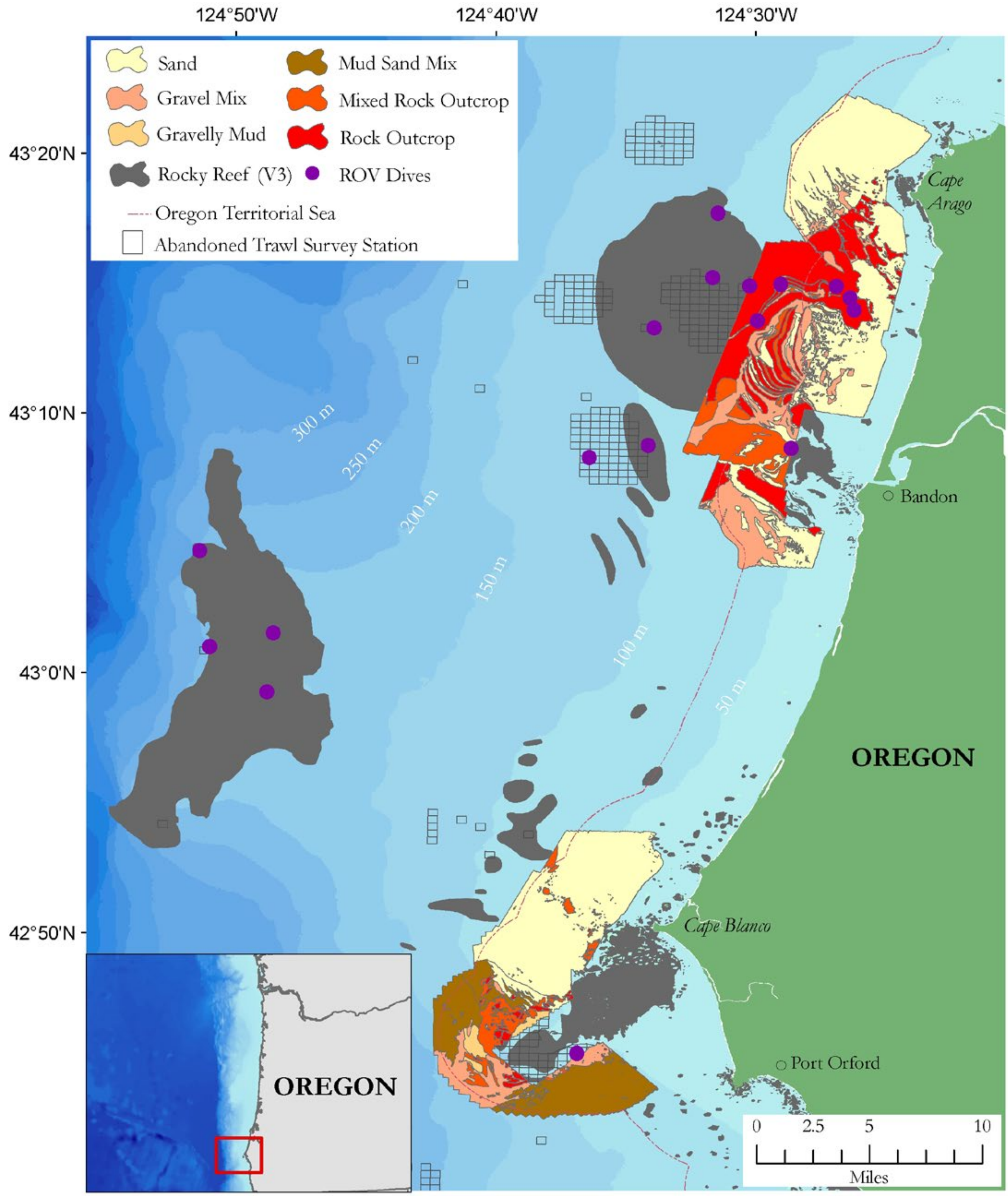


FIGURE 2. **Dive sites overlaid with criteria used to select those sites, including: habitat classification maps (showing final data from OSU ATSML 2011), surficial geologic habitat data version 3 (OSU 2008) and abandoned trawl survey stations (Zimmerman 2003).**



The research vessel's GPS was used to track where the ROV started each dive. After deploying the ROV off the stern ramp of the vessel, we would quickly dive it to the seafloor. Once at the seafloor, we utilized a roving diver technique which involves freely surveying the study area and recording all observations on high definition video for subsequent video analysis. We normally operated the ROV at a speed of roughly 0.2 knots (~0.36 km/hour) and occasionally we would land the ROV on the seafloor to stop and closely inspect features of particular interest. This roving diver technique allows for close examination of fish and invertebrate species and physical habitat features. While the ROV provides real time depth, compass bearing, and heading information for navigation, we did not have an underwater position system necessary for tracking the exact location of the ROV relative to the position of the boat. Using the compass heading of the ROV, we were able to navigate without covering the same ground twice.

While the survey was underway, the captain monitored the position of the vessel throughout the dive and made every effort to hold position. Each dive lasted between 30 minutes and 1.5 hours each. The only dive where the vessel drifted substantially was dive #4 at Orford Reef when we were operating in a 12 foot swell and 20 to 25 knot winds. There the vessel drifted approximately 0.25 km between deploying the ROV and retrieving it at the end of the dive.

VIDEO ANALYSIS

The roving diver method we used is complementary to visual transect surveys (Schmitt et al. 2002) and consistent with our study objectives. We analyzed the video to identify and describe the physical and biological habitats present as well as the fish species utilizing these areas. Fish identification and quantification with this technique gives an indication of rare versus common species within survey areas but not quantitative abundance or biomass. Since our interest was in surveying areas likely to contain rocky habitat, the habitat classification analyses are likely biased towards rocky habitats and the biogenic features present, rather than a random sampling of representative habitat types in the region. Our survey methods and video analysis methods were designed so that no areas within a dive were surveyed twice or double counted.

A. Continuous Analysis:

Fish Identification and Quantification
We analyzed video continuously from start to end point of each dive and all fish species were counted and identified to the lowest possible taxonomic level. Species listed in the Federal Groundfish Fishery Management Plan (FMP) were noted. Some species were difficult to distinguish on video and were assigned to broader species groupings such as Olive and Yellowtail Rockfish. Fishes that were unidentifiable, due to a lack of identifying characteristics or poor video quality, were labeled into the categories of unidentified rockfish, unidentified flatfish, young of the year (YOY) rockfish, and unidentified fish, and included in the non-FMP category. For every fish observed, the corresponding time, and the number of individuals of each species were recorded. Representative still images and video clips were extracted for each species, as well as for all individuals for which there was uncertainty about identification. All fish not clearly identifiable were subsequently reviewed by outside experts affiliated with the Institute for Applied Marine Ecology at California State University, Monterey Bay for positive identification.

B. Interval Analysis:

Information on the primary and secondary substrate types, relief and structure forming invertebrates was recorded for a single frame at intervals of 30 seconds for the entirety of each dive. In areas where data could not be extracted, video was played until data could be collected and the 30 second intervals resumed from that point forward. Further, data was only collected from a frame if there was no overlap with the previous frame to ensure habitat features were not double counted.

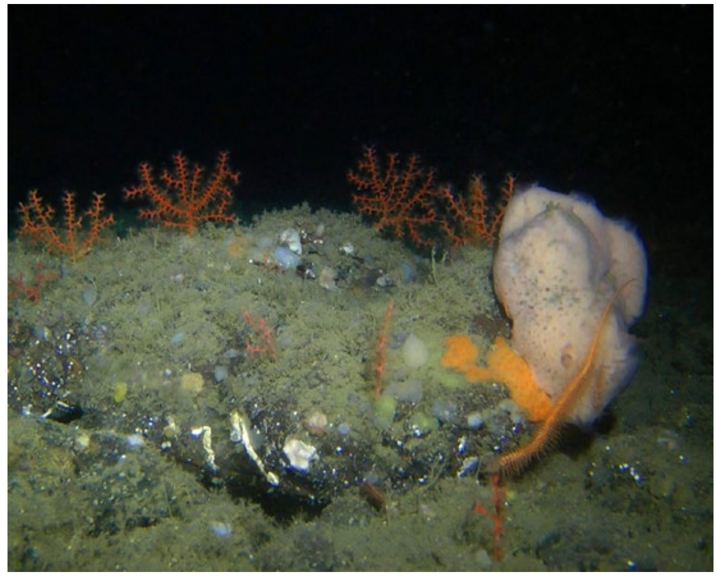
Habitat Classification: Physical Substrate and Relief
Dives 1-5 did not have a sizing laser therefore, substrate was classified into three broad categories: hard, mixed, and soft. The rest of the dives, 6-17, had a sizing laser affixed to the ROV 15 cm from the center of the screen. Substrate was classified at a finer scale for these dives and included five categories following the classifications of Greene et al. (1999) (Table 2). Substrate classifications were separated into primary (>50% of the frame) and secondary (at least 20% of the remaining frame), resulting in two substrate classifications for each 30 second sampling interval (Tissot et al. 2008). To compare substrate composition across different dives, all substrate was compared using the broader-scale classifications. Physical relief was classified as low (<1m), moderate (1m - 2m), and high (>2m) (Tissot et al. 2006).

Offshore Cape Arago: a canary rockfish hides alongside a sea anemone

TABLE 2. Description of substrate types based on availability of a sizing laser. With the sizing laser we were able to make fine-scale substrate classifications, which fall within the broader substrate categories of hard and soft.

WITHOUT SIZING LASER		WITH SIZING LASER	
SUBSTRATE CLASSIFICATION	DESCRIPTION	SUBSTRATE CLASSIFICATION	DESCRIPTION
Hard	Rock, including all grain sizes, from bedrock to cobble	Bedrock	Continuous flat rock
		Boulder	Individual rocks greater than 20 cm
		Cobble	Individual rocks smaller than 20 cm
Mixed	A combination of hard and soft substrates within one frame		
Soft	Soft sediment, including sand and mud	Sand	Grains visible, generally lighter color
		Mud	Grains not visible, generally darker color and in deeper water

Orford Reef: a basket star



Coquille Bank: gorgonian coral and sponge

Habitat Classification: Structure-forming Macro-invertebrates

We included structure-forming macro-invertebrates into the habitat classification due to their addition to habitat complexity (Auster et al. 2003; Tissot et al. 2006; Tissot et al. 2007). We seperated them into two broad categories: high (breaks the plain of the seafloor and extends into the water column, such as *Metridium sp*., crinoids, etc.) and low (small, or encrusting organisms that do not substantially break the plane of the seafloor, such as cup corals, encrusting sponges, burrowing brittle stars, etc.). Highly mobile invertebrates such as arthropods were not included, while primarily sessile invertebrates such as anemones and crinoids (feather stars) were included. The two categories of structure forming macro-invertebrates were recorded as being either present or absent for every 30 second sampling interval.

Sponge and Coral Identification

We recorded sponges and corals along with the habitat characteristics at 30 second intervals. Sponges were identified using broad morphology categories including: barrel, foliose, mound, branching, shelf, vase, and other (NOAA 2011). These broad categories were used to be consistent with those defined by NOAA and because no physical samples were collected for sponges; therefore, identification to species was not possible. Corals were identified to order including: *Alcyonacea* (soft corals), *Antipatharia* (black corals), *Gorgonacea* (sea whips, sea fans), *Pennatulacea* (sea pens), *Scleractinia* (cup corals), *Stylasterina* (branching hydrocorals), and Unidentified Corals (anything that does not fit into the other groupings) (PaCOOS [date unknown]). These categories were used to be consistent with NOAA's West Coast coral and sponge database where coral and sponge records have been collected during slope and shelf trawl surveys since 1977.

We recorded the presence of each category of coral and sponge at each 30 second interval of video. Sponge and coral presence was converted to an overall percentage of observations to compare relative occurrence among different dives. Since sponges and corals were observed at intervals, rather than continuously, it is likely that the presence of some categories were missed on each dive. To identify the co-occurrence of groundfish species with each category of corals and sponges, we noted the presence/absence of managed groundfish species on dives where we documented coral and sponge. This is considered "level 1" distribution data under NOAA essential fish habitat regulatory guidelines (50 CFR 600.815).

RESULTS

Overall, we observed 2,299 individual fish, 900 of which are federal Groundfish FMP species (Table 3). A total of 1,399 non-FMP and unidentified fish species were also recorded over all dives (Table 4). At least thirty-one percent of the unidentified rockfish were likely blue or black rockfish (*S. melanops*), which closely resemble each other, but we were unable to make a clear identification between the two due to poor video quality. These rockfish were often indistinguishable because they were just out of range of the ROV lights or out of range of the camera focus. Three orders of corals and six types of sponge morphologies were observed (Table 5).

TABLE 3. List of all FMP species observed for each study area.

FISH	SCIENTIFIC NAME	INSHORE CAPE ARAGO	OFFSHORE CAPE ARAGO	INSHORE COQUILLE REEF
Blue Rockfish	*Sebastes mystinus*	X	X	
Canary Rockfish	*Sebastes pinniger*	X	X	X
China Rockfish	*Sebastes nebulosus*	X		
Greenstriped Rockfish	*Sebastes elongatus*		X	
Olive/Yellowtail Rockfish	*Sebastes serranoides/flavidus*	X	X	X
Quillback Rockfish	*Sebastes maliger*	X	X	X
Rosy Rockfish	*Sebastes rosaceus*		X	X
Tiger Rockfish	*Sebastes nigrocinctus*		X	
Widow Rockfish	*Sebastes entomelas*		X	
Yelloweye Rockfish	*Sebastes ruberrimus*	X	X	X
Rex Sole	*Glyptocephalus zachirus*		X	
Kelp Greenling	*Hexagrammos decagrammus*	X	X	X
Lingcod	*Ophiodon elongatus*	X	X	X

TABLE 4. Non-FMP fishes observed for each study area.

FISH	SCIENTIFIC NAME	INSHORE CAPE ARAGO	OFFSHORE CAPE ARAGO	INSHORE COQUILLE REEF
Blackeye Goby	*Rhinogobiops nicholsii*		X	
Eelpout	*Zoarcidae*			
Hagfish	*Eptatretus stoutii*			
Poacher	*Agonidae*			
Ronquil	*Bathymasteridae*		X	
Unidentified Fish		X	X	X
Unidentified Flatfish			X	
Unidentified Rockfish*	*Sebastes sp.*	X	X	X
Y.O.Y. Rockfish	*Sebastes sp.*			

* 31 percent of unidentified rockfish were likely either blue or black rockfish but were not distinguishable due to poor video quality of the fish being too far in the distance to discern to make a positive species ID.

Inshore Cape Arago: sea anemones

OFFSHORE COQUILLE REEF	INSHORE ORFORD REEF	OFFSHORE COQUILLE BANK	TOTAL NUMBER OF OBSERVATIONS	NUMBER OF DIVES WITH OBSERVATIONS
			16	4
	X		119	8
			2	1
		X	5	3
	X		45	6
	X		20	8
		X	17	4
			4	1
			571	1
	X		20	5
			1	1
X	X		38	9
X	X		42	9

OFFSHORE COQUILLE REEF	INSHORE ORFORD REEF	OFFSHORE COQUILLE BANK	TOTAL NUMBER OF OBSERVATIONS	NUMBER OF DIVES WITH OBSERVATIONS
			1	1
		X	13	1
		X	1	1
		X	4	1
X	X	X	44	8
X	X	X	118	17
X	X	X	49	7
X	X	X	1144	12
	X		25	1

TABLE 5. List of corals and sponges observed for each study area.

CORALS	INSHORE CAPE ARAGO	OFFSHORE CAPE ARAGO	INSHORE COQUILLE REEF	OFFSHORE COQUILLE REEF	INSHORE ORFORD REEF	OFFSHORE COQUILLE BANK	TOTAL % OF FRAMES WITH OBSERVATIONS	NUMBER OF DIVES WITH OBSERVATIONS
Gorgonacea	X	X	X	X	X	X	20	14
Scleractinia	X	X	X		X		8	8
Stylasterina	X	X	X		X		2	5
SPONGES								
Barrel						X	1	3
Foliose	X	X	X	X		X	13	13
Mound	X	X	X	X	X	X	12	14
Branching	X	X	X	X	X	X	30	13
Shelf		X					0	1
Vase						X	0	1
Unidentified	X	X	X		X		2	8

TABLE 6. Co-occurrence of managed groundfish species with each category of corals and sponges on the same dive, indicating where groundfish were observed in habitats containing respective corals and sponges.

		Greenstriped Rockfish	Widow Rockfish	Quillback Rockfish	Blue Rockfish	China Rockfish	Tiger Rockfish	Canary Rockfish	Rosy Rockfish	Olive/ Yellowtail Rockfish	Yelloweye Rockfish	Rex Sole	Kelp Greenling	Lingcod	# Groundfish Species
CORAL (Order)	Gorgonacea	X	X	X	X	X	X	X	X	X	X		X	X	12
	Scleractinia		X	X	X	X	X	X	X	X	X		X	X	11
	Stylasterina		X	X	X	X	X	X	X	X	X		X	X	11
SPONGE (Morphology)	Barrel	X							X						2
	Foliose	X	X	X	X	X	X	X	X	X	X		X	X	12
	Mound	X	X	X	X	X	X	X	X	X	X		X	X	12
	Branching	X	X	X	X	X	X	X	X	X	X		X	X	12
	Shelf		X	X	X		X	X	X	X	X		X	X	10
	Vase														0
	Unidentified Sponge		X	X	X	X	X	X	X	X	X	X	X	X	12

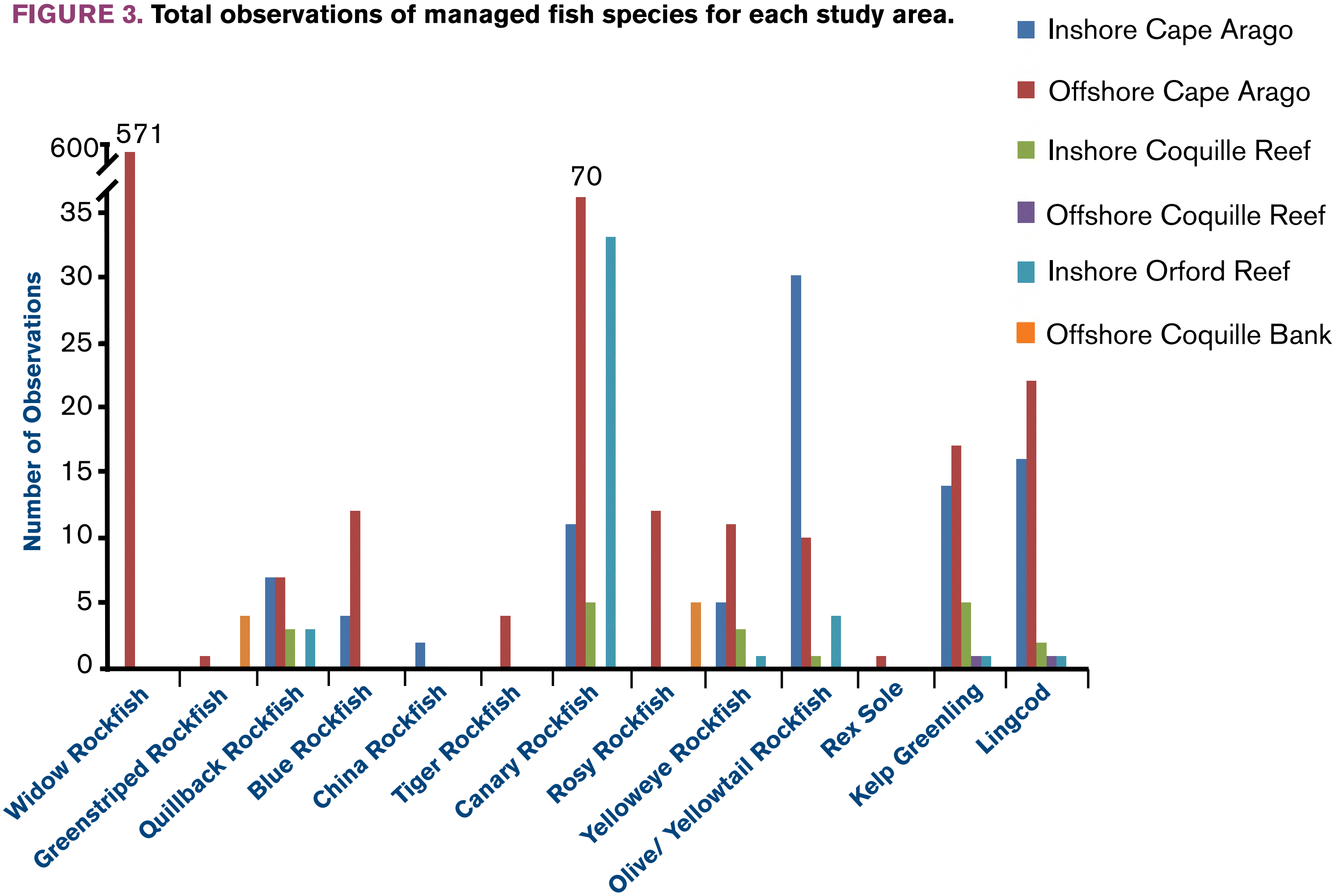
A. Continuous Analysis:

Fish Identification and Quantification

We identified a total of 13 FMP species at the different study sites (Figure 3). We observed twelve managed fish species at the offshore Cape Arago area, the highest number of species of all study sites. Here we also had the most fish observations of all study sites, with a total of 738 observations of managed fish species. At inshore Cape Arago we had the second highest number of fish observations at 89, followed by inshore Orford Reef with 43 observations, inshore Coquille Reef with 19 observations, offshore Coquille Bank with nine observations, and offshore Coquille Reef with two observations. When we normalize the number of managed fish observations by dive time we found the offshore Cape Arago area had the highest rate of managed fish observations at 2.76 fish observations/ minute of bottom time, followed by the inshore Cape Arago site at 0.88/minute, the inshore Orford Reef site at 0.54/minute, the inshore Coquille Reef site at 0.39/minute, the offshore Coquille Bank site at 0.05/minute, and finally the offshore Coquille Reef site at 0.02/minute.

At both offshore Coquille Reef and offshore Coquille Bank, we observed only two managed fish species, while at inshore Coquille Reef and inshore Orford Reef we observed six managed fish species. At inshore Cape Arago we observed eight managed fish species. Widow rockfish (*Sebastes entomelas*) and tiger rockfish (*S. nigorinctus*) were observed only at the offshore Cape Arago site. The species compositions of the inshore Coquille Reef and inshore Orford Reef sites were the same, but the number of observations differed, especially for canary rockfish (*S. pinniger*), which were observed at greater numbers at the inshore Orford Reef site.

FIGURE 3. Total observations of managed fish species for each study area.



B. Interval Analysis

Habitat Classification: Physical Substrate and Relief We grouped all substrates for reporting as hard, mixed or soft. Soft substrate was the most prevalent substrate type observed overall (Figure 4). The offshore Cape Arago, inshore Cape Arago, offshore Coquille Reef, and offshore Coquille Bank study sites are predominately composed of soft substrate, while the inshore Cape Arago site is dominated by hard substrate. The inshore Orford Reef study site has an even distribution of all substrate types.

Offshore Cape Arago: basket star and gorgonian coral

The substrate compositions are slightly different for the identified secondary substrate (Figure 5). The offshore Cape Arago, inshore Cape Arago, offshore Coquille Reef, and offshore Coquille Bank study sites are still dominated by soft sediment, but offshore Coquille Reef and offshore Coquille Bank have a larger amount of hard substrate. The results of the secondary substrate analysis show the inshore Cape Arago study site to be dominated by hard substrate. The inshore Orford Reef study site has all three substrate types based on the secondary substrate analysis, but we observed slightly more hard substrate than soft or mixed.

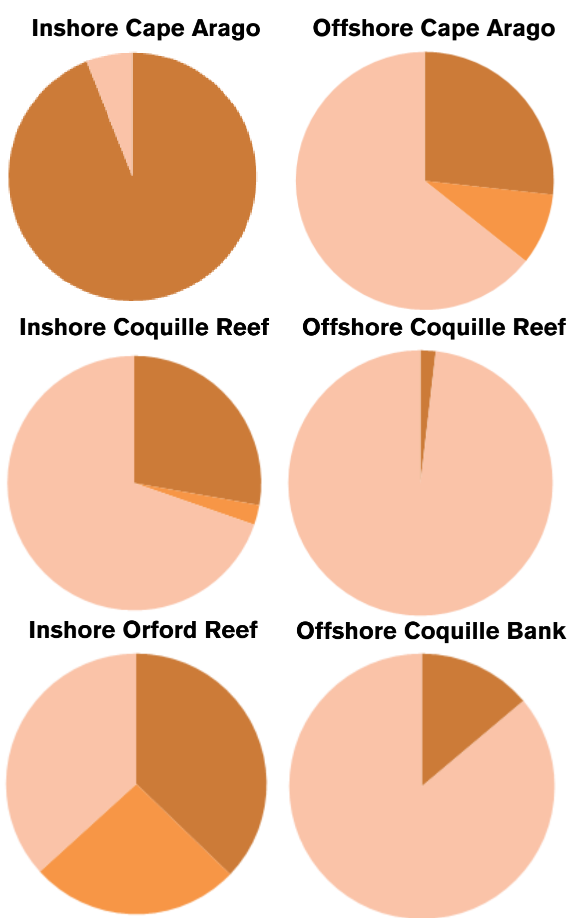
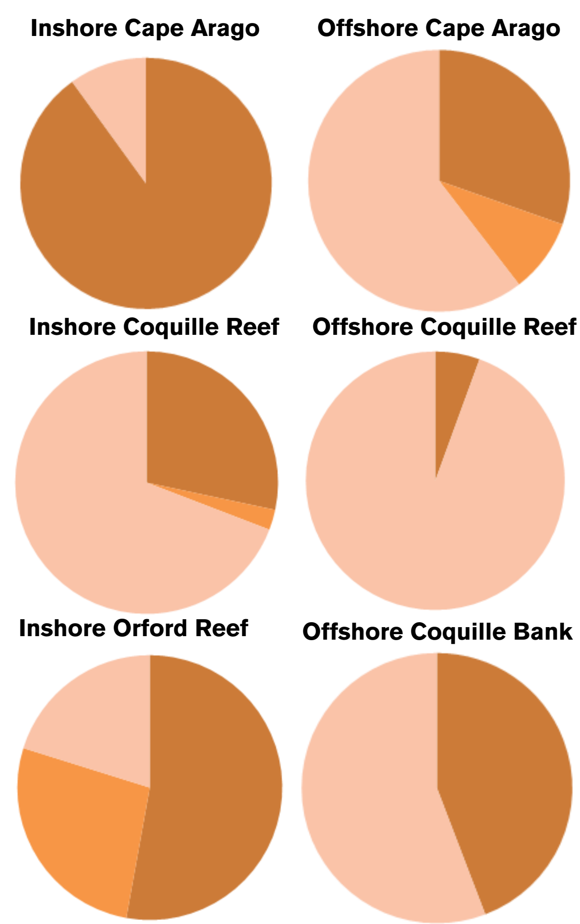


FIGURE 4. (left) Comparison of primary substrate (> 50% of the frame) among the six study areas.

Hard
Medium
Soft

FIGURE 5. (right) Comparison of secondary substrate (at least 20% of the remaining frame) among the six study areas.



All study sites are dominated by low relief habitat (Figure 6). The inshore Cape Arago and offshore Cape Arago study sites are the only sites where we documented high relief; however it was a very small percentage of the overall composition. Moderate relief made up approximately 25% of the inshore Cape Arago, offshore Cape Arago, inshore Coquille Reef, and inshore Orford Reef study sites.

Habitat Classification: Structure-forming Macro-invertebrates

We observed biogenic structure at all study sites. Low biogenic structure (less than 10 cm tall) was observed most frequently for all study sites except for offshore Coquille Reef, where bare substrate comprised approximately 40% of all observations (Figure 7). High biogenic structure was most abundant at the inshore Orford Reef study site, comprising approximately 40% of all observations.

Sponge and Coral Observations

We observed three coral orders in this study; Gorgonacea, Scleractinia, and Stylasterina (Figure 8). Alcyonacea, Antipatharia, and Pennatulacea were not observed at any of the study sites. We observed corals at all study areas and at 15 of 17 dives. We observed all three coral orders at the inshore Cape Arago, offshore Cape Arago, inshore Coquille Reef, and inshore Orford Reef study sites. At the offshore Coquille Reef and offshore Coquille Bank study sites only *Gorgonacea* corals were observed. Of all the study sites combined, the observed coral composition did not exceed approximately 30% of all observations (30% of all frames analyzed). For the offshore Cape Arago site, however, 36% of the frames we analyzed had coral.

We observed all sponge morphologies in this study (Figure 9). Sponges were also observed at all study areas and at 16 of 17 dives. Overall we observed more sponges than corals. Branching sponge was the most commonly observed morphology, followed by foliose and mound. Over 50% of the frames we analyzed for the offshore Cape Arago site had branching sponges. Barrel, shelf, and vase sponges were the least observed morphologies. At the offshore Cape Arago study site we had the highest number of sponge observations, followed by inshore Coquille Reef and inshore Cape Arago.

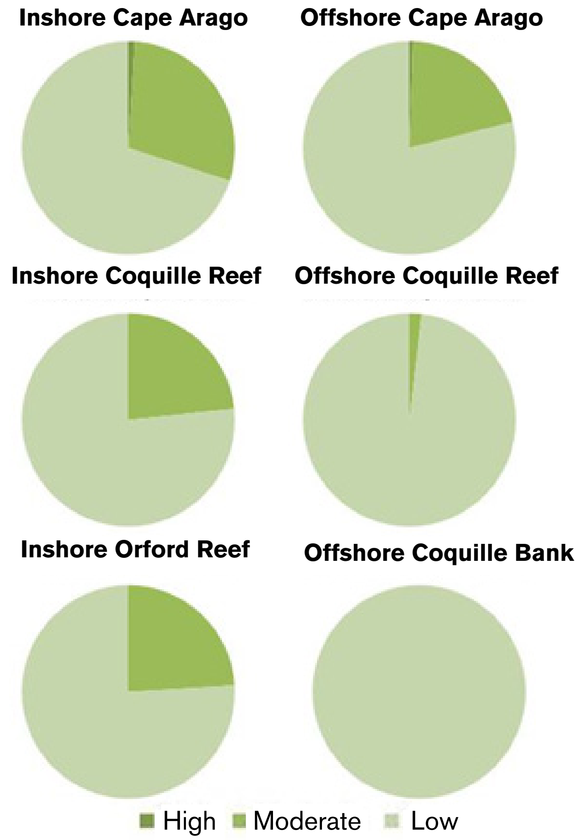


FIGURE 6. Comparison of relief among the six study areas.

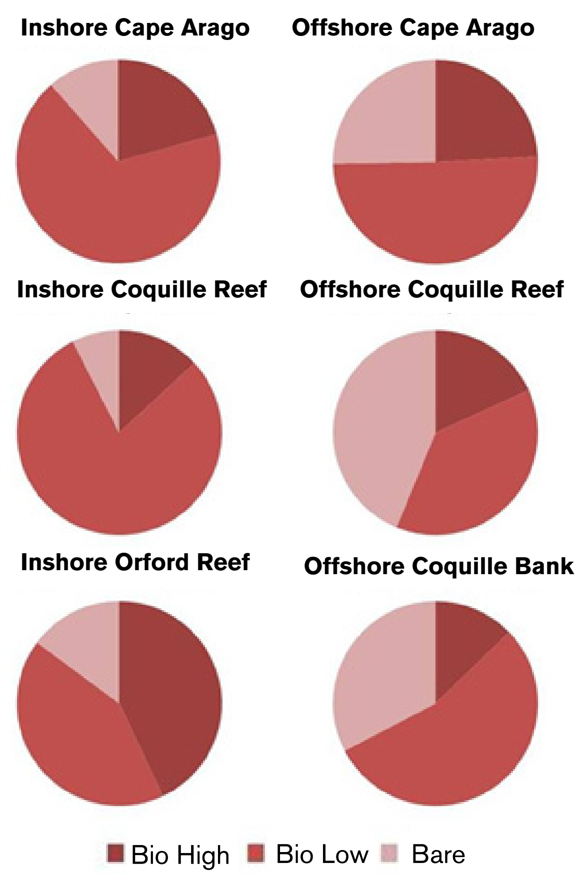


FIGURE 7. Comparison of structure forming macro invertebrates observed for each study area (Bio High = high biological structure, Bio Low = low biological structure).

FIGURE 8. Proportion of 30-second interval video frames with each coral type present. (%) indicates percentage of 30-second interval frames with one or more coral types within each study area: inshore Cape Arago (ICA), offshore Cape Arago (OCA), inshore Coquille Reef (ICR), offshore Coquille Reef (OCR), inshore Orford Reef (IOR) and offshore Coquille Bank (OCB).

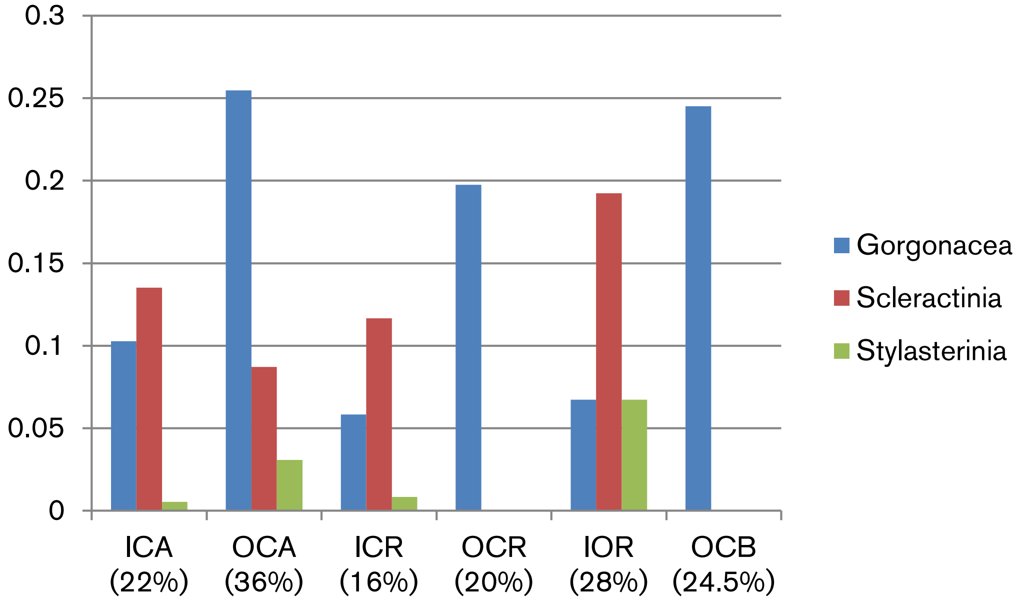
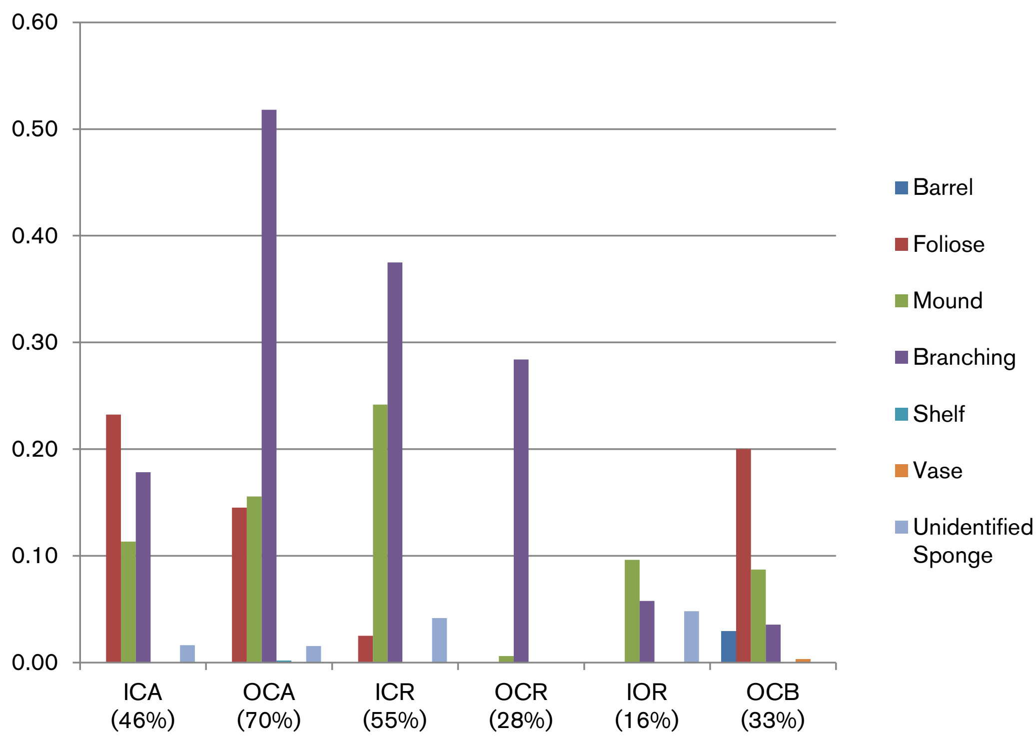
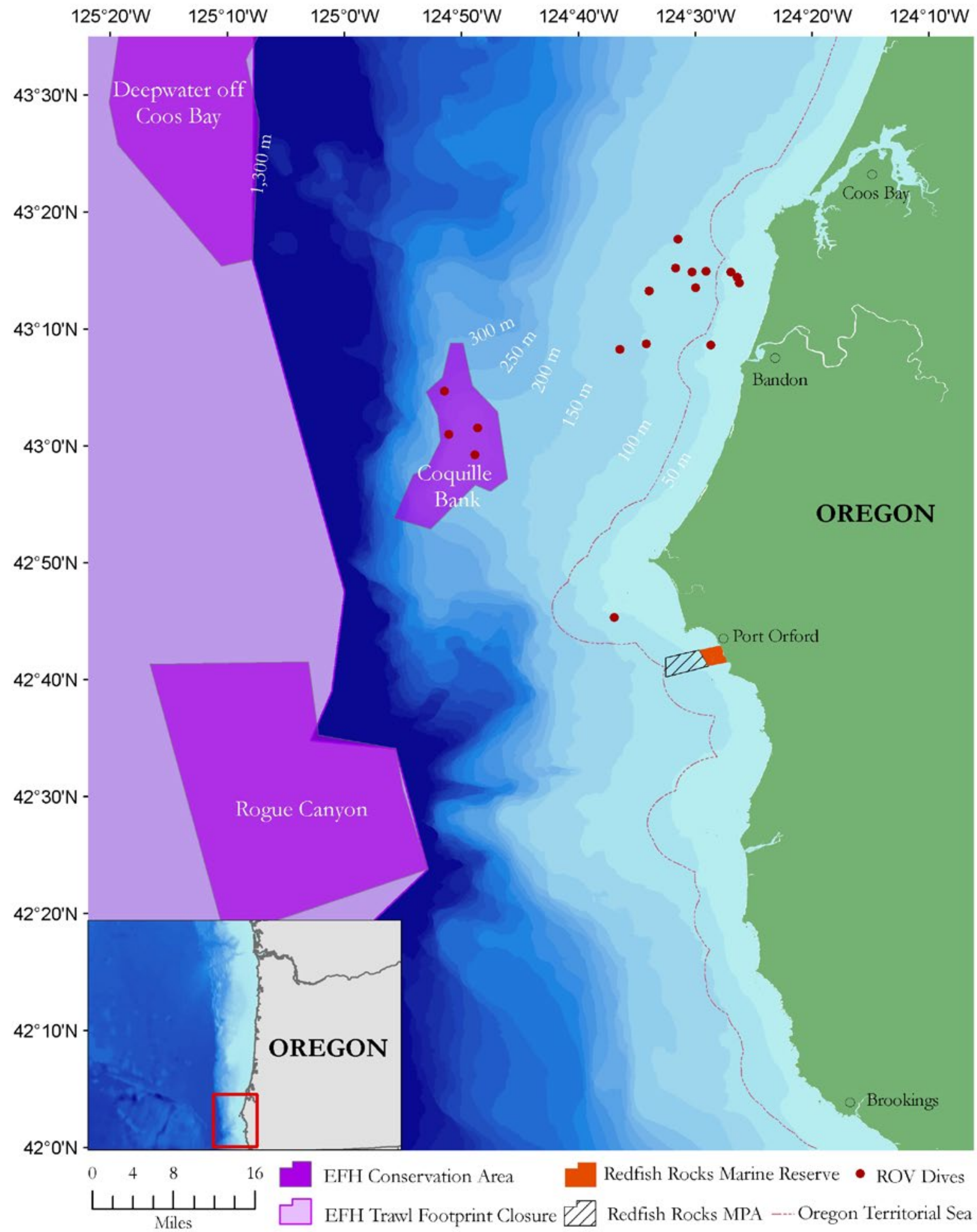


FIGURE 9. Proportion of 30-second interval video frames with each sponge morphology present. (%) indicates percentage of 30-second interval frames with one or more sponge types within each study area.



While this analysis did not examine fish behavior relative to various habitat components, we assessed whether each groundfish species occurred on the same dive as each coral and sponge category (Table 6). This provides "Level 1" presence/ absence information as described in the NOAA EFH regulatory guidance (50 CFR 600.815). We identified a total of 12 groundfish species present in habitats containing corals and sponges. Only rex sole was observed in a habitat area that did not contain coral.

FIGURE 10. ROV dives and state and federal marine protected areas off southern Oregon. EFH areas are closed to bottom trawling. The state Redfish Rocks area includes a no-take marine reserve and an MPA where fishing only for salmon and crab is allowed.



DISCUSSION

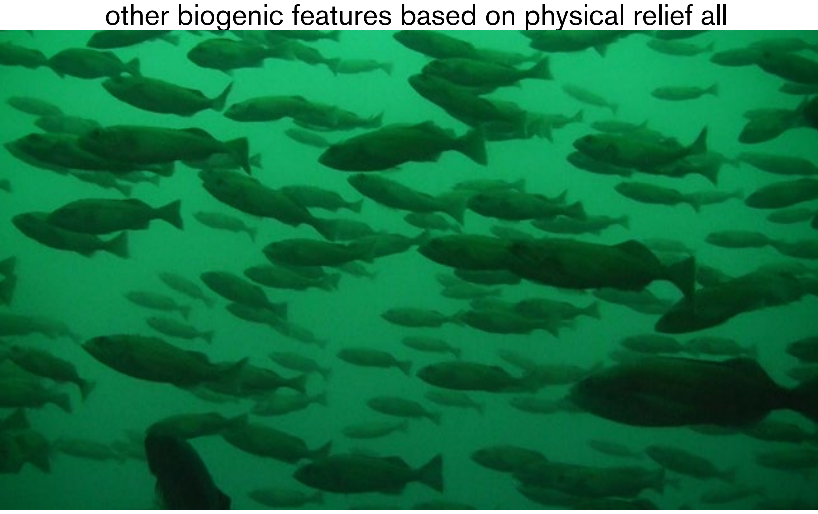
In this analysis we documented a diverse underwater ecosystem in the Pacific Ocean waters off Southern Oregon. With the ROV we surveyed and recorded a variety of physical and biogenic habitats and many different fish species across a wide range of depths. We also documented depleted fish species and sensitive habitat features that are vulnerable to impacts.

This analysis distills hours of video into site specific data designed to help improve understanding of the associations of managed fish species, physical and biological habitats, and coral and sponge distribution, across a range of different substrate types, depths and relief. The continuous analysis methodology used to analyze the ROV video allowed for detailed documentation of fish species in the areas surveyed and the interval analysis allowed for site characterization of the physical and biological seafloor habitats. Combining these methods provides a robust way to characterize the physical and biological habitat associations of fish species. This information increases our understanding of the biological communities in areas recently mapped with high resolution multibeam sonar and in areas for which there are little or no habitat data available.

The ROV allowed us to make *in situ* observations of complex habitats without disturbing the sites with extractive survey techniques such as trawls or dredges. Meanwhile without physical samples, identification of invertebrate species to the species level is not feasible, particularly the sponges. Grouping corals to taxonomic order, identifying sponges based on morphology, and other biogenic features based on physical relief all allow for a characterization of these sites indicative of habitat type, structural complexity and sensitivity consistent with analyses conducted by NOAA (NOAA 2011, Shester et al. 2012).

Of our data collected, the offshore Cape Arago area had the highest fish diversity and the highest percentage of coral and sponge observations of all areas observed. Our observations also suggest this area is primarily low physical relief. Thus, this diverse and relatively biologically rich habitat is likely susceptible to impacts from commercial bottom trawl gear. Our results suggest that closing this area to bottom trawling is warranted given the presence of sensitive habitat features and managed fish species.

Our data show the inshore reefs at Cape Arago, Coquille, and Orford all have similar compositions of corals and sponges. The inshore Cape Arago area had substantially more hard rock substrate in the areas we surveyed compared to the Coquille and Orford sites that have hard, soft and mixed substrates. We observed canary and yelloweye rockfish at all three inshore sites, as well as the offshore Cape Arago site, suggesting these areas with complex physical and biological features are important habitats for these overfished rockfish species. This finding largely confirms existing knowledge about the distribution of canary and yelloweye rockfish in the Oregon nearshore ecosystem except that essential fish habitat suitability maps did not previously identify the inshore Cape Arago site as habitat suitable for these overfished species (PFMC 2005).



Offshore Cape Arago: widow rockfish

Offshore Cape Arago: a red sea cucumber

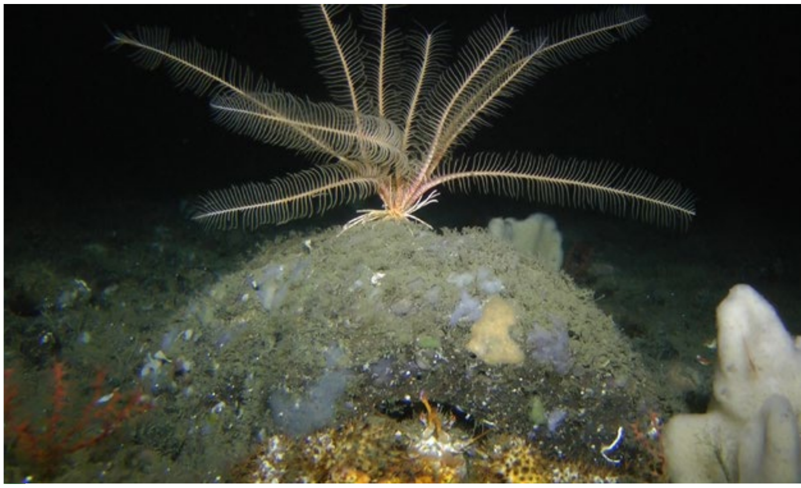
The offshore Coquille Reef study area, characterized by low physical relief and soft sediments had the fewest observations of macroinvertebrate structure and managed fish species. There was a noticeable contrast in this area between the two dive sites, where at dive number six we documented gorgonian corals, branching sponges and other high relief macroinvertebrates, and at dive number seven we documented far fewer biological features and no observed managed fish species. The only indication we had of high relief at dive number seven prior to deploying the ROV was the Zimmerman (2003) data suggesting a trawl hang in the area. The Zimmerman (2003) data may coarsely indicate areas of physical relief and structure, yet the OSU seafloor habitat data (OSU 2008) appears to be a more precise indication of seafloor habitat types in areas where those data are available. This could be further clarified with additional analysis of the data we collected, additional research dives, and multibeam seafloor habitat surveys.

The offshore Coquille Bank area is the only area studied that is currently protected from bottom trawling as part of the groundfish essential fish habitat conservation areas. We documented gorgonian corals, various sponge types, and managed fish species there and this area should remain protected. The other areas surveyed in state and in federal waters are not in any protected area status and these areas also have gorgonian corals, sponges and managed fish species. Closing these areas to bottom trawling would help ensure lasting protection for the habitats there.

There are important caveats to consider in interpreting quantitative data collected with the roving diver technique used in this study. Given the methodology used we cannot quantify the exact area surveyed and species counts cannot be extrapolated into quantitative estimates of abundance. This makes it difficult to draw comparisons of relative abundance or density of organisms across dive sites. The comparisons of relative abundance between survey areas should be viewed as initial estimates. Further, the 17 dives and 13.5 hours of video are a relatively small sample size compared to the large areas of reef habitat in the region. Additional dives and transects would be complementary to this study and further elucidate these findings.

A combination of roving diver technique and transect techniques could be used in future expeditions to allow for statistical comparisons between dive sites and for the identification of commercially and ecologically important species. This would allow for statistical analyses between dive sites while still allowing for detailed investigations of specific species, habitats and Important Ecological Areas.

Inshore Cape Arago: canary rockfish, sponge



Coquille Bank: the tip of a crab is visible underneath a rock decorated with a crinoid

CONCLUSION

This habitat assessment represents the first characterization of the nearshore rocky reefs in the Cape Arago inshore area, the offshore Cape Arago area and the nearshore Coquille reef area using an ROV. This is also the first reported seafloor habitat data collected inside the Coquille Bank essential fish habitat conservation area that was designated by the National Marine Fisheries Service in 2006 (NMFS 2006). In this study we documented commercially important groundfish species using biogenic habitat in both hard and soft substrates.

Our findings suggest that each of the areas surveyed are Important Ecological Areas as evidenced by the observations of managed fish species, sensitive seafloor habitat features such as corals and sponges, and complex physical and biological features. What is more, these findings significantly add to the direct observations of corals and sponge locations in the Pacific Ocean off southern Oregon.

In this habitat assessment we document Important Ecological Areas that are sensitive and vulnerable to disturbance and these areas warrant consideration for conservation as marine protected areas. The habitat and associated fish species information will be used in the Pacific Fishery Management Council's review of groundfish essential fish habitat identification and conservation. These findings will also be useful to current and future efforts to identify and protect Important Ecological Areas off the Oregon coast. Areas inside state waters should be considered for protection during marine spatial planning processes considering how to appropriately site renewable energy development, and in future Oregon marine reserve and protected area processes.

Simpson Reef at Cape Arago: an Important Ecological Area in southern Oregon.
Photo: Ben Nieves

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ADDITIONAL INFORMATION:

A sample of the ROV video taken at the inshore Cape Arago area is available at:
http://oceana.org/en/our-work/oceana-on-the-water/pacific-hotspots/video

Additional photos from this research expedition are available at:
http://oceana.org/en/our-work/oceana-on-the-water/pacific-hotspots/photos

FIGURE 11. Master table of all dives including managed fishes, corals, sponges, biogenic structure, substrate and relief.

Managed Fish (total observed)	Dive 1	Dive 2	Dive 3	Dive 4	Dive 5	Dive 6	Dive 7	Dive 8	Dive 9	Dive 10	Dive 11	Dive 12	Dive 13	Dive 14	Dive 15	Dive 16	Dive 17
Greenstriped Rockfish	0	0	0	0	0	0	0	1	1	3	0	0	0	0	0	0	0
Widow Rockfish	0	0	571	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quillback Rockfish	4	1	4	3	3	0	0	0	0	0	0	0	2	1	2	0	0
Blue Rockfish	3	0	11	0	0	0	0	0	0	0	0	0	0	1	1	0	0
China Rockfish	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Tiger Rockfish	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Canary Rockfish	2	2	7	33	5	0	0	5	0	0	0	0	0	9	56	0	0
Rosy Rockfish	0	0	5	0	0	0	0	0	2	3	0	0	0	0	7	0	0
Olive/ Yellowtail Rockfish	28	0	8	4	1	0	0	0	0	0	0	0	0	2	2	0	0
Yelloweye Rockfish	0	0	10	1	3	0	0	0	0	0	0	0	0	5	1	0	0
Rex Sole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Kelp Greenling	4	3	5	1	5	1	0	0	0	0	0	0	1	9	9	0	0
Lingcod	5	1	12	1	2	1	0	0	0	0	0	0	4	7	9	0	0
Corals (proportion of frames)																	
Gorgonacea	0.00	0.16	0.14	0.07	0.06	0.33	0.00	0.45	0.60	0.06	0.12	0.09	0.10	0.15	0.37	0.40	0.00
Scleractinia	0.05	0.22	0.04	0.19	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.18	0.00	0.00
Stylasterinia	0.00	0.02	0.12	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
No Corals	0.95	0.65	0.71	0.72	0.84	0.67	1.00	0.55	0.40	0.94	0.88	0.91	0.82	0.66	0.45	0.60	1.00
Sponges (proportion of frames)																	
Barrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.04	0.03	0.00	0.00	0.00	0.00	0.00
Foliose	0.08	0.06	0.53	0.00	0.03	0.00	0.00	0.06	0.48	0.10	0.09	0.04	0.04	0.46	0.02	0.02	0.00
Mound	0.03	0.52	0.17	0.10	0.24	0.01	0.00	0.02	0.15	0.10	0.04	0.04	0.24	0.05	0.03	0.00	0.00
Branching	0.00	0.34	0.41	0.06	0.38	0.48	0.00	0.79	0.08	0.02	0.00	0.01	0.15	0.29	0.77	0.69	0.00
Shelf	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vase	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Unidentified Sponges	0.05	0.02	0.02	0.05	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.05
No Sponges	0.84	0.30	0.20	0.84	0.45	0.52	1.00	0.18	0.31	0.79	0.84	0.86	0.58	0.36	0.22	0.27	0.95
Biogenic Structure (proportion of frames)																	
High	0.58	0.51	0.30	0.49	0.14	0.30	0.05	0.29	0.56	0.00	0.00	0.00	0.13	0.20	0.54	0.42	0.27
Low	0.42	0.80	0.93	0.48	0.86	0.70	0.00	0.93	0.91	0.74	0.61	0.59	0.97	0.91	0.94	0.95	0.12
Primary Substrate (proportion of frames)																	
Hard	1.00	0.35	0.53	0.37	0.28	0.03	0.00	0.07	0.14	0.25	0.04	0.09	0.99	0.88	0.34	0.02	0.00
Mixed	0.00	0.30	0.11	0.26	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soft	0.00	0.35	0.36	0.37	0.70	0.97	1.00	0.93	0.86	0.75	0.96	0.91	0.01	0.12	0.66	0.98	1.00
Secondary Substrate (proportion of frames)																	
Hard	0.97	0.42	0.59	0.53	0.28	0.09	0.00	0.07	0.66	0.64	0.05	0.23	0.96	0.83	0.33	0.02	0.00
Mixed	0.00	0.31	0.11	0.26	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soft	0.03	0.27	0.30	0.20	0.69	0.91	1.00	0.93	0.34	0.36	0.95	0.77	0.04	0.18	0.67	0.98	1.00
Relief (proportion of frames)																	
High	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Moderate	0.32	0.24	0.47	0.24	0.23	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.36	0.23	0.23	0.00	0.00
Low	0.68	0.76	0.51	0.76	0.77	0.97	1.00	0.99	1.00	1.00	1.00	1.00	0.61	0.78	0.77	1.00	1.00
# of Frames Analyzed (interval analysis)																	
	38	124	129	103	120	96	66	112	95	84	57	74	67	80	105	55	60
Bottom Time (minutes)																	
	21	65	77	80	62	57	34	63	53	44	28	40	36	44	54	30	32
Depth (meters)																	
Range	40	72	55	63-69	39	96-98	118	80-82	126-128	205-210	127-129	226-228	28-34	38-41	60	80-81	99-100

Inshore Coquille Reef: kelp greenling

“We can only sense that in the deep and turbulent recesses of the sea are hidden mysteries far greater than any we have solved.”

Rachel Carson, The Sea Around Us (1951)

Offshore Cape Arago: basket star and anemone

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March 29, 2013

Mr. Dan Wolford, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, OR 97220-1384

RE: Agenda Item D.6: Groundfish Essential Fish Habitat 5-year Review

Dear Chairman Wolford and Council members:

As organizations intimately involved in the development of Essential Fish Habitat (EFH) Conservation Areas off the U.S. West Coast we express our continued interest in the long-term protection and responsible management of groundfish EFH. We support the Pacific Fishery Management Council's Groundfish EFH 5-year review process, and we urge the Council to approve and release the Request for Proposals (RFP) as currently drafted at this meeting. It is important that the Council approve the RFP and move forward with the 5-year review process as the success of EFH management depends on iterative improvements based on new information and new science.

The draft RFP is the product of significant work by the Essential Fish Habitat Review Committee (EFHRC) and has benefited from input from various stakeholders and the Council. It strikes an appropriate balance between rigor and flexibility—requiring a set of essential information to be contained in each proposal, while also encouraging and allowing for more detailed proposals. Proposers have the option of providing detailed analysis, but are not precluded from submitting proposals if they are unable to do such analysis.

We concur with the EFHRC's conclusion that the Phase I Report presents substantial new information and new analyses of previously available information relevant to EFH management. This new information has become available since the Council made its final decision on EFH measures in 2005. In particular, there is substantial new information relevant to the criteria the Council used as the basis for EFH Conservation Areas, including new locations and shapes of rocky reef habitats, biogenic habitats (e.g., corals and sponges) as well as fishing effort. We commend the National Marine Fisheries Service and the EFHRC for making this data publicly available in a variety of formats, as it is now accessible to a much wider audience of stakeholders.

The Magnuson-Stevens Fishery Conservation and Management Act contains a clear mandate to "minimize to the extent practicable adverse effects on [EFH] caused by fishing" 16 U.S.C. § 1853(a)(7). This mandate requires incorporation of the best available science and the primary vehicles for ensuring compliance on an ongoing basis are the required 5-year reviews of EFH. *See id.* § 1855(b)(1)(A); 50 C.F.R. § 600.815(a)(10). Requesting input from stakeholders, partner agencies, and Tribes will provide the Council with a broad range of ideas and input on how the new information developed since 2005 can be used to better minimize fishing impacts on EFH. This is all part of refining management in an adaptive, iterative manner—precisely the process envisioned by the Magnuson-Stevens Act. By approving the RFP and moving forward with the EFH 5-year review process, this Council can help ensure vibrant, productive fisheries for generations to come. We hope to see the Council continue its leadership on EFH management, and we look forward to participating as partners in this important process.

Sincerely,

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Agenda Item D.7
Situation Summary
April 2013

TRAWL RATIONALIZATION TRAILING ACTIONS – ELECTRONIC MONITORING REGULATORY PROCESS

The Council has been considering the possible use of electronic monitoring (EM) for the trawl catch share program (trawl rationalization). At its November meeting, the Council directed that an EM workshop be held. The announced purpose of the workshop was to develop the policy context and identify necessary elements for a thorough Magnuson-Stevens Act (MSA) process to consider possible regulatory changes providing for the use of EM in the West Coast groundfish trawl catch share program. If electronic monitoring is implemented, the current 100 percent catch observer coverage requirement could be changed. A workshop Terms of Reference was developed, including a clear purpose statement for the workshop and four specific objectives (Agenda Item D.7.a, Attachment 1). The workshop was held February 25-27, 2013, and the workshop report is provided as Agenda Item D.7.b, EM Workshop Report. The trawl rationalization program goals and objectives and current language pertaining to monitoring of the catch share program fishery are provided in D.7.a, Attachment 2.

As part of the exploration of the potential utility of EM, Pacific States Marine Fisheries Commission (PSMFC) conducted a field study in 2012 and will conduct another such study in 2013. The results of the study for 2012 (Agenda Item D.7.c, PSMFC Report 1) and plans for 2013 (Agenda Item D.7.c, PSMFC Report 2) will be provided in a presentation by Mr. Dave Colpo, PSMFC.

Under this agenda item, the Council will decide whether, and if so, how to proceed with consideration of an electronic monitoring policy, and may wish to provide comment on the fieldwork being conducted by PSMFC.

<u>Council Action</u>:

1. Consider adopting regulatory goals and objectives.
2. Provide guidance on developing a scoping package, including
    a. initial alternatives for public review and comment
    b. an option for electronic monitoring co-ops
    c. consideration of adopting other workshop information requests.
3. Provide comments on PSMFC study.
4. Consider adopting a regulatory process for moving forward.
5. Respond to other workshop recommendations.

<u>Reference Materials</u>:

1. Agenda Item D.7.a, Attachment 1. Terms of Reference for the Pacific Council Workshop on Electronic Monitoring for Vessels Participating in the Groundfish Trawl Catch Share Program.
2. Agenda Item D.7.a, Attachment 2. Trawl Rationalization Goals and Objectives and Provisions for Tracking and Monitoring.

3. Agenda Item D.7.b, EM Workshop Report. Trawl Catch Share Program Electronic Monitoring (EM) Workshop Report.
4. Agenda Item D.7.c, PSMFC Report 1. Electronic Monitoring Program: Review of the 2012 Season.
5. Agenda Item D.7.c, PSMFC Report 2, Electronic Monitoring Program: Plan for the 2013 Season.

<u>Agenda Order</u>:

a.	Agenda Item Overview	Jim Seger
b.	Electric Monitoring Workshop Report	Jim Seger
c.	Pacific States Marine Fisheries Commission Report	Dave Colpo
d.	Reports and Comments of Advisory Bodies and Management Entities	
e.	Public Comment	
f.	**Council Action**: Discussion and Guidance on Electronic Monitoring Issue	

PFMC
03/25/13

TERMS OF REFERENCE
for the PACIFIC COUNCIL WORKSHOP on
ELECTRONIC MONITORING FOR VESSELS PARTICIPATING IN THE GROUNDFISH TRAWL CATCH SHARE PROGRAM

I. Purpose

The purpose of the workshop is to develop the policy context and identify necessary elements for a thorough Magnuson-Stevens Act (MSA) process to consider possible regulatory changes providing for the use of electronic monitoring to adjust the current 100 percent catch observer coverage requirement in the West Coast groundfish trawl catch share program, with the intent of providing recommendations for consideration at the Pacific Council April, 2013 meeting.

II. Workshop Objectives[1]

1. Identify draft objectives related to the possible use of electronic monitoring.
2. Identify key questions about and requirements for an electronic monitoring program, and recommend approaches to more thoroughly investigate concerns and requirements as workshop follow-ups. The following categories apply to this workshop objective.
    a. Enforcement.
    b. Observer program products[2].
    c. Repercussions to current management systems, including total cost.
    d. Legal issues.
    e. Constituent issues.
3. Identify elements that should be included in the at-sea and on shore components of the study design for the 2013 Pacific States Marine Fisheries Commission (PSMFC) field project.
4. Develop a draft process and schedule for a consideration of regulatory changes, including a Council decision-making process and the National Marine Fisheries Service (NMFS) approval and implementation process.

III. Workshop Objectives Detail, Responsible Presenters, and Rapporteurs

1. Workshop Objective 1. This workshop objective deals with discussion of the "why" reasons for considering a change in the current program to allow for electronic

[1] For the purpose of this Terms of Reference document, it is useful to distinguish the different uses of the word objective. There are four objectives of this workshop as described in section II.; it is the intent to refer to these consistently as workshop objectives. There are policy goals and objectives currently established for the groundfish trawl catch share program that are at a higher level of policy generality, do not typically get into specific detail, and currently do not mention electronic monitoring; this document will consistently refer to these as existing policy objectives. One intent of this workshop is to identify draft "new" objective statements or recommended regulatory objectives to be achieved by an electronic monitoring program; these objectives will be referred to simply as objectives or regulatory objectives for an electronic monitoring program, to be viewed as a product of this workshop for consideration by the Council at the April, 2013 Council meeting.

[2] It may be useful to separate the discussion of the current observer program products into two categories: one relating to pure catch compliance purposes (counting the number of fish caught), and another relating to what has been termed scientific or ancillary purposes (at-sea biological data on discarded fish, such as halibut liveliness at time of release, observations of sea bird interactions, etc.). This is an important distinction in that it is commonly felt that electronic monitoring, as currently being considered, cannot provide information that falls into the category of scientific or ancillary purposes (such as sea bird interactions).

monitoring, and developing draft objective statements can be achieved through the use of electronic monitoring. As examples, a presumed cost savings to individual fishing businesses has frequently been spoken to at Council meetings as a reason to move to electronic monitoring, particularly in the context of this being done when Federal subsidies of catch observer costs phase out; there has also been mention of electronic monitoring enhancing the scientific information beyond what is currently collected; it has also been suggested a shift to electronic monitoring would help maintain the economic competitiveness and participation by small vessels as Federal subsidies for catch observers phase out. Workshop participants then need to identify specific objectives, or modifications of existing policy objectives, expressing what is expected to be achieved by a shift to an electronic monitoring program.

To accomplish this workshop objective, it is appropriate to first review the relevant existing policy objectives regarding fishery monitoring and data collection that imply the necessity of 100 percent observer presence (from MSA, Fishery Management Plan (FMP), and Amendment 20). MSA and FMP goals and objectives will be distributed prior to the workshop. It may be useful to separate the discussion of electronic monitoring objectives into two categories: one relating to pure catch compliance purposes (counting the number of fish caught), and another relating to what has been termed scientific or ancillary purposes (at-sea biological data on discarded fish; observations of sea bird interactions, etc.). While the primary purpose of this workshop objective is to develop draft objective statements, it would be useful for participants to consider recommending elements of a draft purpose and need statement that can also be considered at the April Council meeting.

a. Responsible presenter: Jim Seger
b. Rapporteur: Shems Judd

<u>2. Workshop Objective 2.</u> This workshop objective is to identify the key questions and potential problems associated with a possible shift to, or supplemental use of, electronic monitoring and to recommend program design elements to be considered for possible inclusion as part of the program and those design elements that need to be more thoroughly investigated after the workshop. Discussion of this workshop objective would come after reviewing the functions and purposes of the current 100 percent observer program and other electronic monitoring studies and results. Follow-up investigations after the workshop could be in the form of a White Paper or Data Report, for example. This workshop objective can be separated into several separate components, as described below. As a foundation of considerations under this objective, it will be useful to look at a preliminary feasibility evaluation of potential for use of electronic monitoring for monitoring compliance; this will be provided in advance of the workshop (see matrix attached). The preliminary scoping which occurs under this agenda item will be used to generate a report to the Council which includes: identification of key concerns, important elements of the a program design, and areas needing further investigation (e.g. whitepaper topics).

a. Key Considerations to be Addressed:
    i. Enforcement needs met by observer coverage.
        1. Responsible presenter: Dayna Mathews
        2. Rapporteur: Dave Anderson
    ii. Current observer program data products.
        1. Responsible presenter: ~~Michelle McClure~~ [Council Staff]
        2. Rapporteur: Dan Erickson

iii. Repercussions to current management systems, including total cost.
   1. Responsible presenter: ~~Frank Lockhart~~ Colby Brady
   2. Rapporteur: ~~Colby Brady~~ Kelly Ames

iv. Legal considerations.
   1. Responsible presenter: Niel Moeller
   2. Rapporteur: David Anderson

v. Constituent perspectives.
   1. Responsible presenter: Invited Constituents
   2. Rapporteur: Jim Seger

b. Design elements for an electronic monitoring program to be implemented through regulatory changes and identify elements that need further investigation. To help the workshop discussion get specific, some ideas about gear-specific strawman regulations for trawl quota share program electronic monitoring will be presented. Gear-specific strawman would include the multi-species trawl fishery, the mid-water trawl fishery, and the gear-switched fixed gear fishery.
   1. Responsible presenter: Dayna Matthews, and Dave Colpo
   2. Rapporteur: Jim Seger

2. <u>Workshop Objective 3.</u> A presentation of the 2012 field season will be made, as well as a presentation on 2013 field season possibilities. This workshop objective deals with the Council process of the MSA requirement for an Scientific and Statistical Committee (SSC) review of the best available science for use in any regulatory changes, in the context of advance advice on a study design to explore electronic monitoring capabilities to accomplish expected results. The term study design and field season refers to both the at-sea design for camera placement on boats and the sector/geographic/temporal/logistic array of boats collecting data, and the on-shore review of camera recordings. This workshop objective is not to produce a detailed study design recommendation, but rather to identify the elements of a study design that can be refined to a recommendation during the Council process at the April, 2013 Council meeting.
   a. Responsible presenter: Dave Colpo
   b. Rapporteur: John DeVore

3. <u>Workshop Objective 4.</u> This workshop objective is to provide a draft process and schedule for a full Magnuson regulatory process, including the information development and Council decision-making components and the NMFS approval and implementation component. While it should not be presumed that the Council process will result in a regulatory change decision, nor that NFMS will approve any Council recommendation, it is useful to outline a reasonable process so as to achieve a realistic idea of an accomplishable timeframe and the necessary steps involved. The Council would consider what is produced at this workshop at the April, 2013 Council meeting.
   a. Responsible presenter: Jim Seger
   b. Rapporteur: Kelly Ames

IV. Outcomes

1. Workshop Report document, to be completed by the advance Briefing Book deadline for the April, 2013 Council meeting (March 13, 2013). This would include a summary of key workshop discussion points, reference materials, and the following targets:
    a. Workshop Objective 1.
        i. A list of draft objectives that might be achieved through the use of an electronic monitoring program.
        ii. A draft purpose and need statement for a Council regulatory process.
    b. Workshop Objective 2.
        i. A listing of questions about EM and implementing an electronic monitoring program.
        ii. A listing of potential design elements and requirements of an electronic monitoring program.
        iii. A listing of follow-up white papers or data reports needed for Council consideration on how to proceed.
    c. Workshop Objective 3.
        i. Recommendations on summer 2013 at-sea fieldwork study design elements or issues for particular attention by the SSC.
        ii. Recommendations for on-shore camera recording study design elements (such as video review).
    d. Workshop Objective 4.
        i. A draft process and schedule for Council deliberations.

V. Logistical Matters

1. Dates and location: February 25-27, 2013
2. Workshop Terms of Reference distribution: February 1, 2013
3. Workshop Chair and responsible Council Staff Officer:
    a. Dan Wolford
    b. Jim Seger
4. Potential attendees/participants formally invited –40 (expected: 38)
    a. SSC representatives: 2
    b. Groundfish Advisory Subpanel reps (Trawl, Nontrawl, and Environmental): 9
    c. Groundfish Management Team reps (state commercial, NMFS): 4
    d. Enforcement Consultant reps – (state , NMFS Office of Law Enforcement, U.S. Coast Guard): 4
    e. NMFS specialists –
        i. Northwest Region: 1
        ii. Northwest Fisheries Science Center: 1
        iii. NOAA General Counsel – policy and litigation: 3
        iv. NMFS – Headquarters: 1
    f. “Outsider” special invitees
        i. Observer Company : Lake
        ii. Archipelago: McElderry
        iii. PSMFC: Colpo
        iv. National Fish and Wildlife Foundation Projects –Leipzig and Haflinger
        v. Morro Bay Project –Bell
        vi. Fixed Gear Participant –Bettencourt
        vii. Alaska Fishery Science Center- Wallace

g. Council Member(s): Dan Wolford, Dorothy Lowman, Michele Culver, Gway Kirchner, Frank Lockhart (5)
h. Other Council Staff
   i. Don McIsaac
   ii. Kelly Ames
   iii. John DeVore

5. Documents due in the Council office on February 14.
   a. A 1-2 page synopsis for each West Coast or Alaska electronic monitoring study to be presented at the workshop.
   b. For Workshop Objective 1
      i. A compilation of existing policy objectives.
      ii. A draft purpose and need statement.
      iii. Listing of draft objectives describing what providing for electronic monitoring would accomplish.
   c. For Workshop Objective 2
      i. Matrices listing functions carried out by existing observers, and identifying those functions that might be carried out by electronic monitoring, the characteristics of the electronic monitoring required to fulfil the function, complementary regulatory changes, and, as appropriate, alternative (non-electronic monitoring) means for fulfilling the function.
      ii. Hypothetical strawman ideas about regulatory design features of an electronic monitoring program.
   d. For Workshop Objective 3
      An initial list of elements for a 2013 field season study design.
   e. For Workshop Objective 4
      i. Possible process as shown at the June and November, 2012 Council meetings.
6. Potential Agenda/Format
   a. (See attached preliminary detailed draft agenda)

TRAWL RATIONALIZATION GOALS AND OBJECTIVES AND PROVISIONS FOR TRACKING AND MONITORING

Excerpts from Amendment 20

TRAWL RATIONALIZATION GOALS AND OBJECTIVES
Goal *Create and implement a capacity rationalization plan that increases net economic benefits, creates individual economic stability, provides for full utilization of the trawl sector allocation, considers environmental impacts, and achieves individual accountability of catch and bycatch.*
Objectives The above goal is supported by the following objectives:
1. Provide a mechanism for total catch accounting.
2. Provide for a viable, profitable, and efficient groundfish fishery.
3. Promote practices that reduce bycatch and discard mortality and minimize ecological impacts.
4. Increase operational flexibility.
5. Minimize adverse effects from an IFQ program on fishing communities and other fisheries to the extent practical.
6. Promote measurable economic and employment benefits through the seafood catching, processing, distribution elements, and support sectors of the industry.
7. Provide quality product for the consumer.
8. Increase safety in the fishery.
Constraints and Guiding Principles The above goals and objectives should be achieved while the following occurs:
1. Take into account the biological structure of the stocks including, but not limited to, populations and genetics.
2. Take into account the need to ensure that the total OYs and allowable biological catch (ABC) are not exceeded.
3. Minimize negative impacts resulting from localized concentrations of fishing effort.
4. Account for total groundfish mortality.
5. Avoid provisions where the primary intent is a change in marketing power balance between harvesting and processing sectors.
6. Avoid excessive quota concentration.
7. Provide efficient and effective monitoring and enforcement.
8. Design a responsive mechanism for program review, evaluation, and modification.
9. Take into account the management and administrative costs of implementing and oversee the IFQ or co-op program and complementary catch monitoring programs, as well as the limited state and Federal resources available.

Trawl Rationalization Program Provisions for Tracking and Monitoring

The following provisions are part of an appendix to the FMP which will be updated as changes are implemented through regulatory amendments.

Table D-1. Full description of the IFQ Program for shoreside trawl deliveries.	
A-2.3.1 Tracking, Monitoring and Enforcement	It is the Council intent to provide NMFS flexibility sufficient to design and implement a tracking and monitoring program that will achieve the goals and objectives of the trawl rationalization program. **Discarding by Shoreside Sector** Nonwhiting – Discarding of IFQ species allowed, discarding of IBQ species required, discarding of nongroundfish species allowed. Whiting Maximized retention vessels: Discarding of fish covered by IFQ or IBQ, and nongroundfish species prohibited. Vessels sorting at-sea: Same as for nonwhiting. **At-Sea Catch Monitoring for Shoreside Sector** Nonwhiting – The sorting of catch, the weighing and discarding of any IBQ and IFQ species, and the retention of IFQ species must be monitored by the observer. Whiting For maximized retention vessels: video monitoring as proposed under Amendment 10. Observers would be required in addition to or as a replacement for video monitoring. For vessels that sort at-sea: The sorting, weighing and discarding of any IFQ or IBQ species must be monitored by an observer with supplemental video monitoring. Shoreside Landings Monitoring The sorting, weighing and reporting of any IFQ species must be monitored by a shoreside landings monitor (IBQ will have been discarded at sea). **Catch Tracking Mechanisms for Shoreside Sector** **Electronic vessel logbook report** VMS-based electronic logbook required to be transmitted from vessel. At-sea entry by vessel personnel required including catch weight by species and if retained or discarded. **Vessel landing declaration report** Mandatory declaration reports. **Electronic ITQ landing report** Mandatory reports completed by processors and similar to electronic fishticket report. **Processor production report** Mandatory reports (possible inclusion of proprietary data included to be recommended as option is fleshed out). **Cost Control Mechanisms for Shoreside Sector** **Shoreside landing hour restrictions** Landing hours may be restricted. **Shoreside site Licenses** Mandatory license for shoreside deliveries. License can be issued to any site that meets the monitoring requirements. **Vessel Certification** Mandatory certification. Certificate can be issued to any vessel that meets the monitoring requirements. **Program Performance Measures for Shoreside Sector** Integrate into the tracking and monitoring program the collection of data on cost, earnings and profitability; economic efficiency and stability; capacity measures; net benefits to society; distribution of net benefits; product quality; functioning of quota market; incentives to reduce bycatch; market power; spillover effects into other fisheries; contribution to regional economies (income and employment); distributional effects/community impacts; employment in seafood catching and processing; safety; bycatch and discards; administrative, enforcement, and management costs. (See A-2.3.2)

B-1.4 At-sea Observers/ Monitoring

At-sea Whiting Fishery: 100 percent observer coverage aboard MS and CP will continue. Observers would be required in addition to or as a replacement for video monitoring.

For some coverage, cameras may be used in place of observers (feasibility to be determined). It is the Council's intent to provide NMFS flexibility sufficient to design and implementation a tracking and monitoring program that will achieve the goals and objectives of the trawl rationalization program.

TRAWL CATCH SHARE PROGRAM ELECTRONIC MONITORING (EM) WORKSHOP REPORT

Portland, Oregon

February 25-27, 2013

Pacific Fishery Management Council

March 2013

TRAWL CATCH SHARE PROGRAM ELECTRONIC MONITORING (EM)
WORKSHOP REPORT

Executive Summary – Findings, Recommendations, and Requests, Organized by Council Action Item

General Feasibility Evaluation

Finding: Participants at the workshop believe that it is reasonably likely that electronic monitoring (EM) will be found to be technically and economically viable as a substitute for the use of human observers in the function of compliance monitoring for the catch share program.

1. Consider adopting goals and objectives.

Recommendation. The regulatory objectives for this action are closely tied to the purpose and need and would be intended to further the policy goals and objectives of the Magnuson-Stevens Act (MSA) and the groundfish fishery management plan (FMP) including Amendment 20. The regulatory objectives for this action pertain to catch share program compliance monitoring and, as proposed by workshop participants, would be to:

1. reduce total fleet monitoring costs to levels sustainable for the fleet and agency;
2. reduce observer costs for vessels that have a relatively lower total revenue;
3. maintain monitoring capabilities in small ports;
4. increase national net economic value generated by the fishery;
5. decrease incentives for fishing in unsafe conditions;
6. use the technology most suitable and cost effective for any particular function in the monitoring system; and
7. reduce the physical intrusiveness of the monitoring system by reducing observer presence;

while

8. maintaining current individual accountability for catch and preserving equitable distribution of monitoring coverage among members of the fleet,
9. supporting the collection of biological information necessary for managing the fishery, for stock assessments, and to meet other needs for scientific data, with no degradation relative to pre-trawl catch share program standards,[1]
10. taking into account agency budgets and abilities to support any new policy,
11. maintaining capabilities for ACL management (e.g. for non-quota species), and
12. following an implementation path most optimal for the fishery.

[1] Finding a way to describe information need for scientific purposes is quite difficult. Section 2.c of Executive Summary for an information requests related to this objective.

Note: These regulatory objectives are for an action to develop an EM program for trawl catch share program compliance monitoring, not for the collection of scientific data. The first seven items in the above list are direct regulatory objectives, i.e. reasons for considering EM. Items eight through twelve in this list are constraints, i.e. the Council would not be undertaking this action in order to achieve items eight through twelve but rather in pursuing the first seven objectives will be bounded by the concerns listed in items eight through twelve. These objectives do not displace the original objectives for the trawl catch share program (Amendment 20 objectives) or the groundfish FMP.

2. Provide guidance on developing a scoping package, including

a. initial alternatives for public review and comment

Recommendation (Strawman Programs) .... Page 11

Strawman alternatives were provided during the workshop. Those alternatives have been modified based on the following recommendations and are provided in revised form in in Attachment 2.

Recommendations.

- The workshop participants did not feel it useful to focus on alternatives which would require a minimum of four years to perfect, however, attention to structuring the program to facilitate rapid adoption of new improved technologies and procedures as they become available should be considered as part of the current process.

- For all sectors, the issue of the necessity of a ban on night fishing needs to be explored further. There is currently a regulatory ban on night fishing in the whiting fishery (Section 661.131(f)[2]). There is some reason to believe that images may be clearer at night, with appropriate lighting, than during the day. The Pacific States Marine Fisheries Commission (PSMFC) study may provide an opportunity to do needed research. For the bottom trawl fishery in particular, ability to fish at night is crucial, especially in winter months in the north when there may only be 8 or 9 hours of daylight. With respect to any ban on night fishing, it would be haul back, rather than setting, that would be the issue. Ability to night fish might be considered as a criterion around which an alternative is developed.

- Include a retention option which would allow the discard of small sized sablefish and lingcod to meet conservation objectives. Vessel revenue might be increased if this were combined with a proposal being considered under trawl rationalization trailing actions, which would give survival credit for discards.

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[2] "Vessels fishing in the Pacific whiting primary seasons for the Shorebased IFQ Program, MS Coop Program or C/P Coop Program shall not target Pacific whiting with midwater trawl gear in the fishery management area south of 42°00′ N. lat. between 0001 hours to one-half hour after official sunrise (local time)."(660.131(f))

- If halibut are allowed to be discarded at-sea, the option in the initial strawman that specifies that all halibut are assumed dead would not reflect what occurs in the fishery. Another approach would be to use the historical observer information to estimate a likely average halibut mortality rate by gear type and fishery and to update those estimates over time based on observer data from more recent observations. Individual accountability would still provide an incentive to avoid halibut catch, however survivability would be based on fleetwide averages, therefore there would be less direct incentive to modify fishing strategies and handling techniques to minimize the mortality rate on each haul or set.

- Adding objectives for each strawman would be useful.

- The strawmen should note that compliance with monitoring is required only while participating in the IFQ fishery.

- Before implementing EM, obtain a clear agreement on what counts against quota when there are operational discards in a whiting fishery.

- Consideration needs to be given to how the West Coast system might be coordinated with requirements for Alaska programs.

- Workshop participants believe there would be utility in convening a workgroup to continue development of the alternatives and has recommended that the appointment occur at the June Council meeting.

b. an option for electronic monitoring co-ops

Recommendation (Electronic Monitoring Co-ops (EMCs)) Page **Error! Bookmark not defined.**

Recommendation. EMCs are a potentially innovative approach which warrants further consideration.

c. consideration of adopting other workshop information requests.

Information Request (Observer Coverage and Sampling)...Page 6

Information Request. With respect to the perspective of personnel at the Northwest Fisheries Science Center (NWFSC) that were provided in the preliminary feasibility matrices, participants have the following questions:

(1) What level of observer coverage will be necessary to compliment shoreside sampling if EM is adopted?
   a. What is the minimum observer coverage needed to obtain necessary biological data?
      i. How much biological data was collected prior to trawl rationalization? What was the biological sampling rate?
      ii. How much biological data are acquired now that trawl rationalization has been implemented? What is the biological sampling rate?
   b. What is the minimum observer coverage needed to respond to other requirements (protected resources, Endangered Species Act (ESA), etc. requirements)?
(2) When NWFSC filled out the feasibility matrices, what was the premise with respect of the amount of biological observer coverage expected for each segment of the fishery?
(3) For vessels delivering to motherships, is catch composition and biologically sampling data collected or needed off of the catcher vessel or is/can these data be collected off of the mothership processor? How often are these data collected from catcher vessels?
(4) What percentage of the time do observers actually sample catches on whiting catcher vessels?

Information Request. It would be useful to have a diagram of the relevant operational differences for the various sectors in relation to EM requirements and monitoring risks. The compliance monitoring situation for pot and longline vessels may be different from one another and should be considered separately. Similarly each segment of the fleet may have different conditions. For example, mothership catcher vessels are out for longer periods of time without returning to shore, as compared to shoreside whiting vessels, therefore there might be different data storage requirements and different data transfer procedures. Another example is that for shoreside whiting catcher vessels there may be a greater likelihood of discards than for vessels delivering to motherships because for the shorside vessels fish is taken onto the catcher vessel while for mothership catcher vessels the codend is generally transferred directly to the mothership.

Information Request. Observers have now collected two years of data on activities for the mothership whiting and shoreside whiting catcher vessels. Observer information was not available during the cameral monitoring that was done on whiting vessels under exempted fishing permits (EFPs) of the previous decade. A summary of that information would be useful for the design of an EM system.

Information Request. While it is difficult to make cost estimates without knowing program design specifics and participation rates, it might be useful to develop estimates that bracket a reasonable ranges of assumptions. With multiple uncertainties bracketing might be difficult but may provide information that will help assess tradeoffs during program design.

Information Request (Analysis of Night Data) .... Page 13

Ask for an evaluation of video quality for whiting hauls delivered in darkness under the whiting EFP and an assessment of whether there is enough of such video to have confidence in EM at night on whiting vessels.

3. Provide comments on PSMFC study.

Recommendations (Study Design) .... Page 17

Recommendations.

- Dungeness crab should not be retained in the study.
- It would be advantageous to experiment with deck lighting at night for whiting and non-whiting (including fixed gear). The biggest problem may be lighting on the water to evaluate and potentially enumerate net bleeding and other forms of operational discard.
- Video from the study should be used to evaluate the effectiveness of image recognition software.
- Study halibut viability and correlate to length of tow, time on deck, water, and air temperatures along with standard IPHC viability criteria.
- Experiment with EM without observer interference.
- Evaluate cameras under normal discard behavior conditions.
- Attempt to discern individual fish to species and include lengths of fish discarded.
- Subsample video to provide a statistical analysis of subsampling protocols.
- A variety of fishing vessel types (i.e., gear types) and sizes need to be included in the study.
- The study should include at least one vessel rigged with a fish discard conveyer equipped with a camera to test that configuration.
- Consult with the observer program for its protocols on what counts as a discard.

4. Consider adopting a regulatory process for moving forward.

Recommendation (Calendar) .... Page 18

Recommendation: The following is the draft process that workshop participants recommend the Council consider for moving forward with an EM program.

Dates	**Process Considerations**	**Comments**
	• PSMFC continues preliminary planning for 2013 season and in anticipation of likely Council guidance.	
Apr 2013	• Consider results of EM workshop and recommendations • Adopt goals and objectives. • Provide guidance on development of scoping package. • Request *special studies*, as needed. • Consider results of the 2012 PSMFC EM study. • Provide comment on the 2013 PSFMC EM study design. • Adopt regulatory process plan.	Consider whether any regulatory changes should be pursued, if the NMFS/PSMFC field project demonstrates potential feasibility (for just whiting catcher vessels?)
Spring 2013	• NMFS/PSMFC finalize 2013 study design (starting in April – w/Council meeting results).	
June 2013	• Full scoping session on EM. • Appointment of workgroup on this issue.	
Summer 2013	• Execute at-sea and shoreside field studies	
Sept 2013	• Review results from *special studies* and provide guidance on alternative development (if necessary).	
Nov 2013	• Consider initial results of NMFS/PSFMC 2013 field season • Adopt alternatives for analysis.	
June 2014	• Consider full analysis of alternative. • Select preliminary preferred alternative.	
Sept 2014	• Select final preferred alternative.	
Sept 2014 through 2015	• Secretarial approval process and implementation, including ○ regulation drafting and paperwork reduction act submissions, ○ securing contracts for video review, ○ commercial installation and testing, and ○ observer program adjustments.	

5. Respond to other workshop recommendations.

Recommendation: Participants acknowledged the extensive EM work conducted to date and recommended the scope of future work be narrowed based on the workshop recommendations.

Trawl Catch Share Program Electronic Monitoring (EM) Workshop Report

The Pacific Fishery Management Council held a workshop on the potential use of electronic monitoring (EM) in the trawl fishery catch share program, February 25-27, 2013. The workshop was chaired by Dan Wolford, Council Chairman, and there were 54 people in attendance, including 32 invited participants. A complete list of those in attendance is provided at the end of this document. This report provides a summary of central workshop discussion points along with findings, information requests, and recommendations.

Workshop Report Contents

Location of Findings, Recommendations, and Information Requests

Workshop Materials, Including Agenda and Terms of Reference

All workshop materials, including handouts at the workshop and powerpoint presentations, are available electronically from the Council EM webpage http://www.pcouncil.org/groundfish/trawl-catch-share-program-em/. For anyone viewing this report electronically while connected to the internet, hyperlinks are provided to those materials. Additional background materials, including a number of white papers on EM recently released by NMFS, are also available from the Council EM webpage.

Initial Presentations

The workshop started with a number of presentations on past and present work on EM.

Presentation Agenda Item	Description
Agenda Item B.1: Electronic Monitoring in the Shoreside Hake Fishery 2004 to 2010 - Howard McElderry • Electronic Monitoring in the Shoreside Hake Fishery 2004 to 2010 Attachment 1 –Cameras for Whiting • Powerpoint: Electronic Monitoring in the Shore-Side Hake Fishery 2004 to 2010	Report on seven years of experience with EM in the Pacific coast whiting fishery. Over the life of the program, there were improvements in both monitoring system performance and fishery compliance as a result of several factors including improved technology, maturing operational systems, and improved feedback and reporting processes.
Agenda Item B.2.a: NFWF Funded Project (Fishermen's Marketing Association) - Pete Leipzig • National Fish and Wildlife Grants to the Fishermen's Marketing Association: Attachment 1 – FMA Project • Powerpoint: Summary of National Fish and Wildlife Foundation Grants to the FMA	Evaluated ability of individuals to identify species based on video images and ability of software to detect in video images motions indicating a possible discard from trawl vessels.
Agenda Item B.2.b: – EM for Fixed Gear Vessels – Morro Bay Project - Michael Bell • Electronic Monitoring Pilot Study Report for West Coast Groundfish Trawl ITQ Program Attachment 1 – Fixed Gear Vessels – Morro Bay • Introduction to Economic Model and Summary of Monitoring Concepts for the West Coast Groundfish IFQ Program Attachment 2 – Cap Log Report • Powerpoint: Electronic Monitoring Pilot Studies on Fixed Gear Vessels in Central California	Compared counts of sablefish and grouped rockfish discarded, as detected from three different sources (observers, fishermen logbooks, and EM) and noted instances of unusable video due to poor lighting.

Presentation Agenda Item	Description
Agenda Item B.2.c: NFWF Funded Project (Sea State) and Image Analysis Programming - - Karl Haflinger and Eric Torgerson • Sea State, February 13, 2013, EM Workshop Presentation Description Attachment 1 – Sea State Project • Powerpoint: Overview of NFWF Grant to Develop Video Monitoring for Full-Retention Fisheries	Worked on developing software to detect activities on deck indicating that video should be examined to determine if discarding occurred and to mark those sections of video to facilitate rapid and efficient review.
Agenda Item B.2.d: PSMFC Project – 2012 Season Results – Dave Colpo • PSMFC Project – 2012 Season Results Attachment 1 – PSMFC Project 2012 • Powerpoint: 2012 EM Season Results Pacific States Marine Fisheries Commission	Conducted a video monitoring implementation study for a system using video to detect discards events. 2012 study includes data for whiting and fixed gear vessels. Compared video results to observer results. Evaluated video data quality.
Agenda Item B.3: Electronic Monitoring in Alaska – Farron Wallace • Electronic Monitoring in Alaska – Synopsis for Agenda Item B.3 Attachment 1 – EM in Alaska • Powerpoint: Monitoring Technology in Alaska	Conducted a feasibility study for automated image processing techniques to identify and capture serial catch events and obtain length measurements of catch using stereo cameras; and a feasibility study ("EM light") for collection of temporal-spatial catch and effort data in the small boat commercial groundfish and halibut fleet. Report to NPFMC scheduled for June 2013.
Agenda Item B.4: Northeast Region Pilot Program – Melissa Hooper • Northeast Region Pilot Program - Supplemental Attachment 1 – NER Pilot • Powerpoint: Northeast Region Pilot Program	Pilot project has focused on building capacity and exploring methods for estimating weight and identifying to species in a quasi-full retention fishery. Target fishery currently has 30% observer coverage.

Workshop Objective 1: Regulatory Goals and Objectives

Presentation
Mr. Jim Seger presented background information, a draft purpose and need statement, and strawman goals and objectives developed by Council staff (Agenda Item C.1, Attachment 1 – Strawmen P&N, G&O). A list of Magnuson Stevens Act (MSA) and groundfish fishery management plan (FMP) goals and objectives was also contained in this attachment, along with the current catch share program language on catch monitoring. The purpose and need statement from that document is provided in this report as Attachment 1. The workshop participants neither modified nor explicitly endorsed the purpose and need statement. The goals and objectives, as revised and recommended by workshop participants, are provided below in this section.

Discussion
Participants agreed that reducing the costs associated with catch accounting should be the focus of the EM program rather than the collection of biological data. Biological data may be collected through other means, e.g. onboard observer coverage at a lower than 100 percent coverage levels. The social and economic benefits of the program that are beginning to show up may be threatened as the cost of observers begins to shift to industry with the ending of the observer cost subsidies. Ultimately, costs must be lowered enough to ensure that the program is sustainable. However, cost reduction itself is not the only objective, since this could be achieved, to adverse effect, through substantially greater consolidation of the fleet. Fewer vessels would mean fewer ports; and the loss of trawlers can result in loss of support businesses that benefit other vessels (ice, fuel etc.) creating a negative ripple effect within the port community. In addition to cost reduction, EM can also enhance flexibility (because vessels do not have to wait for the arrival of observers) and make participation more practical for smaller vessels less able to carry observers.

At the same time, one workshop participant noted that while cost reduction is a concern motivating this workshop, there are costs other than observer costs that can be reduced and observer presence provides confidence in the data. However, it was also noted that observer data is not perfect: observers take breaks, sleep, get sick, misidentify species, etc.

There was extensive discussion on the need for biological data. Even without 100% observer coverage, full retention would provide significant opportunity for collecting data during shoreside sampling. At the same time, there is other data which can only be collected at-sea. Determining the amount of data collection "needed" for science is difficult. Frequency of encounter, variation in the data, and tolerance for uncertainty, among other factors, influence the assessment of need. Generally speaking, more information is better, but at some point the value of additional information is relatively small and the costs of collecting that additional information may be high. In this state of uncertainty, participants generally agreed that the baseline for the collection of scientific data should not be 100% observer coverage. Full observer coverage is in place because of the need for 100% catch monitoring, not for the collection of scientific data. One possibility might be to use the pre-trawl catch share observer level as a baseline (about 20% coverage). However, it was noted that a baseline level of scientific data collection is not necessarily a measure of the need for such data.

It was suggested that because of the need to integrate a number of tools, this should not be considered just an EM policy but consideration of a general fishery monitoring policy. While needs for scientific information must be met, participants agreed that the focus of EM should be on full catch accounting.

Recommendation. The regulatory objectives for this action are closely tied to the purpose and need, and would be intended to further the policy goals and objectives of the Magnuson-Stevens Act (MSA) and the groundfish fishery management plan (FMP) including Amendment 20. The regulatory objectives for this action pertain to catch share program compliance monitoring and, as proposed by workshop participants, would be to:

1. reduce total fleet monitoring costs to levels sustainable for the fleet and agency;

2. reduce observer costs for vessels that have a relatively lower total revenue;
3. maintain monitoring capabilities in small ports;
4. increase national net economic value generated by the fishery;
5. decrease incentives for fishing in unsafe conditions;
6. use the technology most suitable and cost effective for any particular function in the monitoring system; and
7. reduce the physical intrusiveness of the monitoring system by reducing observer presence;

while

8. maintaining current individual accountability for catch and preserving equitable distribution of monitoring coverage among members of the fleet,
9. supporting the collection of biological information necessary for managing the fishery, for stock assessments, and to meet other needs for scientific data, with no degradation relative to pre-trawl catch share program standards,[3]
10. taking into account agency budgets and abilities to support any new policy,
11. maintaining capabilities for ACL management (e.g. for non-quota species), and
12. following an implementation path most optimal for the fishery.

These regulatory objectives are for an action to develop an EM program for trawl catch share program compliance monitoring, not for the collection of scientific data. The first seven items in the above list are direct regulatory objectives, i.e. reasons for considering EM. Items eight through twelve in this list are constraints, i.e. the Council would not be undertaking this action in order to achieve items eight through twelve but rather in pursuing the first seven objectives will be bounded by the concerns listed in items eight through twelve. These objectives do not displace the original objectives for the trawl catch share program (Amendment 20 objectives) or the groundfish FMP.

The workshop participants discussed at length the inclusion of the term" sustainable," in regulatory Objective 1. It is understood that some consolidation is expected relative to current levels but that it is not the intent through the EM program to achieve sustainability through even greater levels of consolidation. At the same time, there needs to be something against which cost cutting is balanced, otherwise costs could be minimized by eliminating the fishery. In this context "sustainability" should be interpreted as providing for a sustainable program from both the fleet and agency perspectives.

Regulatory Objective 7 recognizes that cameras may be considered more intrusive from a privacy perspective and that a special discard chute and camera might have greater physical intrusiveness but focuses specifically on physical intrusiveness associated with observer presence.

[3] Finding a way to describe information need for scientific purposes is quite difficult. See the following section for information requests related to this objective, Items (1).

Workshop Objective 2: Feasibility and Key Questions

Finding: Participants at the workshop believe that it is reasonably likely that EM will be found to be technically and economically viable as a substitute for the use of human observers in the function of compliance monitoring for the catch share program.

Preliminary Feasibility Matrices

The primary focus of this segment of the workshop was to review the preliminary thoughts on feasibility provided by the National Marine Fisheries Service (NMFS) Northwest Fishery Science Center (NWFSC), NMFS Northwest Region (NWR), National Oceanic and Atmospheric Administration General Counsel (NOAA GC) Enforcement Section, and NMFS Office of Law Enforcement (OLE) and to discuss concerns of the invited constituents and the public. Agency thoughts were provided in matrices filled out in advance of the workshop. These matrices asked respondents to consider what functions the current observer program fills for them, whether EM might fulfill that function, and, if not, whether there are other ways that the function might be fulfilled. Respondents were also requested to provide their assumptions about the design of the EM system and to indicate if there are functions that the EM system might serve which are not currently served by observers.

Workshop participants felt that longline and pot gears were different enough with respect to EM that they should be considered separately, particularly when it comes to factors such as the need to monitor catch drop-off.

At the workshop presentations were provided from each of these agency offices, except the NWFSC (due to an uncontrollable circumstance).

NWFSC

Presentation
Due to unforeseen and uncontrollable circumstances, staff from the Northwest Fishery Science Center (NWFSC) were unable to attend this workshop, and Mr. Jim Seger, Pacific Fishery Management Council (PFMC) staff, presented the preliminary feasibility matrix (PFMC EM Workshop Agenda Item D.1.a, Attachment 1).

Discussion
The initial discussion concentrated on what each table represents and whether their contents are conclusive or open to revision after further deliberations. The group concluded that questions and comments should be made during the workshop and the NWFSC could be asked to provide answers at the April Council meeting.

Information Request. With respect to the perspective of personnel at the NWFSC that were provided in the matrices, participants have the following questions:

(1) What level of observer coverage will be necessary to compliment shoreside sampling if EM is adopted?

a. What is the minimum observer coverage needed to obtain necessary biological data?
    i. How much biological data was collected prior to trawl rationalization? What was the biological sampling rate?
    ii. How much biological data are acquired now that trawl rationalization has been implemented? What is the biological sampling rate?
b. What is the minimum observer coverage needed to respond to other requirements (Protected resources, ESA, etc. requirements)?

(2) When NWFSC filled out the feasibility matrices, what was the premise with respect of the amount of biological observer coverage expected for each segment of the fishery?
(3) For vessels delivering to motherships, is catch composition and biologically sampling data collected or needed off of the catcher vessel or is/can these data be collected off of the mothership processor? How often are these data collected from catcher vessels?
(4) What percentage of the time do observers actually sample catches on whiting catcher vessels?

The NWFSC matrix shows that there will by higher mortality for halibut under EM, however, while measured or assumed mortality may increase, actual mortality may not change. Halibut size can be measured as it is released through a chute. Using EM could result in more rapid release of halibut with lower mortality, since observer handling would not necessarily be required.

It was noted that, in general, there needs to be consideration and specification of not just the technology but how it is applied.

NWR

Presentation
Mr. Colby Brady reviewed the outcomes of completed EM projects and ongoing investigations (PFMC EM Workshop Agenda Item D.1.b Powerpoint). He noted the success of the Pacific whiting EFP (2004-2010), Morro Bay fixed gear EM project, and the Canadian commercial fisheries model. Mr. Brady said the NWR agrees with the matrices provided by the Office of Law Enforcement (PFMC EM Workshop Agenda Item D.1.b&c, Attachment 1).

Discussion
A participant inquired whether EM could identify sorted catch or if EM should only be used to verify maximized retention. Mr. Brady believes a well designed system with cameras focused on a discard chute could work well to measure discards and that a system could be designed to identify the species composition of the discard. He also saw the potential for incorporating a flow scale and image recognition software in the future.

Recommendation: Participants acknowledged the extensive EM work conducted to date and recommended the scope of future work be narrowed based on the workshop recommendations.

NOAA General Counsel for Enforcement Section

Presentation
Mr. Niel Moeller, NOAA GC Enforcement Section, made a presentation on legal and enforcement considerations (PFMC EM Workshop Agenda Item D.1.c, Supplemental Attachment 2 – NOAA GCEL). Mr. Moeller supplemented his prepared remarks by offering four recommendations for implementing and enforcing an EM program:

1) Follow the vessel monitoring system (VMS) example and publish type-approval standards for EM technology in the Federal Register.
2) Ensure that type-approved vendors are required to provide litigation support to the government in law enforcement proceedings based on EM evidence.
3) Write regulations or permits pertaining to EM requirements that use clearly defined terms, and that allow only limited exceptions, if any.
4) Provide that State joint enforcement partners have access to EM information, to the same extent as with VMS data.

Discussion
There was a question about whether it would be possible to have a provision which would require vessels to pay for increased review if discrepancies were shown between their logbooks and camera monitoring. The issue brings up due process concerns. Due process concerns might be addressed by analyzing and providing opportunity for the public to comment on the requirement that vessels pay for increased review when discrepancies appear during the regulatory development process.

Questions were asked that centered on the effectiveness of EM and/or observers in prosecuting a case. Mr. Moeller stated that to the best of his knowledge neither had been used, although there was a large discard case that involved turning off the power to the camera. There were a number of potential violations of the 2004-2010 EFPs, however none were prosecuted. Often it was claimed that fish were discarded for safety reasons. Video provide much information but with respect to prosecutions, the main question is whether it provides information pertaining to what needs to be provided. In court, video evidence will likely need to be backed up by expert testimony explaining how the images were collected and what they mean. With respect to observers, the primary litigations issues are around observer harassment, rather than use of observer data to support a prosecution.

NOAA Northwest Division OLE

Presentation
Mr. Dayna Matthews (Northwest Division OLE) presented preliminary thoughts on observer functions and the corresponding capabilities of EM (PFMC EM Workshop Agenda Item D.1.b&c, Attachment 1).

Discussion
There was a discussion of the data storage requirements and who would bear the costs. The statute of limitations for data storage is five years. The data needs to be available that long. Under the whiting EFPs (2004-2010) OLE stored the data. That eliminated the question of who owned the data, but going forward OLE does not want to store the data. One question that needs

to be answered is where the data would be stored. Currently, the NWFSC West Coast Groundfish Observer Program (WCGOP) holds the data. There might be some kind of a combined responsibility involving the Pacific States Marine Fisheries Commission (PSFMC), as there is today for logbook data.

At present, based on the information available from studies and experience, the OLE presentation indicated that the at-sea whiting and fixed gear fisheries are closer to moving forward than bottom trawl, for which there is no camera monitoring at present.

General Discussion on Feasibility

After presentation of the Federal agency's perspectives, there was a general discussion among all participants during which the following were some of the main points.

- EM program design should be specific to the fishery and objectives for the fishery and there should be an evaluation of the relative benefits of one approach over another (tradeoffs).
- The issue of appropriate accounting for drop-offs (fish which are not brought on board the vessel) needs to be addressed for the fixed gear vessels and trawl vessels. The drop off issue would not be applicable to pot vessels.
- The feasibility matrices need to be looked at as a whole, rather than linearly. For example, just because EM cannot fulfill a function, as reflected in column 3, does not necessarily mean that an adjustment to some other aspect of the system cannot be made such that the move to EM is feasible. Those potential compensatory adjustments are reflected in column 5.
- Consider the feasibility of moving away from a model that proscribes compliance activities to a model that sets monitoring standards that might be met through a variety of technologies and procedures. This will provide more flexibility in the initial design and for future changes.

Information Request. It would be useful to have a diagram of the relevant operational differences for the various sectors in relation to EM requirements and monitoring risks. The compliance monitoring situation for pot and longline vessels may be different from one another and should be considered separately. Similarly each segment of the fleet may have different conditions. For example, mothership catcher vessels are out for longer periods of time without returning to shore, as compared to shoreside whiting vessels, therefore there might be different data storage requirements and different data transfer procedures. Another example is that for shoreside whiting catcher vessels there may be a greater likelihood of discards than for vessels delivering to motherships because for the shorside vessels fish is taken onto the catcher vessel while for mothership catcher vessels the codend is generally transferred directly to the mothership.

Consideration of Strawman Electronic Monitoring Programs and Co-ops

Strawman Programs

Presentation
Mr. Dayna Matthews (Northwest Division OLE) and Dave Colpo (PSMFC) presented electric monitoring strawmen for consideration. Strawmen were provided for each of four groups: midwater trawl mothership sector, midwater trawl shorebased sector, bottom trawl, and fixed gear (PFMC EM Workshop Agenda Item D.2.a, Attachment 1 – EM Strawmen). The strawmen provided at the workshop provide an excellent basis for Council discussion. The work that Dayna Matthews, Dave Colpo, Steve Freese and others put into developing them was greatly appreciated. Staff should work with the strawmen and provide them to the Council, incorporating the recommendations provided in this section of the workshop report. The strawmen, as modified by the specific recommendations, are provided as an attachment to this report (Attachment 2).

Discussion.
Canada has implemented an EM system with paper logbooks, but the development of electronic logbooks (e-logbooks) may have an important efficiency benefit when it comes to reviewing camera information. While PSMFC has developed an e-logbook prototype based on current state logbooks, the data needs for EM with cameras are different and development should start from scratch. E-logbooks need to have information that is somewhat different from the current state trawl logbooks. The development of e-logbooks may also benefit other sectors. There is a longstanding direction from the Council to develop e-logbooks for the fixed gear fishery. It may be useful to consider the data elements and standard format in which e-logbook data will have to be provided and then leave flexibility for others to develop protocols and software that meets that standard.

The EFPs issued for the whiting catcher vessel fleet from 2004 through 2010 may provide a good starting place for designing an EM program. However, those EFPs did not apply to other sectors of the fleet and the whiting fishery now operates under a quota share program which incentivizes different behaviors than did the pre-catch share fishery. Therefore work may be required to adapt previous EFP provisions to today's fishery. The 2010 whiting vessel EFP and a related statement of work is provided as an attachment to this document (see Attachments 4 and 5).

For one design approach, the Council might identify as a design criteria a maximum cost that would acceptable and then develop a program based on that criteria. If such an alternative can be developed then other alternatives could be explored to further lower costs.

An EM program should not be evaluated against an assumption that the existing human observers are providing 100% accurate and complete monitoring. For this first EM effort we should not focus on designing an EM system to perform tasks or meet higher standards than a human observer (though in some cases the EM system will do so, e.g. continuous deck monitoring).

For the nonselective discards[4] allowed under some strawman options, information on retained catch may be used to estimate species composition of the nonselective discards.

Any advance on feasibility of EM for one segment of the vessels participating in the trawl catch share program is likely to benefit the overall fishery, particularly with respect to gear switching and vessels fishing fixed gear. Eventually there may be collateral benefits for the fixed gear limited entry and open access fisheries.

On the one hand, it might be most effective to proceed with EM for some gears within the trawl catch share program while needed protocols and technologies are developed for other sectors. On the other hand, performance standards for EM for all sectors might be developed in regulation, and then implementation could occur as soon as someone brings forward a system that meets those performance standards.

The comment was made that there is no existing design out there that is ready to apply and appropriate to the specifics of this fishery. Looking at the shortcomings that designs for other fisheries would have if applied in this fishery is not likely to move us forward. We need to focus on developing the best approach for this fishery. A potential program that would work should be designed, the costs evaluated, and additional research done on that basis.

It was noted that the results on fixed gear studies report numbers of fish and that this information needs to be augmented with weight estimates, possibly based on length weight relationships—assuming that discard is being allowed. On the other hand, if it is to be a maximum retention fishery, then we only need to be certain of compliance with maximum retention. Maximum retention will probably reduce the costs of video analysis relative to allowing selective discards.

With respect to compliance issues and possible discarding of nonIFQ species, it is important to keep in mind that there are a number of compliance standards to be met including individual quota, but also ACLs for species that are not under the trawl catch share plan.

It is likely easier to develop systems that include “tamper evident” components than “tamper proof” components.

During other discussion, it was noted that there is not a clear agreement on what counts against quota when there are operational discards in a whiting fishery. This needs to be cleared up before implementing EM.

Recommendations.

- The workshop participants did not feel it useful to focus on alternatives which would require a minimum of four years to perfect, however, attention to structuring the program to facilitate rapid adoption of new improved technologies and procedures as they become available should be considered as part of the current process.

[4] Discards which are released through net bleeding or other techniques that do not target the discard of particular species in the catch

- For all sectors, the issue of the necessity of a ban on night fishing needs to be explored further. There is currently a regulatory ban on night fishing in the whiting fishery (Section 661.131(f)[5]). There is some reason to believe that images may be clearer at night, with appropriate lighting, than during the day. The PSMFC study may provide an opportunity to do needed research. For the bottom trawl fishery in particular, ability to fish at night is crucial, especially in winter months in the north when there may only be 8 or 9 hours of daylight. With respect to any ban on night fishing, it would be haul back, rather than setting, that would be the issue. Ability to night fish might be considered as a criterion around which an alternative is developed.

- Include a retention option which would allow the discard of small sized sablefish and lingcod to meet conservation objectives. Vessel revenue might be increased if this were combined with a proposal being considered under trawl rationalization trailing actions, which would give survival credit for discards.

- If halibut are allowed to be discarded at-sea, the option in the initial strawman that specifies that all halibut are assumed dead would not reflect what occurs in the fishery. Another approach would be to use the historical observer information to estimate a likely average halibut mortality rate by gear type and fishery and to update those estimates over time based on observer data from more recent observations. Individual accountability would still provide an incentive to avoid halibut catch, however survivability would be based on fleetwide averages, therefore there would be less direct incentive to modify fishing strategies and handling techniques to minimize the mortality rate on each haul or set.

- Adding objectives for each strawman would be useful.

- The strawmen should note that compliance with monitoring is required only while participating in the IFQ fishery.

- Before implementing EM, obtain a clear agreement on what counts against quota when there are operational discards in a whiting fishery.

- Consideration needs to be given to how the West Coast system might be coordinated with requirements for Alaska programs.

- Workshop participants believe there would be utility in convening a workgroup to continue development of the alternatives and has recommended that the appointment occur at the June Council meeting.

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[5] "Vessels fishing in the Pacific whiting primary seasons for the Shorebased IFQ Program, MS Coop Program or C/P Coop Program shall not target Pacific whiting with midwater trawl gear in the fishery management area south of 42°00′ N. lat. between 0001 hours to one-half hour after official sunrise (local time)."(660.131(f))

Information Request. Observers have now collected two years of data on activities for the mothership whiting and shoreside whiting catcher vessels. Observer information was not available during the cameral monitoring that was done on whiting vessels under experimental fishing permits (EFPs) of the previous decade. A summary of that information would be useful for the design of an EM system.

Information Request. While it is difficult to make cost estimates without knowing program design specifics and participation rates, it might be useful to develop estimates that bracket a reasonable ranges of assumptions. With multiple uncertainties bracketing might be difficult but may provide information that will help assess tradeoffs during program design.

Information Request. Ask for an evaluation of video quality for whiting hauls delivered in darkness under the whiting EFP and an assessment of whether there is enough of such video to have confidence in EM at night on whiting vessels.

Electronic Monitoring Co-ops

Presentation

Mr. Matthews also presented a concept for an electronic monitoring co-op (EMC) (Attachment 3). An EMC would be a co-op formed to monitor and provide incentives for compliance with Federal regulations governing EM. Vessels participating in the groundfish trawl catch share fishery would be given the option of meeting the monitoring requirements either through carrying a human catch monitor on their trip or joining an EMC and carrying and using EM equipment.

Discussion

There was extensive discussion on this issue. The key incentive for participation is that only vessels participating in the co-op would be allowed to use cameras. A remaining question was “What would be the incentive for the co-op to enforce EM criteria on its members?” The incentive structure for a monitoring co-op would be different than for co-ops in which all members mutually benefit and rely on one another to keep bycatch rates down, or otherwise harvest the proper amount of fish. Under such programs, the amounts caught are tracked through government monitoring programs, not by the co-op. This provides the crosscheck which ensures co-op performance. To ensure performance of a monitoring co-op, would there have to be requirements for the co-ops proscribed through regulation, and if so, would there then have to be enforcement and monitoring applied to the co-op? A heavy regulatory proscription might defeat the purpose of the co-op, though an effectively performing co-op might more rapidly respond to compliance problems than could occur through the court system. Are there other methods to ensure co-op performance, such as relying on a quasigovernmental organization to manage the co-op, such as the PSFMC?

An indicator of the potential value of co-ops for encouraging compliance, as an alternative to the court system, is the low rate at which cases of possible violations caught on camera are taken to court. For the EM which occurred under shoreside whiting EFPs, despite some indication of possible violations (18 cases of unreported discards caught on camera were referred for possible enforcement action) there were never any that were taken to court because vessel owners claimed the discards were required for safety reasons.

In addition to compliance advantages, a co-op might also be able to more rapidly adopt new technologies and procedures. EM is not just about cameras, there are a large number of elements which have to be designed to work together.

Another approach to providing a compliance incentive might be to include in the program a blanket adjustment such that, if something inappropriate happens on camera on a particular trip, there would be an additional precautionary deduction from the vessels account – some proportion of the total catch on the trip.

Another factor to consider in evaluating the utility of co-ops is the additional cost to manage them.

Recommendation. EMCs are a potentially innovative approach which warrants further consideration.

Workshop Objective 3: PSMFC 2013 Field Study Design

Statistical analysis of risk of missing rare events

Presentation

Mr. Dave Colpo presented a statistical analysis of the risk of missing rare events during video review. The study was conducted by Jennifer Cahalan (Rare Events Simulation Study Presentation, starting on slide 4). The EM program may rely on fishermen logbook entries to document catch and discard events, validated with video review. One design element having a substantial impact on costs will be proportion of the video reviewed to audit the accuracy of logbook entries (a 100% census or some lower rate of sampling). An analysis was conducted to indicate the probability that different rates of video sampling would detect the catch of rarely caught species (overfished rockfish species) (PFMC EM Workshop Agenda Item E.1, Attachment 1 - PSMFC - Rare Events). The study used 2011 observer data for non-hake IFQ trips using bottom trawl, hook and line, and pot gears and focused on six rebuilding species (bocaccio, canary, cowcod, darkblotched, POP, and yelloweye). A simulation exercise evaluated 10%, 25%, and 50% minimum sampling rates applied to a data set with 1,471 observed trips. For this exercise, it was assumed that if a discard was observed that the camera would have detected the event. The analysis indicated that for species that were rarely caught and discarded on observed trips in 2011, even very high video sampling rates, on a fleetwide basis, would have a low probability of detecting a discard events for some species.

Discussion

If discarding were to increase under cameras (and in the absence of observers) the probability of detection would increase. It was noted that there is management uncertainty for all fisheries and that these results might still be robust when compared to sampling challenges in other fisheries. Additionally, the probability of rare event detection might be increased by increasing the sampling rate on those trips with higher bycatch risk, as indicated by gear, depth, and area of fishing.

The success of an EM monitoring model based on verification of logbook entry through video sampling might rely on a strong penalty structure associated with keeping an accurate log book. Another working model would use EM for accurate catch accounting (e.g., discard chutes equipped with cameras) and compliance (e.g., more cameras to verify the discard chute is being used for all discards).

2013 study design

Presentation

Mr. Dave Colpo presented the 2013 PSMFC EM study design (PSMFC Project – 2013 Study Design Presentation, starting on slide 2, and PFMC EM Workshop Agenda Item E.2, Attachment 1 - PSMFC 2013 Design). Fixed gear (both pot and line gears) and trawlers are proposed for participation in the study. There are no directed whiting vessels in the study although some bottomfish trawlers are expected to participate in whiting. Currently, there is verbal agreement for 12 vessels to participate. The study might be able to fund as many as about 15 vessels of each gear type. PSMFC is presently looking for more vessels to participate and there still may be opportunity for more vessels to join after April. The study includes full retention of catch except for halibut, salmon, large fish (sharks), and logs/crab pots, etc. (any catch that could be pumped into the hold will be retained[6]). It was recommended that Dungeness crab should not be retained in the study. With respect to geographic coverage the study is being expanded into Oregon and Washington. Funds for the study are available through June 2014.

Archipelago Marine Research Ltd. (AMR) is providing cameras and support for the study. All AMR video will be reviewed by PSMFC with AMR providing support if needed. Saltwater Inc. is providing support for Oregon fixed gear vessels.

Observer data analysis associated with the 2012 study will be presented at the April Council meeting.

Discussion

The group discussed the possibility that the EM work already done on whiting vessels may be sufficient to support moving ahead with EM in that fishery.

It was noted that experience is needed with deck lighting for whiting and non-whiting (including fixed gear) efforts at night. There was some question as to whether night fishing would be an issue in the whiting fishery. Whiting are dispersed at night and there are bycatch concerns with whiting fishing at night. There have been some hauls that were delivered in darkness and monitored with cameras. These hauls could be evaluated for the effectiveness of camera monitoring. It was noted that the challenge with night video monitoring is not with respect to retained catch but with respect to discards, some of which occur through net bleeding. The biggest problem may be lighting on the water to evaluate and potentially enumerate net bleeding and other forms of operational discard. Otherwise, deck lighting on whiting vessels seems sufficient.

[6] This is a criterion – catch is not routinely offloaded using a pump.

Question was raised as to the hypotheses being tested through the PSMFC program. The initial focus has been garnering experience using this technology. During the discussion, Mr. Colpo stated that PSMFC might vary retention and discard activities to test EM.

There was a discussion of the value of reviewing the study design within the Council process. Such review provides an opportunity to reduce the probability of design flaws and increase the amount of useful information generated by the study. Absent some sort of a small work group on program design, the Council would likely rely on the SSC for comments at the April Council meeting. It would be better for the SSC to review than to generate hypotheses for testing.

Concern was expressed that the study might miss a geographic quadrant that could hamper implemetnation. Mr. Colpo stated that the study was reliant on the distribution of effort of the vessels that volunteered to participate but that there was opportunity for other vessels to volunteer.

Video for 2012 has been reviewed but not yet analyzed and there is no plan to test electronic log books as part of this study. This could be added but has not been a priority. Paper log books can be used and then developed into an electronic log book later. The incorporation of electronic logbooks into the program would likely be more rapid, not requiring additional years of study. If there is a marginal cost to evaluate electronic log books, then that should be considered.

Mr. Colpo was asked whether operational discards will be analyzed and enumerated and replied that they will attempt to enumerate fish discarded before coming on deck, although this is difficult in the whiting fishery. They will more precisely enumerate discards off the deck.

It was suggested that to test cameras vessels be asked to operate as if there were no observer, operate as they would have two or three years ago. This would help develop software for detecting activities that might indicate discard events. Such a study design might or might not require an EFP.

Dr. Hamel said the SSC is concerned that they need to evaluate normal discard behaviors, that there needs to be discard behavior along the lines of what would be expected with cameras in place. There is some utility of experimenting with EM without observer interference. If salmon and halibut are being discarded, will there be individual images of those fish? If that can be done, it will begin to indicate what might be done with other species of fish. They are concerned that EM needs to discern individual fish, including lengths of fish discarded. Some subsampling of video will provide a statistical analysis of subsampling protocols. Finally, a variety of fishing vessel types (i.e., gear types) and sizes need to be included in the study. Mr. Colpo indicated he would continue a conversation with Dr. Hamel. Other workshop participants concurred on the need to evaluate cameras based on the behaviors likely to occur in the absence of observers.

During discussion it was suggested that for fixed gear vessels the effect of observers, in contrast to no coverage, could be tested while the vessels are operating in the limited entry fixed gear fishery, where there is only partial observer coverage. A contrast between EM and observers (or no observers) might be investigated using data from fixed gear vessels that gear switch in the trawl fishery and also participate in the limited entry fixed gear fishery.

Workshop participants agreed study design needs to address EM objectives and provide information helpful to decision-makers.

Recommendations.

- Dungeness crab should not be retained in the study.
- It would be advantageous to experiment with deck lighting at night for whiting and non-whiting (including fixed gear). The biggest problem may be lighting on the water to evaluate and potentially enumerate net bleeding and other forms of operational discard.
- Video from the study should be used to evaluate the effectiveness of image recognition software.
- Study halibut viability and correlate to length of tow, time on deck, water, and air temperatures along with standard IPHC viability criteria.
- Experiment with EM without observer interference.
- Evaluate cameras under normal discard behavior conditions.
- Attempt to discern individual fish to species and include lengths of fish discarded.
- Subsample video to provide a statistical analysis of subsampling protocols.
- A variety of fishing vessel types (i.e., gear types) and sizes need to be included in the study.
- The study should include at least one vessel rigged with a fish discard conveyer equipped with a camera to test that configuration.
- Consult with the observer program for its protocols on what counts as a discard.

Workshop Objective 4: Possible Regulation Amendment Process for Consideration of Electronic Monitoring

Presentation

Mr. Jim Seger presented a draft possible regulation amendment process for consideration of EM (PFMC EM Workshop Agenda Item F, Attachment 1 – Draft Calendar). The calendar is provided below, as revised based on workshop participant recommendations.

Discussion

The participants noted that the 2012 PSMFC study results are important to support the actions outlined on the schedule. Further, the 2013 study design should be scientifically robust and support industry operations and regulation development. The schedule must therefore provide for sufficient time for communication between various entities.

EFPs could be used to support Council action and the development of the regulatory package. The process for the 2013-2014 EFPs has already been completed. Consideration for 2015-2016 EFPs is currently scheduled for November 2013 (preliminary) and June 2014 (final). Participants noted that off cycle EFPs could be considered since the proposals do not require additional set-asides (i.e., EFPs would operate under the permit holders QP).

Participants acknowledged that an expedited schedule might be possible if the Council could prioritize implementation by gear type and fishery.

Recommendation: The following is the draft process that workshop participants recommend the Council consider for moving forward with an EM program.

Dates	**Process Considerations**	**Comments**
	• PSMFC continues preliminary planning for 2013 season and in anticipation of likely Council guidance.	
Apr 2013	• Consider results of EM workshop and recommendations • Adopt goals and objectives. • Provide guidance on development of scoping package. • Request *special studies*, as needed. • Consider results of the 2012 PSMFC EM study. • Provide comment on the 2013 PSFMC EM study design. • Adopt regulatory process plan.	Consider whether any regulatory changes should be pursued, if the NMFS/PSMFC field project demonstrates potential feasibility (for just whiting catcher vessels?)
Spring 2013	• NMFS/PSMFC finalize 2013 study design (starting in April – w/Council meeting results).	
June 2013	• Full scoping session on EM. • Appointment of workgroup on this issue.	
Summer 2013	• Execute at-sea and shoreside field studies	
Sept 2013	• Review results from *special studies* and provide guidance on alternative development (if necessary).	
Nov 2013	• Consider initial results of NMFS/PSFMC 2013 field season • Adopt alternatives for analysis.	
June 2014	• Consider full analysis of alternative. • Select preliminary preferred alternative.	
Sept 2014	• Select final preferred alternative.	
Sept 2014 through 2015	• Secretarial approval process and implementation, including ○ regulation drafting and paperwork reduction act submissions, ○ securing contracts for video review, ○ commercial installation and testing, and ○ observer program adjustments.	

Attachment 1 – Draft Purpose and Need Statement

These circumstances, under which electronic monitoring (EM) was originally rejected, have changed. Fishery managers have now had two years of experience under the program, which has provided a better understanding of how the fishery performs and how fishermen operate under the program. This has reduced some of the uncertainty about potential unintended consequences. Now, increasing information is becoming available on the performance of EM and there is time to more carefully consider the utility of EM relative to human observers. There are a number of needs that an alternative to monitoring with observers may address. First, for vessels, the need to pay for vessel observers is one of the most expensive compliance costs associated with participation in the trawl catch share program. For the first years of the program, NMFS has subsidized observer costs to help the fleet though the period of adjusting to the new management system. Overall fleet profits, and consequently the price of quota, will be below what they might otherwise be if less expensive monitoring is available. Second, small vessels may be disproportionately affected by observer costs. Vessels are billed for observers on a per day basis, and because smaller vessels have a lower total revenue per day at sea [this statement needs to be verified with data] observer costs reduce vessel net revenue disproportionately more than for larger vessels. On this basis, over time it might be expected that quota will migrate to larger vessels and there will be fewer smaller vessels in the fleet—assuming small vessels do not have other countervailing advantages. Third, because of the overhead involved with maintain observer availability in small somewhat isolated ports with relatively low demand for observers, at least one observer company has indicated that it may pull out of at least one of the small ports on the West Coast. Thus, over time, smaller ports may be disadvantaged by the observer requirement, relative to larger ports. Fourth, if overall monitoring costs can be reduced (those borne by both private parties and the public), national net economic benefits may be increased. And finally, the observer fee system puts pressure on vessels to fish in unsafe conditions. Because vessels are billed on per day both for at-sea and for standby time, vessels may incur higher costs for standing down due to marginal weather conditions. In summary, the needs for action are:

- to reduce total observer costs for the fleet as a whole,
- to reduce relative cost burden for small vessels,
- to ensure that vessels operating out of smaller ports have an equitable opportunity to acquire observers,
- to increase national net economic benefits, and
- to reduce the pressure on vessels to fish in poor weather

while at the same time providing for catch monitoring adequate to maintain full functionality of the trawl catch share program, in particular with respect to maintaining individual accountability.

While considering policy adjustments to meet these needs, there is also a need to ensure continued collection of adequate scientific data on the fishery. The effect of any changes in observer coverage on the quantity and quality of other biological and habitat data will need to be considered and appropriate adjustments made. On the one hand, the use of EM may reduce the amounts of some types of data collected by the fishery monitoring system. On the other hand, it is possible that EM might otherwise mitigate some of the potential losses or that the amounts of other types of useful data might be increased.

Attachment 2 – Electronic Monitoring Strawmen

Electric Monitoring Strawmen for Consideration

For these strawmen, the general goals and objectives of the program apply. There may be some additional objectives pertaining to each strawman alternative.

- Midwater Trawl for Catcher Vessels Delivering At-Sea
    - Additional Objective – ensure no selective discarding
    - Others?
- Midwater Trawl for Shoreside IFQ Deliveries
    - Additional Objective – ensure no selective discarding
    - Others?
- Bottom Trawl (Large and Small Footrope, including Flatfish Trawl)
    - Additional Objective – ensure no selective discarding
    - Others?
- Vessels Participating in Trawl catch share Program Using Fixed Gear
    - Additional Objective – For retention option allowing discard of IFQ species, provide species and weight for discarded IFQ species.
    - Others?

Midwater Trawl for Catcher Vessels Delivering At-Sea

Maximum Retention / Full Accountability Fishery:

- Non selective discards only ("Non selective" discards are discards made without selecting for species – for example, as a result of bleeding a net.)
- Regardless of why or how the discard happened, the vessel will be held accountable for the discard and deductions will be debited from IFQ vessel accounts.

Electronic Monitoring Plans (EMP):

- Each camera system application will have elements unique to the vessel (similar to the catch monitor plan for first receiver site licenses)

System Components:

- Tamper Proof or Tamper Evident System, Secure/Watertight Data Storage, Digital Cameras, Encrypted Data, Sensors, Deck/Stern Lighting, Bridge Monitor, GPS, VMS, Geo Fencing, E-logbook, Maximum Retention, Video Analysis by Sustainable Fisheries Division (SFD) and Pacific States Marine Fisheries Commission (PSMFC).

System Configuration:

- Consistent with previous standards, i.e. EFP and PSMFC pilot.
- E logbook compatibility

Data Analysis:

- Responsibility of SFD/PSMFC
- Models to consider
  - (1) A system similar to the one used by Archipelago for the shoreside whiting fishery EFPs. This approach involved an analysis team reviewing all data or subsamples from all vessels from the time of first set to the vessel's return to port and is labor intensive. See Attachment 4 to Electronic Monitoring Workshop Report. [7]
  - (2) Others options?

Regulation Considerations:

- Time and Area Restrictions.
  - Option 1: Prohibit night fishing. Currently there is a limited prohibition on night fishing: "Vessels fishing in the Pacific whiting primary seasons for the Shorebased IFQ Program, MS Coop Program or C/P Coop Program shall not target Pacific whiting with midwater trawl gear in the fishery management area south of 42°00′

[7] Software analysis model being developed and tested by Alaska Science Center to narrow video review to times when events occurring on the deck with potential species identification through software capable video imagery analysis. Because it is expected that this would require a minimum of 4 years to perfect, EM Workshop participants recommended that it not be included in options for consideration.

N. lat. between 0001 hours to one-half hour after official sunrise (local time).”(660.131(f))
    - Option 2: Allow night fishing, with adequate artificial lighting (NOTE: Viability of artificial lighting needs to be demonstrated. Some comment indicates that artificial light conditions may be superior to daylight for video monitoring).
- Use EM as implemented for Amendment 10 as template (see Attachment 4 and Attachment 5 to this report).
- Update equipment specs to reflect upgrades in the technology.
- Use specs approval process to update technology specifications in the future.
- Will need regulations or other administrative process to determine methodology for estimating discards, large and small, for deducting vessel accounts.
- Others?

E-logbook:

- Verification of randomly selected video against log book entries allows for audit procedure that reduces the need to review 100% of the video data
- Log Book is a self reporting component that along with camera establishes trust and verification of the data. State long books will need to be modified for reporting discards and expanded specifications.
- E-logbook needs to be compatible with camera, i.e. timestamp and GPS
- E-logbook will use state log book as template and convert format from paper to electronic, i.e. same approach used in e fish tickets
- Federal and state regulations will need to be addressed making groundfish log books a Federal Requirement.
- E-logbooks have a significant “value added” component to their development and implementation.

Biological Sampling

- Presume the pre-IFQ NW Science Center sampling program will continue.
- Observers deployed on a percentage basis, with data extrapolated across the fleet.

Note: Compliance with monitoring requirements would apply only while a vessel is participating in the trawl catch share program.

Midwater Trawl for Shoreside IFQ Deliveries

[Covers both whiting targeting and other targeting with midwater gear (e.g. pelagic rockfish)]

Same as for “Midwater Trawl for Catcher Vessels Delivering At-Sea” except

[no differences at this time]

Bottom Trawl

Large and Small Footrope, including Flatfish Trawl

Same as for “Midwater Trawl for Catcher Vessels Delivering At-Sea” except

- Maximum Retention / Full Accountability Fishery
  - Add a suboption to allow discard of small sized sablefish and lingcod.

- Data Analysis – additional comments
  - Cameras, to date have not proven adequate for species identification let alone length and weight calculations.
  - For trawl, passing under a camera using some type of measurement scale has proven feasible in some controlled experimental environments.
  - Could prove to be extremely labor intensive which increases the cost significantly.
  - Software analysis may provide mechanism for species identification and catch accounting, but years away from implementation
- Halibut viability measures may be needed:
  - Option 1. All halibut considered dead under the camera option.
  - Option 2. Long-term potential for developing a different type of halibut viability model (additional research required)
  - Option 3. Use the historical observer information to estimate a likely average halibut mortality rate by gear type and fishery and to update those estimates over time based on observer data from more recent observations.
  - Others options?

- **Going Forward:**
  - We need PSMFC cameras on bottom trawl vessels this summer! With no history on camera deployment on bottom trawl we are operating at a severe disadvantage.
  - One potential would be a species identification camera/software system deployed in the net itself (a potential application of the research being done by Alaska Science Center, but we are years away).

Vessels Participating in Trawl catch share Program Using Fixed Gear

Same as for "Midwater Trawl for Catcher Vessels Delivering At-Sea" except

- May only need full retention on
  - Option 1: IFQ species,
  - Option 2: rockfish and sablefish – assuming that cameras can provide some basic species differentiation for other species.
  - SubOption (to combine with either Option 1 or 2): allow discard of small sized sablefish and lingcod.
- There are no fixed gear state logbooks from which to develop an E-logbook.
- Halibut viability measures may be needed:
  - Option 1. All halibut considered dead under the camera option.
  - Option 2. Long-term potential for developing a different type of halibut viability model (additional research required)
  - Option 3. Use the historical observer information to estimate a likely average halibut mortality rate by gear type and fishery and to update those estimates over time based on observer data from more recent observations.
  - Others options?

Attachment 3 – Electronic Monitoring Cooperative for Compliance

Creating an Incentive Based Environment for Compliance: Consideration of a Cooperative Agreement Program for Furthering Electronic Monitoring Compliance

Premise: Programs which depend upon compliance to achieve program goals and objectives, whether implemented by regulation or as a demonstration pilot are influenced by participant behavior. For example: pilot programs behavior is influenced by whether the participant wants the program to succeed or fail.

Traditionally, compliance has been pursued through either voluntary or regulated behavior. The regulatory approach which includes regulation development, enforcement, and due process can be arduous, time consuming, and expensive for all parties involved. Is there an alternative?

Cooperatives / Agreements / Contracts: The success of directing / controlling behavior derived through participants receiving perceived benefits, as seen in the At-Sea Pacific Whiting Fishery Cooperatives and IFQ Shoreside Risk Pools are achieved through the underlying agreements/contracts binding the participants.

Proposal: (*This proposal has not been vetted by General Counsel and will require significant legal analysis.)*

1. A regulation which says Compliance Monitoring (100% compliance monitoring for catch reporting) is required to fish in the Limited Entry Trawl fishery to include: MSCV endorsed vessels, Shoreside IFQ Pacific whiting vessels, IFQ bottom trawl vessels, and IFQ fixed gear vessels.

2. The compliance monitoring requirement may be met by either:
   a. Arranging for the presence of a human compliance monitor on the fishing trip, or
   b. Joining an Electronic Monitoring Cooperative (EMC) – possibly run by the Pacific States Marine Fisheries Commission and using in lieu of a human compliance monitor, an approved Electronic Monitoring System (EMS) as describes in an Electronic Monitoring Plan (EMP), provided by a certified EMS provider. Provisions for becoming an EMS provider to be developed.
      i. SubOptions: emulate certified observer provider program (Amendment 10), PSMFC as sole provider, others.

3. Federal Regulations Applying to PSFMC EMC *(list is not exhaustive, will need further development and vetting)*
   - Comply with all Federal and State Regulations
   - Maximized Retention (non selective discards only)
   - Full Accountability
   - Time and Area Restrictions
   - Data Collection Equipment Criteria
   - Data Collection Requirements
   - Vessel Responsibilities

- System Audits, Pass /Fail Criteria
- Loss of Camera use Privilege Criteria
- Vessel Operator Performance Standards and Responsibilities
- Administrative Accountabilities (i.e. conditions for permit renewal)

4. Required Elements of EMC Contract with Vessel *(again, list is not exhaustive, will need further development and vetting)*

- Comply with all Federal and State Regulations
- Maximized Retention
- Full Accountability
- Time and Area Restrictions
- Data Collection Equipment Criteria
- Data Collection Requirements / Vessel Responsibilities
- Vessel Operator Performance Standards and Responsibilities
- Discard Assessment Protocols and Procedures,
    - based on management and accounting goals and objectives
- Scale for Assessing Deductions
- Vessel Account Deduction made on "Best Information Available"
    - used as a proxy for exact poundage
- Systems Audits, Pass/Fail Criteria
- Revocation of Cooperative Membership
- Administrative Accountability
- Escape Clause

Industry Cooperative Development Committee:
As addressed above, the list(s) are not exhaustive, especially regarding behavior that the cooperative would like to see emulated by the participants. In that regard, a committee of industry participants should be convened to:

(1) Do further provision scoping for consideration/inclusion in the EMC industry agreement contract, and
(2) Develop a list of vessel operator performance standards and responsibilities, along with
(3) Proposed accountability measures for those who ignore or underperform said performance standards and responsibilities.

Attachment 4 – Shoreside Whiting EFP (2010)

Draft language for the 2010 EFP, provided to the Council on October 23, 2009 (Agenda Item G.3.b, Supplemental NMFS Report November 2009) and includes provisions to facilitate electronic monitoring, such as maximized retention. This is the type of activity allowed under Amendment 10 to the groundfish FMP. , In June 2007 the Council approved a regulatory amendment to obviate the need for continued EFPs. With the implementation of Amendment 20, and its requirement for 100% observer coverage, that regulatory amendment was viewed as no longer necessary.

1) **Project Title:** The 2010 Pacific Whiting Shoreside Fishery Maximized Retention and Monitoring Exemption Program

2) **Project coordinator:** NMFS Northwest Region, Sustainable Fisheries Division. For further information contact: Becky Renko by mail at 7600 Sand Point Way NE, Seattle, WA 98115, by email at becky.renko@noaa.gov, by fax at 206-526-6736, by phone at 206-526-6110.

3) **Purpose of the exemption program and exempted fishing permits (EFP)**

NMFS is in the process of transitioning the Pacific whiting shoreside fishery to an Individual Fishing Quota (IFQ) program with implementation planned for 2011. The purpose of the EFPs are to provide for monitoring of the fishery until the IFQ tracking and monitoring provisions are effective. The EFP would allow vessels to retain unsorted Pacific whiting catch for efficient prosecution of fishery while assuring that there is adequate monitoring at-sea and verification of electronic fish ticket reports.

4) **Specific regulations from which an exemption is being requested**

The EFP, if issued, would authorize, for limited purposes, the following activities which would otherwise be prohibited:

Under 660.306 (a)(2) it is unlawful for any person to retain any prohibited species. Prohibited species must be returned to the sea as soon as practicable with a minimum of injury when caught and brought on board. An EFP is needed to allow vessels to retain prohibited species until offloading and to require deliveries to processors participating in the program.

Under 660.306 (a)(10) it is unlawful for any person to take, retain, possess or land more than a single cumulative limit of a particular species, per vessel, per applicable cumulative limit period. An EFP is needed to allow vessels and first receivers to take, retain, possess or land more than a single cumulative limit.

Under § 660.306 (a)(7), it is unlawful for any person to fail to sort, prior to the first weighing after offloading, those groundfish species or species groups for which there is a trip limit, size limit, scientific sorting designation, quota, harvest guideline, or OY, if the vessel fished or landed in an area during a time when such trip limit, size limit, scientific sorting designation, quota, harvest guideline, or OY applied. An EFP is needed to allow Pacific whiting shoreside first receivers to use a hopper type scale to derive an accurate total catch weight prior to sorting providing that immediately following weighing of the total catch and prior to processing or transport away from the point of landing, the catch is sorted to the species groups and all incidental catch is accurately weighed and the weight of incidental catch deducted from the total catch weight to derive the weight of target species.

5) Catch information

The species (target and incidental) expected to be harvested and/or discarded under the program are similar to those observed in recent years. Please see the attached Pacific whiting shoreside fishery summary from 2008 for the expected catch by species.

Pacific whiting shoreside vessels participating with the EFP would be required to dump unsorted catch directly below deck and would be allowed to land unsorted catch providing an electronic monitoring system (EMS) is used on all fishing trips to verify retention of catch at sea.

On shore monitoring conducted by catch monitors would be required under the EFP. Catch monitors are third party employees procured from NMFS-specified providers, paid for by industry, and trained to NMFS standards. Catch monitor duties would include overseeing the sorting, weighing, and recordkeeping process. Catch monitors would also gather information on incidentally caught salmon.

Marine mammal catch will continue to be document on NMFS forms and submitted by the vessels per NMFS reporting requirements for the Pacific Coast Groundfish Fishery. The monitoring program under an EFP could be used to verify that reporting occurred.

6) Anticipated number of participants

The estimated number or EFPs that would be issued is as follows:

Catcher Vessels: 30-40
First Receivers: 12-16

7) **EFP Terms and conditions for Pacific whiting shoreside** vessels

The terms and conditions of EFPs issued to Pacific whiting shoreside vessels would include the following:

Reporting requirements:

- Vessels must have a valid declaration for midwater trawl gear in the Pacific whiting shoreside fishery
- Trawl logbooks must be maintained as required by the applicable state law.
- On each EFP trip "Maximum Retention Fishing Trip" (or "MAX") must be legibly written at the bottom of each logbook page.
- Logbooks must be completed in a timely manner and include:
    - o The estimated weight of all species and their disposition, including, prohibited species.

Maximized Retention requirements:

- All catch must be brought on board the vessel and retained until offloading, with some exceptions:
    - o Pacific whiting removed from the deck and fishing gear during cleaning may be discarded, provided that the total does not exceed one basket from any single haul, with the maximum dimensions of the basket being 24 inches by 16 inches by 16 inches. All catch in excess of the one basket would need to be placed into the fish hold. Discarding species other than Pacific whiting would be prohibited.
    - o Large individual marine organisms, such as marine mammals or fish species longer than 6 ft (1.8 m) in length, could be discarded provided the species and the reason for discarding were properly recorded in the required logbook.
    - o All incidentally caught marine mammals would need to be documented in the vessel logbook and reported to the NMFS Office of Protected Resources by submitting a completed Marine Mammal Authorization Program mortality/injury report form.
- All prohibited species incidentally caught in a midwater trawl, and required to be retained under this section, would be abandoned to the State of landing immediately upon offloading.
- All groundfish caught in excess of the trip limits would be abandoned to the State of landing immediately upon offloading.
- No vessel could receive payment for any fish landed in excess of any cumulative trip limits.
- All fish from a delivery must be offloaded at only one first receiver.

EMS requirements:

- Owners of vessels participating in the Pacific whiting shoreside fishery, would be required to arrange for EMS services from a NMFS-approved provider and pay all associated costs.
- Vessels required to procure EMS services may also be required to pay for and carry a third-party observer or an NMFS West Coast Groundfish Observer Program observer.
- The vessel operator would be required to schedule maintenance of EMS equipment.
- One each trip prior to leaving port, the vessel operator must conduct an EMS status check as specified by the EMS provider to confirm that all components of the EMS are functioning properly. The EMS will record the results of this check. If the EMS check identifies a malfunction, the vessel must contact the NMFS-specified EMS provider immediately.
- From 30 minutes before official sunset until 30 minutes after official dawn, each vessel required to have EMS would be required to provide lighting to areas where the trawl nets and fish are handled and fish hold openings, deck spaces, and the trawl ramp so the activities could be clearly recorded by the EMS cameras:
- When aware that EMS is not functioning properly or the power has been interrupted, the vessel operator would be required to immediately contact the EMS service provider.
- The vessel is obligated to monitor the EMS performance and contact the EMS service provider immediately when the system malfunctions. The EMS provider is required to provide technical service within 24 hours of notification.

Prohibited actions:

- Failure to comply with all EFP requirements.
- Failure to maintain the trawl logbook as required by the State of landing and the EFP.
- Delivery of unsorted whiting catch to first receivers that do not hold EFPs.
- Fish with a vessel that does not have properly installed and functioning EMS equipment and an observer when the vessel has been notified of the added requirement to carry an observer.
- Tamper with, disconnect, damage, destroy, alter, or in any way distort, render useless, inoperative, ineffective, or inaccurate any component of the EMS unit.
- Fail to provide notice to NMFS of any interruption in the power supply to the EMS unit or intentionally interrupting the power supply to the EMS unit (failure to provide notice to NMFS OLE will be considered as an intentional interruption);
- Use a gear other than midwater trawl gear.
- Fail to have a valid declaration report for midwater trawl.
- Target a species other than Pacific whiting when the vessel has a declaration for midwater trawl gear in the Pacific whiting fishery.
- Fail to abandon all prohibited species and overage catch to the state of landing
- Fail to bring all catch onboard the vessel and retain that catch until offloading, with the exception of large marine organisms and operational discards.
- Fail to cease fishing and return to port immediately following a discard event of more than one basket of fish.
- Fish for, land, or process fish without observer coverage when a vessel is required to carry an observer under § 660.314(c).

8) **EFP Terms and conditions for Pacific whiting shoreside first receiver**

The terms and conditions of EFPs for Pacific whiting shoreside first receivers would include the following:

Maximized retention requirements:

- Procure catch monitor services from a NMFS approved catch monitor provider and pay all associated costs.
- Catch monitors would be required for all Pacific whiting shoreside fishery deliveries by vessels holding EFPs.
    - Pacific whiting shoreside fishery landings are those landings taken during the primary season by a vessel declared to be using limited entry midwater trawl. Catch monitor would be given notification in person, by personal communications radio, or by telephone of planned facility operations, including the receipt of fish, at least 30 minutes and not more than 2 hours prior to the start of the planned operation.
- Catch monitors would be give free and unobstructed access to the catch throughout the sorting process and the weighing process.
- Catch monitors would be given free and unobstructed access to any documentation required by regulation including fish tickets and scale test results.

- Catch monitors would be given free and unobstructed access to a telephone and facsimile during the hours that Pacific whiting is being processed at the facility and 30 minutes after the processing of the last delivery each day.
- The owner or manager of each Pacific whiting shoreside first receiver would be required to provide reasonable assistance to the catch monitors to enable each catch monitor to carry out his or her duties. Reasonable assistance includes, but is not limited to: informing the monitor when bycatch species will be weighed, and providing a secure place to store equipment and gear.
- The owner or manager of each Pacific whiting shoreside first receiver would be required to adhere to all applicable state and federal rules, regulations, or statutes pertaining to safe operation and maintenance oaf processing and/or receiving facility.

<u>NMFS-Approved Monitoring plans</u>:

- Each Pacific whiting shoreside first receiver would be required to have a NMFS accepted monitoring plan before being issued an EFP.
- A monitoring plan would be submitted to NMFS by the owner or manager of a first receiver at least 14 days prior to receiving Pacific whiting shoreside fishery deliveries.
- The catch monitoring plan must include the following types of information:
    - Name and signature of the person submitting the monitoring plan.
    - Address, telephone number, fax number and email address (if available) of the person submitting the monitoring plan;
    - Name and location of the first receiver;
    - A detailed description on how the first receiver will meet the weighing and sorting requirements including:
        - The sorting locations and the amount of space for sorting catch, the number of personnel assigned to catch sorting and the maximum rate that catch will flow through the sorting area.
        - Personnel skills and training for sorting catch to federal species groups.
        - The process for weighing catch, including large and small volumes of target and incidentally caught species.
        - The scale makes and models being used to weigh catch during the Pacific whiting shoreside fishery, including the most current test date provided by the Department of Weights and Measures for the state of landing and whether or not the scale met the testing criteria either initially or upon retesting.
    - A description of how the catch monitor requirements would be met, including:
        - How the first receiver operates and maintains a safe processing and/or receiving facility.
        - Who would be responsible for notifying the catch monitor of planned facility operations, including the receipt of fish.
        - How the catch monitor would be given access to the catch throughout the sorting process and the weighing process and to any documentation required by regulation including fish tickets and scale test results.
        - The name and contact information for an individual(s) who will be responsible for assuring that the catch monitor obtains the necessary information from the first receiver.

    - o A description of when and where prohibited species will be counted.·
- NMFS will review the monitoring plans within 14 days of receiving a complete monitoring plan submission. If NMFS does not accept a monitoring plan the first receiver owner or manager may resubmit a revised monitoring plan.

Specifications and management measures:

- An allowance would be made to allow Pacific whiting shoreside first receivers that use a hopper type scale to derive an accurate total catch weight prior to sorting. Providing that immediately following weighing of the total catch and prior to processing or transport away from the point of landing, the catch must be sorted to the species groups and all incidental catch (groundfish and non groundfish species) is accurately weighed and the weight of incidental catch deducted from the total catch weight to derive the weight of target species.

Prohibited actions:

- Receive for transport or processing, catch from a Pacific whiting shoreside vessel without obtaining verification from vessel personnel that the vessel has an EMS from the NMFS provider installed on the vessel
- Process catch without coverage oaf catch monitor unless NMFS has granted a written waiver specifically exempting the first receiver from the catch monitor coverage requirements.
- Fail to sort fish to federal species groups.
- Process, sell, or discard any groundfish received from a Pacific whiting shoreside vessel that has not been accurately weighed on a scale and accounted for on an electronic fish ticket report
- Fail to weigh fish landed from a Pacific whiting shoreside vessel prior to transporting the catch away from the point of landing.
- Mix catch from more than one delivery prior to the sorting and weighing of catch.
- Fail to allow the catch monitor unobstructed access to catch sorting, processing, catch counting, catch weighing, or electronic or paper fish tickets.
- Fail to provide reasonable assistance to the catch monitor.
- Forcibly assault, resist, oppose, impede, intimidate, harass, sexually harass, bribe, or interfere with a catch monitor.
- Interfere with or bias the procedure employed by a catch monitor.
- Tamper with, destroy, or discard a catch monitor's equipment, records, photographic film, papers, or personal effects without the express consent of the catch monitor.
- Harass a catch monitor by conduct that: has sexual connotations, has the purpose or effect of interfering with the catch monitors work performance, and/or, otherwise creates an intimidating, hostile, or offensive environment.
- Require, pressure, coerce, or threaten a catch monitor to perform duties normally performed by processor employees.

Attachment 5 – Shoreside Whiting Electronic Monitoring Statement of Work (2010)

NOAA Fisheries
Electronic Monitoring System Project for the
2010 Pacific Whiting Shoreside Fishery

1.0 Background

1.1 Overview

The Northwest Regional office (NWR), and the Office for Law Enforcement (OLE) of the National Marine Fisheries Service (NMFS), National Oceanic & Atmospheric Administration (NOAA), Department of Commerce (DOC) are the government offices responsible for managing the West Coast fisheries and for monitoring compliance with fishery regulations. Within the NWR, the Sustainable Fishery Division (SFD) is responsible for managing the Pacific whiting fishery off the West Coast.

This contract is in support of an at-sea monitoring program administered by SFD in cooperation with OLE for the purpose of compliance information collection. The monitoring program uses an Electronic Monitoring System (EMS) that is designed to be a cost effective means to collect specific types of at-sea fisheries information.

This statement of work describes an EMS project for commercial trawl vessels participating in the Pacific whiting shoreside fishery off the coasts of Washington, Oregon, and California. The overall goal of this project is to refine an EMS system so it can be effectively used to collect at-sea information for monitoring compliance with catch retention and closed area requirements. The EMS would be used to collect vessel information from digital closed circuit television (CCTV), information from global positioning systems (GPS), and information from other on-board sensors. The information will be analyzed and presented to OLE and SFD for assessing the effectiveness of retention requirements and area restrictions and for incorporation into the process for developing a new regulatory program for the Pacific whiting shoreside fishery. The project will include six major objectives: providing industry outreach; supplying an adequate number of EMS units that meet the specifications and performance requirements; successfully installing the EMS equipment on vessels; maintaining the EMS equipment throughout the season with minimal system down time; reviewing EMS information and compiling information by vessel; and providing a final report that can be used to assess the effectiveness of the EMS monitoring. The final report should include a comparison of previous years success, information to assess the level of non-compliance with the terms and conditions of EFPs, and recommendations for future improvements.

From 2004 to 2006, the NWFSC paid for the entire EMS project. During the 2007 season, the cost of EMS was shared between the participating industry members and NOAA Fisheries. All vessels participating in the Pacific whiting shoreside fishery in 2007 were required to pay for the installation, lease, maintenance (in part) and removal of EMS equipment during the entire season. The outreach, maintenance (in part), analysis and production of the results were paid for by NOAA Fisheries. In 2008 and 2009, all participating vessels were again required to pay for the use of EMS equipment, installation, and removal, plus they were also asked to pay for all EMS maintenance and half of the initial cataloging of information collected from their vessel. The final report and industry outreach were paid for by NOAA Fisheries. In 2010, the vessels and NOAA Fisheries responsibilities would be the same as in 2008 and 2009.

Pacific Whiting Shoreside Fishery

The Pacific whiting shoreside fishery is a midwater trawl fishery in which most vessels fish under exempted fishing permits (EFPs). The EFPs require maximized retention of the catch until the vessel is offloaded in port. Maximized retention encourages full retention of all catch while allowing minor discarding of very large species (>6 feet in length) and small amounts (<150 pounds) associated with fishing operations. Unsorted catch is placed into refrigerated salt water holds and is delivered to land-based Pacific whiting first receivers. Fishing trips typically last one-two days.

Annually, up to 40 vessels deliver their catch to roughly 16 first receivers in seven ports. The major portion of the fleet operates out of three Oregon ports, Charleston/Coos Bay, Newport and Astoria. The remaining portion of the fleet delivers catch to Illwaco, Washington, Westport, Washington, Eureka, California and Crescent City, California.

Timeline

The term of this project is approximately twelve months with the option for a second twelve month term. NOAA fisheries anticipates that there may be a need for EMS in 2011, during the transition to a Individual Fishery Quota program.

In most years, there are two start dates for the Pacific whiting shoreside season, coinciding with the movement of hake along the coast. The first portion of the Pacific whiting shoreside season will begin on April 1, 2010 off the coast of California and represents up to 5% of the overall shore-based allocation. If the fishery reaches 5% of the allocation, the California season is closed until the coastwide season begins June 15, 2010. In 2007 and 2008, there were three seasons because the coastwide fishery was closed early due to bycatch concerns and reopened later in the fall when bycatch limits were increased. The coastwide season primarily occurs off the Oregon and Washington coasts. Participating vessels in the early California season may also participate in the coastwide fishery.

The Pacific whiting allocation is set in the spring each year following the Pacific Fishery Management Council's March meeting where the results of new or revised Pacific whiting stock assessments are considered. The length of the Pacific whiting shorebased fishing season is closely related to increases or decreases in the allocation and well as the availability of non-whiting species that are incidentally taken. In general, the length of the Pacific whiting shoreside season is estimated to approximately 9 weeks.

Objectives overview

The contractor must provide written outreach materials that summarize the 2009 EMS program, that outline the vessel's role in procuring and using EMS in 2010; and that describes what each vessel can expect for service during the fishing season. The contractor must provide EMS units that meet the defined specifications and performance standards for all of the participating vessels. The EMS units must be successfully installed on each vessel in the fleet. The EMS must be maintained in good working order throughout the season such that system down time is minimal. The collected information must be reviewed and an inventory of discard events compiled. The final objective is to provide a report that: allows NWR and OLE to assess the effectiveness of EMS as a management tool; to identify the level of compliance with the EMS requirements defined in the EFPs; and to identify issues that may need to be resolved to improve compliance with EMS requirements. Must establish two workstations where OLE can view EMS data, provide written instructions and a demonstration of the viewing software.

Service Requirements

Each of the objectives described below must be fully met by the contractor. Due to fishery management changes a third season is not expected in 2010, however we are requesting that estimate consider the costs associated with a fall fishery. The contractor must keep the lines of communication open at all times.

2.1 Outreach

The contractor must provide written outreach materials that:

- Summarize the vessel activity in the 2010 EMS program
- Outline the vessel's role in procuring and using EMS in 2010
- Describes what each vessel can expect for service during the fishing season

2.2 EMS Units to be supplied

The contractor will provide all the EMS units necessary to supply the entire Pacific whiting shoreside fleet. The units supplied by the contractor must meet the equipment and data capture specifications listed below.

2.2.1 EMS Equipment Specifications.

At the minimum, the electronic monitoring equipment will include the following components:

- An EMS computer box for logging digital video imagery and other vessel data that has a waterproof, tamper resistant housing with tamper evident seals.
- A system with a removable hard drive that is capable of interfacing with high capacity commercial off the shelf hard drives using either Integrated Drive Electronics (IDE) of Serial Advanced Technology Attachment (SATA) interferences and capable of storing at least 500 gigabytes of data.

- High resolution closed circuit television network suitable for marine environmental conditions with a sufficient number of cameras to create imagery of all fish hold openings, deck spaces, all manipulation of the net on the trawl ramps such that fish handling and discarding of catch can be clearly observed and documented from all areas aboard the vessel during daylight and under low light conditions at night.

- Sensors for Global Positioning System accurate to within 100 meters.

- Sensors for hydraulic pressure.

- Winch or net drum count sensors.

- 12 volt DC or 110 volt AC capability, with built in Uninterruptible Power Supply that can log all power interruptions, the status of system sensors and the video recording settings at the time of power loss.

- Visible EMS display monitor and audible alarm for notifying vessel operator of EMS system malfunctions or power outages, alarm will sound until cancelled by operator.

2.2.2 EMS data capture specifications.
EMS units will be configured to provide the following data from the time that fishing begins until the vessel returns to any port for offloading:

- Global Positioning System location and date at all times.

- The closed circuit television network shall record at least two frames per second, and create a signal that is transmitted at a minimum of 480 horizontal lines of resolution which will be converted to a digital format of at least 640 x 480 pixels for storage on high capacity hard drives. Conversion of the closed circuit television network to a digital format shall be in a non-proprietary format that can be easily accessed by commercial off the shelf software.

- A record of EMS system performance that includes an operator initiated system check on the status of the power supply, GPS system, each camera on the system, hydraulic pressure sensors, winch or net drum sensors, and the main computer board. The record of any power interruption must include the status of sensor readings from each component just prior to the system shutting down.

- NMFS OLE, or authorized officers or others as specifically authorized by NMFS must be able to directly access information from the EMS system during the fishing season.

2.3 Installation of EMS units aboard vessels
Prior to fishing in the Pacific whiting shoreside fishery and the active data collection, the EMS units must be installed, tested, the system initialized and the EMS computer box sealed with

tamper evident seals. Each vessel must be fully outfitted with EMS equipment and the vessel's crews must be provided with both verbal and written instructions on the proper operation and maintenance of the EMS equipment. The EMS service provider will determine the scheduling of the EMS installation for each vessel and will take into account the vessel's schedules and concerns.

2.4 Maintenance of the EMS

The contractor must maintain each deployed EMS unit during the fishing season. Following the successful initial installation of EMS equipment, the contactor must offer the following EMS services for the fishing vessels during the length of the project:

> **2.4.1** If necessary, the contractor will go to sea with the fisher to demonstrate the EMS equipment and monitor EMS performance.
>
> **2.4.2** The contractor must provide prompt and continuous service for routine maintenance of EMS units; downloading data from EMS computers; and the troubleshooting of EMS units or system components that have been damaged or failed. The EMS service provider must provide technical support in the field within 24 hours from the time of notification of an EMS malfunction aboard a fishing vessel. The contractor must provide routine servicing of EMS units the fishery on an approximately biweekly basis.
>
> **2.4.3** During the fishing season, the contractor must notify NMFS OLE at 800-853-1964 of any and all interruptions in the EMS system within 4 hours of identifying that an interruption has occurred. The notification must identify the affected vessel; the length of the interruption; if known, the cause of the interruption; and if the issue was resolved.
>
> **2.4.4** During the fishing season or during removal of EMS equipment, the contractor must notify NMFS OLE at 800-853-1964 within 4 hours of discovery of all breaks in tamper evident seals or suspected tampering of any component or connection of the EMS unit, including the date that the broken seal was discovered or tampering was first suspected.

2.5 EMS Vessel Review

On an ongoing basis during the season the contractor will provide OLE with a report that includes information on EMS malfunctions and potential discard events. The contractor will provide OLE with instructions and procedures for the removal of EMS information from vessels. These instructions and procedures must be agreed on by the contractor and NMFS OLE at the start of the project.

> **2.5.1** The contractor is responsible for reviewing the EMS information and providing the following information for each vessel:

- A complete inventory of all information retrieved for each vessel, including GPS readings, winch counter data, hydraulic pressure data and video imagery catalogued in a Microsoft Access database format.

- System performance, including the total number of trips, the number of cameras, the quality and completeness of the information, sensor performance and imagery performance.

- EMS malfunctions, including but not limited to: power losses, camera interference, etc. If known, a reason for each malfunction should be provided. As well as, confirmation that notification was provided when system malfunctions occurred.

- Discard events or events that indicate that discarding may have occurred. Discard events shall be classified as follows: operational discards of whiting from deck (if it is possible to identify the amount is as being one basket or less, 150 pounds it should be classified as such), discards of large species (> 6 feet in length), operational discards of non-whiting species from the deck (selective discards), net bleeding, and net flushing. Discard events shall include information including: the location of the event in the data set confirmation that discard events were properly logged by the vessel operator, and an estimate of discard quantity.

- Confirmation that all fishing occurred within permissible locations. If fishing occurred in closed or restricted areas, an inventory of fishing events in restricted areas should be provided. Anomalous events in the data set that may warrant further investigation.

2.5.2 After all data is reviewed and compiled into the summarized report to NOAA Fisheries, the unaltered hard drives must be returned to OLE. No copies of images shall be retained by the provider after submission of the hard drives to NOAA Fisheries. Raw sensor data and summarized Access tables could retain until all the reporting and outreach/feedback is completed (6-8 months after the fishery).

2.6 Final report

The contractor will provide NOAA Fisheries with a final report within 90 day of the end of the Pacific whiting shoreside fishing season. The final report on the project will provide:

2.6.1 A clear and straightforward overview of the EMS project.

2.6.2 Summary of EMS performance and malfunctions, including improvements from previous years and recommendations for resolving performance issues.

2.6.3 Summary of the fishing activity, including trip departure dates and durations, and spatial and temporal information for all fishing events.

2.6.4 Summary of discard activity by the magnitude, type of event, and occurrence within the fishing trip.

2.6.5 A summary of the effectiveness of maximized retention requirements and levels of non-compliance with the terms and conditions of EFPs or federal regulations and recommendations for improvements.

2.7 Optional Data Analysis and Reporting

NOAA Fisheries would like to include optional data analysis and reporting that is estimated at 10 percent of the cost associated with the data analysis and reporting identified under paragraph 2.6 above. This work is not automatically included, but rather it would be specifically authorized by NOAA Fisheries if determined to be needed.

2.8 Federal Regulatory Requirements

2.8.1 The contractor must comply with the Service Contract Act and Fair Labor and Standards Act.

2.8.2 The contractor must keep all data confidential.

2.8.3 Work on this contract may require that the contractor has access to information covered under the Privacy Act. The contractor shall adhere to the Privacy Act, Title 5 of the US Code and any applicable agency rules and regulations.

3.0 Performance

3.1 Performance period

The period of performance shall be from the award date through the submission of the final report.

3.2 Performance measures

The contractor's performance will be based on the following measures:

3.2.1 Maintenance of EMS on-board vessels, such that:

- No more than 5% of data collection potential shall be lost due to EMS down time on any one vessel.

- Vessels are not unduly delayed by EMS malfunctions.

3.2.2 Adherence to the schedule for the analysis of collected data.

4.0 Required skills

Due to the close working relationship between the contractor and NOAA Fisheries, the sensitivity of this issue, and the large amount of work to be successfully completed in a short timeline, the contractor must have a solid history of successful performance with similar projects in the past. This history shall include the following:

4.1 The contractor shall have a proven success of deploying EMS in other fisheries of similar scale.

4.2 The contractor shall have experience implementing and servicing EMS units in the field.

4.3 The contractor must have knowledge of West Coast fisheries management and current issues, especially in regards to the Pacific whiting fishery.

4.4 The contractor must have demonstrated experience and ability in resolving liability and privacy concerns inherent in the collection of images on vessels.

5.0 Point of Contact

For the purposes of this contract, the NOAA Fisheries staff point of contact for the contractor for questions, review and acceptance of submitted work will be Becky Renko (206-526-6110). The point of contact will be responsible for task coordination and acknowledgement for the hours and performance of the contractor.

6.0 Travel

Services will require travel as agreed upon by the contractor and the NMFS point of contact. Travel costs which include airfare, hotel and per diem, mileage and other miscellaneous travel expenses will be reimbursed in accordance with government travel regulation approved rates. The contractor shall be required to provide set-up of two enforcement viewing stations; one located in Newport, OR the other in Astoria, OR. Additionally, the contractor shall be required to pick up hard drives from enforcement. Travel costs for these services shall be borne by the contractor.

7.0 Materials and equipment

7.1 EMS equipment

Owners of vessels participating in the Pacific whiting shoreside fishery, must arrange for EMS services from the EMS contracted provider and pay all associated costs with: the purchase or lease of EMS equipment, installation, removal, maintenance, and for a half the cost of the initial cataloguing of information collected from their vessel.

7.2 Other EMS Supplies

OLE will provide removable high capacity commercial off the shelf hard drives using either Integrated Drive Electronics (IDE) of Serial Advanced Technology Attachment(SATA) interferences and capable of storing at least 500 gigabytes of data.

8.0 Harmless from Liability

8.1 The contractor shall hold the Government, its officers, agents, and employees harmless from liability of any nature or kind, including costs and expenses to which they may be subject, for or on account of any or all suits or damages of any character whatsoever resulting from injuries or damages sustained by any person or persons or property by virtue of performance of this contract, arising or resulting in whole or part from the fault, negligence, wrongful act, or wrongful omission of the contractor, or any subcontractor, their employees, and agents.

9.0 Privacy and Security

9.1 The contractor must maintain confidentiality of all subjects and materials collected during this project.

9.2 Work on this contract may require that the contractor has access to information covered under the Privacy Act. The contractor shall adhere to the Privacy Act, Title 5 of the US Code and any applicable agency rules and regulations

APPENDIX -- Observer providers permitted by the North Pacific Groundfish Observer Program under 50 CFR 679.50(i).

Alaskan Observers, Inc. (AOI) 130 Nickerson, Suite 206 Seattle, WA 98109	VOICE 206/283-7310, 206/283-6604 FAX 206/283-6519 aoistaff@alaskanobservers.com www.alaskanobservers.com
MRAG Americas Inc. 1810 Shadetree Circle Anchorage, AK 99502	VOICE 907/677-8772 FAX 907/677-6022 bryan.belay@mragamericas.com www.mragamericas.com
NWO, Inc. (NWO) P.O. Box 624 Edmonds, WA 98020	VOICE 425/673-6445 FAX 425/673-5995 alaska@nwoinc.com www.nwoinc.com
Saltwater, Inc. (SWI) 733 N. Street Anchorage, AK 99501	VOICE 907/276-3241 FAX 907/258-5999 Mary@saltwaterinc.com www.saltwaterinc.com
TechSea International (TSI) 2303 W. Commodore Way Suite 306 Seattle, WA 98199	VOICE 206/285-1408 FAX 206/285-1535 Toll Free 877/980-1408 info@techsea.com dave@techsea.com www.techsea.com

Attachment 6 – List of Workshop Invited Participants(*) and Attendees

Al-Humaidhi, Alia	PSMFC, Data Analyst
Ames, Kelly*	PFMC, Staff
Anderson, David*	Oregon State Police, EC
Batty, Adam	Archipelago Marine Research Ltd.
Bell, Michael*	The Nature Conservancy
Bodnar, Steve	Coos Bay Trawlers Association
Brady, Colby*	NMFS, NWR, GMT
Busch, Rick	Finsight
Chadwick, Dan	Washington Department of Fish and Wildlife, EC
Colpo, Dave*	PSMFC
Cooper, Mark	Cooper Fishing Inc.
Corovano, Kathryn	Saltwater, Inc
DeVore, John*	PFMC, Staff
Easton, Ryan	PSMFC
Erickson, Dan*	Oregon Department of Fish and Wildlife, GMT
Exline, Joe	California Department of Fish and Wildlife, Consultant
Falvey, Dan	Alaska Longline Fishermen's Association
Fredston-Hermann, Alexa	Environmental Defense Fund
Haflinger, Karl*	Sea State, Inc
Haflinger, Michaela	Sea State, Inc
Hamel, Owen*	NMFS, NWFSC, SSC
Hanson, Dave	PSMFC, Council Member
Holliday, Mark*	NMFS, Policy Office
Hooper, Melissa*	NMFS, NER
Hull, Dan	NPFMC Council Member and Observer Advisory Committee Chair
Hunter, Travis*	Fishermen's Marketing Association
Joner, Steve	Makah Tribe
Jud, Shems*	Environmental Defense Fund, GAP
Kirchner, Gway*	Oregon Department of Fish and Wildlife, Council Member
Krause, Sandra	PFMC, Staff
Lake, Michael*	Alaskan Observers, Inc.
Leipzig, Pete*	Fishermen's Marketing Association
Leos, Bob*	California Department of Fish and Wildlife, GMT
Longo Eder, Michelle*	Fixed Gear, GAP
Lowman, Dorothy*	Council Member, Vice Chair
MacGregor, Paul	At-sea Processors Association
Mann, Heather*	Midwater Trawlers Cooperative, GAP
Matthews, Dayna*	NOAA OLE, EC
McElderry, Howard*	Archipelago Marine Research Ltd.
McIsaac, Don*	PFMC, Exec Director

McTee, Sarah	Environmental Defense Fund
Moeller, Niel*	NOAA GC, Enforcement Section
Munro, Nancy	Saltwater, Inc
Niles, Corey*	Washington Department of Fish and Wildlife, GMT
Nomura, Vicki*	NOAA, OLE, EC
Paine, Brent*	United Catcher Boats, GMT
Pettinger, Brad*	Oregon Trawl Commission
Seger, Jim*	PFMC, Staff
Torgerson, Eric	Finsight
Waldeck, Dan	Pacific Whiting Conservation Cooperative
Wallace, Farron*	NMFS, AFSC
Watson, Jennifer	NMFS, Alaska Region
Williams, Steve*	Oregon Department of Fish and Wildlife, Council Member
Wolford, Dan*	Council Member, Chair

Electronic Monitoring Workshop Report - Summary

Agenda Item D.7.b

EM Workshop Report

April 2013

EM Workshop

- Held February 25-27, 2013
- Chaired by Dan Wolford
- 32 invited participants
- 22 additional participants in attendance
- Recommendations
  - Overall Finding
  - Objectives
  - Scoping – Alternatives and Information Requests
  - PSMFC Field Study
  - Regulatory Process Calendar
  - Recommendation on Narrowing Focus

Overall Finding
(Executive Summary , page ii)

- It is reasonably likely that electronic monitoring will be found to be technically and economically viable as a substitute for the use of human observers in the function of compliance monitoring for the catch share program.

1. Objectives (Executive Summary , page ii)

- Objectives 1-7 – why consider EM
- Objectives 8-12 – important constraints to keep in mind while developing EM
- Primary focus for EM –
  - fulfilling the catch monitoring function required for catch shares
- It was recognized that scientific data needs to be collected but this would not be the focus of EM designed for compliance.

2. Scoping Package

a. Alternatives – Strawmen

- Workshop recommendations - most incorporated in strawmen provided in Attachment 2 (p. 20)
  - Focus on available technologies
  - Provide options for night fishing
  - Provide options to allow discard of undersized lingcod & sablefish
  - Provide options for alternative halibut mortality estimation methods
- Clarify what counts against quota pounds
- Coordinate with Alaska
- Identify objectives for each strawman
- Convene a workgroup to further develop alternatives

Also, Substantial discussion of performance based alternatives

Strawman Provisions – Whiting Example Shorebased and Mothership (complete list in Attachment 2)

- Maximum Retention/Non-Selective Discards Only
- Electronic Monitoring Plan – for each vessel
- System Components and Compatibility
  - E-logbooks
- Provisions for Data Analysis/Video Review – subsampling of video
- Time-Area Restrictions (e.g. night fishing)

Variations for Other Sectors

- Bottom trawl – options to discard small sized sablefish and lingcod and alternative halibut mortality estimation methods
  - Emphasizes the need for additional information and study on electronic monitoring for bottom trawlers
- Fixed Gear –
  - retention options – mandatory retention of
    - Option 1: IFQ species (other discards allowed)
    - Option 2: Rockfish and sablefish
    - Suboption – allow discard of small sablefish or lingcod
  - Option for alternative halibut mortality estimation methods

2. Scoping Package

b. Electronic Monitoring Co-ops (EMC)

- Problem – previously difficult and time consuming to prosecute cases.
- Establish an industry self enforcement mechanism.
- In order to use EM instead of observers
  - a vessel would be required to join an EMC – or some joint agreement.
- Video would be reviewed by the Feds or a trusted contractor.
- Co-ops would be responsible for ensuring compliance of their membership.

2. Scoping Package

c. Information Requests –
- Questions for NWFSC pertaining to biological data collection needs (p. v). Prior to the meeting preliminary feasibility matrices were provided asking –
  - What functions are filled by 100% observer coverage?
  - Can cameras be used or other adjustments made to fill those function?
  - What other functions might EM fill?
- Diagram of relevant operational differences among sectors.
- Comparison of whiting observed trips (2011-2012) to pre-catch share camera-observed trips.
- Evaluate existing video on whiting trips delivered at night.
- Cost estimate – bracket costs based on scenarios.

3. PSMFC Field Study

- Requests for 2013 study.
  - List of recommendations on page vi of report.

4. Regulatory Process for Moving Forward

- Draft process recommended by the workshop.
- Calendar recommendation on page vii of report.
    - Commences at this meeting with adoption of a process.
    - Scoping and work group appointment in June 2013
    - Final action in September 2014
    - Implementation for 2016

Dates	Process
Apr 2013	• Consider results of EM workshop and recommendations • Adopt goals and objectives. • Provide guidance on development of scoping package. • Request *special studies*, as needed. • Consider results of the 2012 PSMFC EM study. • Provide comment on the 2013 PSFMC EM study design. • Adopt regulatory process plan.
Sprg 2013	• NMFS/PSMFC finalize 2013 study design (starting in April – w/Council meeting results).
June 2013	• Full scoping session on EM. • Appointment of workgroup on this issue.
Sumr 2013	• Execute at-sea and shoreside field studies
Sept 2013	• Review results from *special studies* and provide guidance on alternative development (if ncssry).
Nov 2013	Consider initial results of NMFS/PSFMC 2013 field season • Adopt alternatives for analysis.
June 2014	• Consider full analysis of alternative. • Select preliminary preferred alternative.
Sept 2014	• Select final preferred alternative.
Sept 2014 through 2015	• Secretarial approval process and implementation, including ○ regulation drafting and paperwork reduction act submissions, ○ securing contracts for video review, ○ commercial installation and testing, and ○ observer program adjustments

5. Other Workshop Recommendations

- Participants acknowledged the extensive EM work conducted to date and recommended the scope of future work be narrowed based on the workshop recommendations.

Overall Finding (Executive Summary , page ii)

- It is reasonably likely that electronic monitoring will be found to be technically and economically viable as a substitute for the use of human observers in the function of compliance monitoring for the catch share program.

Electronic Monitoring Program: Review of the 2012 Season

Alia W. Al-Humaidhi, Dave A. Colpo, and Ryan R. Easton

Pacific States Marine Fisheries Commission

205 SE Spokane Street, Suite 100

Portland, OR 97202

Publication Date: April 2013

Contents

Overview/History

In 2012, Pacific States Marine Fisheries Commission (PSMFC) received funds to test the feasibility of using electronic monitoring for catch accounting in the newly implemented Pacific Trawl Rationalization Program within the west coast groundfish fishery. In order to effectively and accurately debit discarded catch from individual fishing quota (IFQ) holder account, the Pacific Fishery Management Council (PFMC) instituted 100% human compliance monitor coverage on all trips for all vessels participating in the IFQ fishery. The cost of this program was regulated to transition from federally subsidized to industry funded over the course of the first 3 years of the program. The industry is interested in finding a less costly method to monitor catch and discards at sea. The electronic monitoring project is meant to address some key questions, including; can video monitoring be used effectively to track an individual's catch to be debited from a quota account? And how much would such a program cost the industry as compared to the human compliance monitor program?

The expectation is that the West Coast Groundfish Observer Program (WCGOP) will continue to administer a level of scientific observer coverage to provide stock assessors and other scientists the necessary scientific data for effective management of the various west coast fisheries. This program is not meant to replace scientific observers. This program is solely meant to explore the ability of electronic monitoring systems to capture the at sea discards of vessels to effectively debit quota accounts throughout the fishing season, therefore replacing the need for 100% at sea human compliance monitor coverage.

PSMFC contracted with Archipelago Marine Research (AMR) to provide and install electronic monitoring (EM) systems on 11 volunteer fishing vessels (6 whiting and 5 fixed gear), collect data drives from the vessels, provide Electronic Monitoring Interpret™ Pro (EMI) software for converting the raw data into usable catch information, training PSMFC video reviewers, and providing logistical support.

The AMR system includes sensors for drum movement, hydraulic pressure, and GPS locations from which the speed of the vessel is calculated, and 1-4 cameras. A GPS location along with any sensor data was recorded every ten seconds during a trip. Sensor data was recorded at all times that the vessel's power was on. Gaps therefore occurred when in port and the vessel was powered down or the system was turned off manually to prevent the system from draining the vessel's battery when in port. On hake vessels, the system was configured to trigger recording video when the vessel moved outside of a "port area" designated by AMR and continue recording imagery until they returned to port. On fixed gear vessels, systems were configured to trigger recording video when the hydraulic pressure exceeded a threshold that was set by the technician that installed the equipment and was specific to each vessel. Imagery recording would then continue for 20 minutes past the last use of those hydraulics to allow for all catch handling to be captured for each haul.

When the raw sensor and video data were received by PSMFC, annotations were made using the AMR software EMI. Start and end dates, times and locations, for trips and hauls as well as gear and catch information were captured using EMI. The annotation data were imported into a Microsoft Access Database for analysis.

Preliminary 2012 at-sea compliance monitoring data were received from the WCGOP for comparison to the video data. Since retained catch is weighed and accounted for by fish dealers at the dock, discards were the main concern for at-sea catch accounting of IFQ species on this project. While analysis of both retained and discarded data are presented in this report, the discard analysis should be more closely scrutinized for this reason.

Fixed Gear

Methods

The electronic monitoring system was installed on 5 volunteer fixed gear vessels fishing IFQ quota out of Morro Bay and Half Moon Bay, California the week of August 21st 2012. All 5 fishing vessels carried the EM system for the remainder of the fishing year. Four of the five vessels fished pot gear solely. One fished both pot and longline gear.

Compliance monitor and video trips were matched using vessel ID and departure date. The quality of the match was then confirmed manually in excel.

Two definitions for fixed gear hauls are presented in the WCGOP manual for the IFQ fishery:

> "A set begins at a buoy and ends at a buoy. The set includes all of the hooks or pots in between the two buoys." (NWFSC 2012, Section 5-8)

> "Small pieces of gear with individual buoys are often set haphazardly in a general area or fishing spot. The gear is frequently set and retrieved over and over again, with individual pieces of gear soaking for as little as 5 minutes between retrievals. If each retrieval was considered a set, one day of fishing could have over fifty sets, with each set only having one or two fish caught. Obviously, this would create an unreasonable quantity of paperwork for the amount of data collected. Therefore, individual pieces of gear can be grouped to form a single set using a standard set of criteria." (NWFSC 2012, Section 6-10)

Since strings of gear were distinguishable by the EM system, the former definition was used. It appears the compliance monitor used the second method to define a haul on most of the corresponding trips.

All pot strings had 10 pots or less. On most trips, the haul count in the compliance monitor data was much lower than the count from the video data (Table 1). The number of pots counted on each trip by both programs was very similar (Table 2). This difference in haul definition at the data level led to an inability to assess catch counts at the haul level and thus counts were compared to compliance monitor data at the trip level. All 70 trips monitored electronically had corresponding trips in the compliance monitor data. One trip was missing electronic data entirely.

Of the 70 trips for which electronic data were collected, one had no video data associated with it. The trip was the first trip of the season for this vessel and the problem was resolved before the second trip. 12 trips were classified as problem trips. On these trips, a minimum of one haul during the trip was given a video quality score of "low". The majority of these low scores were not due to equipment failure but due to fisherman or compliance monitor behavior. For this study, fishermen were not given feedback on how to maximize data quality for the video project. Thus, there were instances where the fishermen or the compliance monitors stood with their backs to the camera while sorting, or sorting of catch was conducted out of camera view, which made counting and classifying catch into species groupings impossible.

In this fishery, weights were not directly estimated by the video reviewer. Instead, counts of individual pieces for each species or grouping were recorded. All fish seen on the video were counted by the reviewer including fish that dropped off of the line before being pulled onto the fishing vessel and fish that were damaged or partially eaten. Fish whose fate could not be determined due to being taken or thrown out of camera view or the video ending before fish being put into the hold or discarded were assumed to be retained and recorded as such.

Existing video technology does not allow for effective species identification of difficult to differentiate species such as many rockfishes, thornyheads, or flatfishes. Compliance monitor data therefore contained more species specific information than was possible to collect from the video data. To accommodate this difference, both the compliance monitor and video data were aggregated to a species grouping level for direct comparisons of the counts.

Ten of the trips included at least one haul where compliance monitor data were expanded to the haul level due to subsampling of the haul. Since these numbers were not true counts, we excluded them from the count comparison. Unfortunately, even if only one haul of a trip was expanded, the whole trip had to be removed due to the inability to compare at the haul level.

Retained and discarded counts of fish were compared to compliance monitor data at the trip and species grouping level. Rockfish and thornyheads were combined into one grouping due to the difficulty to differentiate them on video. Results for the IFQ groupings sablefish, rockfish + thornyheads, and flatfish are reported in this document.

Since only one vessel used longline gear, results could not be reported by fixed gear types (pot vs. longline) due to confidentiality rules. Both pot and longline gears were therefore reported on the same figures. Counts of fish on trips where both gears were used were aggregated together into one value for the trip.

Results

For the three groups reported, sablefish, rockfish + thornyheads, and flatfish, compliance monitor catch counts overall and on a trip bases tended to be greater than video counts for both retained and discarded catch, with one exception (Table 3, Figures 1-3).

The only exception was discarded sablefish, where the total video count was 3 fish greater than the total compliance monitor count. There was one trip where the sablefish discarded video count was 40 and the compliance monitor count was 2. This was the largest discrepancy in count in all of the fixed gear counts and was due to the video reviewer counting a large number of damaged, lice eaten sablefish that were immediately discarded, and the compliance monitor not counting these fish.

Despite the pattern that compliance monitor total counts were generally greater, the minimum, maximum, mean and median counts per trip were very similar and counts were generally qualitatively similar. Discards of IFQ fish were consistently low, with median discard per trip falling at zero or 1 fish for all three groupings.

The similarity of counts between the compliance monitor and video data and pattern of compliance monitor counts being on average larger than video counts is demonstrated in figures 1-3.

Discussion

Video counts of fish were similar to the compliance monitor counts at the trip and species group level. This indicates that the video is seeing the fish that the compliance monitor is seeing. What is clear is that the video system is not yet able to assess weights of fish, or species of rockfish, thornyheads or flatfish. Weights and species are important, since quotas are given to quota holders in weight of IFQ species or grouping. If the EM system cannot assess weight of discards and the species of discard, it would be impossible to accurately debit a fisherman's quota or assess accuracy of logbooks. PSMFC is working with the Alaska Fisheries Science Center to develop methods to resolve these issues moving forward.

Communication with fishermen will be more immediate in the future when behavioral changes need to be made to improve data quality, such as sorting fish one or two at a time so that the viewer can get an accurate count, or ensuring that discards take place in camera view.

Hake

Methods

The electronic monitoring system was installed on 6 volunteer hake trawl vessels fishing IFQ quota out of Newport and Astoria, Oregon the week of May 9th 2012. All 6 fishing vessels carried the EM system for the remainder of the fishing year and made both shoreside and mothership deliveries.

Retained catch, or catch transferred to the mothership, was calculated by video reviewers by counting the number of straps of the codend that contained fish. This number was then multiplied by an estimated weight per strap to get the total weight of fish in the codend.

Compliance monitors are advised to use skipper hailed weights recorded in the vessel's logbook for retained catch when they are available and to make individual estimates of the catch only when a vessel logbook is not available (Ryan Shama, personal communication, March 19, 2013).

There were two categories of discards; selective and nonselective. A selective discard was recorded if the deckhands deliberately removed a fish or group of fish from the haul. An example of a selective discard is a 300 pound shark that was pulled aside when the net came up. Nonselective discards were discards that were not deliberately sorted. Examples or nonselective discards are spillage out of the mouth of the codend as the deckhands tied the net off for transfer to a mothership, or fish that were gilled in the net and were then hosed off the deck of the vessel. Nonselective discard weights were recorded based on qualitative volume estimates. If an estimate was below 100 pounds, no discard was recorded.

Compliance monitor and video trips were initially matched using vessel ID and departure date. The quality of the match was then confirmed manually in excel. Hauls were then matched based on order within the trip. For example, haul 3 of a trip in the compliance monitor data was matched to haul 3 of the previously matched trip in the video data. This was necessary since there could be multiple hauls in a day and the haul times did not match exactly. Again, the quality of the match was confirmed manually in excel, and adjustments were made where necessary. Adjustments were only necessary if a time gap occurred in the electronic data that led to the EM system missing a haul or if the EM data recorded a water haul where the observer data did not.

All 166 of the 169 trips monitored electronically had corresponding trips in the compliance monitor data. Of the three that did not, two were NOAA research trips and one was a single water haul to clean the net. Of all the hake trips, 15 were mothership catcher-vessel trips and 152 were shoreside delivery hake trips. One trip in the dataset included one mothership delivery haul and the catch from the remaining hauls of the trip was stored onboard and delivered shoreside.

41 trips were missing electronic data entirely, 31 of which came from one vessel. Three were the last three trips of the year for a different vessel. Two were at the end of a data drive suggesting the drive on

the vessel was full and had not been replaced in a timely fashion. The last 5 occurred between recordings on a trip suggesting the box had been disconnected or the skipper forgot to switch the box on for a particular trip.

Most hauls had corresponding hauls in the compliance monitor data. It was therefore possible to compare catch at the haul level.

16 trips were classified as problem trips. On these trips, a minimum of one haul during the trip was given a video quality score of “low”. The majority of these low scores were due to poor deck lighting, camera angles, or water on the lens of the camera.

Official haul level catch amounts delivered to motherships were available from NORPAC data in PacFIN. Since fish tickets are not available for this fishery, the NORPAC dataset is the best estimate for total catch amounts delivered from the catcher vessels to the motherships. The delivered catch weight was calculated by taking the NORPAC official total catch weight which includes all species, and deducting the WCGOP discard amount, which was made on the catcher vessels prior to codend transfer.

Official trip level landed weights were available for the shoreside deliveries from the state landing receipts in PacFIN. These were matched based on vessel ID and return date. All hauls or trips had corresponding official retained catch amounts.

To address concerns voiced in the PFMC Electronic Monitoring Workshop, hauls brought on board in day light and night light were differentiated in the figures. Hauls brought onboard between 6 AM and 6 PM were labeled day hauls, and hauls brought onboard between 6 PM and 6 AM the next day were labeled night hauls.

Results

Mothership Catcher Vessels

Discard

The video data contained a larger number of discard events than the compliance monitor data, and those discard events were estimated by the video to be larger than the compliance monitor estimate (Table 4 and Figure 4). Most discard events were very small. There was no obvious difference between the quality of the night and day time estimates. Both were biased in the same directions with similar magnitude of bias.

Retained

Retained catch estimated by the video compared to the compliance monitor data and the official catch data from NORPAC had very similar patterns (Figure 5). Again, night and day estimates did not differ in direction or magnitude of bias. The bias was much more pronounced in the retained estimates with video estimates falling low at larger catches and high on smaller catches compared to the compliance monitor and NORPAC data.

Shoreside Hake

Discard

The compliance monitor data contained a larger number of discard events than the video data. Despite this, the total amount of discarded weight captured by the video was estimated to be almost double the discarded weight captured by the compliance monitor (Table 4). Most discard events were very small

(Figure 6). Only six observations of discards occurred during the night and all were from the compliance monitor dataset. No observations of discard were made in the shoreside hake fishery in the night by video reviewers. No trend line was drawn due to there being only 5 hauls where discards were recorded in both datasets.

Retained

Retained catch estimated by the video compared to the compliance monitor data and the official catch data on fish tickets from PacFIN had very similar patterns (Figure 7). In both cases the trend line qualitatively tracked the video = compliance monitor reference line closely with the line hovering just above the reference line.

Discussion

Mothership Catcher Vessels

For the mothership catcher vessel fishery, video retained catch estimates tended to be higher than compliance monitor estimates on loads smaller than 50,000 pounds, and tended to be lower than compliance monitor estimates on loads larger than 50,000 pounds (Figure 5). Vessels targeting hake use different codends when fishing with the intent to deliver to motherships than if the intent is to deliver to shoreside processors. No information was obtained from the vessels about the capacity of their nets or the dimensions of their vessel to aid in catch estimation from the camera view. Obtaining this information would likely help with the accuracy of estimation of catch weight in codends.

Discard events were much more abundant in the video data than in the compliance monitor data for this fishery. The majority of the discard events recorded in the video data were of a magnitude smaller than 2000 pounds. This suggests that compliance monitors were not recording discards in most instances when the magnitude was considered small. There were a number of discard events recorded by the video that did not occur in the compliance monitor data. The majority of these discard events were small, under 2000 pounds. There were five large discard events above 2000 pounds, ranging from 5000 to 16000 pounds not reported in the compliance monitor data. All five of these events were net bleeds due to the codend being over full making it impossible to tie the codend off prior to transfer to the mothership.

Shoreside Hake

The shoreside hake retained weights were on average (using the trend line as a gauge) accurate but had variability when assessing at the trip level (Figure 7). This was likely due to vessel to vessel variability of nets and codend capacity and the lack of information about each vessel that the viewers had available to them when estimating catch. Measurements like width and depth of trawl alley, estimated catch weight when codend is full and the vessel's hold capacity would assist viewers in their catch estimates. Therefore, the variability in the accuracy of estimation of retained catch is not necessarily due to a shortfall of the EM system, but rather could likely be resolved by obtaining additional information from skippers about their vessels to video reviewers.

The discarded catch estimates were more variable with only 5 of the 30 total discard observations in both datasets overlapping (Table 4). Most of the discard observations were only detected in one of the two datasets. The magnitude of most of these discard events were generally small at less than 2000 pounds (Figure 6). Relative to the magnitude of catch, these are very small. There were four discard events that were larger than 2000 pounds that were recorded by the video but not the compliance monitor. Two of these were blowout panel discards prior to the net boarding the vessel. The other two were due to deck washing of fish. The one discard event recorded in the compliance monitor data but not in the video data that was larger than 2000 pounds was also a deck washing event. The blowout panel events recorded by the video reviewer but not the compliance monitor resurfaces the regulatory question: when is a fish considered caught? It is clear that video can detect and quantify these discard events if needed for catch accounting. The deck washing events indicate a difficulty for the video reviewer to assess whether fish are being washed into a hold (retained) or off the vessel (discard). This may be resolved by adjustment of camera angles, or changes in fisher behavior.

Acknowledgements

We would like to thank the owners, skippers, and crew of the 11 volunteer fishing vessels for volunteering and helping this project move forward. We would like to thank the West Coast Groundfish Observer Program for providing data for this report.

References

Northwest Fisheries Science Center (NWFSC). 2012. West Coast Groundfish Observer Program 2013 Catch Shares Training Manual. West Coast Groundfish Observer Program. NWFSC, 2725 Montlake Blvd. East, Seattle, Washington, 98112.

Tables

Table 1. Summary of data including: number of vessels, number of trips, data quality of trips, trip length, number of hauls, video data quality of hauls, and reason for low video data quality.

Number of Vessels	Fixed Gear	Mothership Catcher Vessel	Shoreside Hake
Total	5	6	6

Trips

Number of Trips	Fixed Gear	Mothership Catcher Vessel	Shoreside Hake
Compliance Monitor	71	17	191
Video	70	15	152

Trip Data Quality	Fixed Gear	Mothership Catcher Vessel	Shoreside Hake
Low Video Quality (at least one haul on trip had low video quality)	11	3	13
No Video Data Recorded	1	1	10
Compliance Monitor Data Expanded - Trips not included in comparison	10		
One or both ends of trip based on timegap	10	3	6
No Data Quality Problems	38	8	123

Sea Days Per Trip	Fixed Gear	Mothership Catcher Vessel	Shoreside Hake
Minimum	1	1	2
Median	1	3	12
Mean	1	3	12
Maximum	3	7	18
Total	98	178	394

Hauls

Number of Hauls	Fixed Gear	Mothership Catcher Vessel	Shoreside Hake
Compliance Monitor	273	313	396
Video	851	306	392

Haul Video Data Quality	Fixed Gear	Mothership Catcher Vessel	Shoreside Hake
High	619	184	263
Medium	177	87	97
Low	49	33	15
No Video	6	2	17

Low Haul Video Data Quality Reason	Fixed Gear	Mothership Catcher Vessel	Shoreside Hake
Corrupt Video Files	1		1
Crew Catch Handling - Not in Camera View	34		
Poor Image Quality - Glare	1		
Poor Image Quality - Night Lighting	6	7	13
Poor Image Quality - Poor Camera Angles	4	24	1
Poor Image Quality - Water Spots		2	
Unclosed Video Files	2		
No Reason Given	1		
Total	49	33	15

Table 2. Comparison of number of pots counted per trip by compliance monitor and video.

Pot counts	Video	Compliance Monitor
Minimum	12	12
Median	34	36
Mean	45	46
Maximum	118	118
Total	3,096	3,168

Table 3. Comparison of counts of fish per trip of three broad IFQ groups by compliance monitor and video.

	Sablefish		**Rockfish and Thornyheads**		**Flatfish**	
Discarded	**Video**	**Compliance Monitor**	**Video**	**Compliance Monitor**	**Video**	**Compliance Monitor**
Minimum	0	0	0	0	0	0
Median	1	1	0	1	0	0
Mean	5	5	2	3	2	2
Maximum	40	44	28	31	12	12
Total	296	293	139	175	102	116
Retained						
Minimum	42	42	0	0	0	0
Median	455	488	3	2	0	0
Mean	518	542	53	58	1	1
Maximum	1,730	1,758	380	414	7	9
Total	30,547	31,988	3,153	3,396	49	70

Table 4. Summary of number of discard events (haul counts) in the compliance monitor and video data, and the catch weight that they represent in the mothership catcher vessel and shoreside hake fisheries.

	Mothership Catcher Vessel		Shoreside Hake	
Total Number of Discard Events in Each Dataset	**Number of Discard Events**	**Discard (lbs)**	**Number of Discard Events**	**Discard (lbs)**
Compliance Monitor	28	31,650	22	77,189
Video	137	136,210	13	132,655
Hauls with Discards in the Observer Dataset but not the Video Dataset				
Compliance Monitor	6	7,000	17	14,199
Hauls with Discards in the Video Dataset but not the Observer Dataset				
Video	115	83,420	8	55,255
Hauls with Discards in both the Video and Observer Datasets				
	22		5	
Compliance Monitor		24,650		62,990
Video		52,790		77,400

Figures

Figure 1. Fixed Gear Fishery. Comparison of compliance monitor and video total counts of: a. discarded and b. retained sablefish aggregated to the trip level. Each point represents a trip. Trips where compliance monitor expansions were applied were removed from the plots. The dashed line is the video = compliance monitor line. If video and compliance monitor counts agreed for a trip, the point for that trip would fall on the dashed line. The solid line is a fitted trend line to give a snapshot of the relationship between the two datasets. If the trend line falls below the video = compliance monitor line, compliance monitor counts tend to be larger than video counts. If the trend line falls above the video = compliance monitor line, compliance monitor counts tend to be smaller than video counts.

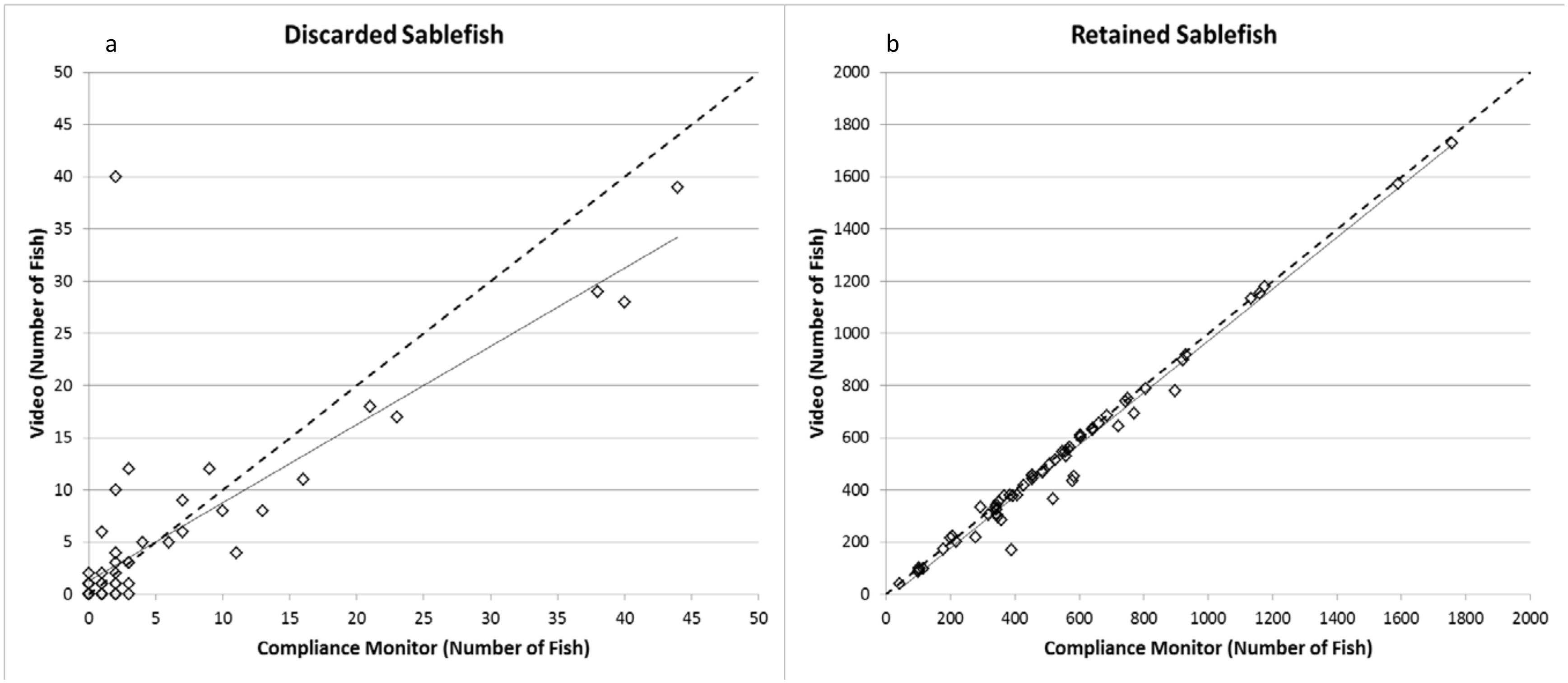


Figure 2. Fixed Gear Fishery. Comparison of compliance monitor and video total counts of a. discarded and b. retained rockfish and thornyheads aggregated to the trip level. Each point represents a trip. Trips where compliance monitor expansions were applied were removed from the plots. The dashed line is the video = compliance monitor line. If video and compliance monitor counts agreed for a trip, the point for that trip would fall on the dashed line. The solid line is a fitted trend line to give a snapshot of the relationship between the two datasets. If the trend line falls below the video = compliance monitor line, compliance monitor counts tend to be larger than video counts. If the trend line falls above the video = compliance monitor line, compliance monitor counts tend to be smaller than video counts.

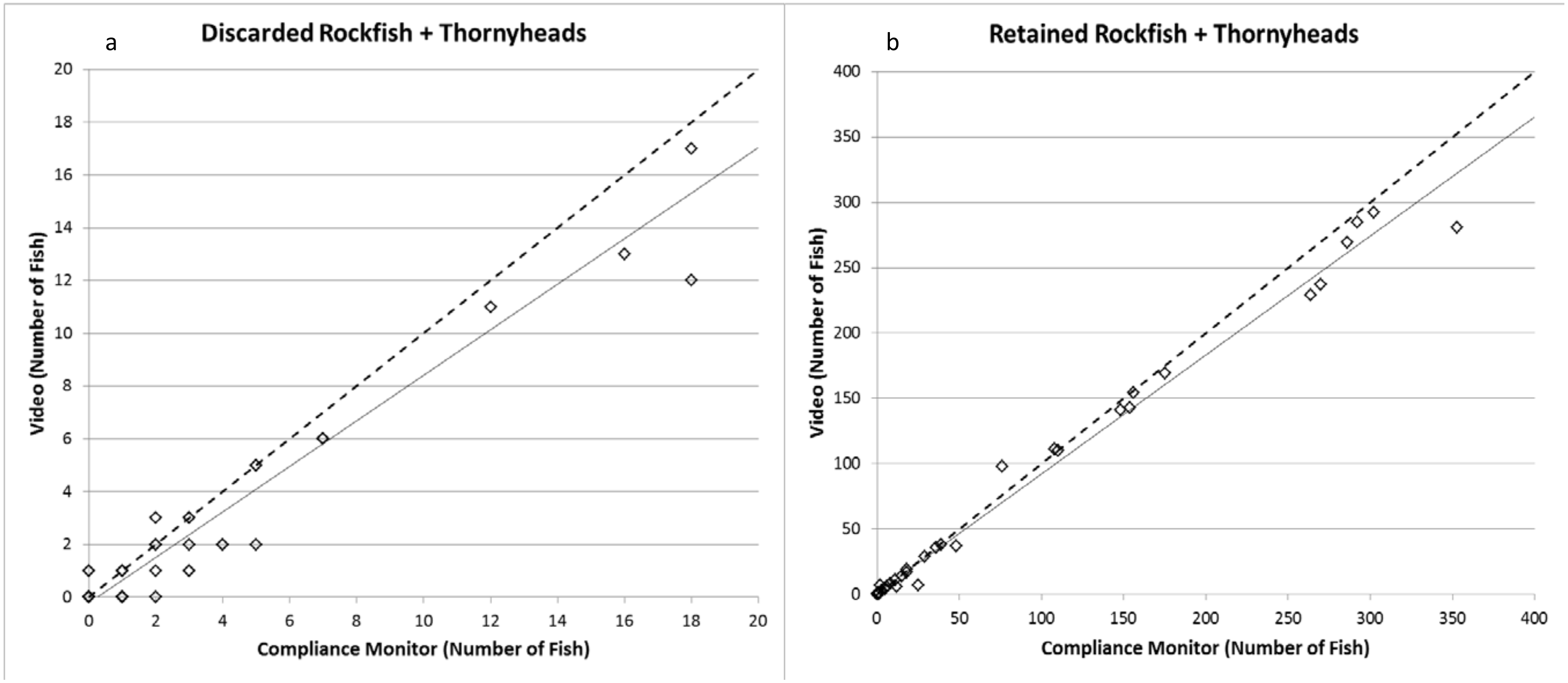


Figure 3. Fixed Gear Fishery. Comparison of compliance monitor and video total counts of a. discarded and b. retained flatfish aggregated to the trip level. Each point represents a trip. Trips where compliance monitor expansions were applied were removed from the plots. The dashed line is the video = compliance monitor line. If video and compliance monitor counts agreed for a trip, the point for that trip would fall on the dashed line. The solid line is a fitted trend line to give a snapshot of the relationship between the two datasets. If the trend line falls below the video = compliance monitor line, compliance monitor counts tend to be larger than video counts. If the trend line falls above the video = compliance monitor line, compliance monitor counts tend to be smaller than video counts.

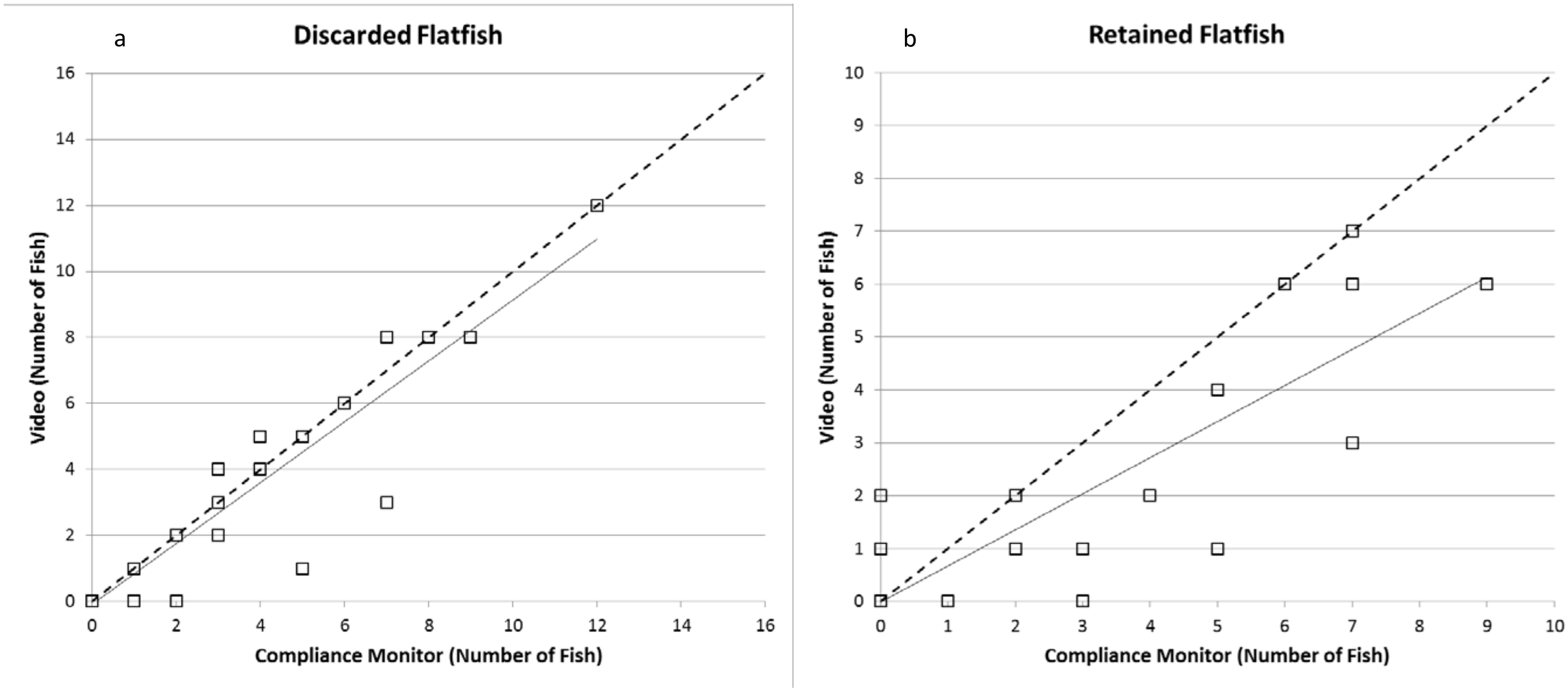
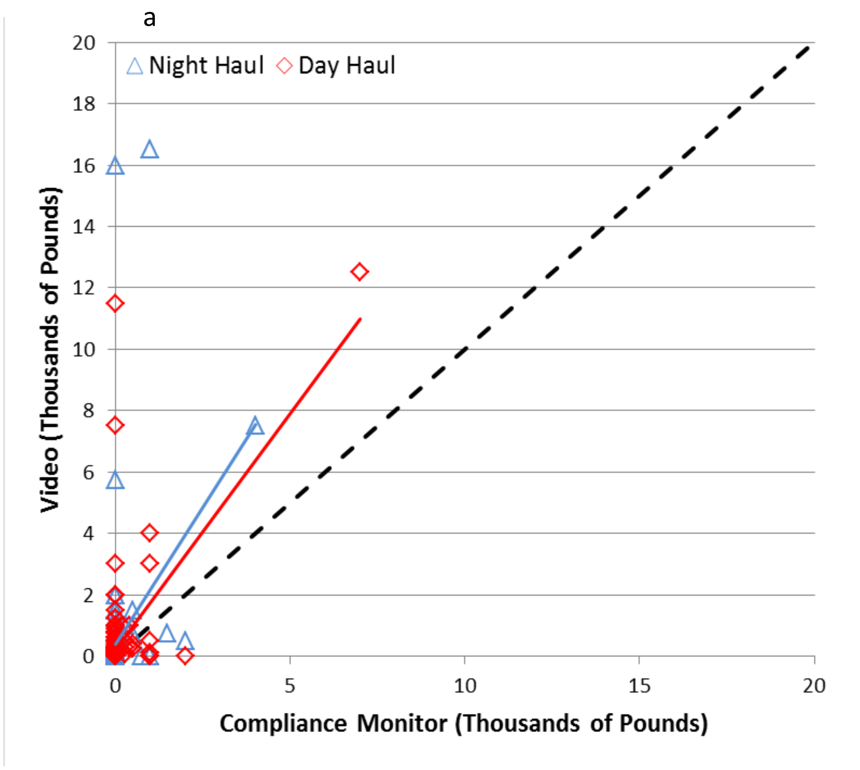


Figure 4. Mothership Catcher Vessel Fishery. Comparison of compliance monitor and video discarded catch weight of all species aggregated to the haul level. Figure b. is the same data as figure a. with different axis scales to show the data clustered in the bottom left corner of figure a. Each point represents a haul. Blue triangles represent hauls brought onboard in the dark, red diamonds represent hauls brought onboard in daylight. The dashed line is the video = compliance monitor line. If video and compliance monitor weights agreed for a haul, the point for that haul would fall on the dashed line. The solid line is a fitted trend line to give a snapshot of the relationship between the two datasets. If the trend line falls below the video = compliance monitor line, compliance monitor weights tend to be larger than video weights. If the trend line falls above the video = compliance monitor line, compliance monitor weights tend to be smaller than video weights.



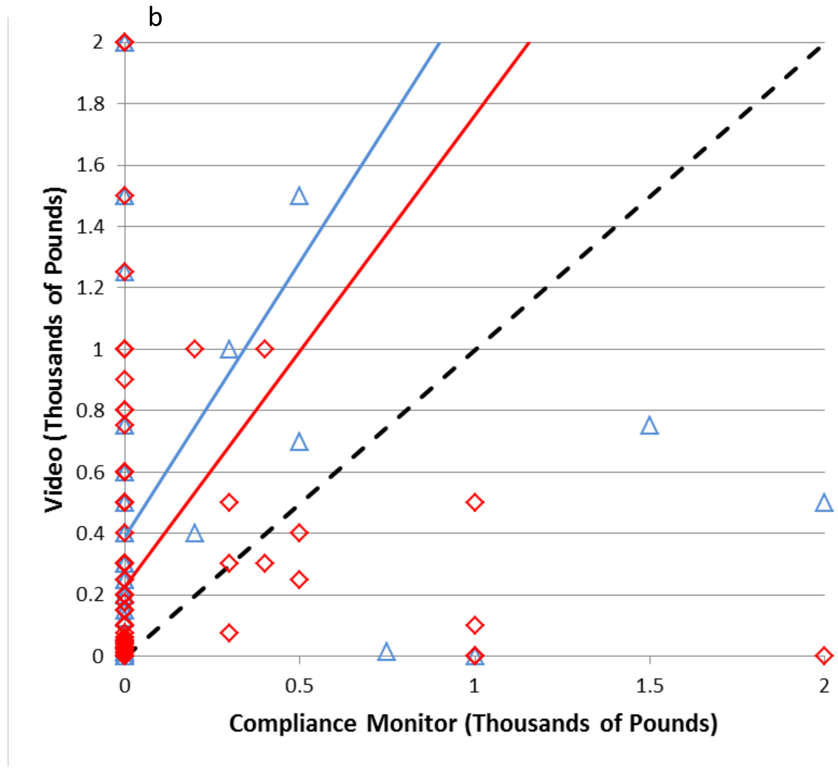


Figure 5. Mothership Catcher Vessel Fishery. Comparison of video retained catch weight to: a. compliance monitor and b. official catch from NORPAC retained catch weight of all species aggregated to the haul level. Each point represents a haul. Blue triangles represent hauls brought onboard in the dark, red diamonds represent hauls brought onboard in daylight. The dashed line is the video = compliance monitor line. If video and compliance monitor weights agreed for a haul, the point for that haul would fall on the dashed line. The solid line is a fitted trend line to give a snapshot of the relationship between the two datasets. If the trend line falls below the video = compliance monitor line, compliance monitor or official weights tend to be larger than video weights. If the trend line falls above the video = compliance monitor line, compliance monitor or official weights tend to be smaller than video weights.

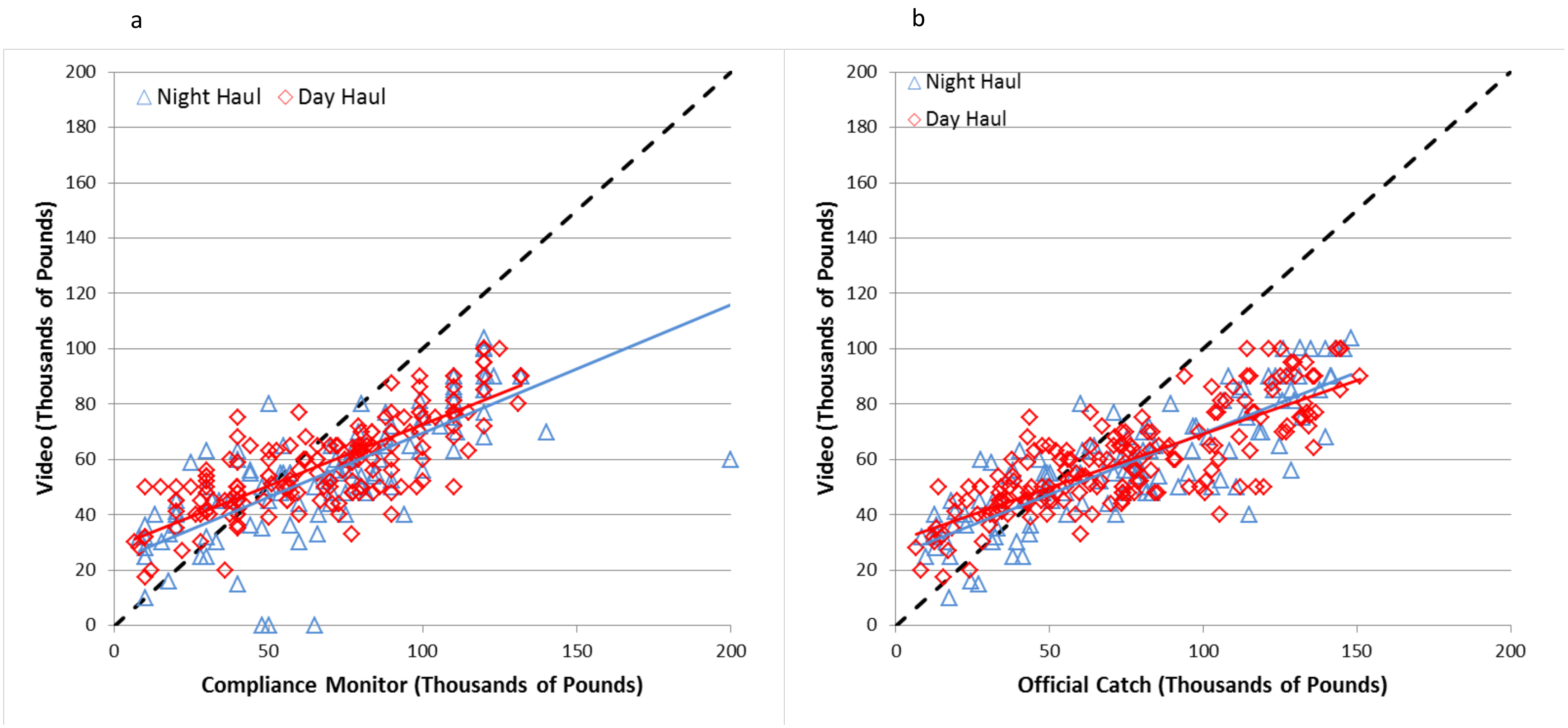


Figure 6. Shoreside Hake Fishery. Comparison of compliance monitor and video discarded catch weight of all species aggregated to the haul level. Figure b. is the same data as figure a. with different axis scales to show the data clustered in the bottom left corner of figure a. Each point represents a haul. Blue triangles represent hauls brought onboard in the dark, red diamonds represent hauls brought onboard in daylight. The dashed line is the video = compliance monitor line. If video and compliance monitor weights agreed for a haul, the point for that haul would fall on the dashed line. If the data point falls below the video = compliance monitor line, compliance monitor weights are larger than video weights for that haul. If the data point falls above the video = compliance monitor line, compliance monitor weights tend to be smaller than video weights for that haul.

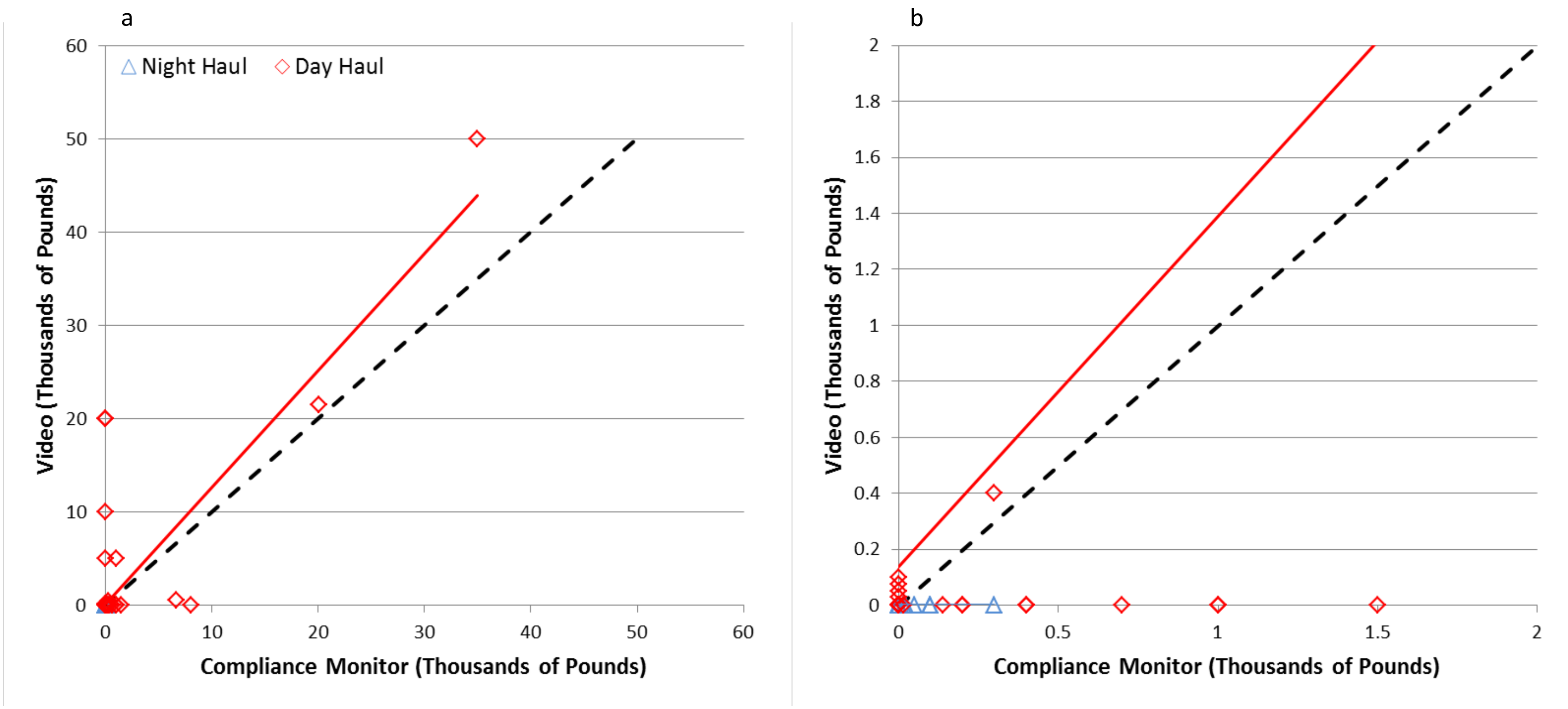
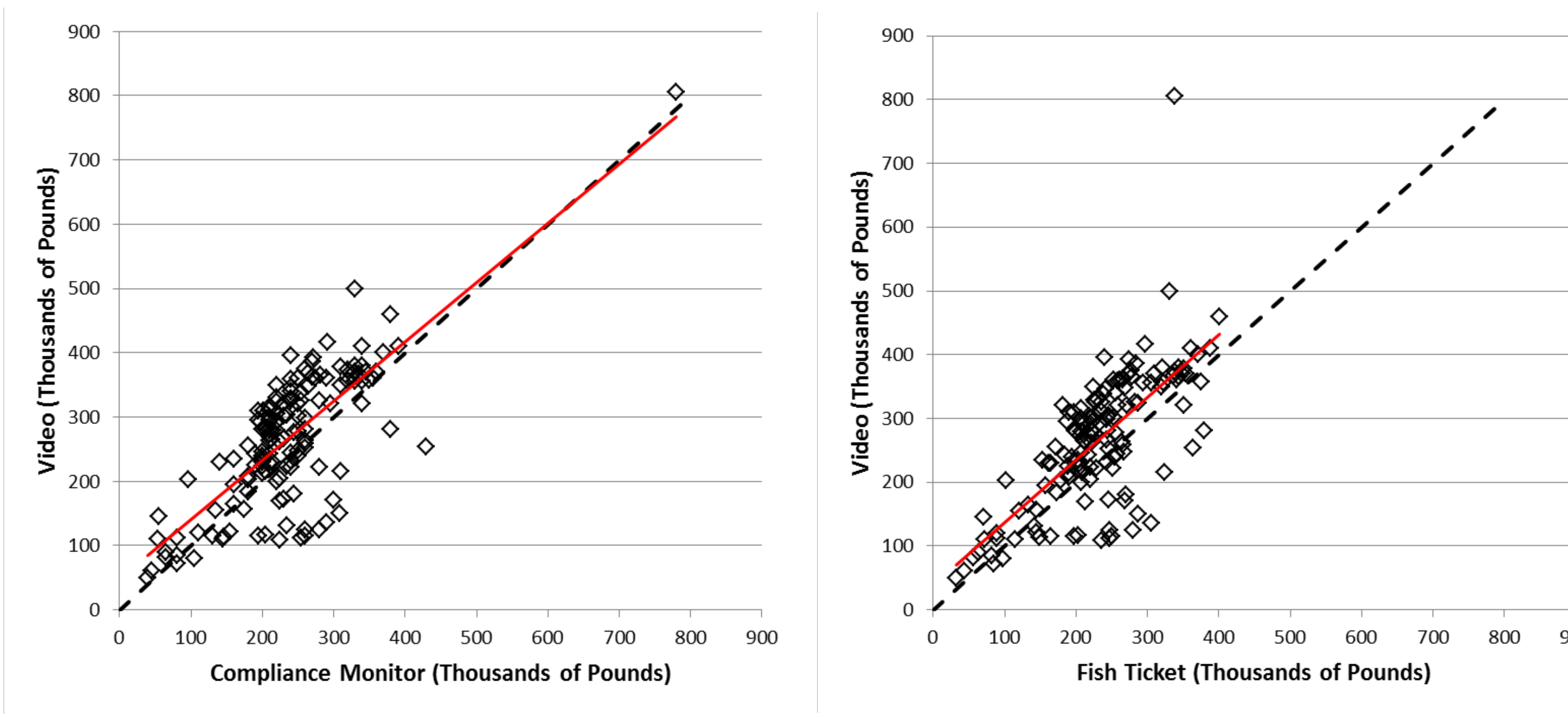


Figure 7. Shoreside Hake Fishery. Comparison of video retained catch weight to: a. compliance monitor and b. official fish ticket or landing receipt retained catch weight of all species aggregated to the trip level. Each point represents a trip. The dashed line is the video = compliance monitor line. If video and compliance monitor weights agreed for a trip, the point for that trip would fall on the dashed line. The solid line is a fitted trend line to give a snapshot of the relationship between the two datasets. If the trend line falls below the video = compliance monitor line, compliance monitor or fish ticket weights tend to be larger than video weights. If the trend line falls above the video = compliance monitor line, compliance monitor or fish ticket weights tend to be smaller than video weights.

a

b



Agenda Item D.7.c
PSMFC Report 2
April 2013

Electronic Monitoring Program: Plan for the 2013 Season

Dave Colpo, Pacific States Marine Fisheries Commission

The electronic monitoring (EM) program was designed to provide the Pacific Fishery Management Council with information to inform a decision regarding options for compliance monitoring of discards in the Pacific Trawl Rationalization Program other than the current human compliance monitor model. The expectation is that the West Coast Groundfish Observer Program will continue to administer a level of scientific observer coverage to provide stock assessors and other scientists the necessary scientific data for effective management of the various west coast fisheries. This program is not meant to replace scientific observers. This program is solely meant to explore the ability of electronic monitoring systems to capture the at sea discards from vessels of IFQ species to effectively debit quota accounts throughout the fishing season, therefore replacing the need for 100% at sea human compliance monitor coverage.

The 2012 season included 11 fishing vessels carrying electronic monitoring equipment, 5 fixed gear vessels in California and 6 hake targeting vessels in Oregon. All 6 hake targeting vessels delivered to both at-sea motherships and to shoreside processors during the fishing season. Pacific States Marine Fisheries Commission (PSMFC) is in discussion with the fishing industry to find vessels willing to test the electronic monitoring system in the 2013 fishing season in the fixed gear and bottom trawl sectors.

The study design includes: a. coast wide coverage, with vessels carrying the equipment fishing and landing in California, Oregon and Washington to test the system in a variety of conditions, fishing styles and catch compositions, b. coverage of both bottom trawl and fixed gear sectors of the fishery, but no hake directed sector coverage, c. a range of vessel sizes, d. complete retention of legal IFQ species, e. recording of discarded catch in logbooks provided to the vessels.

There are a few limitations of this project that affect the ability to implement this study design. First, this is an opportunistic study. Vessels are not required to participate and therefore ensuring the randomness of vessels and the variety of geographic and vessel size ranges for an ideal study design is difficult. Also ensuring consistent fishing behavior (i.e. complete retention of legal IFQ catch) among vessels cannot be enforced. Second, to reduce cost of the project, PSMFC would prefer vessels carrying EM equipment to be fishing out of ports clustered together geographically for efficiency of equipment installation, maintenance, and data retrieval. Third, the current system cannot identify all species effectively nor can it provide accurate weights of discarded fish. Fourth, due to the requirement of human compliance monitors on every IFQ trip, testing the EM system in the absence of the compliance monitor is not an option. This limits the ability to test the EM system in conditions that will closely mimic fishing where a vessel can choose between a human compliance monitor or an EM system. Fifth, cost information will be estimated with the caveat that economies of scale will undoubtedly drive down the cost to each vessel. Finally, funding is limited to testing this equipment on an estimated 12 fixed gear and 12 bottom trawl vessels.

Data collected by the electronic monitoring systems will be compared to the at-sea compliance monitoring data and the logbook data to assess how effectively the EM system captures the occurrence of discard events as well as the nature of the discard including species and quantity. This comparison will be done at the haul level if possible. This level of review proved to be problematic with 2012 data given the differences between how the EM reviewers and at-sea compliance monitors track hauls in the fixed gear sector of the fishery.

Goals of the current grant

- Compare EM with at-sea compliance monitoring data
    - Develop logbooks as needed
    - Fixed gear logbook in draft
- This program will not replace science observers

2013 vessels (expected):

- Groundfish trawlers
    - Verbal agreement on up to 12 vessels
    - Expectation of discards of halibut, salmon, large fish (sharks) and logs/crab pots, etc.
    - Working with fleet to address discards of other species
- No directed whiting vessels expected in 2013
    - Some groundfish trawlers expected to participate in whiting
- Fixed gear vessels: 12 vessels
    - Mix of pot boats and pot/line boats
    - 4 of 5 CA vessels are expected to return
    - Adding OR/WA fixed gear vessels

Cameras

- Archipelago Marine Research (AMR)
    - AMR expected to provide cameras for most groundfish trawlers and CA fixed gear vessels
    - AMR expected to provide cameras/support for some OR/WA fixed gear vessels
    - Expectation is all AMR video will be reviewed by PSMFC staff with AMR providing backstop support as needed
    - Sub-contract negotiations are ongoing at this time
- Saltwater, Inc.
    - Saltwater Inc. expected to provide cameras/field support for up to 4 OR fixed gear vessels and 2 groundfish trawl vessels (Newport/Astoria?)
    - Limited video software review options at this point
    - Sub-contract negotiations are ongoing at this time
    - Expectation is all Saltwater video will be reviewed by PSMFC staff

Agenda Item D.7.d
Supplemental EC Report
April 2013

ENFORCEMENT CONSULTANTS REPORT ON TRAWL RATIONALIZATION TRAILING ACTIONS – ELECTRONIC MONITORING

The Enforcement Consultants (EC) has reviewed the associated briefing materials for Agenda Item D.7 Trawl Rationalization Trailing Actions – Electronic Monitoring Regulatory Process and has the following comments.

Goals and Objectives

The EC's thoughts regarding the goals and objectives of an Electronic Monitoring (EM) program can be summarized as:

A program that identifies and documents harvest and discard events with sufficient accuracy that reasonable estimates of discards can be ascertained while maintaining fleet and individual accountability.

And that achievement of this primary goal and objective is done at a reduced cost, with more timely reporting and greater logistics flexibility than the current human observer model.

Strawman

The EC generally endorses the Strawman as presented, but would like to comment on a few highlighted issues:

1 Foremost is agreement that the proposed EM Strawman is about compliance monitoring of harvest and discard events and not collection of scientific data. Use of the monitoring data for scientific purposes is a value added component, not a primary objective.
2 While we appreciate the ongoing research and data that is occurring in the field of EM, these technologies do not currently meet the Strawman qualifiers: what do we know, what do we trust, what can be verified? As such, these technologies are not currently available for deployment and should not be included or considered.
3 The regulatory package which will support EM should include a defined mechanism for adopting new technologies as they become available without having to go through labor intensive and time consuming rule making.
4 We recognize costs are a primary concern. The EC believes the maximum retention (non-discretionary discards only) is the most cost effective approach. The discard of small lingcod and sablefish coupled with survivor credits as proposed, are deviations from the maximum retention model and will add complexity to the video analysis, create delays in verification, and thus drive up cost.
5 Halibut individual bycatch quota (IBQ) discards and the corresponding viability indexes are a different matter and will need considerable focus under an EM model.
6 We recognize that night fishing is a necessity for some sectors, especially bottom trawl. Future studies need to focus on this issue. Past studies and exempted fishing permit (EFP)

experiences have not been sufficiently evaluated to determine whether EM cameras can be effectively used during times of darkness for some sectors, especially bottom trawl.

7 Future camera studies should focus on deck, stern, and gunnel lighting, camera placement, and video/data quality monitoring by the skipper from the bridge. Future video applications will depend not only on the quantity of data (ego lost or gaps in the data), but the quality of the data (focus, high resolution, obscured views, etc). As such, the skipper will play a significant role in assuring both standards are met.

8 Clear agreement on what constitutes a discard (defined criteria) and the corresponding estimate and scaling of that discard are required prerequisites for proper vessel account management.

PSMFC Electronic Monitoring Cooperative

The EC strongly endorses the concept of behavior modification through incentive based regulations. We recognize that Cooperative is a buzz word that means many different things to different groups. Going forward, we suggest the Pacific States Marine Fisheries Commission (PSMFC) EM Cooperative concept, as presented, in the workshop report be referred to as the PSMFC EM Participant Agreement.

As reported to the Council in the past, Office of Law Enforcement (OLE) was not successful in prosecuting illegal discard events detected by cameras (exceeding the definition of operational discard, 2 baskets) under the Whiting EFP. Safety concerns cited by the alleged offenders "trumped" OLE allegations of illegal discards. Additionally, Federal prosecution is too slow, often taking years, and can be extremely costly for all parties involved. State prosecution would make alleged violations a criminal offense, which may not be appropriate.

Leveraging the desires of the industry to use cameras as an incentive for assuring good performance makes sense. Enforcement does not want to be in the accounting business, but rather the accountability business. We need a timely, cost effective mechanism for defining and rewarding good performance, while discouraging poor performance. We believe an administrative process, like the proposed participant agreement, has merit and recommend further exploration and development of this approach.

The EC believes the persons best suited to explore the concept of a participant agreement are the industry itself. They know what can and cannot be accomplished on the water. Given criteria/standards that must be met, they know what behavior they want emulated by the fleet. Whiting coops and risk pools have demonstrated the industry can organize, develop performance based participant agreements, and hold each other accountable under these agreements, complete with sanctions and penalties where necessary.

We recommend this industry committee be small, with representation from all four sectors/gear types: At Sea Whiting, Shoreside Midwater Trawl, Shoreside Bottom Trawl, and Individual Fishing Quota (IFQ) Fixed Gear. Participants should encompass expertise in fishing and contractual arrangements as demonstrated by participation in cooperatives and risk pools. The EC does not believe an enforcement representative needs to "sit" on the committee, but would be happy to make a member available to the committee as a technical advisor.

Exempted Fishing Permit

The Council time line for a proposed EM program implemented through the regulatory process is 2016. The EC has been asked if we have concerns or would object to moving forward with an EM EFP prior to a 2016 regulatory implementation. The EC has no objection and believes information collected through an EFP may actually improve a potential 2016 regulatory package.

Prior to the 2011 implementation of trawl rationalization, there was an EFP where the E-ticket, shoreside Catch Monitor, and First Receiver Site License requirement were “test driven” under the auspices of an EFP. That experience helped inform the Council and the regulators on what worked and what needed to be further refined as the regulatory package was developed. We anticipate an EM EFP could yield the same results.

It appears there is consensus that further EM study of at-sea whiting, shoreside midwater trawl, and perhaps fixed gear is unnecessary, with the caveat that deck and stern ramp lighting on midwater trawls may still need further analysis. Whereas, bottom trawl would benefit substantially from further study. This leads us to conclude that a whiting/fixed gear EFP may be the next logical step. Potential EM test components could include: the electronic log book, camera placement, data quality monitoring by the bridge crew, estimation and scaling of discard events, lighting configurations, and the utility of a participation agreement.

PFMC
04/08/13

Agenda Item D.7.d
Supplemental GAP Report
April 2013

GROUNDFISH ADVISORY SUBPANEL REPORT ON Trawl Rationalization Trailing Actions – Electronic Monitoring Regulatory Process

Mr. Jim Seger briefed the Groundfish Advisory Subpanel (GAP) on the electronic monitoring (EM) regulatory process and provided a report on the February EM Workshop. The GAP offers the following comments and recommendations. The GAP would like to thank Mr. Seger and the Council for holding the February Workshop, and all of the attendees and presenters, especially Mr. Dave Colpo and Mr. Dayna Matthews. GAP members in attendance felt that it was a productive meeting and were heartened to see everyone working together toward a viable, cost-effective, flexible solution to the problem of high observer costs in the fishery. The GAP urges the Council to continue that momentum by voting to begin a formal EM process at this meeting, dedicating resources to scoping and analysis, and scheduling EM onto future Council meeting agenda so that it can be implemented as soon as possible.

Goals and objectives

In general, the GAP supports the goals and objectives described in the February Workshop Report (Agenda Item D.7.b, EM Workshop Report, April 2013). However, the GAP suggests modifying the workshop recommendation as follows:

- Move line 2, placing it between lines 9 and 10, and change the language to read "reducing observer costs for vessels that have relatively lower total revenue."

There was significant discussion about this line at the workshop. The GAP appreciates the intent behind it (i.e., to recognize fleet diversity), but recommends that it be a consideration while developing an EM program rather than one of the primary goals.

- Insert a new line 2 that reads, "increase flexibility for fishermen to time trips to weather windows and market opportunities;"

There has been a longstanding misconception that the fleet's interest in EM is based entirely on cost concerns and the inconvenience of having an extra person on board. While those are important considerations, many fishermen have also experienced difficulty in scheduling and obtaining observers leading to missed trips and lost revenue. Some fishermen have expressed interest in moving forward with EM even if costs are comparable to current observer rates. On that point, it should be noted that many of the preliminary discussions comparing human observer costs to EM have focused on the current costs of human observers. We have already seen those costs increase in the first two years of this program. Human observer costs have increased even more dramatically in other regions, and over time we can expect they will continue to increase in this region. In contrast, after the initial costs of EM program development and hardware, EM costs are likely to be relatively stable over time.

Guidance on developing a scoping package

In general, the GAP supports the recommendations and information requests found on pages iii-v of the Executive Summary of the EM Workshop Report.

Strawmen proposals

The GAP feels, however, that it is difficult to determine whether the proposals are adequate or how they might be modified to be more efficient without having a concrete understanding of the standards they were designed to meet. Therefore, the GAP recommends that the proposals be included when considering initial alternatives for public review and comment, but the GAP further recommends that the Council outline clear performance standards that a program must meet. This would not only facilitate discussion of ways the current proposals might be improved to best achieve the goals, but would also allow for consideration of completely new proposals that may prove more effective (and cost-effective).

The GAP notes that the language contained in the bottom trawl proposal on page 24 of the EM Workshop Report seems to make assumptions about whether or not EM will ultimately prove viable for bottom trawl vessels. The GAP does not feel that language is appropriate and requests that it be removed before the proposal go forward.

The GAP further notes that the fixed gear proposal described on page 25 of the report fails to differentiate between pot and longline gear. Because the operations are different, it may be necessary to have a separate proposal for each, but again, without clear performance standards it is hard to know.

Co-ops

The GAP appreciates the creative thinking that has gone into the co-op concept and believes it is something that should go forward for analysis. The devil will be in the details and the GAP firmly believes that this concept is one that should be carefully vetted by industry and other stakeholders.

Comments on PSMFC Study

The GAP supports the recommendations in the EM Workshop report, but adds one additional recommendation. We heard from Mr. Colpo that one of the principle reasons for discrepancies in the year-one PSMFC test between the EM data and the observer data is that it is not clear when fish should be counted against individual fishing quota (IFQ). The fundamental question is when is a fish caught? For example, what about fish that shake off at the rail? Or just below the rail? Or at the surface of the water? Or underwater but clearly visible? What about whiting that come out of the bag well behind the boat due to sloshing in rough weather? Or small fish that escape from the mesh when the net is coming up?

The EM system seems to be counting a different number of discard events and a different amount of pounds per event than human observers. It is therefore critical that before the EM data is compared to observer data for the year-two PSFMC test, that we have a clear understanding of the answer to this question. Otherwise, we will not have a fair comparison between EM and observer data, and any information gleaned will be almost useless for decision making purposes.

The GAP also heard that many of the initial vessels that had agreed to participate in PSMFC's 2013 bottom trawl EM study have backed out. Several members of the GAP have committed to line up replacement vessels for the study so that it can go forward in a meaningful way.

Adopting a regulatory process for moving forward

The GAP would like to see EM implementation as quickly as possible. In the timeline outlined on page vii of the Executive Summary of the EM Workshop Report, it looks like the earliest EM could be implemented is 2016, and only then if we perfectly meet all of the regulatory hurdles. At the same time, we understand that the observer subsidy is likely to decrease dramatically in 2014 (and possibly disappear entirely by 2015), and Amendment 20 cost recovery is likely to come into effect. Meanwhile, catch of target species remains low relative to overall actual catch limits. Taken in combination, negative repercussions for the fleet could be profound. With that in mind, the GAP urges the Council to think about ways to accelerate this EM development timeline.

One suggestion would be to consider an out of cycle EFP for the whiting fishery, and for fixed gear if it is ready to move forward on the same timeline. The GAP previously raised concerns with moving to a two-year EFP process for EFPs that don't require set asides, because we believe doing so "would likely impair flexibility and the opportunity to accelerate management improvement." (Agenda item E.4.b, Supplemental GAP Report, June 2011). Without taking action on the issue, several Council members recognized the concern of the GAP and recommended it be considered at a later date. The GAP believes the time is now.

On the issue of the workgroup to be appointed at the June meeting, the GAP recommends a small group of interested stakeholders (2 bottom trawl members, 2 midwater trawl, 1 fixed gear, 1 processor, chaired by PSMFC) with technical advisors coming from Council and Agency staff. Large groups are cumbersome and will not facilitate effective or timely decision making.

Other recommendations and comments

- The focus of EM needs to be on compliance monitoring.

- We don't need a Cadillac. We need an EM program that can be implemented in the near term that will bring down management costs and improve flexibility. At the same time, the program needs to be able to accommodate new technology as it comes online without having to go through a cumbersome amendment process.

- The GAP notes that any advances in EM by participants in the IFQ trawl program using fixed gear could facilitate and streamline later adoption of EM in the tiered sablefish program.

Conclusion

The GAP requests that the Council maintain EM as a high priority trailing amendment by voting to move forward with a formal process and scheduling EM on future Council meeting agendas. The GAP recommends convening a small group of interested and knowledgeable stakeholders to work on the issue. Finally, the GAP recommends clarifying who will lead the process, and highlights the importance of close coordination between that body and stakeholders.

PMFC
04/08/13

Agenda Item D.7.d
Supplemental GMT Report
April 2013

GROUNDFISH MANAGEMENT TEAM REPORT ON TRAWL RATIONALIZATION TRAILING ACTIONS – ELECTRONIC MONITORING REGULATORY PROCESS

The Groundfish Management Team (GMT) had the opportunity to engage Mr. Dave Colpo (Pacific States Marine Fisheries Commission, [PSMFC]) and Mr. Jim Seger (Council staff) in a discussion regarding the possible design and implementation of an electronic monitoring program for some or all sectors in the West Coast groundfish fisheries. The GMT's discussion revolved around two main themes: the importance of developing performance standards that will adequately measure progress relative to the goals and objectives highlighted in the Electronic Monitoring Workshop Report (Agenda Item D.7.b, April 2012); and how to measure and verify that the quality of data collected from electronic monitoring technology is comparable with (or better than) what is currently collected by human observers. This latter issue acknowledges the difficulty of quantifying discards when using electronic monitoring technology without human observers to verify what is captured by the implemented technology. The former issue highlights the team's agreement that effective performance standards can only be developed when program objectives are clear. More discussion on these and additional items are presented below for Council consideration.

Consider Adopting Regulatory Goals and Objectives

We spent the bulk of our discussion time on the proposed regulatory goals and objectives appearing on p. 4-5 of the Electronic Monitoring (EM) Workshop Report. We do not weigh in on the question of whether the Council should adopt them or not, but instead offer the following thoughts in hopes that they may help with that decision.

We focused mostly on Objective 8, which is to develop the program while "maintaining current individual accountability for catch and preserving equitable distribution of monitoring coverage among members of the fleet." Its meaning was unclear to some. Those team members having attended the workshop explained their recollection of the intent behind it, which was: (1) that EM should not undermine the core incentive in the individual fishing quota (IFQ) and co-op fisheries; and (2) that quota pounds (QP) should be monitored to a similar degree of precision and accuracy whether taken by a vessel carrying a human observer or an electronic-monitoring system.

On the first part, the strength of the individual accountability incentive is directly proportional to the strength of catch accounting. The IFQ program is intended to account for very small amounts of fish, yelloweye and cowcod being the extremes. Catch accounting has to be very precise to make participants individually accountable for these small amounts. Catch accounting relates to monitoring the trawl allocation and ultimately the annual catch limit. Greater precision is more important for species in which the trawl allocation and the ACL are attained at a high rate (e.g., sablefish, petrale sole, etc.). Another example discussed by the team is the special case of halibut. For halibut, the Council set up the extra incentive to improve the survival of discards by encouraging individual accountability through halibut viability metrics, instead of using fleet wide averages.

On the second part of objective 8 about equitability, some participants at the EM Workshop remember the point being more that QP are not necessarily equivalent units if measured under systems that differ in their precision of catch accounting. Hypothetically, one system might be able to track catch to the nearest pound and another only to the nearest 100 pounds. Such differences in monitoring might also raise issues of fairness in a system where QP are traded as if they were equivalent. The way Objective 8 reads in the EM Workshop Report might be interpreted differently to mean that monitoring options are fairly available to all. This may also be a valid point, but it is different those that address catch accounting.

Importantly, we do not mean to imply that EM cannot be as accurate or precise as observers. Future analysis could explore the differences between the two methods, understanding that the true catch is unknown. It may be difficult to quantify the differences between observers and EM in terms of precision and accuracy. Nonetheless, there may be ways to compare the relative precision of various alternatives.

Lastly, some note that Objective 12 is somewhat of an outlier. It speaks more to the process for implementation while the other objectives speak to desired qualities and characteristics of the outcome.

Definition of total catch for catch accounting

An additional question that needs to be resolved before electronic monitoring (EM) can be effectively evaluated for compliance monitoring is:

What should be included in "total catch" for catch accounting purposes?

Following our discussion with Mr. Colpo, it became clear to the GMT that the definition of "catch" is uncertain and not clearly defined under the objectives of the EM or in Groundfish Mortality Reports. In other words, the definition is unclear regarding the "observable" fishing mortality that should be included for catch accounting purposes. This is exemplified in the EM Workshop Report provided by the Pacific States Marine Fishery Commission under Agenda Item D.7.c, PSMFC Report 1, April 2013. In this study, it was shown that discard reported by video occasionally exceeded that reported by the human observer. For example, fish bled from codends by whiting mothership catcher vessels prior to transfer to the mothership was recorded using EM, whereas the human observer sometimes did not record these fish. A fair and accurate evaluation of the performance of EM requires a clear definition of "catch" used for accounting purposes. This should be clearly defined for each fishery under consideration.

Option for electronic monitoring co-op

The GMT believes that electronic monitoring cooperatives may have either been explored or are already in use in other regions. There is merit in summarizing the experiences from other areas to inform the potential for electronic monitoring co-ops on the West Coast.

GMT Recommendations:

1. **The GMT recommends that the Council provide guidance on defining "catch" needed for catch accounting.**

2. **If the Council wishes to consider EM co-ops, the GMT recommends looking to other regions for their experiences.**

PFMC
04/09/13

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON TRAWL RATIONALIZATION TRAILING ACTIONS – ELECTRONIC MONITORING REGULATORY PROCESS

The Scientific and Statistical Committee (SSC) reviewed the Trawl Catch Share Program Electronic Monitoring (EM) Workshop Report (D.7.b, EM Workshop Report), along with documents prepared by the Pacific States Marine Fisheries Commission (PSMFC) including: 1) the results of a pilot EM program in 2012 (D.7.c, PSMFC Report 1), and 2) a plan for EM work to be conducted in 2013 (D.7.c, PSMFC Report 2). Mr. Jim Seger provided an overview of how this research relates to Council objectives and the groundfish trawl share catch program, and Mr. Dave Colpo (PSMFC) was available to answer questions about the EM program.

SSC noted that there was no coverage of non-whiting trawlers in 2012, and the relative performance of the EM system differed between the shoreside and mothership whiting vessels sampled. A clear explanation for the differences was not presented; however, it was noted that the observer data provided in the 2012 report are preliminary. The SSC recommends that when the finalized data are available, the 2012 report results should be re-analyzed and presented in an updated report. The 2013 study will focus on non-whiting trawl, where species identification will be particularly important. One limitation of the cameras is that they cannot, at present, be used to identify rockfish and flatfish discards to species.

Mr. Colpo provided his perspective on the prospects for the work planned in 2013. He noted that, thus far, it has been difficult to recruit trawl vessels to participate in the research program. The SSC notes that, without knowing the number and variety of vessels available for the 2013 research, and a detailed study design, it is not possible to evaluate the likelihood of project success in 2013. For example, a detailed study design should address possible management measures that could be implemented. The SSC also encouraged the collection of information in 2013 that can help to evaluate the costs associated with the program. This could help to evaluate management options that could be proposed in the future.

Review of the 2012 EM sampling results suggests that an ancillary benefit of this research is the opportunity it could provide to examine the performance of at sea observers. Detailed analysis of the videos could yield insights about how the observers operate and some of the particular challenges they face at sea that affect the uncertainty of discard estimates.

PFMC
04/07/13

ENVIRONMENTAL DEFENSE FUND
Finding the ways that work

March 31, 2013

Mr. Dan Wolford, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, OR 97220

RE: Agenda Item D.7 Trawl Rationalization Trailing Actions – Electronic Monitoring Regulatory Process and B.7 Future Council Meeting Agenda and Workload Planning.

Dear Chairman Wolford and Council Members:

I would like to commend the work of Council staff, especially Mr. Jim Seger in organizing a successful workshop on the potential use of electronic monitoring technologies in the Pacific groundfish IFQ fishery. Not only was the workshop well attended, but the significant preparatory work allowed for a collaborative and open discussion of some of the most pressing issues and questions to be addressed before the Council can move forward with refining the fishery's monitoring program. With the understanding that the Council will be reviewing the outcomes of the monitoring workshop and recommending next steps both for research and approval of a possible regulatory amendment process, Environmental Defense Fund (EDF) would like to provide the following comments to inform your discussion.

EDF is a non-profit organization with over 750,000 members and as you know, we have been involved in the development of the West Coast groundfish catch share program since its inception in 2003. From the outset we have worked closely with stakeholders to ensure that the program meets conservation, social, and economic objectives. As you will recall, during the November 2012 Council meeting, the Groundfish Advisory Subpanel (GAP) identified electronic monitoring (EM) as its highest priority for trailing actions, stating that EM would likely reduce program costs and increase operational flexibility. **EDF agrees that EM should remain a high priority, not only for the reasons highlighted by the GAP, but also to ensure this fishery is able to maintain a high level of accountability and robust collection of fisheries data moving into the future.** We are concerned that as operational costs mount and as agency resources are further constrained the fishery will either see a reduction in the diversity of participating vessels and ports, or a reduction in the 100% monitoring currently in place. By allowing for flexibility in the monitoring tools employed for compliance and catch accounting purposes, the Council will help to ensure monitoring is not only cost-efficient, but also employs the best, most effective tools to meet monitoring objectives and standards.

Reviewing the Year-at-a-Glance Summary, Agenda Item F.4.a Supplemental Attachment 3 from the March 2013 briefing book, I note there is no mention of electronic monitoring after the April 2013 Council meeting. Although future work will be determined by decisions made at the April meeting, the timeline adopted in June 2012 and refined during the February EM workshop (PFMC EM Workshop Agenda Item F Attachment 1 – Draft Calendar) leave very little room for

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slippage. As the timeline currently stands, should the Council decide at this meeting to move forward to scope a regulatory amendment, the earliest such an amendment would come into effect is January 2016. **We therefore strongly encourage the Council to consider the various steps necessary to continue progress on this issue (including scoping, review of ongoing research, and development of alternatives to be analyzed) and take action under agenda item B.7 Future Council Meeting Agenda and Workload Planning to include EM as one of the trailing actions addressed during upcoming Council meetings.**

One of the recommendations discussed during the February workshop was the need to establish a work group focused specifically on EM. **Given the importance of optimizing the Council's time and resources, EDF supports the recommendation to convene a small EM working group, with those appointments occurring during the June Council meeting.** Establishing a working group will help ensure full scoping is carried out this summer, contribute to the further development of the EM strawmen, identify additional options, standards, or considerations for EM deployment, and provide guidance on future research priorities for the various sectors of the groundfish IFQ fleet.

The Council and Pacific stakeholders are fortunate to have the Pacific States Marine Fishery Commission (PSMFC) guiding research in the application of EM for this fishery. As was pointed out during the recent EM Workshop, this relationship is rare and one that should be capitalized on. **It is our hope that the Chair, or a designated representative, of the Scientific and Statistical Committee (SSC) can be appointed to serve as an official liaison with PSFMC.** This will ensure Council concerns and needs are taken into account in the deployment of gear and analysis of EM data for the 2013 field season. Increased collaboration may also help streamline or facilitate SSC consideration and review of study results.

Thank you for your time and consideration of these comments. We hope they are helpful as you consider the importance of advancing the use of EM tools in this fishery and prioritize upcoming work for the Council.

Sincerely,

Shems Jud
Deputy Director, Pacific Oceans Program
Environmental Defense Fund

CONSIDERATION OF INSEASON ADJUSTMENTS

Management measures for groundfish are set by the Council with the general understanding these measures will likely need to be adjusted within the biennium to attain, but not exceed, the annual catch limits. This agenda item will consider inseason adjustments to ongoing 2013 fisheries. Potential inseason adjustments include adjustments to Rockfish Conservation Area (RCA) boundaries and adjustments to commercial and recreational fishery catch limits. Adjustments are, in part, based on catch estimate updates and the latest information from the West Coast Groundfish Observer Program.

<u>Council Action:</u>

1. **Consider information on the status of 2013 fisheries and adopt inseason adjustments, as necessary.**

<u>Reference Materials:</u>

None.

<u>Agenda Order:</u>

a. Agenda Item Overview — Kelly Ames
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action:** Adopt Recommendations for Adjustments to 2013 Groundfish Fisheries

PFMC
03/15/13

GROUNDFISH ADVISORY SUBPANEL REPORT ON CONSIDERATION OF INSEASON ADJUSTMENTS

The Groundfish Advisory Subpanel (GAP) met with the Groundfish Management Team (GMT) to discuss progress of this year's fishery and possible inseason adjustments. The GMT discussion was led by Dr. Sean Matson. The GAP offers the following recommendations and comments on proposed inseason adjustments to ongoing groundfish fisheries.

Washington Recreational

The GAP discussed the supplemental Washington Department of Fish and Wildlife (WDFW) report found in Agenda Item D.8.b relating to inseason adjustments for recreational cabezon and lingcod. The GAP supports the WDFW proposals.

Halibut IBQ Release

The GAP acknowledges there has been a delay in the release of halibut individual bycatch quota (IBQ) in 2013 and understands that IBQ will be released soon. The GAP recommends the Council urge the National Marine Fisheries Service (NMFS) to release halibut in a timely manner in the future, as these kinds of delays cause a serious hardship on the trawl individual quota (TIQ) fleet.

Trawl RCA Changes

The GAP held a discussion with Mr. Frank Lockhart from the Northwest Region of the National Marine Fisheries Service about the Agency's view on a legally defensible way to make changes to the trawl rockfish conservation area (RCA).

It appears to be NMFS' view that the requested changes to RCA boundaries are not the result of recently available data that generally drive inseason recommendations and decisions. The fact that there are low attainments for many non-whiting annual catch limits (ACLs) post-implementation of the catch share program was well-known before and at each Council meeting. Ongoing catch reports demonstrate the low attainments; this is not "new" information that would dictate "inseason" action. Inseason actions are exempt from certain rulemaking processes because of the analyses done in the biennial specifications process. Despite this new interpretation, the GAP still believes the impacts associated with the trawl RCA boundaries have been adequately analyzed in past NEPA documents.

However, the GAP was apprised by NMFS that a more prudent and legally defensible approach for making changes to the trawl RCA would be to go through a formal rulemaking process that includes a Council recommendation to NMFS, then a proposed and final rule process that includes the opportunity for the public to provide their comments on the proposed changes. To that end, the GAP requests a change to the trawl RCA that would last through the current management biennium, which is through 2014.

The GAP recommends making changes to the trawl RCA boundaries north of 40° 10’ N. lat. to 48° 10’ N. lat. through the remainder of 2014 beginning in period 6 of 2013. Specifically:

Period	Shoreward	Seaward
2013: Period 6	100 fathoms	150 fathoms
2014: Periods 1-6	100 fathoms	150 fathoms

The GAP requests the Council recommend NMFS engage in a formal rulemaking process following this meeting in order to make these changes. We would anticipate this would include a proposed and final rule in time for implementation by Nov. 1, 2013.

The GAP remains concerned that the current shoreward RCA configuration is too restrictive for fishermen north of 40° 10’ N. lat. to effectively prosecute their intended fishing strategies. The GAP believes this is clearly demonstrated by the NMFS 2012 Annual Catch Report under Agenda Item D.2 that demonstrates the low attainments for 2011 and 2012 with cumulative non-whiting attainments for 2012 at 29 percent of the ACL, including economically important species such as Dover sole, lingcod and Pacific cod. Liberalizing the RCA lines will allow trawlers to take advantage of opportunities to maximize the potential of their business plans. The TIQ program has created a system where conservation is inherently addressed, thus minimizing risks to stocks of concern associated with liberalizing the RCA.

The changes would bring consistency to the regulations over the remainder of the biennium. The shoreward and seaward lines will remain the same beginning in period 3 of 2013 (periods 3, 4 & 5 already adhere to these lines) and remain in place throughout all of 2014. These changes would result in an open fishery area that is easier for the fleet to comply with, is easier to enforce, saves on agency workload and eliminates enforcement time to reprogram VMS maps each period.

While it is difficult to quantify what the increased opportunity is worth, if the change in the RCA boundary allowed a 10 percent increase in Dover sole, lingcod and Pacific cod, landings, revenues could increase by $1.9 million in 2013 alone.

PFMC
04/09/13

Agenda Item D.8.b
Supplemental GMT Report
April 2013

GROUNDFISH MANAGEMENT TEAM REPORT ON
CONSIDERATION OF INSEASON ADJUSTMENTS

Introduction

The Groundfish Management Team (GMT) considered the most recent information on the status of ongoing fisheries, research, and requests from industry, and provides the following recommendations for 2013 inseason adjustments.

The GMT also received guidance from the National Marine Fisheries Service (NMFS) Northwest Region (NWR) regarding timing of implementation of inseason recommendations from this meeting. NMFS anticipates implementing potential routine inseason adjustments to 2013 fishery management measures potentially as early as May 15, 2013.

2013 Action Items

Recreational Fisheries

- **See Agenda Item D.8.b, Supplemental WDFW Report**

The GMT concurs with the Washington Department of Fish and Wildlife (WDFW) recommendation that the Council adopt Federal regulations that conform to state regulations recently adopted by the Washington Fish and Wildlife Commission. State regulations that conform to regulations implemented into Federal regulation by NMFS provide consistency for stakeholders and strengthen the ability to enforce regulations pertaining to recreational groundfish fishing in coastal waters. To provide this consistency, the GMT is recommending that the following regulations be approved by the Council and adopted into Federal regulations through inseason action.

Between the U.S./Canada border and 48°10' N. lat. (Cape Alava; Washington Marine Area 4):

1 Adopt a minimum size of 18 inches for cabezon and reduce the daily bag limit from 2 per angler per day to 1 per angler per day.

2 Reduce the minimum size for lingcod from 24 inches to 22 inches.

Bag limits for cabezon were analyzed as part of the harvest specification and management measure analysis for the 2011-2012 biennial cycle, when a daily bag limit of 2 per day was adopted. WDFW does not currently have a minimum size limit for cabezon. The 2009 status of cabezon stocks off Oregon and California http://www.pcouncil.org/groundfish/stock-assessments/by-species/cabezon/ shows that approximately 70 percent of the cabezon off Oregon are mature by the time they reach 17 inches. This suggests that, if there is some similarity in the
Washington and Oregon cabezon stocks, that an 18 inch minimum size is reasonable to provide additional protection to cabezon stocks off Washington.

The lingcod size limit in the Washington recreational fishery in all management areas except for the area north of Cape Alava is 22 inches. The size limit north of Cape Alava was kept at 24 inches to maintain consistency with the adjacent Washington management area east of the Bonilla-Tatoosh line.

The Council considered reducing, or removing, the minimum size limit for lingcod in both the commercial and recreational fisheries for the 2013-2014 cycle. The environmental effects of the action(s) were included in the 2013-2014 Biennial Harvest Specifications and Management Measures Final Environmental Impact Statement (FEIS; September_2012-AppendixC_13-14_FEIS_SPEX). Therefore, as stated in the preamble for the proposed rule for 2013-2014, adjustments to lingcod size limits are considered a routine measure and may be implemented through inseason action (77 FR 67974,67988 (November 14, 2012).

2013 Informational Items

Scorecard updates

The overfished species scorecard is in Attachment 1.

GMT Recommendations:

1 **Adopt Federal regulations that conform with the Washington recreational regulations; specifically Between the U.S./Canada border and 48°10' N. lat. (Cape Alava, Washington Marine Area 4):**

a Adopt a minimum size of 18 inches for cabezon and reduce the daily bag limit from two per angler per day to one per angler per day.

b. Reduce the minimum size for lingcod from 24 inches to 22 inches.

PFMC
04/08/13

Attachment 1. Scorecard for April 2013 Allocations and projected mortality impacts (mt) of overfished groundfish species for 2013

Fishery	Bocaccio b/		Canary		Cowcod b/		Dkbl		Petrale		POP		Yelloweye	
Date: 07 April 2013	Allocation a/	Projected Impacts	Allocation a/	Projected Impacts	Allocation a/	Projected Impacts	Allocation a/	Projected Impacts	Allocation a/	Projected Impacts	Allocation a/	Projected Impacts	Allocation a/	Projected Impacts
Off the Top Deductions	8.4	8.4	17.5	17.5	0.1	0.1	20.8	20.8	234.0	234.0	16.5	16.7	5.8	5.8
EFP c/	6.0	6.0	1.5	1.5	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Research d/	1.7	1.7	4.5	4.5	0.1	0.1	2.1	2.1	11.6	11.6	5.2	5.2	3.3	3.3
Incidental OA e/	0.7	0.7	2.0	2.0	--	--	18.4	18.4	2.4	2.4	0.4	0.6	0.2	0.2
Tribal f/			9.5	9.5			0.1	0.1	220.0	220.0	10.9	10.9	2.3	2.3
Trawl Allocations	74.9	74.9	52.5	52.5	1.0	1.0	281.4	281.4	2,323.0	2,323.0	126.8	126.8	1.0	1.0
---SB Trawl	74.9	74.9	26.2	26.2	1.0	1.0	266.7	266.7	2,318.0	2,318.0	109.4	109.4	0.6	0.6
---At-Sea Trawl			8.6	8.6			14.7	14.7	5.0	5.0	17.4	17.4		
a) At-sea whiting M			3.6	3.4			6.1	6.1			7.2	7.2		
b) At-sea whiting C			5.0	4.8			8.6	8.6			10.2	10.2		
Non-Trawl Allocation	236.7	125.5	46.0	27.2	1.9	0.8	14.8	3.5	35.0	2.2	6.7	0.2	11.2	10.4
Non-Nearshore	72.3		3.5										1.1	
LE FG				0.9				2.8				0.2		0.4
OA FG				0.1				0.5				0.0		0.1
Directed OA: Nearshore	0.9	0.5	6.2	7.2		0.0		0.2					1.2	1.1
Recreational Groundfish														
WA			3.1	0.9				--		--		--	2.9	2.9
OR			10.8	4.7				--		--		--	2.6	2.5
CA	163.5	125.0	22.4	13.4		0.8		--		--		--	3.4	3.4
TOTAL	320.0	208.8	116.0	97.2	3.0	1.9	317.0	305.7	2,592.0	2,559.2	150.0	143.7	18.0	17.2
2013 Harvest Specification	320	320	116	116	3.0	3.0	317	317	2,592	2,592	150	150	18	18
Difference	0.0	111.2	0.0	18.8	0.0	1.1	0.0	11.3	0.0	32.8	0.0	6.3	0.0	0.8
Percent of OY	100.0%	65.3%	100.0%	83.8%	100.0%	64.7%	100.0%	96.4%	100.0%	98.7%	100.0%	95.8%	100.1%	95.7%

Key		
	(hatched)	= not applicable
	--	= trace, less than 0.1 mt
	(black)	= Fixed Values
	(light blue)	= off the top deductions

a/ Formal allocations are represented in the black shaded cells and are specified in regulation in Tables 1b and 1e. The other values in the allocation columns are 1) off the top deductions, 2) set asic sea petrale only) 3) ad-hoc allocations recommended in the 2013-14 EIS process, 4) HG for the recreational fisheries for canary and YE.

b/ South of 40° 10' N. lat.

c/ EFPs are amounts set aside to accommodate anticipated applications. Values in this table represent the estimates from the 13-14 biennial cycle, which are currently specified in regulation.

d/ Includes NMFS trawl shelf-slope surveys, the IPHC halibut survey, and expected impacts from SRPs and LOAs.

e/ The GMT's best estimate of impacts as analyzed in the 2013-2014 Environmental Impact Statement (Appendix 8), which are currently specified in regulation.

f/ Tribal values in the allocation column represent the the values in regulation. Projected impacts are the tribes best estimate of catch.

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE REPORT ON INSEASON ADJUSTMENTS FOR 2013

Every two years, the Washington Department of Fish and Wildlife (WDFW) considers proposed changes to sport fishing regulations. Proposals are submitted by agency staff and members of the public. The WDFW sport rule process includes significant analysis and input from agency staff and opportunities for the public to review and provide comments on the proposals. The Washington Fish and Wildlife Commission considered several proposals that affect sport fishing regulations for coastal Washington management areas during the most recent sport rule proposal cycle which concluded with final action on March 1, 2013. The changes approved by the Fish and Wildlife Commission will be adopted into state regulations and effective May 1, 2013. All of the regulations adopted by the Washington Fish and Wildlife Commission in coastal waters are more restrictive than current federal regulations. State regulations that conform to regulations implemented into federal regulation by the National Marine Fisheries Service provide consistency for stakeholders and strengthen WDFW's ability to enforce regulations pertaining to recreational groundfish fishing in coastal waters. To provide this consistency, WDFW is recommending that the following regulations be approved by the Council and adopted into federal regulations through inseason action.

Between the U.S./Canada border and 48°10' N. lat. (Cape Alava) (Washington Marine Area 4):

1) Adopt a minimum size of 18 inches for cabezon and reduce the daily bag limit from two per angler per day to one per angler per day.
2) Reduce the minimum size for lingcod from 24 inches to 22 inches.