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Supplemental Public Comment 3
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Dr. John Stadler
Essential Fish Habitat Coordinator
NMFS West Coast Region
510 Desmond Drive SE
Lacey, WA 98503

RE: Essential Fish Habitat, Notice of Intent to Prepare an EIS (RIN 0648-XE401)

Dear Dr. Stadler:

Oceana is writing to provide comments on the scope of the National Marine Fisheries Service ("NMFS") and Pacific Fishery Management Council ("Council") environmental impact statement (EIS) being developed for Amendment 28 to the Pacific Coast Groundfish Fishery Management Plan. As discussed in the notice of intent to prepare an EIS, Amendment 28 to the FMP will consider revisions to multiple components of groundfish essential fish habitat (EFH) designation, conservation and management.[1] Amendment 28 and the EIS will also consider changes to trawl Rockfish Conservation Areas and it will consider the prohibition of bottom-contact gear in water deeper than 3,500 meters using discretionary authorities provided by the Magnuson-Stevens Act (MSA). Oceana has a long-standing interest in the conservation of seafloor habitats from bottom trawling, including participation in the Council's FMP Amendment 19 process, membership on the Essential Fish Habitat Review Committee, and participation in the Council's five year EFH review process.

In this letter we provide comments and recommendations on:

- Alternatives to modify EFH conservation areas with specific support and changes to the Oceana, Natural Resources Defense Council and Ocean Conservancy coastwide conservation proposal for modifying EFH conservation areas.
- Identification of the major prey species for groundfish.
- Midwater trawl gear impacts to seafloor habitats.
- Alternatives to prohibit bottom contact gear in water deeper than 3,500 meters.
- Changes to Trawl Rockfish Conservation Areas.

[1] 81 Fed Reg. 5102 (February 1, 2016).

- Identification of environmental issues to consider in the EIS including the effects of trawling on seafloor habitats, the importance of biogenic habitats to managed species and healthy ocean ecosystems, the analysis of cumulative impacts, and the potential for adverse impacts caused by bottom trawling in areas that are currently closed as EFH or rockfish conservation areas.

I. Background: The Council and NMFS have ongoing responsibilities to identify and protect EFH

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C. § 1801 *et seq.*, requires NMFS and Councils to "describe and identify essential fish habitat" and "minimize to the extent practicable adverse effects on such habitat caused by fishing," while also identifying "other actions to encourage the conservation and enhancement of such habitat."[2] EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity."[3] The EFH implementing regulations define "waters" as including, "aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish," and define "substrate" as including "sediment, hard bottom, structures underlying the waters, and associated biological communities."[4] The regulations further explain that "necessary," in the context of the statutory EFH definition, means "the habitat required to support a sustainable fishery and the managed species contribution to a healthy ecosystem," and that "'spawning, breeding, feeding, or growth to maturity' covers a species' full life cycle."[5]

To protect EFH, Councils are required to "prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable, if there is evidence that a fishing activity adversely affects EFH in a manner that is more than minimal and not temporary in nature."[6] Adverse effects mean "any impact that reduces quality and/or quality of EFH," and may include "direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH."[7]

Protecting ocean habitats is critical to responsible fishery management. It is necessary for ensuring long-term sustainable and productive fisheries, vibrant coastal communities and healthy marine ecosystems. The Council and NMFS West Coast Region have been at the

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[2] 16 U.S.C. § 1853(a)(7).
[3] *Id.* § 1802(a)(10).
[4] 50 C.F.R § 600.10.
[5] *Id.*
[6] *Id.* § 600.815(a)(2)(ii).
[7] *Id.* § 600.810(a).

forefront of fish habitat protections nationally and internationally since the implementation of Amendment 19 to the Groundfish Fishery Management Plan in 2006. Amendment 19 implemented coastwide seafloor habitat protections focused primarily on minimizing and preventing the adverse effects of bottom trawling to the extent practicable.

The obligation to protect EFH, however, did not end with Amendment 19. The Council and NMFS correctly recognized that the Council has an ongoing responsibility to protect EFH, by among other things, reviewing the EFH regulations and proposing updates to them in response to new information and data.[8] As the Groundfish FMP states, "[p]rotecting, conserving, and enhancing EFH are long-term goals of the Council, and these EFH provisions . . . are an important element in the Council's commitment to a better understanding, and conservation and management, of Pacific Coast groundfish populations and their habitat needs."[9]

II. NEPA: Developing a reasonable range of alternatives is a critical element of this Groundfish FMP amendment process

We appreciate the agency is now conducting this scoping process and we support consideration of a broad range of alternatives that will protect and enhance EFH, and protect the deep-water ecosystem beyond 3,500 meters. As you know, the National Environmental Policy Act (NEPA) is the "basic national charter for protection of the environment."[10] Congress enacted the statute "to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore and enhance the environment."[11] To meet this goal, NEPA requires that agencies prepare an Environmental Impact Statement (EIS) for all "major Federal actions significantly affecting the quality of the human environment." [12] An agency's solicitation and consideration of informed public opinion as a component of its decision making is fundamental to the NEPA process.

Scoping consists of the range of actions, alternatives, and impacts to be considered in an EIS.[13] To determine the scope of an EIS, agencies must consider "reasonable courses of action."[14] Amendment 19 employed an EIS to analyze a range of alternative strategies to

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[8] *See* Pacific Fishery Management Council, Pacific Coast Groundfish 5-Year Review of Essential Fish Habitat: Phase 1 Report, at ES-1 (2012) (EFH Phase 1 Report); 50 C.F.R. § 600.815(a)(10) (instructing regional councils to review the adequacy of their EFH protections at least every five years).
[9] Groundfish FMP § 7.0.
[10] 40 C.F.R. § 1500.1(a).
[11] *Id.* § 1500.1(c).
[12] 42 U.S.C. § 4332(C).
[13] 40 C.F.R. § 1508.25.
[14] 40 C.F.R. § 1508.25(b)(2).

conserve and enhance groundfish EFH,[15] and the Council and the agency have appropriately called for scoping an EIS here.

NMFS and the Council must "give full and meaningful consideration to all reasonable alternatives."[16] "The choice of alternatives is 'bounded by some notion of feasibility' and an agency is not required to consider 'remote and speculative' alternatives."[17] Instead, the "touchstone" for determining whether a range of alternatives is sufficiently broad "is whether [the agency's] selection and discussion of alternatives fosters informed decision-making and informed public participation."[18]

III. Alternatives to consider

The EFH review process was set up to include three phases: Phase 1, data consolidation; Phase 2, request for proposals to modify EFH, and Phase 3, management action.[19] In response to the Council's call for public proposals, on July 31, 2013, Oceana, the Natural Resources Defense Council (NRDC) and Ocean Conservancy submitted a coastwide conservation proposal to modify groundfish EFH designation, conservation and enforcement.[20] NMFS and the Council are now in "Phase 3" of the EFH process and at its September 2015 meeting the Council adopted a preliminary range of alternatives that includes our coastwide conservation proposal to modify existing and establish new EFH conservation areas closed to bottom trawling.

A. Modifications to EFH conservation areas

In 2005 with Amendment 19, the Council's approach was to establish an array of EFH conservation areas prohibiting bottom trawling in areas known to have sensitive habitat (criteria included hard substrate, biogenic habitats such as corals and sponges, submarine canyons, seamounts, ridges and other areas of interest), to establish EFH conservation areas closed to all bottom contact fishing gear, to designate Habitat Areas of Particular Concern, and to freeze the bottom trawl footprint by closing waters deeper than 700 fathoms as a precautionary measure. Particularly for managed groundfish which are known to associate with and utilize physical and biogenic seafloor structures as habitat,

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[15] NMFS, Pacific Coast Groundfish FMP, Essential Fish Habitat Designation and Minimization of Adverse Impacts, Final EIS (Dec. 2005), available at http://www.westcoast.fisheries.noaa.gov/publications/nepa/groundfish/final_groundfish_efh_eis.html.

[16] *Te-Moak Tribe of Western Shoshone of Nev. v. United States*, 608 F.3d 592, 601-02 (9th Cir. 2010); *Citizens for Better Henderson v. Hodel*, 768 F.2d 1051, 1057 (9th Cir. 1985) (stating that the "existence of a viable but unexamined alternative renders an environmental impact statement inadequate").

[17] *Westlands Water Dist. v. United States*, 376 F.3d 853, 868 (9th Cir. 2004) (quoting *Vt. Yankee Nuclear Power Corp. v. Natural Res. Def. Council, Inc.*, 435 U.S. 519, 551 (1978).

[18] *Id.* (quoting *California. v. Block*, 690 F.2d 753, 767 (9th Cir. 1982).

[19] Council Operating Procedures (COP) 22 (June 13, 2007, revised Sept. 11, 2008, April 12, 2011).

[20] Oceana, NRDC, OC. 2013, Proposal to the Pacific Fishery Management Council to Modify Groundfish Essential Fish Habitat Designation, Conservation, and Enforcement (July 31, 2013), available at ftp://ftp.pcouncil.org/pub/GF_EFH_Review%202011-2012/Oceana.NRDC.OC/.

these habitat protections should ideally maintain and enhance the overall productivity of the groundfish fishery, resulting in dual long-term conservation and fishery benefits. The initial implementation of this approach was groundbreaking. Due to the general paucity of information on seafloor habitats and their relationship to managed groundfish, however, it was broadly recognized that the ultimate success of EFH conservation and management would depend on the incorporation of new scientific information and refinements of management measures over time through an adaptive management framework.

Using new fishery and habitat information compiled during the Council's EFH review process, our coastwide conservation proposal builds on the approach adopted by the Council in 2005 and implemented by NOAA Fisheries in 2006 to protect sensitive seafloor habitats while avoiding significant economic impacts to bottom trawl fisheries. Our proposal includes 75 modifications (additions, deletions, and boundary changes) to currently designated EFH conservation areas plus the closure of deepwater (>3,500 m depth) areas to bottom trawling. This proposal was the result of a multi-year outreach and research effort and it benefited greatly from input of the Council's EFH Review Committee and the data contained in the EFH Data Catalog. It received high review scores from other members of the EFH Review Committee and it performed exceptionally well in the preliminary analysis conducted by NMFS[21] (highest increase in habitat protections while restoring and minimizing further displacement of recent bottom trawl fishing effort). In addition, the proposal has broad public support from over 50,000 California, Oregon, Washington, and Idaho residents.[22]

Since July 2013 when the original proposal was submitted, we have received further input from agencies and stakeholders, and we have minor modifications to the original proposal as it moves forward in the NEPA process. As stated in our August 14, 2015[23] letter to the Council, we ask that NMFS consider all changes to area boundaries contained in the original proposal with the following exceptions:

- Remove Proposed Closure Area 4 ("Copalis Inner Shelf"): based on input from Treaty Tribes in Washington State;
- Remove Proposed Closure Area 21 (Pt. St. George Reef): based on information from the shrimp trawl fleet on the importance of this area to their fishery;

[21] See Tables 3 through 8 of NMFS Response to Council's Questions concerning the Effectiveness, Accuracy, and Completeness of Pacific Coast Groundfish EFH. Supplemental Informational Report 7. PFMC September 2014 Meeting. http://www.pcouncil.org/wp-content/uploads/IR7_Sup_NMFS_EFH_EvalRpt_Sept2014BB.pdf

[22] See October 9, 2013 Public Comment from 52,165 U.S. West Coast residents supporting analysis, adoption, and implementation of the Oceana, NRDC, and Ocean Conservancy Comprehensive Conservation EFH proposal. Available at p. 3-596 of http://www.pcouncil.org/wp-content/uploads/H7d_PC_ELECTRIC_SIGS_NOV2013BB.pdf

[23] Geoff Shester and Ben Enticknap (Oceana) letter to Ms. Dorothy Lowman (PFMC). PFMC Agenda Item H.8.b. Public Comment 2. September 2015. Available at: http://www.pcouncil.org/wp-content/uploads/2015/08/H8b_PubCom2_SEPT2015BB.pdf

- Remove Proposed Reopenings 43 and 44 (Cordell Bank East and South Reopenings): based on concerns raised by the Cordell Bank National Marine Sanctuary (CBNMS) regarding reopening of areas currently closed to trawling within CBNMS boundaries;
- Remove Proposed Closure 59 (Monterey Canyon Deep Expansion): based on input from participants in the collaborative MBNMS proposal; and
- Do not analyze Proposed Reopening 76 (Concept for Monterey Bay State Waters): reopening of state waters closed by California legislature is not within the scope or authority of the Council's action.

B. Amend the Groundfish FMP EFH designation to identify major groundfish prey species based on new diet composition studies and a Major Prey Index.

Federal regulations instruct fishery management councils to list the "major prey species" for managed species in each FMP.[24] Once major prey species are identified, potentially adverse impacts to major prey species, such as harvesting or habitat destruction, can be monitored and managed.[25] In our 2013 proposal we requested NMFS and the Council make changes to the prey component of groundfish EFH based on updated scientific information on the diet of groundfish, but without any additional management measures.

We proposed 31 major prey taxa based on development of a Major Prey Index assessing the diet composition for 11 groundfish species.[26] In April 2015 the Council requested that for prey species, Appendix B to the Groundfish FMP be updated, "but do not include this within the scope of issues to be advanced."[27] We understand that the Council provided this guidance based on the premise that our proposed additions to the major prey taxa in Appendix B could occur outside the FMP amendment process. However, if this is not the case, we request it be included within the scope of this action, as the Council clearly directed staff to move forward with this issue. We view this decision by the Council as clear direction to the agency and Council staff to move forward with an update of groundfish prey in the Groundfish FMP appendix. The scoping notice includes one action alternative to "[u]se the best scientific information available to revise the descriptions of the habitat requirements for each species and life stage in Appendix B to the FMP."[28] This suggests changes to the prey component of groundfish EFH may be included in this action. We request clarity from NMFS on the process moving this forward and if not part of this EIS, we request that NMFS complete the update parallel to this FMP amendment process. As no other stakeholders have suggested prey species to add to the FMP appendix, we respectfully request the agency start with the major prey index and species highlighted in our 2013 coastwide conservation proposal.

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[24] 50 C.F.R. § 600.815(a)(7).
[25] Id.
[26] Oceana et al. 2013, *supra note* 20 at 37-38.
[27] PFMC Decisions. http://www.pcouncil.org/wp-content/uploads/2015/04/0415decisions.pdf at 3.
[28] 81 Fed. Reg. 5102, 5104 (Feb. 1, 2016).

C. Consider midwater trawl gear regulation changes

In Amendment 19, seafloor habitat impacts by the Pacific hake midwater trawl fishery were not considered based on the assumption that this gear types does not contact the seafloor. As described in the EFH Review Committee Phase 2 report:

> 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.[29]

New analysis by the Northwest Fisheries Science Center (NWFSC) indicates that the original rationale for excluding midwater trawl vessels from EFH conservation area regulations is no longer valid. While the quantitative extent of bottom contact by midwater trawls cannot be precisely determined due to the lack of direct monitoring of bottom contact, the September 2014 NWFSC report indicated significant bottom contact based on the presence of benthic fish and invertebrate taxa in the catch. [30] The NWFSC April 2015 report found that approximately 12.1% of hauls occurring inside EFH conservation areas and 22.8% of hauls outside of EFH conservation areas had at least one "benthic taxa," which indicates seafloor contact and potential seafloor habitat impacts.[31] What is more, 70 percent of shore-side whiting trips landed at least one benthic taxa. From the present data it is clear that bottom contact is occurring both inside and outside EFH conservation areas, confirming the basis for prohibitions against bottom contact by midwater trawls, as articulated in the Oceana/NRDC/OC EFH proposal. Consequently, we request that NMFS include regulations addressing midwater trawl bottom contact inside EFH conservation areas within the scope of this action.

At the April 2015 meeting, the Council passed a motion stating:

> "Relative to the midwater trawl fisheries (both whiting and non-whiting), request that the industry voluntarily avoid contacting the bottom with trawl gear in EFH conservation areas, continue to monitor and estimate whether bottom contact occurred in a manner similar to what was

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[29] Essential Fish Habitat Review Committee (EFHRC), Supplemental EFHRC Report 2 (April 2013), available at http://www.pcouncil.org/wp-content/uploads/D6c_SUP_EFHRC_APR2013BB.pdf.

[30] NMFS Response to Council's Questions Concerning The Effectiveness, Accuracy, and Completeness of Pacific Coast Groundfish EFH (Sept. 2014), available at http://www.pcouncil.org/wp-content/uploads/IR7_Sup_NMFS_EFH_EvalRpt_Sept2014BB.pdf.

[31] NMFS 2015. NMFS Report: Analysis of Seafloor Contact in Midwater Trawls Engaged in The U.S. West Coast Pacific Hake Fishery. PFMC. Information Report 4. April 2015.

> presented in NMFS Informational Report 4 (in the April 2015 briefing book), and assess whether regulatory measures relative to the use of midwater trawl gear in EFH conservation areas should be considered in the future, as appropriate."[32]

In the event NMFS chooses not to analyze the impacts of midwater trawls on EFH resulting from the bottom contact identified in the NWFSC reports in this EIS and consider alternatives for minimizing adverse impacts of midwater trawl on EFH, we request NMFS solidify the Council's direction by formally notifying the midwater trawl fleet of the location of EFH conservation areas and requesting that "the industry voluntarily avoid contacting the bottom with trawl gear in EFH conservation areas." Further we request NMFS follow through with this motion by monitoring and periodically estimate midwater trawl impacts. NMFS should consider requiring gear sensors on midwater trawl nets to more accurately detect seafloor impacts.

D. Prohibit bottom contact gear in water deeper than 3,500 meters

Oceana supports consideration of an alternative to prohibit bottom-contact gear in water deeper than 3,500 meters as a precautionary measure to protect pristine and highly sensitive habitats in this deep sea region and as described in the notice of intent. In our 2013 coastwide conservation proposal we proposed this area be closed to bottom trawling, and we suggested this could be accomplished either through EFH authority or other discretionary authorities under the MSA. If NMFS believes the most effective approach is to close this area to all bottom contact gear, we would support that decision.

In its motion adopting Amendment 19, the Council recommended protecting all waters deeper than 700 fathoms from bottom trawling. NMFS only partially approved this action, however, limiting the extent of the footprint closure to 3,500 meter depth. NMFS acknowledged in the Amendment 19 Record of Decision that "bottom trawling outside 3,500 m . . . is likely to have long-lasting environmental consequences."[33] NMFS continued on to state that hydrothermal vents, soft-bottom sediments and hard bottom areas with biogenic habitat such as deep sea corals beyond 3,500m "are likely to be highly sensitive to impact, including very low levels of fishing effort (e.g. a single trawl), and have extended recovery times (over 7 years)" and concluded that they "can be very sensitive to bottom trawling and would take a long time to recover from this impact."[34]

As you know, at the time the agency declined to designate the area as EFH or otherwise protect it. However, as stated in our proposal, in various public comments to the Council,

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[32] PFMC 2015. PFMC Decision Summary Document, available at: http://www.pcouncil.org/wp-content/uploads/2015/04/0415decisions.pdf at 4.
[33] National Marine Fisheries Service, Record of Decision: Final EIS for EFH Designation and Minimization of Adverse Impacts at 18 (2006).
[34] *Id.* at 24.

and this notice of intent to prepare an EIS, "the MSA contains several discretionary authorities that the Council may use to close these waters regardless of their designation as EFH [MSA sections 3039(b)(2)(A), 303(b)(2)(B) and 303(b)(12)]."[35] With these discretionary provisions it is clear NMFS and the Council have ample authority to protect this region from groundfish fishing impacts. What is more the science clearly suggests such an approach is warranted.[36]

Based on our GIS analysis of the area beyond 3,500 meters to the edge of the West Coast EEZ, this alternative would protect roughly 123,221 square miles of the deep sea seafloor. This area includes 195 distinct coral observations (including the black coral *Bathypathes alternata* and the stony coral *Fungiacyathus marenzelleri*, the gorgonian coral *Chrysogorgia* sp., and the mushroom soft coral *Anthomastus robustus* at depths from 3,800-4,100 m depth and the bamboo coral *Keratoisis* sp. and *Lepidisis* sp., plus 1,141 pennatulid observations, indicating that this area contains deep sea coral and sponge ecosystems. Moreover, based on fishing effort data provided by NMFS in the EFH review process, protecting this area would not displace groundfish fishing effort and therefore not have an economic impact on the fishery.

E. Changes to trawl Rockfish Conservation Areas

As stated in the notice of intent, groundfish trawl RCAs were implemented in 2002 to control bycatch of overfished species. The habitats within the trawl RCAs have been protected from bottom trawling allowing for over a decade of habitat recovery and the year-round trawl RCA contains sensitive and important habitat features including rocky reef habitat (a Habitat Area of Particular Concern), mixed rock habitat, corals, sponges and other biogenic habitat features that are currently outside EFH conservation areas. As such, these sensitive components of EFH would be adversely impacted by resumed bottom trawling if the trawl RCA is opened. The Council preliminarily identified three action alternatives for making adjustments to the trawl RCAs; 1) a complete removal of the existing trawl RCAs, 2) retaining a subset of the existing RCA to protect overfished species and 3) retaining a larger subset of the existing RCAs to protect overfished species and act as a catch-control mechanism for non-overfished species of groundfishes.

Having over a decade to recover from trawl impacts, habitats within the year-round trawl RCA provide valuable fish habitat and are more sensitive to the impacts of resumed trawling than similar areas that were not closed. First, for all trawl RCA action alternatives, it should be clear that where the trawl RCA currently overlaps with existing EFH conservation areas or state-water closures, those areas would remain closed to trawling. Second, Oceana requests action alternatives two and three be designed so that areas within and/or adjacent to the current year-round trawl RCA containing ecologically

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[35] 81 Fed Reg. 510, 5103 (February 1, 2016).
[36] See for example, scientists statement on habitat protection beyond 3,500 meters signed by 137 scientists, at: http://www.pcouncil.org/wp-content/uploads/2015/09/H8b_SUP_PubCom6_SEPT2015BB.pdf

important and/or sensitive habitats important to overfished species and target species remain protected by designating them as EFH conservation areas closed to trawling if bycatch-related spatial protections are lifted.

We request NMFS design these alternatives with consideration of the following criteria:

- Biogeographic representation: maintain area closures in in the northern, central and southern biogeographic regions.
- Habitat representation: maintain a diversity of all physical habitat types (soft, hard, mixed) within bottom trawl closures with a focus on hard/ rocky reef substrates which were designated in Amendment 19 as Habitat Areas of Particular Concern.
- Maintain bottom trawl area closures where the current trawl RCA overlaps with submarine canyons and canyon-heads.
- Protect areas known to contain deep-sea corals and sponges.
- Protect areas that may contain deep-sea corals and sponges based on coral and sponge predictive modeling.[37]

As the current trawl RCA is closed to bottom trawling, any removal of the RCA would authorize bottom trawling. Therefore, the EIS must analyze the potential for new, increased adverse impacts to EFH resulting from the reopening of all areas of the RCA that do not remain closed as EFH.

Last we note that in our 2013 coastwide conservation proposal we envisioned a scenario where the trawl RCA would be fully lifted. Our proposal therefore includes portions of the RCA that we believe should remain closed as EFH conservation areas. Thus that proposal for new and modified EFH conservation areas would keep portions of the current RCA closed as EFH. That fact should be considered when evaluating the public proposals identified in this federal register notice.

IV. Identification of environmental issues to consider in the EIS

A. Effects of bottom trawling on seafloor habitats

Central to the actions being considered and the EIS being prepared for this FMP amendment is the scientific understanding of the effects of bottom trawling on EFH. The literature documenting the effects of bottom trawling, dredging and other fishing on seafloor habitat is substantial, consisting of well over 100 studies globally.[38] There is general scientific consensus that bottom trawling has wide ranging effects on habitats and

[37] Guinotte JM, Davies AJ. 2014. Predicted Deep-Sea Coral Habitat Suitability for the U.S. West Coast. PLoS ONE 9(4): e93918. doi:10.1371/journal.pone.0093918
[38] Johnson 2002 in NMFS 2005. Final Groundfish Essential Fish Habitat (EFH) Environmental Impact Statement. (December 2005).

ecosystems. According to the National Academy of Sciences National Research Council Report[39] on the Effects of Trawling and Dredging on Seafloor Habitat, these adverse impacts include:

- changes in physical habitat of ecosystems
- changes in biologic structure of ecosystems
- reductions in benthic habitat complexity
- changes in availability of organic matter for microbial food webs
- changes in species composition
- reductions in biodiversity

Since that time, as indicated in the EFH Review Committee reports, additional scientific studies have further confirmed these conclusions, and there is no scientific basis for refuting or revisiting the fundamental premise of adverse impacts of bottom trawling on EFH. In particular, the EFH Review Committee's Phase 2 Report's primary conclusion on the current understanding of bottom trawl impacts concludes: "From the Phase 1 report, (1) effects of fishing with mobile, bottom-contact fishing gear on benthic habitats are increasingly well-established worldwide…".[40]

Bottom trawling remains the leading, most widespread cause of reduced habitat complexity that is taking place among major fishing grounds along the North American continental shelf and slope. As trawl gear can crush, displace, expose and bury marine life on the sea floor, habitats that are trawled are far more likely to have reduced overall species diversity. Those organisms remaining after extensive periods of trawling tend to be "comprised of large numbers of a few opportunistic species."[41] Studies have found that the extent of the disruption of a habitat's complexity is dependent upon how long the area has to recover between trawls, how extensive the damage is from the trawling gear, and whether the habitat is constituted primarily of quick-recovering short-lived species or of slow growing, long-lived species.

The National Research Council report concludes that the impacts of trawling can lead to measurable changes in benthic habitats over time, with the greatest impact on those communities which are ecologically most complex. Extended trawling over the same habitat can lead to "a shift from communities dominated by species with relatively large adult body size towards dominance by high abundances of small-bodied organisms". More significantly, areas of intense trawling activities have the potential to be permanently

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[39] National Research Council (NRC). 2002. Effects of Trawling and Dredging on Seafloor Habitat. Washington, D.C, National Academy of Sciences, National Research Council.
[40] http://www.pcouncil.org/wp-content/uploads/D2b_EFHRC_RPT_PHASE2_MAR2014BB.pdf at p. 14
[41] Norse, E. A. and L. Watling. 1999. Impacts of mobile fishing gear: the biodiversity perspective. Fish habitat: essential fish habitat and rehabilitation. P.-i. L. R. B. (ed.). Bethesda, Maryland., American Fisheries Society, Symposium 22.

affected and will lead to the emergence of short-lived organisms which are "readapted to conditions of frequent physical disturbance".[42]

Importantly we urge NMFS to consider observer information on the bycatch of corals and sponge as perhaps the most direct evidence for adverse fishing impacts on the quality and quantity of EFH. As described in the NOAA's State of the Deep Sea Coral Ecosystems for the U.S. West Coast, "Since June 2006, observers of the bottom trawl fishery have recorded a doubling of encounters with sponges and pennatulaceans, while the frequency of occurrence of other corals remained unchanged (Table 3, PFMC 2012). Also, sponge bycatch appears to have increased almost 5-fold [20,585 kg) while bycatch of corals had decreased 4-fold [997 kg]."[43] New EFH conservation areas should be considered that protect coral and sponge bycatch hotspots as in our coastwide conservation proposal and in the NOAA 2014 Deep Sea Coral Research and Technology Program Report to Congress.[44]

B. Importance of biogenic habitats

Corals, sponges, and other habitat-forming invertebrates provide three-dimensional structure on the seafloor that increases the complexity of benthic substrates. While corals and sponges are the most conspicuous and easily observable biogenic structures, they generally occur in diverse biological communities with other invertebrates such as crinoids, basket stars, ascidians, annelids, and bryozoans. Deep-sea corals, sponges and other habitat-forming invertebrates provide three dimensional structures that form habitat for commercial groundfish, shellfish, and other marine life. Corals and sponges are known to be long-lived, slow growing and sensitive to trawl impacts.[45]

Cold-water coral and sponge habitat is an important component of essential fish habitat and is vulnerable to the impacts of bottom trawling. Managed fish species off the U.S. West Coast that have been documented in association with structure-forming invertebrates include arrowtooth flounder, big skate, bocaccio, California skate, cowcod, Dover sole, flag rockfish, greenspotted rockfish, lingcod, longspine thornyhead, Pacific ocean perch, quillback rockfish, rosethorn rockfish, sablefish, sharpchin rockfish,

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[42] NRC 2002, *supra note* 38

[43] Clarke ME, Whitmire CE, Yoklavich MM. 2015. State of Deep-Sea Coral and Sponge Ecosystems of the U.S. West Coast: 2015. In: Hourigan TF, Etnoyer PJ, Cairns SD, Tsao C-F (eds.) The State of Deep-Sea Coral and Sponge Ecosystems of the United States: 2015. NOAA Technical Memorandum X. NOAA, Silver Spring, pp 5-1 – 5-42, at page 21

[44] The 2014 NOAA Deep Sea Coral Research and Technology Program report to Congress recommends the Pacific Council consider protecting eight spatially discrete areas from bottom trawling based on observed coral bycatch and the documented presence of coral aggregations. See: http://www.habitat.noaa.gov/pdf/FINAL_DSCRtC_4_17_2014_Interactive.pdf at 46.

[45] E.g. corals at Davidson Seamount were aged to be over 145 years. See: http://www.astrofish.me/Sea_N_Space/Inverts/Entries/2009/12/5_Follow_up_study_on_bamboo_coral_from_Davidson_Seamount_and_new_work_for_Alaska.html

shortspine thornyhead, spotted ratfish, starry rockfish, tiger rockfish, vermilion rockfish, yelloweye rockfish, and yellowtail rockfish.[46] Therefore, based on the current level of information (Level 1) available for these species, the presence of these species in coral and sponge habitat is sufficient for their inclusion as a component EFH, given the guidance in the EFH Final Rule. Importantly, it would be inappropriate for NOAA not to consider corals and sponges as components of EFH, as they fall within the geographic area designated as EFH in Amendment 19. In the absence of information on the relative importance of biogenic structures in relation to other non-biogenic structures, the fact that managed fish associate with both types of structures indicates that all natural structures (whether biogenic or not) must be considered EFH under the current EFH Final Rule Guidance.

Through the EFH review process much new information has become available on the location structure forming invertebrates that can help NMFS and the Council in the design and selection of new or modified EFH conservation areas. Furthermore there is much new information that both confirms and enhances the scientific understanding of structure forming invertebrates as EFH for managed groundfish species. Included in an appendix to this letter is an overview of recent scientific studies on biogenic habitats and associations with managed groundfish species.

C. Analyze the cumulative impacts of changes to EFH conservation areas and the RCA

In an EIS, the federal agency must identify the direct, indirect, and cumulative impacts of the proposed action, and consider alternative actions and their impacts.[47] In addition, the EIS must analyze "[c]onnected actions," "[c]umulative actions," and "[s]imilar actions" together in one environmental impact statement.[48] Actions are "connected actions" if they: "[a]utomatically trigger other actions which may require environmental impact statements," "[c]annot or will not proceed unless other actions are taken previously or simultaneously;" or "[a]re interdependent parts of a larger action and depend on the larger action for their justification."[49]

As NMFS and the Council consider alternatives to modify both EFH conservation areas and the trawl RCA it is imperative that the combined cumulative impacts and change be considered. These actions cannot be viewed separately as they may result in significant overall changes to the area and extent open and closed to bottom trawling. We strongly recommend and request NMFS prepare spatial analyses comparing the overall changes

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[46] NMFS (2005). Final Groundfish Essential Fish Habitat (EFH) Environmental Impact Statement. (December 2005). At 3-6.
[47] *See* 42 U.S.C. § 4332(C).
[48] 40 C.F.R. § 1508.25(a)(1)-(3).
[49] 40 C.F.R. § 1508.25(a)(1)(i)-(iii).

envisioned in the EFH and RCA alternatives with the status quo. We request these analyses consider the following metrics, for which spatial data are available:[50]

- Total area closed to bottom trawling (coastwide, by biogeographic region and depth strata - shelf, upper slope, lower slope).
- Proportion of substrate type included in EFH conservation areas/ RCAs (hard, mixed, soft) by region and depth zone.
- Total number and proportion of coral and sponge observations included in EFH conservation Areas/ RCAs by region and depth zone (coral and sponge data is available on the EFH Catalogue provided by the NOAA Deep Sea Coral Research Technology Program).
- Total area of predicted coral habitat included in EFH Conservation Areas/ RCAs by region and depth zone (Guinotte and Davies 2014 data on the EFH Review Catalogue).
- The occurrence and abundance of overfished groundfish species and representative groundfish species in EFH conservation areas/ RCAs by region and depth zone based on NOAA NWFSC models.
- Observed coral and sponge bycatch inside and outside EFH conservation areas and RCAs.
- Bottom trawl effort and groundfish landings displaced/ restored.

D. Concerns with alternatives that would open EFH conservation areas or year-round trawl RCAs

We understand some alternatives would open portions of, or all of some EFH conservation areas, to bottom trawling. While some minor boundary modifications, coupled with additional EFH conservation areas in the immediate vicinity that provide an overall increase in habitat protection may ultimately be appropriate, we strongly caution against opening EFH conservation areas or year-round Trawl RCAs to bottom trawling as such actions would fail to minimize adverse impacts to EFH. Regardless of the initial reason for closure, any reopening of an area currently closed year-round to bottom trawling will increase adverse impacts to EFH. In particular, very few EFH conservation areas have been fully mapped and surveyed and in most cases there is little to no new information to suggest that any current EFH conservation areas do not meet their original objectives to protect vulnerable and sensitive habitat features and minimize the adverse effects of fishing.

To protect EFH, Councils are required to "prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable, if there is evidence that a fishing activity adversely affects EFH in a manner that is more than minimal and not temporary in nature."[51] Adverse effects mean "any impact that reduces quality and/or quantity of EFH,"

[50] http://efh-catalog.coas.oregonstate.edu/overview/
[51] 50 C.F.R. § 600.815(a)(2)(ii)

and may include "direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH."[52]

To implement these requirements, the Council and NMFS developed Amendment 19 to the Pacific Coast Groundfish FMP, which protected many coral and sponge hotspots known at that time and other features like rocky reefs and submarine canyons. In implementing Amendment 19, NMFS concluded that "adverse impacts to habitat were possible [from fishing] that could impair the ability of fish to carry out basic biological functions and potentially have long-lasting or permanent implications at the scale of the ecosystem."[53] Therefore, "to protect EFH from the adverse effects of fishing, the Council . . . identified areas that are closed to bottom trawling." These precautionary management measures were carried out in the agency's final rule implementing Amendment 19.[54]

Opening existing EFH conservation areas or the year-round trawl RCA would be certain to increase the adverse effects of fishing on EFH. Moreover, if it was practicable to protect EFH conservation areas in 2006, it remains practicable today to keep these areas closed. As a matter of science, if any areas were considered for re-opening in the future, it should only happen after very detailed surveys of the habitats and species inside the area to ensure there are no vulnerable features and with close scientific study of the fishing impacts.

…

Thank you for your previous actions and ongoing commitment to minimizing adverse effects of fishing on essential fish habitat, while providing for vibrant West Coast fishing opportunities. We look forward to working NMFS and the Council as this process moves forward.

Sincerely,

Geoffrey Shester, Ph.D.
California Campaign Director

Ben Enticknap
Pacific Campaign Manager and Senior Scientist

[52] *Id.* § 600.810(a).
[53] 71 Fed. Reg. 27,408, 27,410 (May 11, 2006)
[54] *See* Groundfish FMP § 6.2.4; 50 C.F.R. § 660.396.

Appendix.

Overview of Recent Scientific Studies on Biogenic Habitat Use by FMP Groundfishes in the Eastern North Pacific (December 20, 2013).

This document provides an overview of recent scientific studies on habitat associations between structure-forming invertebrates and groundfishes managed under the Pacific Fishery Management Council's Groundfish Fishery Management Plan (FMP). The geographic scope of studies included in this document ranges from the southern border of California through the U.S. waters of the Bering Sea (i.e., the eastern North Pacific). This document is provided in response to the Essential Fish Habitat Review Committee (EFHRC) statement of a "top priority" need, during Phase 2 of the Groundfish Essential Fish Habitat 5-year Review, to "Re-assess the role of corals and sponges as habitat for groundfish based on an updated literature review." Pacific Fishery Management Council Briefing Book, April 2013, Supplemental EFHRC Report at 2. Specifically, this literature review addresses the level of available information on biogenic habitat and the relative habitat value of several structure-forming invertebrates, including cold-water corals (stony corals, Scleractinia; black corals, Antipatharia; sea fans and sea whips, Gorgonacea; true soft corals, Alcyonacea; sea pens, Pennatulacea; and stylasterid corals, Stylasteridae; Hourigan et al. 2007); sponges (Porifera), and other structure-forming invertebrates such as worm tubes, barnacle tests, and crinoids. Information in this review was compiled from the scientific literature, as surveyed in a thorough search of digital databases, previously assembled bibliographies, and published works. The literature reviewed ranged from observational notes to directed studies and reviews. Conference abstracts were omitted and an emphasis was placed on peer-reviewed literature; however, grey literature (non-peer reviewed reports), technical memorandum and graduate theses were incorporated when applicable.

Introduction

Many groundfishes are associated with structured environments (Love and York 1996, Yoklavich and O'Connell 2008). This structure may be abiotic (e.g., rock outcrops, boulders, sand waves), biogenic (e.g., corals, sponges, kelp), or a combination of both. Although a complete definition of biogenic habitats includes kelp forests and seagrass beds, this review is limited to those biogenic habitats created by invertebrates. Invertebrates that form structured habitats in marine environments are commonly termed "structure-forming invertebrates.

Federal regulations state that a hierarchical approach should be used to organize the information necessary to identify and describe Essential Fish Habitat (EFH). Four levels of information are defined:

> Level 1: Distribution data are available for some or all portions of the geographic range of the species.
> Level 2: Habitat-related densities of the species are available.
> Level 3: Growth, reproduction, or survival rates within habitats are available.

Level 4: Production rates by habitat are available.

See 50 C.F.R. § 600.815(a)(1)(iii)(A). The distinctions above relate to the type of information available, not the results or findings of the information.

For structure-forming invertebrates along the U.S. West Coast, the great majority of available information falls into Level 1, indicating simple presence-absence associations between groundfish and corals or sponges, and criteria for determining associations vary by study. By the criteria associated with this level, regional distributions of FMP groundfishes (or life stages) "can be inferred on the basis of distributions among habitats where the species has been found and on information about its habitat requirements and behavior." 50 C.F.R. § 600.815(a)(1)(iii)(A)(1). Far fewer studies are available in the eastern North Pacific to determine habitat-specific densities of FMP groundfishes (or life stages) relative to biogenic habitats, which is the overall criterion for Level 2; however, Level 2 studies have become somewhat more common in recent years. Within the eastern North Pacific, no studies currently provide Level 3 information ("Growth, reproduction, or survival rates within habitats are available") or Level 4 information ("Production rates by habitat are available") with respect to structure-forming invertebrates and their relationship to FMP groundfish. For each taxon covered in this study, the level of available data will be indicated.

Cold-Water Corals

The great majority of information available on cold-water corals as biogenic habitat in the eastern North Pacific examines associations between sympatric cold-water corals and groundfishes (Level 1). Several quantitative studies are available, however, and many directed studies have been published since the last EFH review. Numerous publications from Alaskan waters have described associations between groundfishes and cold-water corals. Heifetz (2002) used trawl data collected from National Marine Fisheries Service (NMFS) surveys to associate rockfish, and especially shortspine thornyheads, with sea fans (e.g., *Primnoa* spp.) and flatfish and cods with soft corals in Alaskan waters. Krieger and Wing (2003) specifically investigated *Primnoa* species associations and found that large (40-70 cm total length), but not small (< 40 cm total length), rockfish were highly associated with these sea fans in the Gulf of Alaska. Qualitative video analysis from manned submersible dives indicated high co-occurrence of sharpchin rockfish (100%), juvenile rockfish (96%), rougheye rockfish (74%) and shortraker rockfish (70%) with cold-water corals in the Aleutian Archipelago (Heifetz et al. 2007). In the same region, corals and coral gardens were highly correlated with FMP groundfish and juvenile rockfish occurrence (Stone 2006). Densities of large flatfishes (>15 cm total length) were 2.6 times greater in sea whip habitat than sediment without sea whips in the Gulf of Alaska, but the habitats were not statistically compared (Stone et al. 2005).

In a directed study of longnose skate nursery habitat off Southern California, Love et al. (2008) found that most egg cases were laid on bare rock, but that those placed on biogenic structure (including 4 cold-water corals) were much less likely to suffer predation. While a low percentage of the total number of invertebrates were in close proximity to fishes, Yoklavich (2011) observed thornyhead, aurora, and bank rockfishes, Dover sole, Pacific hagfish, eelpouts and catshark egg cases within one body length of 148 coral and sponges documented during daytime remotely operated vehicle (ROV) dives on Piggy Bank Seamount off Southern California. Off Monterey Bay and Carmel Bay, Shester et al. (2011) observed 20 FMP groundfish species (blue rockfish, cabezon, canary rockfish, China rockfish, copper rockfish, flag rockfish, gopher rockfish, greenspotted rockfish, greenstriped rockfish, halfbanded rockfish, kelp greenling, lingcod, olive/yellowtail rockfish, Pacific sand dab, rosy rockfish, squarespot rockfish, starry rockfish, treefish, vermillion rockfish, and yelloweye rockfish) in ROV transects containing cold-water corals at depths from 22 to 189 meters. Off Southern Oregon, Enticknap et al. (2013) observed 12 FMP groundfish species (greenstriped rockfish, widow rockfish, quillback rockfish, China rockfish, tiger rockfish, canary rockfish, rosy rockfish, olive/yellowtail rockfish, yelloweye rockfish, kelp greenling, and lingcod) in ROV transects containing cold-water corals at depths from 28 to 228 meters. In the Aleutian Islands, rockfish were frequently observed in close association with sea fans and groundfish (including Pacific cod) and cold-water corals were linked by physical habitat type (Zenger 2005).

In addition to these largely descriptive or correlative studies, some directed studies that link cold-water corals and eastern North Pacific groundfishes with more rigorous analysis are available. Using manned submersible video, Pirtle (2005) investigated associations between macroinvertebrates, including cold-water corals, and groundfishes at Cordell Bank. The following taxa occurred in significantly greater abundance in association with sea fans: juvenile rockfish, *Sebastomus* spp., rosy rockfish, and widow rockfish. Conversely, pygmy and yellowtail rockfish were statistically less common near sea fans (Pirtle 2005). Greenspotted rockfish were more often found near sea pens (*Ptilosarcus* spp.), whereas juvenile rockfish avoided them (Pirtle 2005). Tissot et al. (2006) found that swordspine rockfish occurred in significantly greater abundance near sea fans. In the Channel Islands, Bright (2007) found that 13 percent of observed black corals and gorgonian corals had close associations with managed groundfish species (including bank, canary and cowcod rockfishes), but no estimate of relative use was calculated, so this study represents Level 1 information. Bianchi (2011), however, did not find that FMP groundfishes were significantly more abundant near corals.

Three submersible studies have been recently conducted in the U.S. Pacific Northwest and British Columbia that provide information on groundfish associations with cold-water corals. In a comparison of fauna on trawled and untrawled regions of Coquille Bank, there was no correlation found between sea pen and fish densities based on submersible transects, but the authors did find 23% more fish in the untrawled areas, and structure-forming invertebrate density was six times greater in untrawled areas than in trawled areas (Hixon and Tissot 2007). Off the Washington coast, Wang (2005) associated groundfish and invertebrates; however, only four coral types (sea whips) were observed and their habitat importance could not be determined. DuPreez and Tunnicliffe (2011) compared densities of fishes among habitats off northern British Columbia and determined that: 1) half of primnoid corals >30 cm tall had associated rockfishes; 2) less than 2% of the seafloor had large coral, and 3) small coral had no associated rockfishes. In regions where *Primnoa* spp. abundance was greatly reduced, shortspine thornyhead abundance significantly increased whereas rockfish (mainly sharpchin and rosethorn) abundance was reduced significantly.

Many studies on the relationship of groundfish with structure-forming invertebrates have been conducted in Alaskan waters recently, including several Level 2 studies. A study of Pacific ocean perch habitat by Brodeur (2001) in Pribilof Canyon used a combination of ROV dives and trawls to determine that Pacific ocean perch aggregations take shelter in sea whip forests by night, and feed on euphausiids above them by day. Seafloor regions with damaged sea whips had far fewer Pacific ocean perch, and areas without this biogenic habitat had no Pacific ocean perch (Brodeur et al. 2001). Off Southeast Alaska, Else (2002) discovered that shortspine thornyhead occurrence is slightly negatively correlated with cold-water coral occurrence, indicating that coral habitat may not be important to this species. Rooper and colleagues have conducted several contemporary studies in the Aleutian Islands and eastern Bering Sea using primarily trawl data to investigate habitat associations of Pacific ocean perch and flathead sole. Juvenile Pacific ocean perch catch per unit effort (CPUE) increased significantly with increasing coral CPUE (Rooper and Boldt 2005). Pacific ocean perch were closely associated with complex structure, including cold-water corals, based on analysis of ROV video data (Rooper et al. 2007). These results indicate that cold-water corals may have an important role in the early life history of Pacific ocean perch in the Aleutian Islands and eastern Bering Sea. Flathead sole CPUE increased with increasing potential cover (structure-forming invertebrates, including corals) in the eastern Bering Sea (Rooper et al. 2005).

More recent research has been conducted off Kodiak Island and in Bering Sea submarine canyons. At Albatross and Portlock Banks, Rooney (2008) estimated groundfish habitat associations at multiple scales, and associated macroinvertebrate and groundfish assemblages. A similar study on Albatross Bank used multivariate techniques to define sympatric assemblages of groundfishes and invertebrates (Reynolds et al. 2012). A recent publication by Miller et al. (2012) investigated associations between groundfish and structure-forming invertebrates in Pribilof and Zhemchug Canyons, which harbor dense aggregations of gorgonian and pennatulacean corals. Many rockfishes were significantly more likely to occur near gorgonians (Pacific ocean perch, shortraker rockfish, rougheye rockfish, shortspine thornyhead) or pennatulaceans (Pacific ocean perch, shortspine thornyhead, combined rockfish).

Sponges

Compared to cold-water corals there is a slightly greater body of literature available on sponge-groundfish associations in the eastern North Pacific. This is likely a result of the relative ubiquity of sponges on hard-bottom habitats when compared to cold-water corals, especially at shallow depths. Several studies looked at associations of both of these structure-forming invertebrates, sometimes using combined biogenic habitat types. The level of information for groundfish associations with sponges is quite similar to that of cold-water corals, in terms of the EFH framework of information, with the majority of sponge-groundfish studies providing Level 1 data.

A great deal of observational information is available on sponge-groundfish habitat associations in the eastern North Pacific, with much of this information published since the last EFH review. Manned submersible operations off California provide observational data on sponge-groundfish associations. Yoklavich et al. (2000) remarked that most juvenile and adult rockfishes in Soquel Canyon were associated with some structure, including sponges. Starry rockfish and small sharpchin rockfish have been observed within and nearby vase sponges off California (Love et al. 2002). Longspine thornyheads were noted on muddy seafloor with rocks and sponges, whereas yelloweye rockfish were found near sponges on vertical walls (Love et al. 2002). Off southern California juvenile cowcod were observed resting in foliose sponges (Love and Yoklavich 2008). Longnose skate typically lay their eggs on bare rock, but those on structure-forming invertebrates, including sponges (n = 4), were far less susceptible to predation (Love et al. 2008). Off British Columbia, Martin and Yamanaka (2004) incorporated sponges and other macroinvertebrates into habitat types based on towed camera transects, but did not directly associate any fishes with specific structure-forming invertebrates. Off Monterey Bay and Carmel Bay, Shester et al. (2011) observed 22 FMP groundfish species (blue rockfish, cabezon, canary rockfish, China rockfish, copper rockfish, Dover sole, flag rockfish, gopher rockfish, greenspotted rockfish, greenstriped rockfish, halfbanded rockfish, kelp greenling, lingcod, olive/yellowtail rockfish, rosy rockfish, squarespot rockfish, starry rockfish, rock sole, stripetail rockfish, treefish, vermillion rockfish, and yelloweye rockfish) in ROV transects containing sponges at depths from 22 to 189 meters. Off Southern Oregon, Enticknap et al. (2013) observed 13 FMP groundfish species (greenstriped rockfish, widow rockfish, quillback rockfish, China rockfish, tiger Rockfish, canary rockfish, rosy rockfish, olive/yellowtail rockfish, yelloweye rockfish, rex sole, kelp greenling, and lingcod) in ROV transects containing sponges at depths from 28 to 228 meters.

Conway et al. (2001) described extensive hexactinellid sponge reefs on the British Columbia continental shelf and observed rockfish using the reef structure and complex shapes of individual sponges as seafloor habitat and refugia. At these same reefs, Krauter et al. (2001) also observed several groundfishes using sponge reefs as refugia, including ratfishes, flatfishes, and rockfishes (greenstriped, yellowtail, quillback, vermillion, redstripe, yelloweye). Juvenile rockfish may also use the reef for nursery functions (Krauter et al. 2001). Cook et al. (2008) further studied these reefs with mixed results. The greatest abundance of juvenile and adult rockfish occurred at one undamaged sponge reef, but another had the lowest faunal associations observed, even less than highly damaged reefs.

Marliave et al. (2009) compared habitat use of hexactinellid sponges reefs and sponge gardens (consisting of many individual sponges) of the cloud sponge, *Aphrocallistes vastus*. Newly recruited quillback rockfish were much more abundant at sponge gardens, perhaps because of greater associated food subsidies, whereas older juveniles and adults of many rockfishes (quillback, yelloweye, redstripe, greenstripe) were observed in greater abundance on sponge reefs (Marliave et al. 2009).

Juvenile and adult arrowtooth flounder occasionally occur over low-relief rock-sponge bottoms in Alaskan waters (NOAA 1990). Submersible observations in the Gulf of Alaska indicate that dusky rockfish (and/or light dusky rockfish, as these species were not considered distinct at the time of publication) associate with rocky areas that have extensive sponge beds (NMFS et al. 1998). Freese and Wing (2003) noted that juvenile rockfish were strongly associated with sponges in the Gulf of Alaska, and Zenger (2005) also noted rockfish in association with sponges in Seguam Pass, in the Aleutian Islands. In the central Aleutians, Heifetz et al. (2007) found several rockfishes to be frequently observed "in the same video frame" as sponges, including: sharpchin rockfish (100%), juvenile rockfish (100%), dusky (and/or light dusky) rockfish (100%), northern rockfish (97%), rougheye rockfish (90%), shortraker rockfish (89%) and Pacific ocean perch (88%). In the same region, coral gardens, which included three classes of sponges (Demospongiae, Hexactinellida, and Calcarea), were highly correlated with FMP groundfish and juvenile rockfish occurrence (Stone 2006). Far fewer review documents are available concerning sponges as compared to cold-water corals, and none are sponge-specific (Burd et al. 2008; Yoklavich and O'Connell 2008; Boutillier et al. 2010; Buhl-Mortensen et al. 2010).

Several more rigorous, quantitative studies and Level 2 studies have been published on sponges, as well as structure-forming invertebrate assemblages that include sponges, in the eastern North Pacific. Among these, several masters' thesis projects involved the use of manned submersibles to study associations between groundfish and structure-forming invertebrates off the West Coast. Wang (2005) did not find significantly higher densities of yelloweye rockfish, canary rockfish, or lingcod in association with several morphological groupings of sponges off the outer coast of Washington. Bianchi (2011) also used morphological sponge groups to investigate associations between groundfish and structure-forming invertebrates in Carmel and Ascension Canyons. She found that the overall the frequency of fishes observed near structure-forming invertebrates was not significantly different from a random distribution, although lingcod and squarespot rockfish were significantly more abundant near mound sponges in Carmel Canyon (Bianchi 2011).

In the Channel Islands, flat sponges (33%), vase sponges (21%), basket stars (18%), foliose sponges (17%) and barrel sponges (17%) had the highest percent of fish associations (Bright 2007). The following rockfishes occurred at higher densities in association with structure-forming invertebrates: squarespot, pygmy, swordspine, widow, pinkrose, and *Sebastomus* spp. At Cordell Bank, Pirtle (2005) determined that several FMP groundfishes (yellowtail rockfish, squarespot rockfish, widow rockfish, rosy rockfish, pygmy rockfish, canary rockfish, greenspotted rockfish, juvenile rockfish, painted greenling, and lingcod) occurred in greater densities near large sponges with complex morphologies (foliose, barrel, and shelf) and had a similar affinity for hard-substrate habitats preferred by sponges.

From an extensive manned submersible survey off southern California, Tissot et al. (2006) determined that < 1% of the observations of organisms sheltering near or within structure-forming invertebrates involved fishes, but that several species occurred in significantly greater numbers near foliose sponges (pinkrose, shortbelly) or multiple sponge varieties (*Sebastomus* spp., bank, cowcod). An early submersible study off British Columbia determined that cloud sponge gardens are important nursery areas for yelloweye and especially quillback juveniles because of the added structure they provide. By contrast, greenstriped rockfish were slightly negatively correlated with sponges (Richards 1986).

Reynolds et al. (2012) and Rooney (2008) used multivariate techniques to define fish and macroinvertebrate assemblages off Kodiak Island, with Rooney (2008) investigating habitat associations at multiple scales. Directed species studies showed that: 1) bigmouth sculpin eggs deposited in at least four sponges in the Gulf of Alaska and Bering Sea (barrel sponge, *Halichondria lambei*; clay-pipe sponge, *Aphrocallistes vastus*; boot sponge, *Acanthascus dawsoni*; and tree sponge, *Mycale loveni*; Busby et al. 2012); 2) depth, substrate type, and sponge presence were most highly correlated with shortspine thronyhead abundance in the southeast Gulf of Alaska, but the relationship was confounded because sponge abundance also was highly correlated with substrate type (Else et al. 2002), and 3) higher densities of Pacific ocean perch, and especially juveniles, occurred on complex habitat, including those with sponges and other biogenic cover (Rooper et al. 2007).

Six Level 2 studies on sponges, all published within the last decade, were conducted off British Columbia and Alaska. At British Columbia sponge reefs, Cook (2005) determined that densities of juvenile and adult rockfish were significantly greater on live reef than dead reef or seafloor regions near reefs. He further postulated that live reefs are important nursery habitat for juvenile rockfishes, as their relative abundance in these habitats was much greater than that of adults (Cook 2005). In the same general region, the majority of rockfish (80%) were associated with sponges ≥ 50 cm in height, and beds of short sponges contained 400% more rockfish than nearby substrata without large epifauna (De Preez and Tunnicliffe 2011).

Under laboratory conditions, using fishes obtained near Kodiak Island, Stoner and Titgen (2003) determined that: 1) small (48-77 cm total length) and medium (90-134 cm total length) Pacific halibut exhibited a highly significant preference for high-density sponge habitat over sand, whereas the relationship weakened slightly in large juveniles (270-337 cm total length). Small (15-25 cm total length) and large (42-74 cm total length) rock sole also exhibited a significant preference for sponge habitat (Stoner and Titgen 2003). Pacific ocean perch were observed to be strongly associated with boulders, sponges, and gorgonian corals in Pribilof Canyon, where this species was most abundant as compared to other Bering Sea Canyons (Miller et al. 2012). In the Gulf of Alaska, juvenile Pacific ocean perch trawl CPUE increased significantly with increasing sponge (and coral) CPUE

(Rooper and Boldt 2005). The CPUE of flathead sole in the eastern Bering Sea increased with increasing structure-forming invertebrate densities, including sponges (Rooper et al. 2005).

Other Structure-Forming Invertebrates

In addition to cold-water corals and sponges, many other marine invertebrates may form structure on the benthos, including bivalve and gastropod aggregations or shell mounds, barnacle tests, crinoids, brittlestars, bryozoans, polychaete worm tubes, sea cucumbers, sea urchins, and hydroids. In addition, although anemones (Actinaria) are grouped within the cold-water corals, they are treated here because they typically occur shallower than most cold-water corals and have a rather dissimilar morphology. Other structure-forming invertebrates generally are of lower relief and complexity than most sponges and corals and are often mobile. The amount of literature with information on the association between groundfish and other structure-forming invertebrates in the eastern North Pacific is comparable to that of cold-water corals, and only slightly less than that of sponges. These organisms are generally not afforded the same level of attention, however, in publications that associate multiple fishes and invertebrates. The great majority of work simply associates groundfish and other structure-forming invertebrates (Level 1), with less literature providing density or abundance comparisons.

Most of the literature concerning other structure-forming invertebrates and groundfish has been published within the last ten years and is derived from manned submersible studies. Off California, the following relationships have been reported: juvenile sharpchin and speckled rockfish in association with crinoids (Love et al. 2002); unspecified groundfishes and basket stars (Bright 2007); young-of-the-year cowcod and anemones (*Metridium* spp.); unspecified rockfish with crinoids and anemones (Yoklavich et al. 2000); shell mounds, anemones, and sea stars with young rockfishes of large species (cowcod, copper, brown, stripetail, blackgill, greenspotted), small rockfishes (halfbanded, pinkrose, greenblotched, rosy), lingcod, and Pacific sanddab (Love and Yoklavich 2005); cowcod and *Metridium* spp. (Allen 1982), and one longnose skate egg case with a sea anemone (Love et al. 2008). Off British Columbia, Martin and Yamanaka (2004) incorporated other structure-forming invertebrates, such as barnacles, bryozoan, urchins, sea cucumbers, and crinoids, into habitat types but did not directly associate them with groundfishes. Painted greenling nests collected off California and British Columbia were associated with barnacle tests, worm tubes, or scallop shells (Crow et al. 1997).

Habitat off Seguam Pass that contained hydroids and bryozoans also harbored Atka mackerel, Pacific cod, softnose skates (*Bathyraja* spp.), rockfish, and Pacific halibut (Zenger et al. 2005). FMP groundfish and rockfish were associated with sponge habitats in the Aleutian Islands that also contained hydroids, bryozoans, sea anemones, and sea cucumbers (Stone 2006). Qualitative video analysis from manned submersible dives in the Aleutian Islands indicated high co-occurrence of dusky rockfish (100%), sharpchin rockfish (90%), Pacific ocean perch (86%), shortraker rockfish (85%), rougheye rockfish (83%), Pacific cod (75%), and juvenile rockfish (71%) with other structure-forming invertebrates such as hyrdroids, bryozoans, sea anemones, and crinoids (Heifetz et al. 2007). Three reviews summarize groundfish spatial associations with other structure-forming invertebrates in the eastern North Pacific (Tissot et al. 2008; Yoklavich and O'Connell 2008; Buhl-Mortensen et al. 2010).

Quantitative research concerning groundfish spatial associations with structure-forming invertebrates, including density estimates among habitat types (Level 2), can be divided between single species and assemblage studies. In terms of single species studies, Abookire et al. (2007) used general additive models to determine that significantly greater densities of young-of-the year Pacific cod occurred with cucumber mounds near Kodiak Island, AK. In the Aleutian Islands, denser aggregations of Pacific ocean perch were found in association with complex habitats, including those containing bryozoans and anemones (Rooper et al. 2007). Shortspine thornyhead occurrence was significantly correlated with that of sea anemones off southeast Alaska (Else et al. 2002).

Significantly greater densities of the following species were found in association with other structure-forming invertebrates: flathead sole (bivalves and empty bivalve shells, gastropods, anemones, bryozoans) (Rooper et al. 2005), young-of-the-year northern rock sole with worm tubes and sea cucumbers (Stoner et al. 2007); blackeyed goby and orangethroat pikeblenny with worm mats (Zalmon et al. 2010); Pacific halibut and northern rock sole with bryozoan mimics and shells (under laboratory conditions), and bivalve and gastropod shells, sea stars, sea urchins and sand dollars (under field conditions) (Stoner and Titgen 2003). A laboratory study indicated that lingcod abundance was significantly greater in structured environments (shells, eelgrass, rock) but that the type of structure was not relevant (Petrie and Ryer 2006).

Wang (2005) determined that yelloweye rockfish, canary rockfish, and lingcod all occurred in significantly greater densities in association with crinoids. Several studies used multivariate statistics to associate fish and invertebrate assembles (including other structure-forming invertebrates). Tissot et al. (2007) determined that unspecified thornyheads, Dover sole, and rex sole associated with sea urchins, sea cucumbers, and sea stars on mud habitats. Pirtle (2005) discovered that rosy rockfish, adult *Sebastomus* spp., yellowtail rockfish, and rockfish juveniles were strongly associated with the sea anemone, *Urticina picivora*, in hard and mixed-substrate habitats, whereas sharpchin rockfish and flatfishes were more strongly associated with a different anemone (*Metridium gigantium*).

Off Kodiak Island, Rooney (2008) and Reynolds et al. (2012) investigated habitat associations of groundfishes and invertebrates, including several other structure-forming invertebrate (e.g., sea anemones, bryozoans, hydroids, brittlestars). Love and York (2005) found much greater densities of structure-oriented fishes (e.g., halfbanded rockfish, lingcod, stripetail rockfish, greenblotched rockfish, vermillion rockfish) on pipe that were heavily fouled with other structure-forming invertebrates, including sea anemones, sea urchins, sea stars, and basket stars. Dover sole and shortspine thornyheads were grouped with sea stars and hermit crabs as part of an assemblage found on heavily trawled seafloor off the Oregon coast (Hixon and Tissot 2007).

Conclusions

The available literature on biogenic habitat use by groundfishes provides evidence for functional associations for several groundfish species with structure-forming invertebrates. The FMP groundfish species that use cold-water corals, sponges, or other structure-forming invertebrates as habitat tend to be those that are known to occupy structured environments, especially rockfishes in deep rock habitats (e.g., cowcod, lingcod, *Sebastomus* spp., yelloweye rockfish, sharpchin rockfish, squarespot rockfish; Love and Yoklavich 2006). Structure-forming invertebrates may be important to these species because they provide added structure and complexity to physical habitat, regardless of whether these species are also associated with other types of non-invertebrate structures. Other FMP groundfishes, such as shortspine thornyhead and Dover sole, appear not to be found in association with structure-forming invertebrates but rather occur in higher densities on largely featureless, sedimentary seafloors. The evidence for structure-forming invertebrate use by some groundfish species (e.g., greenstripe rockfish, some flatfish species) remains unclear because of limited studies and/or conflicting results.

Overall, the newly-available Level 1 information largely confirms the previous understanding that associations exist between numerous groundfish species and structure-forming invertebrates. Some of the Level 2 studies, moreover, have documented specific relationships in terms of abundance of FMP groundfish with respect to structure-forming invertebrates, including several instances of increased groundfish abundance in the presence of biogenic habitat.

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