Agenda Item F.7.a.
WDFW Report
September 2016

Assessment of Managing Darkblotched Rockfish and Pacific Ocean Perch as Set Asides in the At-Sea Sectors

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1 Purpose and Need for the Proposed Action

1.1 Introduction

In June 2016, the Council considered amending the Groundfish Fishery Management Plan's (FMP) formula for allocation darkblotched rockfish ("darkblotched") and Pacific ocean perch (POP) among the trawl sectors. During Council action (Agenda Item G.2), the Council voted to forgo further consideration of the allocation formulas at this meeting and to instead focus on the narrower set of options contained in the range of alternatives (ROA) related to change in designation of the stocks from allocations to set aside species. As captured in the relevant motion language:

1. Reduce the scope of the draft purpose and need statement and the range of alternatives in Agenda Item G.2.a, WDFW Report 1, to focus on Options A (allocations) and B (set asides) for darkblotched rockfish and Pacific ocean perch , and confirm Option B as the Preliminary Preferred Alternative.

2. Additional analysis would be drafted for the Council's consideration in selecting a Final Preferred Alternative in September 2016 with the intent of implementing the proposed action to be effective May 15, 2017.[1]

"WDFW Report 1" refers to the Agenda Item G.2., WDFW Report 1 from June 2016, the document containing the proposed ROA, purpose and need, and further background. Additional background information and analysis was given in Agenda Item G.2.a, Supplemental WDFW Report 2.

Timely implementation, in time for the 2017 whiting season, was another key motivation for narrowing the Council's decision at this meeting. Importantly, the Council's decision to forgo a redistribution of the darkblotched and POP trawl allocations was made in close coordination with recommended increases to the annual catch limits (ACLs) for the two stocks. The main motivation for the recommended ACL increases was to increase the allocation amounts available to the at-sea sectors and to provide additional buffers for unforeseen groundfish mortality. These buffers would be potentially available to address the risk of early closures in the at-sea sectors when bycatch spikes and they approach or exceed their allocation amounts.

Even with access to the buffer and the additional allocation from higher ACLs, the at-sea fleets are still at risk for exceeding their allocations of both darkblotched and POP. The buffer would only be able to be accessed through routine inseason action at a scheduled Council meeting and therefore does not provide any additional relief if a sector were to exceed its allocation between meetings. By making darkblotched and POP sector specific set asides (Option B, referred to as "Alternative 1" from this point forward) as opposed to allocations (Option A, or the "No Action Alternative"), the at-sea sectors would not have to immediately cease fishing as long as the risks to conservation and management goals were acceptable (discussed further below).

[1] http://www.pcouncil.org/wp-content/uploads/2016/06/G4_CouncilAction_JUN2016.pdf

1.2 Description of the Proposed Action

The Council proposed actions, evaluated in this document, are to change the management of darkblotched rockfish and POP within the at-sea sectors from allocations (i.e. “hard caps”) to sector specific set asides, using the formal allocation structure from Amendment 21 (AM21).

1.3 Purpose and Need for the Proposed Actions

This proposed action is intended to substantially reduce the risk of the mothership (MS) and catcher processor (CP) sectors—also referred to as the at-sea sectors or co-ops—not attaining their respective whiting allocations based on the incidental catch of darkblotched rockfish or POP. Timeliness and administrative feasibility are important pieces of the purpose and the ROA presented in the Council’s motion. The proposed action is intended to be an interim solution to address the immediate needs of the at-sea sectors.

In recent years, both sectors have approached or exceeded their initial allocation of darkblotched rockfish- the CP sector in 2011 and the MS sector in 2014, with the latter resulting in an emergency Council meeting in order to re-open the fishery. The risk of an inseason closure remains high. The MS sector again raised concern over darkblotched catches in 2015 and then for POP in 2016. Other solutions to address this problem, such as allowing transfer of quota between sectors, have been discussed, but they have been deemed too complex to be analyzed and implemented in time for the 2017 fishing season. [2] During the upcoming five year review of the trawl rationalization program, it is the intention to review these allocations (among the other Individual Fishing Quota [IFQ] species) and determine what more appropriate (i.e., fair and equitable) allocations are for each of the sectors as well as consider other long-term solutions.

1.4 Criteria Used to Evaluate Impacts of Proposed Action

The Council’s conservation and management recommendations must be consistent with the Magnuson Stevens Act (MSA) national standards and provisions and other applicable laws such as the National Environmental Policy Act (NEPA) and Endangered Species Act (ESA).

In addition to demonstrating consistency with law, the Council’s consideration of these standards and provisions identifies substantive standards, criteria, and other factors to help compare trade-offs and identify the policy option that best balances the achievement of the purpose and need against potential adverse impacts to other conservation and management goals. The MSA legal standards also provide guidance to the Council on how certain policy trade-offs should be resolved.

In preparing this analysis, Washington Department of Fish and Wildlife (WDFW) analysts interpreted the MSA National Standards as supporting two key considerations for weighing the proposed management of darkblotched and POP using set asides instead of allocations:

1. The degree to which each is expected to achieve the conservation and management purposes of specifying specific amounts for the set asides;

[2] “Scoping Trawl Sector Quota Pound Trading” is currently scheduled for September (Proposed Pacific Council Meeting Agenda, September 12-20, 2016, in Boise, Idaho)

2. The differences in costs, burdens, and adverse economic impacts to the sectors and fishing communities they impose.

The two considerations derive most directly from National Standard 7 (NS7) and National Standard 8 (NS8), which read:

> (7) Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.
>
> (8) Conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities by utilizing economic and social data that meet [National Standard 2], in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities.

Short-term economic interests of fishery participants and fishing communities may sometimes conflict with the conservation mandates of the MSA. The "minimize costs" mandate of NS7 and the "minimize adverse economic impacts" mandate of NS8 do not override the law's conservation requirements. NS7 and NS8 instead provide guidance on how to choose among policy alternatives for achieving conservation and management goals. While the focus of NS8 is on fishing communities, NS7 focuses more broadly on costs to all types of entities and organizations, from fishery participants to fisheries management agencies.

The National Marine Fisheries Service (NMFS) guidelines for NS7 and NS8 provide further considerations, including recommend analyses that follow cost-benefit and cost-effectiveness type approaches to policy analyses. The NS8 Guidelines follow a cost-effectiveness approach, where the conservation goal is seen as fixed, and the focus of analysis is on identifying the alternative that would achieve the goal for the least adverse impact on fishing communities. As the NS8 Guidelines state:

> All other things being equal, where two alternatives achieve similar conservation goals, the alternative that provides the greater potential for sustained participation of such communities and minimizes the adverse economic impacts on such communities would be the preferred alternative.[3]

While the conservation goal is supreme, the use of the word "similar" implies that the preferred alternative may not be exactly equivalent to others in terms of how it is projected to achieve the goal. In terms of analysis, the NS8 Guidelines recommend an assessment of:

> 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.[4]

The goal of the recommended assessment is to:

[3] 50 C.F.R. § 600.345(b).
[4] 50 C.F.R. § 600.345(c)(4).

> identify those alternatives that would minimize adverse impacts on these fishing communities within the constraints of conservation and management goals of the FMP, other national standards, and other applicable law.[5]

The NS7 Guidelines provide similar recommendations, but are focused more on the question of how the benefits of a management measure would compare to its costs. The NS7 Guidelines state that management measures "should not impose unnecessary burdens" and highlight cost as a factor that "may well suggest a preferred alternative."[6]

From comparing and contrasting alternatives, the Guidelines recommend an evaluation of the differences in "effects and costs" between alternatives.[7] The evaluation "not need [be] an elaborate, formalistic cost/ benefit analysis" and can employ qualitative assessment if quantitative estimates are not available. [8] To justify the Council's choice of a preferred alternative, the evaluation:

> should demonstrate that the benefits of fishery regulation are real and substantial relative to the added research, administrative, and enforcement costs, as well as costs to the industry of compliance.[9]

Lastly, the NS7 Guidelines recommend another substantive mandate for selecting a preferred alternative:

> Management measures should be designed to give fishermen the greatest possible freedom of action in conducting business and pursuing recreational opportunities that are consistent with ensuring wise use of the resources and reducing conflict in the fishery.[10]

In June, the Council's focus was on National Standard 4 (NS4) and related provisions concerning fair and equitable allocations between sectors. The analysis focused on comparing the relative hardships and economic impacts between the at-sea and IFQ sectors and on weighing the benefits and costs of any modifications to the allocation formulas.

While NS4 is still relevant to the proposed action here, the focus of analysis has changed. Despite the terminology of the FMP, the Alternative 1 set asides remain a type of allocation or assignment of fishing privileges within the meaning of NS4. Concern over the fairness of the set aside amounts—fairness in terms of the economic impacts and hardships they impose on the at-sea sectors— continues to motivate evaluation of the proposed action. At the same time, the Council's choice to forgo a redistribution of the trawl allocation means that the proposed action would not be expected to directly impact the IFQ sector. A comparison of relative hardships and economic impacts between the at-sea and IFQ sectors is therefore no longer as relevant.

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[5] 50 C.F.R. § 600.345(c)(5).
[6] 50 C.F.R. § 600.340(c).
[7] 50 C.F.R. § 600.340(d).
[8] 50 C.F.R. § 600.340(d).
[9] 50 C.F.R. § 600.340(d).
[10] 50 C.F.R. § 600.340(d)(1).

The proposed action may instead be framed as a modification of the original allocation scheme where the intent is to improve the fairness to the at-sea sectors by reducing the adverse impacts and hardships. In this framing of the standard, the questions for consideration are the same as suggested by NS7 and NS8. In other words, the question of fairness and equity involves a consideration of how set asides compare to status quo in terms of furthering conservation and management purposes and in terms of costs and burdens they impose. The issue of fairness is broad enough to encompass additional factors that may be important to members of the Council. For example, perceptions of different standards for different sectors across all of the commercial and recreational sectors managed by the Council could be seen as relevant.

Finally, other national standards and provisions—such as National Standard 5 guidance on economic efficiency and National Standard 9 guidelines that mandate to minimize bycatch to the extent practicable and bycatch of ESA protected Chinook salmon and eulachon—are of potential relevant to the Council's decision on proposed action. The information presented in this report—and the framework for weighing of conservation and management purposes and economic costs and benefits—is intended to be broad enough to aid in Council's consideration of these other standards and other relevant factors.

Again, these are WDFW's reading of the relevant factors and recommended framework for analysis. NMFS and Council staff may provide additional guidance before Council discussion and action.

2 Description of the Alternatives

The ROA compares and contrasts one action alternative against the no action alternative for managing darkblotched rockfish and Pacific Ocean Perch in the at-sea whiting trawl sectors:

<table>
<tr><th></th><th>No Action</th><th>Alternative 1</th></tr>
<tr><td>Darkblotched Rockfish</td><td rowspan="2">Managed as allocations (i.e. hard caps involving automatic closure)</td><td rowspan="2">Managed as set asides (i.e. soft caps, managed on an "annual basis")</td></tr>
<tr><td>Pacific Ocean Perch</td></tr>
</table>

Per typical practice, the Council does not need to make the same recommendation for both stocks and may chose Alternative 1 for one or both stocks or neither. If the Council recommends Alternative 1 for both, darkblotched and POP would be managed as set asides until changed. The amounts of darkblotched and POP would continue to be determined under the existing FMP's framework for subdividing the annual catch limits between trawl and non-trawl sectors, and then further subdividing the trawl allocation among the at-sea and IFQ sectors. This framework was established by the Council under AM21.

Table 1 identifies the amounts scheduled for 2017 and 2018 based on the Council's June 2016 recommended ACLs for darkblotched and POP. Table 1 also displays the "off-the-top" buffers recommended by the Council because of their connection to the proposed action and the analysis below. While the Table 1 amounts are the focus of analysis here, the effects and costs of Alternative 1 could be different if those amounts increase or decrease in future management cycles.

Table 1: Harvest Specifications for Darkblotched Rockfish and POP in 2017 and 2018

Harvest Specification	Darkblotched Rockfish		POP	
	2017	2018	2017	2018
ACL	641	653	281	281
Buffer	50	50	25	25
CP	16.4	16.7	12.7	12.7
MS	11.7	11.8	9.0	9.0

2.1 No Action Alternative: Allocations

Under the No Action alternative, darkblotched and POP would continue to be managed using sector specific allocations. The function of allocations as total catch limits, or "hard caps", is the key feature under evaluation here.

Currently, the at-sea sectors must stop fishing immediately if their allocations of darkblotched or POP are reached or exceeded. Some flexibility for addressing overage situations does exist. The Regional Administrator of NMFS may make the remaining allocations of darkblotched or POP from one sector available to the other if that sector has: (1) reached its whiting allocation; or, (2) made clear that it does not intend to continue fishing.[11] Furthermore, the Council may move amounts specified as off-the- top deductions—which are used to account for the catches from activities like research, exempted fishing permits, and incidental open access—through routine inseason action if catch from one the activities has or is projected to come in lower than budgeted for in the scorecard. Such inseason action can cover projected overages and keep the at-sea sectors open. Additionally, sectors may be re-opened under limited circumstances. The emergency Council meeting held in October 2014 to reopen the MS sector after exceeding its darkblotched allocation and accompanying administrative record provides an example of how closures are addressed under the existing allocation framework.[12]

In sum, the allocation status of darkblotched and POP serves as a restrictive "hard cap" and to create a very strong incentive for avoiding bycatch and limiting the impact of overages, as further discussed below.

2.2 Alternative 1: Sector Specific Set Asides

Under Alternative 1, darkblotched and POP would be managed as sector specific set asides. The key difference involved with set aside status relates to the management response taken in the case of a sector overage.

This key difference is stated in two provisions of the groundfish regulations, once each in the sections creating and setting forth the requirements of the CP and MS co-op programs. These provisions read as follows:

> species with at-sea sector set-asides will be managed on an annual basis unless there is a risk of a harvest specification being exceeded, unforeseen

[11] 50 CFR § 660.150

[12] PFMC Briefing Book and Meeting Materials October 2015: http://www.pcouncil.org/2014/10/33548/october-2014-emergency-council-meeting/

> impact on another fisheries, or conservation concerns in which case inseason action may be taken.[13]

The “annual basis” is the key phrase. The word “annual” is used as distinct from “inseason.” The remainder of the provision makes clear that inseason closure or action would be limited to the three cases of risk. If an overage did not pose one of the three types of risks, the at-sea sectors could continue fishing. The circumstances posing such risks are a key part of the analysis and are discussed in more detail below in Section 4.3.

The Alternative 1 set asides would also differ from No Action in terms of how they may be used inseason to account for higher than expected catches in other sectors. The regulations define set asides as “not formal allocations, but [nonetheless] amounts which are not available to the other fisheries during the fishing year.”[14] While “not available” to other sectors, the Council may consider any unused amounts after the at-sea sectors have completed their seasons. Alternative 1 would therefore grant a bit more flexibility to the Council in inseason catch accounting compared to No Action. Under No Action, the allocations of darkblotched and POP are not available to another sector inseason except between at-sea sectors when one has completed fishing for the year.[15]

Finally, the regulations imply another difference between set asides and allocations. However, this difference would not exist for set asides of darkblotched and POP. The difference relates to how set aside amounts are changed. The regulations state “[s]et asides may be adjusted through the biennial specifications and management measures process as necessary.” The amounts of darkblotched and POP available to the at-sea sectors, as noted above, are set by the FMP’s allocation framework. While the Council could consider modifying that formula, it would take an FMP amendment to do so. FMP amendments may be made in conjunction with the biennial management process but they require additional procedure. As evidenced by consideration of the issue in June, the allocation scheme for darkblotched and POP involve more controversy and Council deliberation than the typical set aside species.

2.2.1 Alternative 1: Illustrative Changes to FMP Language

Alternative 1 would involve minor changes to the wording of the Groundfish FMP. The key section is found on p.65 of the FMP and reproduced here with the key changes underlined (note: the proposed changes are illustrative—the final amendatory language proposed by Council staff may differ):

> Allocation of Trawl Dominant Overfished Species
>
> Under Amendment 20, the at-sea whiting sectors (i.e. catcher-processors and mothership) are managed in a system of sector-specific harvest cooperatives. Each at-sea whiting sector will manage their bycatch of canary rockfish, darkblotched rockfish, Pacific ocean perch, and widow rockfish. Sector-specific total catch limits will be used for canary and widow rockfish. Sector specific set asides will be used for darkblotched rockfish and POP. An initial allocation or set aside of these four species needs to be made to the four existing LE trawl sectors before initial allocation

[13] 50 CFR §§ 660.150(c) and 660.160(c)
[14] 50 CFR § 660.55(j)
[15] 50 CFR §§ 660.150(c) and 660.160(c)

of quota shares under Amendment 20. Initial sector allocation of canary rockfish would be decided in the biennial harvest specification and management measures process immediately preceding implementation of Amendments 20 and 21. The initial sector allocation or set aside of the trawl-dominant overfished species under Amendment 21 is as follows:

Darkblotched Rockfish

Allocate 9 percent or 25 mt, whichever is greater, of the total LE trawl allocation of darkblotched rockfish to the whiting fisheries (at-sea and shoreside combined). The trawl allocation of darkblotched will be distributed among the whiting sectors pro rata to their whiting allocations.

Pacific Ocean Perch

Allocate 17 percent or 30 mt, whichever is greater, of the total LE trawl allocation of Pacific ocean perch to the whiting fisheries (at-sea and shoreside combined). The trawl allocation of POP will be distributed among the whiting sectors pro rata to their whiting allocations.

2.2.2 Alternative 1: Illustrative Change to regulations.

Alternative 1 would require NMFS to amend the regulations to the make the following, and potentially, other, changes related to the change in status from allocation species to set aside species:

1. Change Darkblotched and POP from "Allocation" to "Set Asides" in Table 1d (Part 660, Subpart C) and Table 2d (Part 660, Subpart C), with the values listed in Table 1.
2. Modify footnotes for darkblotched and POP in Table 2b for Part 660, Subpart D to represent change from allocations to set asides
3. Remove darkblotched and POP from Subpart D, 660.150 (c)(1)(i) and 660.16(c)(1)(i)
4. Change allocation language for describing allocation in Subpart C, 660.55 (i) (A) and (B) to change to set aside

3 Affected Environment

The at-sea sectors fish for whiting in the Exclusive Economic Zone off the coasts of Washington and Oregon, and potentially California as well. However, the sectors tend to stay to the north because the processing of whiting at-sea is prohibited south of the 42 degrees N. latitude. The areas most intensively fished by these sectors are found in outer and upper continental shelf habitats. Catcher vessels in the at-sectors use mid-water trawl gear designed to fish in the water column. The vessels can use the gear to fish near the seafloor, and although contact with the bottom occurs, the gear is not designed to withstand continuous bottom contact. More information on the marine ecosystem and human environment can be found in NEPA analyses recently prepared for Council decision-making under the Groundfish FMP. Other issues like the effect of mid-water whiting trawl on essential fish habitat are being evaluated under other Council related activities.

4 Environmental Consequences

This chapter examines the environmental consequences that result from Alternative 1 compared to No Action using the framework described in Section 1.4. Section 4.1 provides an overview the framework and how it compares to the format of other environmental impacts analyses considered by the Council. The main focus of the section is the potential increased bycatch of darkblotched and POP under Alternative 1. These direct impacts are discussed in Sections 4.2 and 4.3. The indirect effect of potential increase in the bycatch of protected Chinook and eulachon are also evaluated (Section 4.4). Finally, the potential cost reductions and potential for improved harvest of whiting are discussed in Section 4.5. The chapter begins with an overview of the framework for impacts analysis.

4.1 Framework for Comparing Environmental Consequences

The discussion of environmental consequences is organized around the analytical approaches recommended by the NS7 and NS8 guidelines (described in more detail in Section 1.4). In brief, the approach compares set aside management against No Action based the following two considerations:

(1) The degree to which each serves the conservation and management purpose of specifying amounts of darkblotched and POP for the at-sea sectors;
(2) The differences in terms of costs and burdens for the at-sea sectors and adverse economic impacts to fishing communities.

At the time of writing, the required form of NEPA analysis needed to support the Council's final decision on this issue has yet to be determined. WDFW analysts produced this document in anticipation that the material could be incorporated into an Environmental Assessment (EA). The chapter is organized around these NS7 and NS8 considerations based on the view that they most sharply define the issues and provide a clear basis for decision making between the alternatives. Sharply defining the issues and providing a clear basis for choice is the core instruction of the NEPA regulations for the analysis of policy alternatives.[16]

Although the organization deviates some from that used in Chapter 4 of recent Council related EAs, the substance of the impacts analysis is intended to be the same as would be provided under the more typical format. The discussion typically included in the section on "impacts to the biological environment" can be found in Section 4.3. The discussion typically included under am "impacts to the socioeconomic environment" section is found under Section 4.4.

Other sections that have been included in recent Council related NEPA analysis, such as a discussion of impacts to the physical environment, are not included at this time. Unless noted under Sections 4.2 or 4.3, the analysis has not suggested that the proposed action would result in anything but minor or insubstantial changes to impacts relative to those evaluated in the Harvest Specifications and Management Measures for 2015-2016 and Biennial Periods Thereafter Final Environmental Impact Statement and EA analyses, including the EA being produced for the 2017-2018 Groundfish Harvest Specifications and Management Measures Including Changes to Groundfish Stock Designations Description and Analysis for Council Decision-Making (June 2016). However, NMFS may require or conduct additional analysis before making its consistency determination.

4.2 General Considerations on the Potential Effect of Set Aside Management

[16] 40 C.F.R § 1502.14 Alternatives including the proposed action.
https://ceq.doe.gov/nepa/regs/ceq/1502.htm#1502.14

Catch estimates for the at-sea sectors are of the highest quality available to the Council, in terms of their accuracy and timeliness and the length of the time series for which species specific estimates of incidentally caught species like darkblotched and POP are available. The benefits of this data quality, however, do not extend to predicative ability for bycatch. The catch of darkblotched and POP in the at-sea sectors shows high variability. The ability of the Council's Groundfish Management Team (GMT), as well as that of the co-ops, to forecast catch of darkblotched and POP in any given year is very limited. This applies to No Action as well as to Alternative 1. Section 4.3 characterizes this variability using a few different quantitative approaches. The noisy pattern in the data makes it difficult to draw clear cut predications of how bycatch of darkblotched and POP under Alternative 1 would differ from No Action.

Because of these limitations on quantitative analysis, the Council's evaluation of Alternative 1 will require consideration of and policy judgments on assumptions about incentives and fishing behavior. These assumptions and areas for policy judgment relate to how the at-sea sectors might change their fishing behaviors under Alternative 1. Equally important is the question of how directly bycatch outcomes are tied to fishing behavior. Section 4.2.1 identifies some general, theoretical considerations on the question of why and to what degree fishing behavior might change if the "hard cap" feature of the allocation is removed. Section 4.2.1.2 poses the question of how tightly connected bycatch of darkblotched and POP is to fishing behavior. Both sections are intended to aid the Council and the public in interpreting the quantitative analyses found in 4.3.

4.2.1 The Potential for Changed Incentives and Fishing Behavior

The status quo darkblotched and POP allocations serve the Council's conservation and management purposes through two separate mechanisms:

(1) By contributing to the incentive for the at-sea sectors to manage bycatch; and
(2) By limiting the outcome—in terms of total catch—by closing the sectors when their allocations are reached.

In other words, the automatic closure incentivizes the at-sea sectors to mitigate bycatch and then limits the size of overages in the event that the incentives are not enough.

The changes proposed with Alternative 1 would intentionally modify the second mechanism. Bycatch would not be stopped as stringently in all overage situations. Alternative 1 may, in turn, change the bycatch avoidance incentive as well. The next two subsections explore this question about changed incentives. The relaxed limitation on overages, the general issue of the Council's tolerance for overages, and the means by which overages could still be limited under Alternative 1 are then raised in Section 4.3.1.1.

4.2.1.1 The Potential for a Reduced Incentive to Avoid Bycatch

The potential for Alternative 1 to weaken the incentive to avoid bycatch arises from the relaxation of the automatic inseason closure. Under current management, the allocations of darkblotched and POP as well as those for other species are part of the performance standard approach involved with co-op management. The allocation amounts identify the Council's acceptable levels of catch and the co-ops are given the flexibility to determine how to best conduct their fisheries to meet these limits. This approach differs from the more traditional approach taken in fisheries management where regulations dictate the specific types of management measures that fishery participants must follow. The at-sea co-ops have responded by adopting management measures for avoiding rockfish bycatch that are more adaptive and precise than has been possible under typical inseason management by the Council (e.g. more targeted time-area closures than possible with regulation). The approach has been used both on the West Coast and in fisheries off Alaska.[17]

The precise concern with Alternative 1 is that the co-ops might relax their bycatch mitigation measures because they are no longer as concerned by the consequences of failing to control their catch. As sector representatives have noted in public testimony, the risk of closure has led them to give some degree of priority to darkblotched and POP over other species, like Chinook salmon, where the consequence of missing the performance standard is less severe.

Some relaxation of bycatch avoidance measures by the co-ops would be rational under Alternative 1. Bycatch avoidance measures—such as the need to search for areas where marketable whiting are available and bycatch rates are low—impose costs that would not exist if targeting whiting were the co-ops' only objective. As theory suggests, businesses will seek to reduce costs in order to improve profitability. While not only rational, the potential savings in costs and reduced burdens for the co-ops is one of the reasons for considering and possibly favoring set asides, as discussed in Section 2.2 and Section 4.5.

If Alternative 1 should be expected to soften the incentive, the question of how much remains open to judgment. Other factors suggest that the incentives to avoid darkblotched and POP would remain influential. And indeed, representatives have testified that the move to set asides would not result in major changes to their bycatch mitigation measures.[18]

Another factor to consider is that Alternative 1 would still follow the performance standard approach in place under No Action. The co-ops have an interest in maintaining the approach because of the flexibility it offers them around planning their seasons. A failure to maintain bycatch of darkblotched or POP within reasonable levels would be likely to erode the Council's confidence in the approach. Despite the recommended increases for 2017-2018, the ACL levels for POP and darkblotched remain low relative to need and are tightly allocated among sectors. The at-sea sectors could only reasonably expect that the Council has expectations about acceptable levels of bycatch and would act if those levels are exceeded. Such action could include inseason closures, reinstituting the status of darkblotched and POP as allocations, or imposing more traditional fisheries management regulations if the co-op systems fall short.

Lastly, recent experience with other species provides some support for the idea that bycatch incentives would not be substantially weakened under Alternative 1. For one, several species are managed as set aside species in the at-sea sectors now. Although bycatch of these species have yet to pose the same challenges as have darkblotched and POP, bycatch has remained at acceptable levels. In addition, neither spiny dogfish nor rougheye rockfish are designated as set asides. Nonetheless, evidence would suggest

[17] See for example, Michael De Alessi, Joseph M. Sullivan, Ray Hilborn. 2014. The legal, regulatory, and institutional evolution of fishing cooperatives in Alaska and the West Coast of the United States *Marine Policy*, 43: 217-225. doi:10.1016/j.marpol.2013.06.006.
[18] As an example, Brent Paine of United Catcher Boats testified to the likely changes in the MS sector co-op in June 2016, Agenda Item G.2 (meeting recordings of public testimony are available on the PFMC website: http://www.pcouncil.org/2016/06/43070/june-2016-council-meeting.

that the co-ops, as well as other sectors, lowered their encounter rates with these stocks based only on the prospect of increased regulation.

4.2.1.2 Effectiveness of Incentives in Limiting Overages of Darkblotched and POP

As discussed in the preceding section, Alternative 1 could reduce the incentive to avoid darkblotched and POP. This section follows the discussion of incentives by posing the question of to what degree incentives have influenced bycatch outcomes in the at-sea sectors.

In brief, fisheries management measures and the incentives they create aim to influence fishing behavior. However, incentives and management measures can only influence catch levels to the degree that the behavior influences the outcome. Closure of a fishery is the ultimate management measure and clearly stops all possibility of catch. Yet short of closure, bycatch for many stocks is known to be subject to varying degrees of randomness. Among other things, randomness means that the same fishing techniques and behaviors can lead to a wide variety of bycatch levels. In the extreme case where bycatch is totally random and completely independent of fishing behavior, the incentives that influence fishery participants could be expected to have no effect on the outcome.

This extreme case is used just to illustrate the point and cannot be said to apply to the catch of darkblotched and POP in the at-sea sectors. The bycatch avoidance measures taken by the at-sea sectors have clearly had some effect. Nonetheless, the data does suggest that darkblotched and POP are subject to a high degree of randomness and variability. The conditions that would be expected to continue to lead to overages of the allocation or set aside amounts under Alternative 1 and No Action could be as much a product of randomness as of the choices taken by the co-ops on when, where, and how to fish.

A major cause of the variation in bycatch appears to be the “lightning strike” or “disaster tow” phenomenon that has long been of concern to the Council. Section 4.3 takes a new approach to evaluating these infrequent catch events and concludes that they would be the major determinate of overage risk under Alternative 1 and No Action. That quantitative analysis, however, cannot conclude or rule out that Alternative 1 would cause “lightning strikes” to increase in frequency or magnitude.

The issue of how further controllable lightning strikes may be by the co-ops could be a key factor in how strongly to weight concerns over the possible relaxation of bycatch avoidance incentives. The analysis in Section 4.3.4 provides some information on how the frequency of these events has fluctuated over time. The question can also be considered together with the issue of tolerable overage levels, which is discussed in Section 4.3.1.1.

4.3 Impact to Conservation and Management Purposes

The Council has considered the general issue of using “hard caps” (No Action) versus “soft caps” (Alternative 1) to control catch in many contexts. This analysis compares the two approaches using the framework described in Section 1.4. This section focuses on the first part of the framework. The aim is to evaluate how Alternative 1 might differ from No Action based on the degree to which each would be expected to achieve specific conservation and management purposes.

Identifying those conservation and management purposes is the first step. The Council identified three specific purposes when recommending the at-sea allocations of darkblotched and POP as part of AM21:

1. Serving together with other allocations and management measures as part of the system for controlling catch to ACLs.
2. Reducing the chances that catches in one sector affect other sectors.
3. Supporting the rationalization of the trawl fisheries by giving fishery participants certainty for long-term planning.

This section focuses on the first two might be affected by switch to set asides. Both depend on projections of how catches of darkblotched and POP could change under Alternative 1 and question of how large overages could get before being stopped inseason. Projections of catch are given in Section 4.3.2 and bycatch patterns are further discussed in Sections 4.3.3 and 4.3.4. Yet the key question for the Council appears to be the matter of when inseason overages would be stopped under set aside management. If the inseason closure authority is employed accordingly, Alternative 1 could meet the first two purposes just as well as No Action allocations. This key conclusion is described in Section 4.3.1.1.

The third purpose of long-term planning is not discussed in detail, but may be relevant to the consideration on costs and adverse economic impacts in Section 4.5.

Lastly, as noted in the overview to this Chapter, this section also evaluates the possibility of increased bycatch of ESA listed Chinook salmon and eulachon as possible indirect impacts of Alternative 1.

4.3.1 General Considerations for Comparing Expected Conservation Performance

The main difference between Alternative 1 and No Action is, again, that the former is a "soft cap" that would allow overages to occur whereas the latter is a "hard cap" that tightly controls overages. The analyses presented in this section present information on the expected frequency and magnitude of overages. The key policy question for the Council appears to how tightly such overages need to be controlled ahead of time, as with the No Action alternative, versus the question of closure being left open to conditions and circumstances as would be the case under Alternative 1.

As noted in the overview to this section, the primary conservation goal of specifying amounts of darkblotched and POP to the at-sea sectors is controlling catch to the ACLs. In general, allocations and management measures work together to control catches to remain under the ACLs. However, as explained in the next subsection, the risk of catches of darkblotched or POP reaching their ACL levels appears to be sufficiently low as to be of little relevance to the Council's choice, at least under the conditions expected during the 2017-2018 management cycle. Section 4.3.1.2 provides the rationale for this conclusion.

The second conservation purpose for having limits on catch of darkblotched and POP in the at-sea sectors is to reduce the chances that catch in these sectors would get so large as to require the Council to regulate other sectors in order to reduce total annual catch. As discussed in Section 4.3.1.1, Alternative 1 would not allow overages of darkblotched and POP set asides to go unbounded. The impact of unforeseen set aside catches on other sectors is a factor that could lead to closure for overages. However, the limit at which overages of darkblotched and POP would begin impacting other sectors has not been distinctly defined.

In the absence of having clear direction on those limits, this analysis uses the "off-the-top" buffers for unanticipated groundfish mortality recommended by the Council in June to gauge the impact of potential overages. These buffers are described in Section 4.3.1.3. The Council has not determined that it would be acceptable for the at-sea sectors to use the entire buffers as they are in place to address unexpected catch in any sector. Likewise, it may be acceptable for overages in the at-sea sectors to exceed these buffers if conditions in other fisheries mean that the risk of exceeding the ACL remains very small. For now, the off-the-top buffers provide a useful yardstick for analysis. In general, the higher proportion of the buffer that an at-sea overage would take up, the higher the chance that another sectors could be affected.

4.3.1.1 Existing Regulatory Authority Would Allow for Inseason Closure of Set Asides

As described in Section 2.2, the "annual basis" of set aside management means that NMFS will not close a sector inseason unless the overage meets one of the following conditions:

1. Risk of a harvest specification (e.g. ACL) being exceeded,
2. Unforeseen impact on another fishery, or
3. A conservation concern arises.

If none of the three are met, the expectation would be that the Council would consider the causes of the overage and weigh the need for additional management measures after the season had completed.

Based on this regulatory authority, it is clear that it would be possible for Alternative 1 to meet the conservation and management purposes of the darkblotched and POP allocations to the same degree as No Action. The first two conditions match the conservation and management purposes highlighted in AM21. To what degree the inseason closure authority would serve these purposes would depend on how these conditions are evaluated and acted upon inseason. That is, the conditions that would cause "unforeseen impact on another fishery" or a "conservation concern" to arise would be need further definition. The point at which risk becomes unacceptable risk is a matter for policy judgment as well. So even the term "risk of a harvest specification being exceeded" could benefit from more definition.

Therefore, the tolerance for overages is at the center of the choice between Alternative 1 and No Action. The matter of how large an overage would need to get before another fishery experiences an unforeseen impact or a conservation concern arises is not clear cut. The No Action alternative implies that the tolerance for overages is minimal and that there is a need to stop them from happening as precisely and quickly as the catch accounting system and regulatory response allows for. On the other hand, Alternative 1 leaves the question of tolerable limits open for further definition, either in the context of an actual overage inseason or through further discussions on conditions that delineate an acceptable overage from an unacceptable one. It may be that overages which exceed the 50 mt buffer for darkblotched and 25 mt buffer for POP still do not raise a conservation concern or adversely affect other fisheries. There may be other considerations by the Council that would perceive such overages as unacceptable.

The point made here is that further definition of the conditions leading to inseason closure under Alternative 1 could be helpful to the Council's recommendation at this meeting. The information presented below on the plausible frequency and size of overages of darkblotched and POP could help inform that discussion. However, this analysis does not attempt to further define the conditions under which an inseason closure would occur. For the most part, the analysis assumes that inseason closure would never occur if darkblotched or POP were managed as set asides. The reason for this is to provide a fuller analysis of how large overages could plausibly get if never stopped.

To the extent that the timing of an overage happened so that it could be addressed at a Council meeting, the Council could examine the acceptability of the particular overage in light of the conditions that led to it and the best available information on catch across all sectors. At the same time, overages could occur at time when it would be impractical to address at a Council meeting. The Council might therefore wish to authorize NMFS to take automatic action to address overages that go beyond acceptable levels. In the past, NMFS has advised the Council that automatic actions taken by the agency should be based more on criteria that leave little question about when the agency should act to close the sector causing the overage.

4.3.1.2 The Risk of Exceeding ACLs Appears Very Low

A high risk of exceeding an ACL would be one condition where overages under Alternative 1 would become unacceptable. However, at least under the conditions expected during 2017-2018, this risk does not seem likely.

ACLs are the key tool for achieving National Standard 1 and the core mandate to prevent overfishing and achieve optimum yield. The ACLs for darkblotched and POP have served to promote rebuilding of the two stocks on the timelines set by their rebuilding plans. Darkblotched is projected to reach its rebuilding target in the near term (estimated to rebuild in 2017). Once it does, the ACL will serve to prevent overfishing and remain the primary objective for controlling catch. With the Council's recommendation to set the ACL equal to the ABC, the ACL once the stock is rebuilt would be at similar levels as now. More detail on the ACLs and the status of darkblotched and POP can be found in the analysis produced for the 2017-2018 management cycle.

This analysis concludes that the chances that the ACL levels for darkblotched or POP being exceeded under Alternative 1 are low for two reasons. Two main reasons support this conclusion. First, as just discussed in Section 4.3.1.1, NMFS maintains the ability to close the at-sea sectors if there is a risk of exceeding harvest specifications, such as the ACL. With the precise and timely catch estimates available for the at-sea sectors, it can be presumed that overages of the magnitude that would reach ACL levels would be detected and stopped before they occur. The main limitation on stopping the size of an overage are the size of the catches on hauls that have yet to be accounted for by the observer program after the order to stop fishing has been issued.[19] Again, further discussion on the conditions at which the risk becomes unacceptable may be needed. And while yet to be discussed, protocols for stopping overages before ACLs are exceeded are highly feasible.

Second, the risk appears low because conditions across the groundfish fisheries suggest that catch is not likely to approach the ACL level. The darkblotched and POP catch projections detailed below in Section 4.3.2 suggest that catches in the at-sea sector would not get so large as to take up the ACL buffers and there will likely be underages in the IFQ sector. If they did, a number of extraordinary catch events would need to occur. However, these would be detectable in plenty of time to stop the fishery before the overages became extreme.

The IFQ sector's likely catch of darkblotched and POP is a big factor. The at-sea and IFQ sectors are responsible for the great majority of the total annual catch of darkblotched and POP, with the IFQ sector receiving the bulk of the allocation. The non-trawl allocations of darkblotched and POP have also gone

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[19] WDFW did not complete the analysis in time for submission to the advanced Briefing Book but the data is available consider how much catch could be left to enumerate after an overage is detected and the fishery stopped.

and are likely to go mostly unused. The IFQ sector is projected to continue to use less than half of its allocations in 2017-2018.[20] Historical take by the IFQ sector for both species can be found in Agenda Item G.2.a., Supplement WDFW Report 2. If conditions in the IFQ sector change and harvest of darkblotched and POP increases, the risk of exceeding the darkblotched and POP ACLs would need to be reexamined.

All in all, since 2011 total mortality has been roughly 40 percent of the ACLs for both darkblotched (Table 2) and POP (Table 3). And with the recommended ACL increases for 2017 and 2018, the chance of overages would be further reduced. The recommended 2017-2018 levels are substantially higher than catch of either stock as has reached since 2002 (the recommended ACLs are shown in Table 1).

Table 2: Darkblotched Rockfish Total Mortality compared to ACL, 2002-2015 (Source: landings queried from PacFIN, discard from WCGOP with 2014 discard used as proxy for 2015)

Year	ACL	Total Mortality	Percentage
2002	168	198	118%
2003	172	183	107%
2004	240	237	99%
2005	269	141	52%
2006	200	205	103%
2007	260	278	107%
2008	260	254	98%
2009	282	300	106%
2010	282	335	119%
2011	298	125	42%
2012	298	108	36%
2013	317	131	41%
2014	317	138	44%
2015	338	174	51%

[20] See IFQ sector catch projections in the 2017-2018 Groundfish Harvest Specifications and Management Measures Including Changes to Groundfish Stock Designations Description and Analysis for Council Decision-Making.

Table 3: POP Total Mortality (mt) compared to ACL, 2002-2015 (Source: landings queried from PacFIN, discard from WCGOP with 2014 discard used as proxy for 2015)

Year	ACL	Total Mortality	Percentage
2002	250	175	70%
2003	277	148	53%
2004	444	150	34%
2005	447	79	18%
2006	447	81	18%
2007	150	155	103%
2008	150	131	87%
2009	189	179	95%
2010	200	158	79%
2011	180	60	33%
2012	183	58	32%
2013	150	56	37%
2014	153	56	36%
2015	158	71	45%

4.3.1.3 The Council's June 2016 recommended ACLs and Buffers

The increases to both the darkblotched and POP ACLs for 2017-2018 recommended by the Council are now under consistency review by NMFS. The specific ACLs are shown in Table 1. In sum, the darkblotched ACL for 2017 and 2018 is set equal to the ABC, resulting in an ACL of 641 mt and 653 mt respectively. The recommended ACL for POP is 281 mt for both 2017 and 2018. As noted in Section 1.1, the ACL recommendations involved "off-the-top" buffers for both stocks to account for unexpected groundfish mortality in the groundfish sectors. The off-the-top" buffer is 50 mt for darkblotched and 25 mt for POP.

This specific buffer approach is new, but the concept of buffers has been used in various forms by the Council in the Groundfish and other FMPs. For example, the Council has used the same approach during the rebuilding of bocaccio rockfish by leaving considerable room between the ACL and projected catches. The off-the-top buffers were recommended by the GMT in June 2016. More detail can be found in their reports under Agenda Item G.4 and should be forthcoming as part of NMFS consistency review.

The need for such buffers arises from variability in catch between years. In the Council's catch accounting and management framework, ACLs are subdivided among sectors using various management measures. The allocations specified to the IFQ and at-sea sectors are among the most inflexible of management measures in terms of inseason adjustments. When the chances that the sectors are going to use their entire quotas each year are high, this inflexibility does not involve much downside and serves to reinforce the catch control system for preventing overages. However, when the chances that the allocations will be used in a single year are relatively low, the downside is that the amounts can be "stranded" in the sector in the years when they are not needed.

Since 2011, conditions in the IFQ and at-sea sectors have resembled more the latter than the former. As shown in the bootstrap simulation analysis below, the data suggests that the at-sea sectors should be expected to remain below their POP or darkblotched allocation amounts in most seasons but that overages should be expected to occur in some years. As for the IFQ sector, the individual accountability of that program appears to be keeping catch low because of a similar dynamic related to variability of catch. Participants in that fishery appear to be insuring themselves against the consequences of going over their individual quota holdings. While those consequences are potentially severe, the chances that multiple participants will experience large overages in the same season appear to be relatively low. The quota used as insurance goes unused.

As noted in Section 1.1, the Council's recommended increased ACLs and off-the-top buffers were closely connected to the issue of the at-sea darkblotched and POP allocations. The ACL increases raised the amounts allocated to the CP and MS sectors, and in turn, to the IFQ sectors as well. The off-the-top buffers then lower the chances that overages by the at-sea sectors would lead to the Council needing to regulate other sectors. The increased ACLs and buffers do not translate into increased odds that the IFQ or at-sea sectors will fully take their allocations. Catch projections predict that darkblotched and POP catches will continue to come in well below their ACLs.

4.3.2 Bootstrap Simulation Analysis for Darkblotched and POP

The bootstrap simulation is one of the tools used by the GMT for projecting bycatch of select species in the at-sea sector, including darkblotched and POP. Unlike methods that focus on producing point estimates, the bootstrap employs variability in haul-level catches to produce a distribution of possible bycatch outcomes around a point estimate. The bootstrap method is described in more detail in Supplemental WDFW Report 2 from June 2016 and in a report presented to the SSC in November 2015.[21]

In brief, the bootstrap uses observer estimates of catch on at-sea whiting hauls collected during the 2000-2015 seasons. The version used here used 10,000 iterations ("simulated seasons") for each scenario and sector.[22] Each run begins by randomly selecting an actual fishing season (e.g., 2003) and resampling from the observer data from that year with replacement (i.e. every haul is put back into the sample population and can be redrawn). The simulated seasons are constructed from a single year of observer data at a time to better reflect the high level of inter-annual variability in bycatch observed in the sectors. The draws for a simulated season continue until the cumulative sum of simulated catch reaches the scenario's first closure trigger. The main results from the bootstrap simulations are discussed for each stock in the following subsections. Further interpretation and underlying assumptions of the method are discussed in Section 4.3.3.

The bootstrap analysis run here uses four scenarios to compare and contrast Alternative 1 against No Action for each stock and sector. Scenario 1 is the No Action scenario. Simulated seasons in this scenario can be closed for reaching or exceeding the allocation of darkblotched, POP, canary, widow, or whiting. To produce a full range of plausible bycatch outcomes under Alternative 1, three scenarios were used to

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[21] See PFMC November 2015 Briefing Book Agenda Item I.4 Supplemental Attachment 9; and, Supplemental SSC Report.

[22] The source of the data is the Comprehensive NPAC table in Pacific States Marine Fisheries Commission PacFIN database.

explore the effect of choosing Alternative 1 for both darkblotched and POP or just one or the other. The four scenarios are summarized as follows:

1. 2017 FPA Allocations for darkblotched, POP, widow, and canary – evaluates No Action.
2. 2017 FPA Allocation for darkblotched only – evaluates Alternative 1 for POP and No Action for darkblotched.
3. 2017 FPA Allocation for POP only – evaluates Alternative 1 for darkblotched and No Action for POP.
4. Closed on attainment of whiting allocations only – evaluates effect of Alternative 1 for both stocks.

All scenarios are based on the CP and MS whiting allocations resulting from the 2016 U.S. share of the Pacific whiting Total Allowable Catch (TAC) of 325,068 mt, and include the whiting allocations as an inseason trigger. This is a key assumption of the method because number of hauls conducted in a season is the main factor determining the expected levels of bycatch; and, the number of hauls conducted per season is very tightly associated with the size of the whiting harvest. The simulation results are most informative for their relative comparison between Alternative 1 and No Action under TACs of this size. The absolute estimates of catch would scale up or down based on the size of the whiting TAC (or more appropriately, the size of marketable whiting harvest each year). An illustration of this is presented below in the analysis of Chinook salmon bycatch (Figure 30). In light of the most recent whiting assessment, the 2016 TAC should reasonably reflective the general magnitude of the TACs that should be expected over the near-term.

4.3.2.1 Brief Overview of How the Results Are Displayed

The simulation results are summarized using a few different methods. As in earlier reports, quantiles are the main way of describing the results and the results are reported individually for each sector and species.[23] New to this report, the bootstrap is also used to explore how catches in the two sectors may behave in the same season.

As a reminder, the quantiles represent the proportion of simulated seasons that came in less than or equal to the reported value. For example, the 0.99 quantile (or 99th percentile) indicates that 99 percent of the simulated catches were smaller than the values reported. And conversely, the 0.99 quantile means that 1 percent of the simulated values were greater. In a different phrasing used below, the 0.99 quantile can be said to correspond to the catch amount that only 1-in-100 of the simulated seasons reached or exceeded.

Additionally, the median value is marked by the 0.50 quantile. The median corresponds to what could be considered the risk-neutral estimate in that half of the simulation results come in higher and half lower. Furthermore, the median is most analogous to the point estimate the GMT may recommend as the best projection of catch using other statistical techniques. Choosing a larger quantile would be a way of expressing some risk-aversion in the estimate. The spread around the point estimate is highly informative to the question of possible overages of the darkblotched and POP allocation levels explored here.

[23] When stated as percentages, the quantiles are referred to as percentiles.

In terms of overages, there are two key questions to focus on. First is the question of how frequently an overage may be expected to occur under Alternative 1 compared to No Action. Second is the question of how large overages could plausibly get if the at-sea sectors were closed only based on their whiting allocation.

The results suggest that the bootstrap is most informative on the second question. It provides a means of gauging the relative plausibility of overages of different sizes that can then be compared against the size of the 2017 ACL buffers as a means of perspective. To better summarize the distribution of plausible outcomes, the core bootstrap summary is supplemented by displaying the distribution of catch events that happen in overages under Scenario 4 (Alternative 1 selected for both species).

4.3.2.2 Simulation Results for Darkblotched

Table 4 summarizes the simulation results for darkblotched catches using a select set of quantiles. As shown below, the major differences between Alternative 1 (scenarios 2-4) and No Action (scenario 1) appear in the upper quantiles. This pattern is to be expected because the Council's 2017 FPA ACLs place the allocation amounts where closures are triggered into the upper part of the distribution. If the simulations were based on 2016 allocations of darkblotched (and POP), the differences between scenarios would show closer toward the median.

As noted in the overview to this section, the frequency and magnitude of overages are two main metrics of interest. The results underscore that the main impact of Alternative 1 is caused by allowing overages to continue when they occur. Therefore, the bootstrap results are mainly useful for gauging the relative plausibility of overage amounts under the scenario that the sectors fully harvest the amount of whiting made available to them under the 2016 TAC (i.e. Scenario 4).

The minor differences between No Action and Alternative 1 also show up in the median values (i.e. quantile=0.5), which again are analogous to the typical risk-neutral catch projections made by the GMT. At the median, Alternative 1 only differs by 0.2 mt (3.3 percent) for the CPs and 0.4 mt (7.3 percent) for the MS sector. In terms of the overall uncertainty in the projections, these are small differences. To put that uncertainty into perspective, the coefficient of variation for the No Action simulation is 62 percent for the CP sector and 60 percent for the MS sector.

In terms of how the frequency of darkblotched overages might change under Alternative 1, the results suggest relatively small differences. Table 5 reports the exact quantiles at which the simulated seasons experienced an overage of darkblotched. Under No Action, the simulations reach or exceed the CP's allocation of 16.4 mt in 3-in-100 simulated seasons (i.e. the 0.97 quantile). This is also the same pattern for Scenario 3, when darkblotched is managed as a set aside and POP is managed as an allocation. This number increases to 8-in-100 simulations (i.e. the 0.92 quantile) under Alternative 1 for both species or if only POP is selected to be managed as a set aside. The change for the MS sector is even smaller, increasing from 3-in-100 simulated seasons to 5-in-100 seasons. These differences are likely not meaningful given the level of imprecision of the bootstrap forecasts, but again give us broad patterns that are informative. One general conclusion that can be drawn is that the 2017 ACL levels for darkblotched raises the allocation levels to a point where overages have become less likely compared to recent years.

Table 4: Bootstrap Analysis Summary Quantiles for Darkblotched Rockfish

Sector	Scenario	Allocation/Set Aside (mt)	Percentage of Simulated Seasons					
			0.01	0.25	0.5	0.75	0.95	0.9999
CP	1	16.4	0.3	3	5.8	8.2	13.8	18.3
	2		0.3	3.1	6	8.8	16.4	18.3
	3		0.3	3	5.8	8.2	13.8	28.1
	4		0.3	3.1	6	8.8	18.9	28.1
MS	1	11.6	0.2	2.5	5.1	7.1	10.9	14.4
	2		0.2	2.6	5.5	8	11.6	14.4
	3		0.2	2.5	5.1	7.1	10.9	20.3
	4		0.2	2.6	5.5	8	11.7	20.4

Table 5. Quantiles at Which Simulated Seasons Reach the Darkblotched Allocations

Sector	Allocation/Set Aside (mt)	Scenario	Quantile at which amount is reached
CP	16.4	1	0.97
		2	0.92
		3	0.97
		4	0.92
MS	11.6	1	0.97
		2	0.95
		3	0.97
		4	0.95

Again though, when evaluating the impact of managing the species as set asides and not allocations, it is the potential magnitude of overage that is of key importance. In terms of how large overages could plausibly get, the largest simulation result in scenario 4 reaches 36.1 mt for the CP sector and 21.2 mt for the MS sector. This is 120 and 83 percent over the sector allocation amounts, respectively. While overages greater in size are possible, as the bootstrap assumes that the largest haul has been seen within the last 15 years, this maximum, and the 0.9999 quantile (1-in-10,000 simulations), should be interpreted as relatively implausible result. The conditions leading to this and the next top nine results are given in Section 4.3.3.2.

While the overages could potentially exceed the allocations by almost double, Figure 1 and Figure 2 display the full distribution of overages occurring in scenario 4 (i.e. the 8 percent of simulated seasons that reach overages for the CP sector and 5 percent for the MS sector). As can been seen, 50 percent of the overages occur within 3 and 2 mt for the CP and MS sectors respectively when the sectors are closed only upon reaching their 2016 whiting allocations . Ninety percent of the seasons that exceed the allocation for both sectors exceed by 5 mt or less. While each sector could see extreme levels of catches, it is more plausible (a ~1:10 chance) that they would exceed the allocation by more than 5 mt.

One general conclusion to draw is that overages in a single sector would be highly unlikely to take the full 50 mt ACL buffer for darkblotched (see Section 4.3.1.3). The possibility and impact of both sectors experiencing overages in the same year is discussed in Section 4.3.2.4. Lastly, the conditions (i.e. haul level patterns) that lead to overages in the bootstrap simulations are explored in detail in Section 4.3.3.

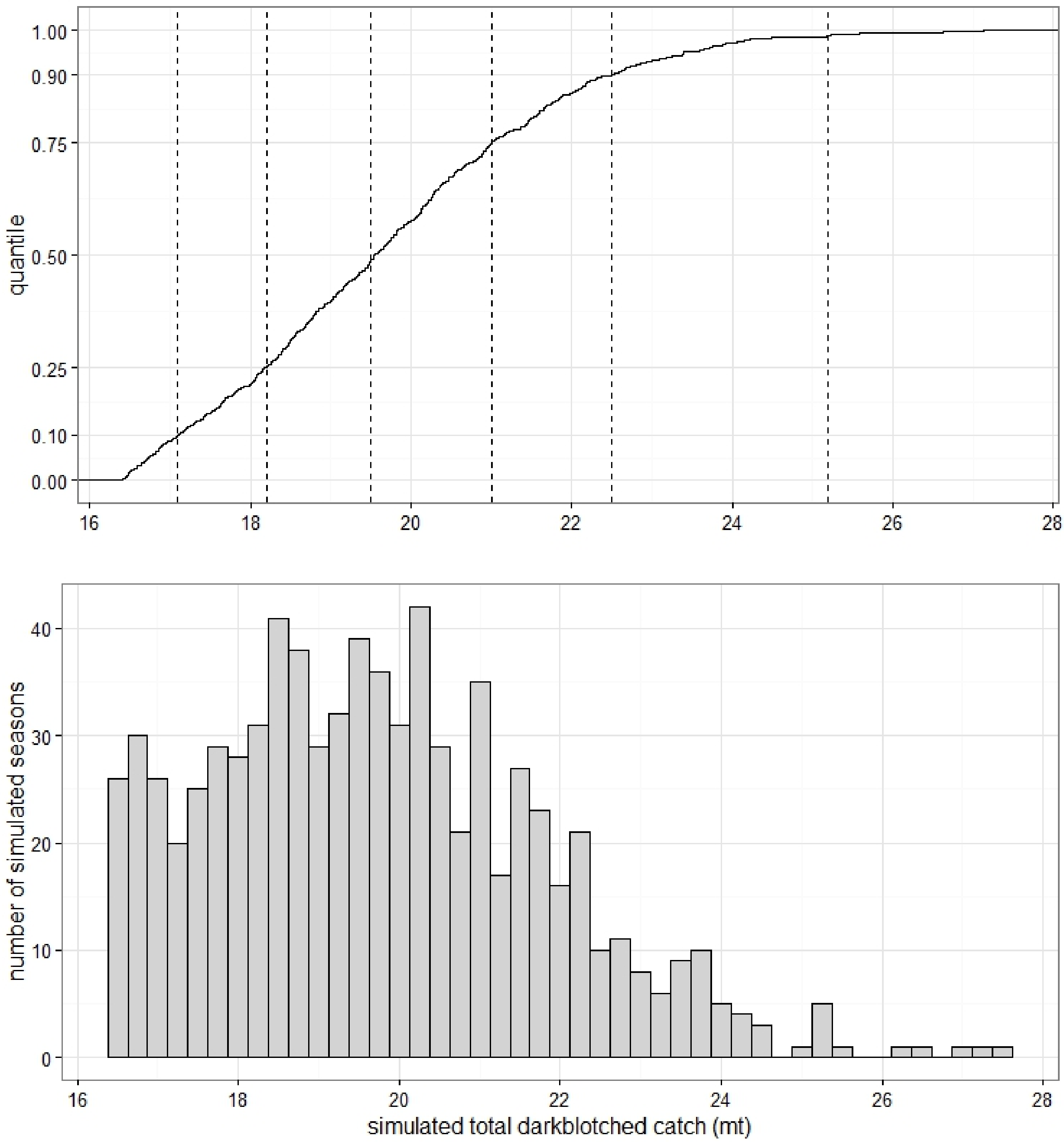


Figure 1. CP sector cumulative distribution graph (top-panel) and histogram (bottom-panel) of simulated total darkblotched catch from scenario 4 in overage seasons only. The vertical dashed lines in the top panel mark the overages corresponding to the 0.10, 0.25, 0.50, 0.75, 0.90, and 0.99 quantiles, moving left to right (actual values are not displayed because of visual overlap).

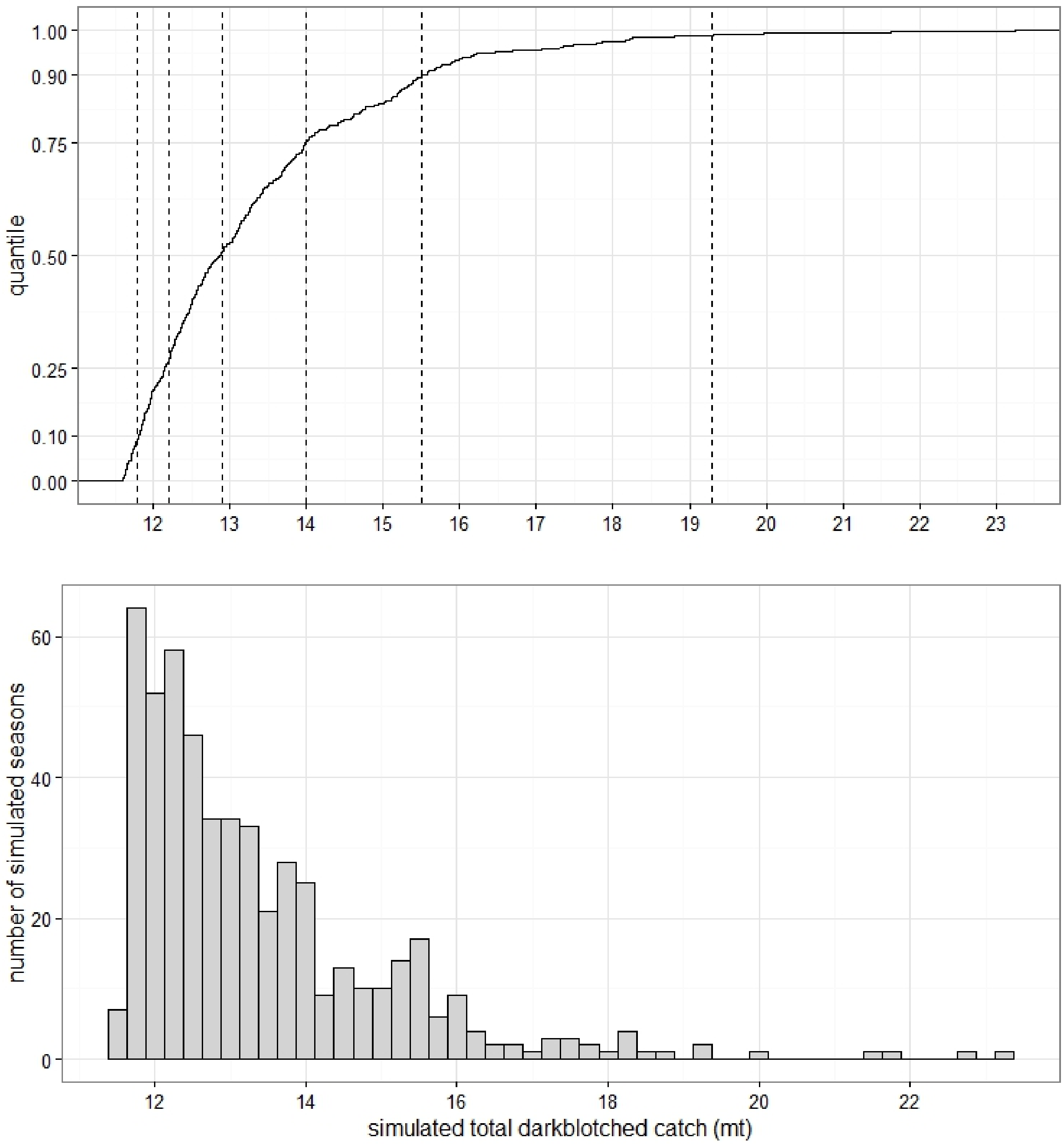


Figure 2. MS sector cumulative distribution graph (top-panel) and histogram (bottom-panel) of simulated total darkblotched catch from scenario 4 in overage seasons only. The vertical dashed lines in the top panel mark the overages corresponding to the 0.10, 0.25, 0.50, 0.75, 0.90, and 0.99 quantiles, moving left to right (actual values are not displayed because of visual overlap).

4.3.2.3 Simulation Results for POP

Table 6 displays the results of the bootstrap analysis for POP under the four scenarios as done for darkblotched above. As with darkblotched, the simulated catches of POP are asymmetric, with the values at the upper quantiles stretching far from the median. This is especially so with the MS sector, where the uppermost quantile under No Action is 5.5 times greater than the median value and more than 18 times the median value under scenario 4. Again, this large increase under scenario 4 is caused by the simulation only closing down a season when a sector reaches its whiting allocation.

Also like darkblotched, the median values vary only to a minor degree between No Action and Alternative 1; for the CP sector, it remains at 5.3 mt across all scenarios. In terms of the frequency of overages, the results for POP show even less difference than for darkblotched. The frequency with which overages occur between No Action and Alternative 1 occur ~1-in-10 seasons for the CP sector and ~1-in-20 season in the MS sector across all scenarios (Table 7). The question of how fishing behavior might influence the frequency of overages is discussed in Section 4.2.1.

Table 6: Bootstrap Analysis Summary Quantiles for POP

Sector	Scenario	Allocation/Set Aside (mt)	Percentage of Simulated Seasons					
			0.01	0.25	0.5	0.75	0.95	0.9999
CP	1	12.7	0.2	1.1	5.3	9.6	13.2	16.8
	2		0.2	1.1	5.3	9.6	22.1	49.3
	3		0.2	1.1	5.3	9.8	13.2	16.8
	4		0.2	1.1	5.3	9.8	27.1	53
MS	1	9.0	0.1	1	2.1	4.1	9.1	11.5
	2		0.1	1	2.1	4.1	20.5	40.3
	3		0.1	1	2.2	4.1	9.1	11.5
	4		0.1	1	2.2	4.1	22.4	40.7

Table 7. Quantile at Which Simulated Seasons Reach POP Allocations

Sector	Allocation/Set Aside (mt)	Scenario	Quantile at which amount is reached
CP	12.7	1	0.87
		2	0.87
		3	0.87
		4	0.87
MS	9.0	1	0.94
		2	0.94
		3	0.94
		4	0.94

In terms of the plausible size of overages, the largest overages rise far above the 25 mt ACL buffer. Maximum values for POP are 53.6 mt for the CP sector and 41.8 mt for the MS sector. These values are between four and five times the allocations for the sectors. However, as with darkblotched, this maximum value should be viewed as relatively implausible. The conditions arising in the simulation resulting in the ten highest runs are detailed in Section 4.3.3.2.

In terms of the full distribution of overage runs, the MS results are remarkably symmetrical compared to the others, with the median/average located right near the 25 mt mark (i.e. the size of the ACL buffer) (Figure 4). Again, this indicates that half of the overage runs came in above this value and half below. The distribution for the CP sectors is not nearly symmetrical (Figure 3). Rather, the pattern is skewed and has two modes (i.e. areas where values peak, most noticeable in the histogram panel of Figure 3), one centered around 14 mt and the other between 30 and 35 mt. The median value of the CP overage distribution is around 18 mt, suggesting that more than half of the seasons that could exceed the allocation would land less than approximately 5 mt over the allocation. These results are, like all the bootstrap simulations, products of the size distribution of hauls in the data, as explored in detail in the next section.

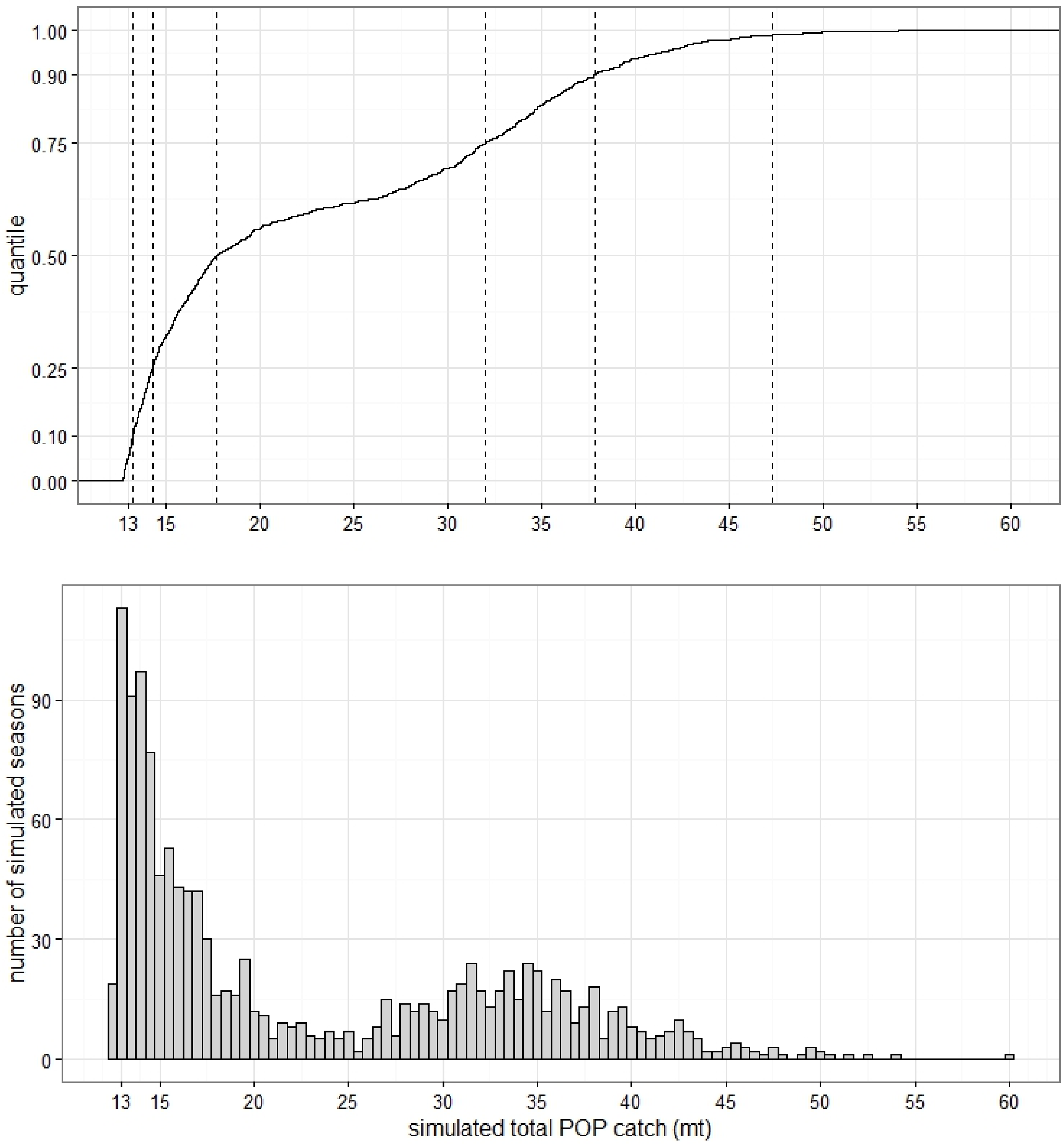
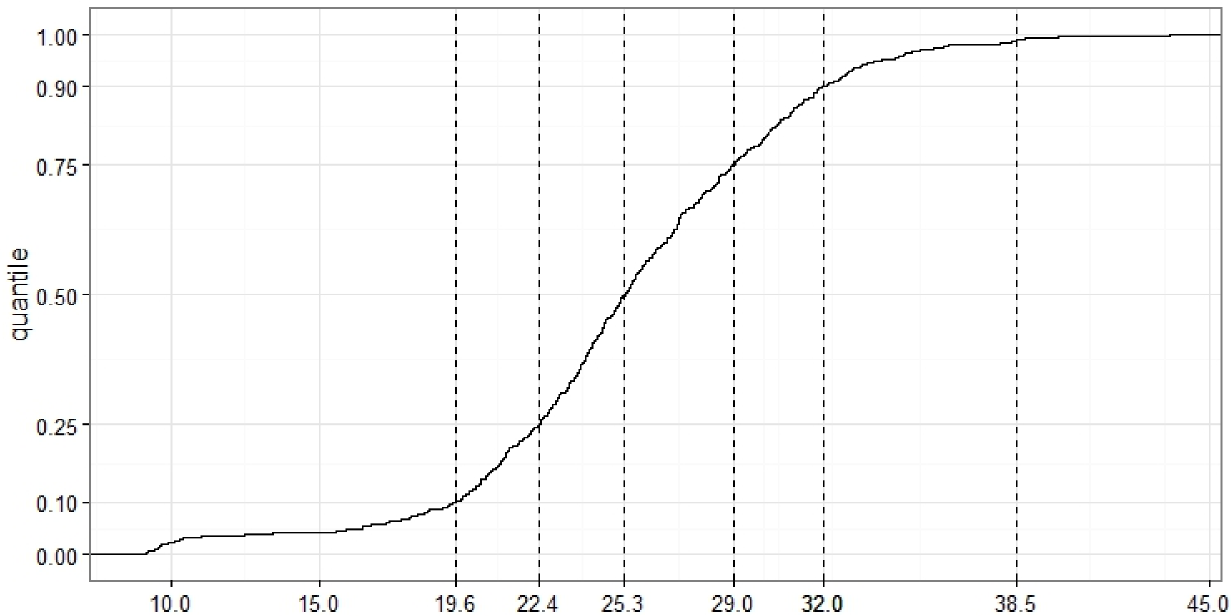


Figure 3. CP sector cumulative distribution graph (top-panel) and histogram (bottom-panel) of simulated total POP catch from scenario 4 in overage seasons only. The vertical dashed lines in the top panel mark the overages corresponding to the 0.10, 0.25, 0.50, 0.75, 0.90, and 0.99 quantiles, moving left to right (actual values are not displayed because of visual overlap).



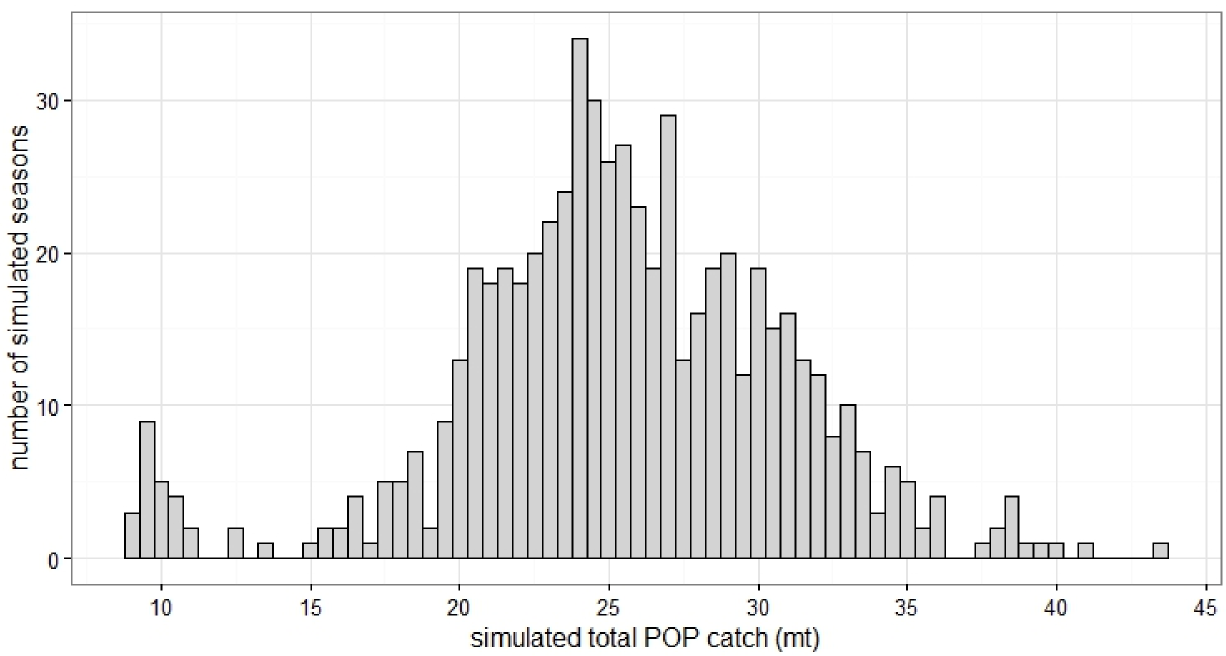


Figure 4. MS sector cumulative distribution graph (top-panel) and histogram (bottom-panel) of simulated total POP catch from scenario 4 in overage seasons only. The vertical dashed lines in the top panel mark the overages corresponding to the 0.10, 0.25, 0.50, 0.75,

0.90, and 0.99 quantiles, moving left to right (actual values are not displayed because of visual overlap).

4.3.2.4 Considering the Combined Simulation Results for Both

The bootstrap simulation results above do not consider the impact of combined catch across both sectors. When considering how much of the ACL buffer the at-sea sectors might need to access in case of overages, the combined catch in the two sectors is important to take into account. The overage in one sector might be balanced out by the underage in the other so that total catch across the two is less than the sum of their allocation or set aside amounts. On the hand, overages in both sectors would cause greater impact in total than a single overage.

In general, the quantiles reported in the bootstrap approximate the probability, or at least, the relative plausibility of catch reaching certain levels. However, the quantiles should not be interpreted to suggest that both sectors have equal probability of reaching that level in the same year. In fact, to the extent that catches in the sectors are uncorrelated, the chance that the higher quantiles are reached in both sectors in the same year would be low. For example, the probability that two independent events with a 1-in-100 frequency would occur together is 1-in-10,000 (i.e. 1/100 * 1/100 = 1/10,000). To the degree that the events are positively correlated, they would be expected to occur more frequently than this. On the other hand, if negatively correlated, it would be even rarer to observe them together.

In terms of annual catches of darkblotched and POP in the at-sea sectors, the data over 2000-2015 shows little evidence of correlation between sectors. The Pearson correlation coefficient for darkblotched is 0.08 with 95 percent confidence intervals of -0.55 and 0.43 (a correlation coefficient of zero would indicate the events are independent). Corresponding values for POP are -0.01 and -0.57 to 0.42. While it appears that there is little to no correlation between the sectors, one may develop.

As noted above, the frequency of an overage is just one metric of interest with the other key factor being the size of the overage. To more thoroughly explore how catch across the two at-sea sectors combines in the simulation results, the simulation was run so that the simulated seasons for each sector were based on the same year of data. The resulting correlation statistics between simulated seasons in each run reflects that in the data. The results in Table 8 show that overages in both sectors are even less plausible for darkblotched than when the sectors are considered individually (Table 4). However, the picture is more mixed for POP as combined overages are more likely than an individual overage occurring in either sector. This is because the size of the overage in a single sector can be large enough to outweigh the underage in the other.

Table 8 shows the distribution at the previously shown select quantiles of the difference between the total simulated catch of darkblotched and POP compared to the combined allocations for all four scenarios. Negative values are those seasons that landed under the combined allocations while positive values are when the total catch exceeds the allocations. For darkblotched, the maximum combined overage is less than 10 mt under Alternative 1 and the risk of exceeding the combined allocation is less than 3-in-10,000 seasons. Again though, POP provides a slightly different picture when the sectors are not held to an allocation of POP (and resulting closure). The chances of exceeding the combination of the closures increase from less than 1-in-10,000 to 12-in-10,000 from No Action to Alternative 1. When the overages do occur, the worst case in terms of Alternative 1 is ten times greater than No Action. However, even when the sectors combined exceed their allocations, in 89.3 percent of seasons, they exceed by less than 25 mt, which is the off-the-top buffer available for POP available in 2017 and 2018.

Table 8. Quantile at which Combined Catch from Both Sectors Exceeds Combined Sector Allocations

Stock	Sum of CP and MS Allocation/Set Asides (mt)	Scenario	Quantile at which amount is reached
Darkblotched	28.0	1	0.9987
		2	0.9948
		3	0.9951
		4	0.9783
POP	21.7	1	0.9905
		2	0.8826
		3	0.9904
		4	0.8765

Table 9: Bootstrap Simulation Results for Difference of Combined Catch and Allocation of Darkblotched and POP (Positive values indicate an overage).

Stock	Scenario	Percentage of Simulated Seasons					
		0.01	0.25	0.5	0.75	0.95	0.9999
Darkblotched	1	-25.7	-20.2	-17.1	-14	-8	1.5
	2	-25.6	-19.8	-16.2	-12	-5.6	2.2
	3	-25.7	-20.2	-17.1	-14	-7.6	8.6
	4	-25.6	-19.8	-16.2	-12	-3.5	9.5
POP	1	-21.2	-17.4	-13.3	-8.7	-4.1	4.8
	2	-21.2	-17.4	-13.3	-7.9	9.8	42.1
	3	-21.2	-17.4	-13.3	-8.6	-4.1	4.8
	4	-21.2	-17.4	-13.3	-7.7	13.9	50.7

4.3.3 Further Examination of Haul Level Variation in the Bootstrap

As described above, the bootstrap simulation works by resampling from the haul by haul observer data to produce a distribution of simulated seasons and bycatch outcomes. The pattern of variation in the individual hauls, i.e. in the relative frequency at which hauls of a given size occur, drives the pattern in the bootstrap results and expectations on overages. This section describes that pattern in detail to explore the causes of overages in more detail.

The source of variation in darkblotched and POP bycatch appears to be very similar to the one described in Thorson, Stewart, and Punt (2011) for highly variable catches in the Northwest Fisheries Science

Center (NWFSC) bottom trawl survey.[24] To start, most hauls made by the at-sea sectors catch zero darkblotched or POP. Considering 2000-2015, only 16.9 percent of hauls in the at-sea sectors have encountered darkblotched and only 12.7 percent encountered POP. Of those positive or non-zero hauls, a substantial majority encounter only a few fish. For example, the most frequently encountered number of darkblotched is two fish.[25] And 75 percent of the non-zero hauls catch 15 or fewer darkblotched.

The hauls that bring up individual fish contribute very little to the risk of overages. The greater risk comes from the hauls that encounter fish shoals (more casually referred to as "schools") that number in the tens, hundreds, and even thousands of fish. The shoals are encountered relatively infrequently, and larger shoals are less common than smaller ones, but their impact is substantial. As with the classic definition of risk—where risk equals the expected frequency/probability of the event times its consequences—these lower frequency catches can pose greater risk because of their larger size.

This section divides hauls of darkblotched and POP into six size bins to more thoroughly explore the impact that infrequent but large hauls have on the risk of overage. This section uses the size bins to further interpret the bootstrap results. The next section uses the same bins to explore the actual bycatch patterns observed in the fisheries from 1991 to the ongoing 2016 season.

4.3.3.1 The Size Bins and Impact on Total Catch

This section further explores the bootstrap simulation results by focusing in on haul-level patterns and the relative impact that hauls of various sizes and frequency have on the outcome of total catch. The six size bins used in the analysis are shown in Table 10. As with all binning of continuous values, some judgment was involved the choice of where to place the boundaries of each bin. The choices here were made based on the size and frequency of catch events in the 2000-2015 data.

Those patterns can be seen in the cumulative distribution of non-zero catches displayed for darkblotched in Figure 5 and POP in Figure 6. Two versions of the distributions are plotted for each: one using metric tons as the unit of size and the other, numbers of fish. The A-SHOP observers produce haul catch estimates using both units. The versions based on numbers of fish illustrate the phenomenon of encountering large shoals of fish in a more intuitive way. The analysis and size bins use metric tons as the unit of size.

Of note, the two sectors appear to be subject to the same level of randomness in catch. Figure 5 and Figure 6 plot the distributions individually for each sector but the overlap is so great that the curves are mostly indistinguishable. This lack of difference contrasts with the very clear differences seen in the distribution of catch per haul of whiting (not shown). The CP vessels have larger catching power and catch a distinctly larger amount of whiting per haul. Analysis to date has not detected any statistical relationship between haul level fishing effort (e.g. duration) and the size of darkblotched or POP catch.

[24] James T. Thorson, Ian J. Stewart, and André E. Punt. Accounting for fish shoals in single-and multi-species survey data using mixture distribution models. Canadian Journal of Fisheries and Aquatic Sciences 68, no. 9 (2011): 1681-1693.

[25] Many of these two fish hauls are likely to have encountered just one fish. Observers typically sample half of a haul. So when they encounter one fish, the total becomes two as the other half is assumed to have the same composition as the sampled half.

As these figures show, the size distribution of hauls follows very similar pattern for the two stocks. There are some differences in the upper limbs, but the same order of magnitude (i.e. the 0.99 quantile for darkblotched is 0.31 mt and 0.43 for POP).The analysis uses the same bins for both species for comparability. As can be seen in Table 10, the average number of fish per bin varies between darkblotched and POP due to the differences in weight, yet both follow the same general rise from individual fish in bin 2 and then to shoals numbering the few thousands of fish in bin 6.

Another key pattern in the distributions is seen in the size of the largest hauls relative to the "typical" size hauls in the middle of the distribution. For example, the 0.75 quantile—which conventionally is used to describe values on the upper end of the middle of a distribution—catch for both darkblotched and POP is an order of magnitude smaller than the 0.99 quantiles values and two orders of magnitude smaller than the average of hauls in the top one percent. To illustrate, the 0.999 quantile value for darkblotched of 1.37 mt—which is near the center of the upper one percent— is 137 times the size of the 0.01 mt value at the 0.75 quantile (see top panel of Figure 5).

The last key pattern to note relates to the frequency at which hauls of various sizes occur. The largest values are relatively infrequent, much more so than would be expected under more typical statistical distributions (e.g. the normal bell curve). This can be seen in the large distance that the very upper quantiles stretch across the x-axis. The top 0.99 of darkblotched hauls stretches from 0.31 to close to 3.0 mt. This is a spread of 2.7 mt, or nearly 90 percent of the x-axis' total length (Figure 5, top panel). With the top one percent of the y-axis accounting for 90 percent of the range on the x-axis, the converse is that the remaining 10 percent of the x-axis—i.e. the smallest 10 percent in terms of size—covers 99 percent of the y-axis. In other words, the smallest 10 percent of catches appeared ~90 percent of the time over 2000-2015 and the largest 90 percent appeared ~1 percent of the time.

Table 10: Haul Bin Sizes with Average Number of Fish per Bin

Bin Number	1	2	3	4	5	6
Catch of per Haul	0	0-.005	0.005-0.03	0.03-0.01	0.1-0.4	>0.4
Average Number of Darkblotched	0	3.2	17.5	79.9	263.5	1150.2
Average Number of POP	0	2.8	14.2	61.3	217.5	1025.4

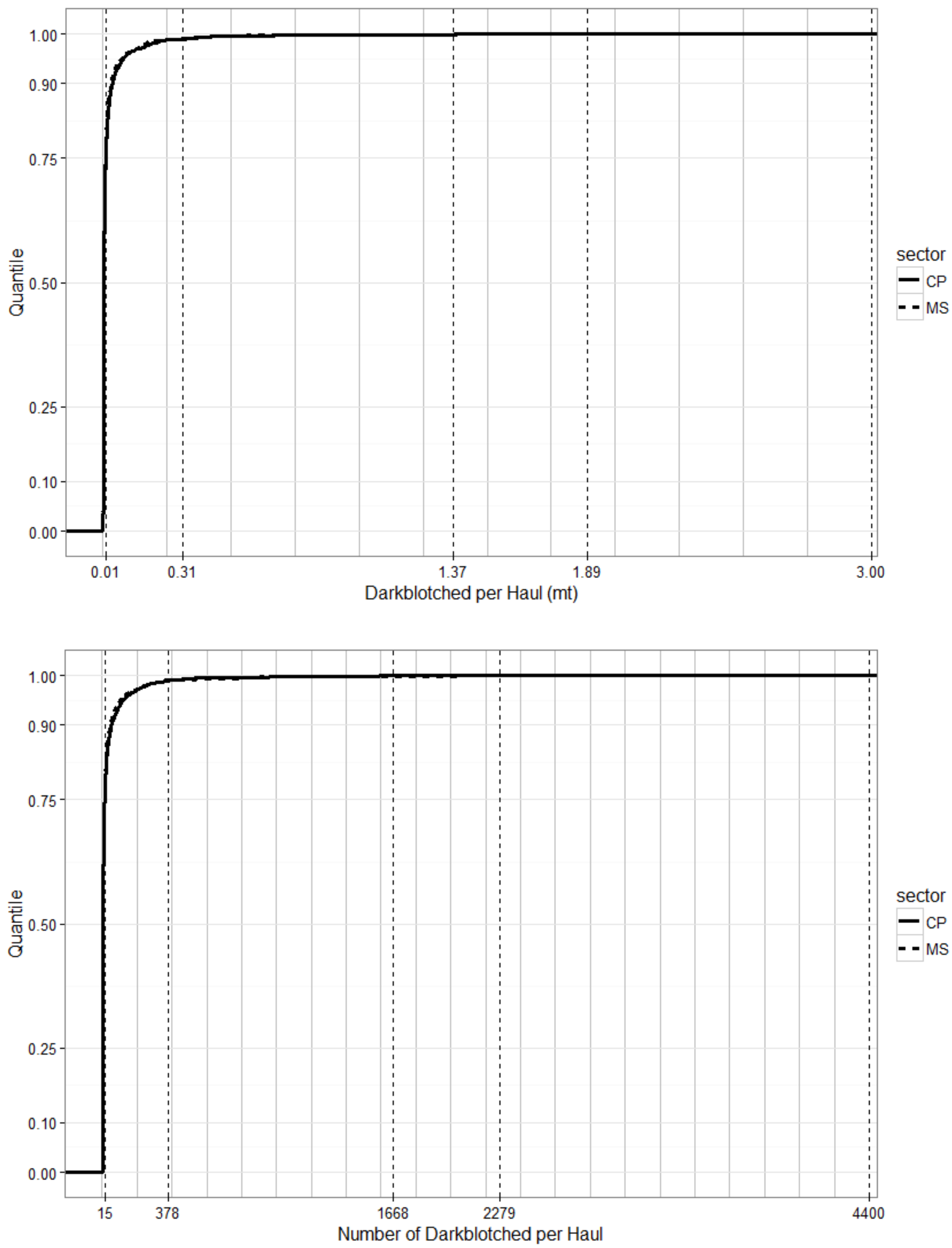
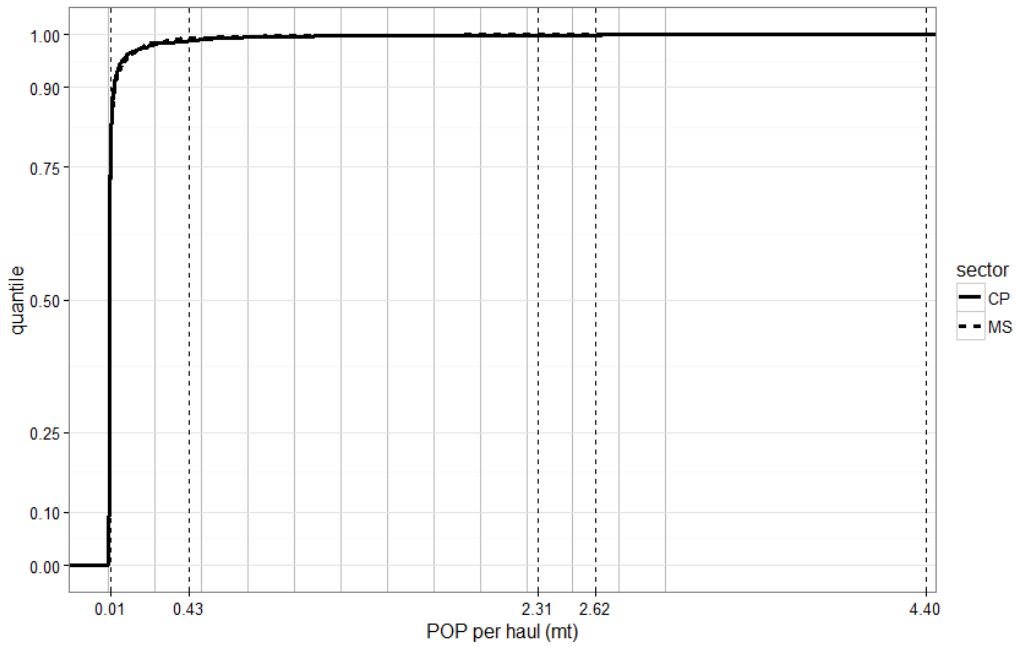


Figure 5: Cumulative Distributions of Darkblotched Rockfish Positive Hauls, 2000-2015 (top panel (metric tons) and bottom panel (numbers of fish). The distributions of both sectors are plotted separately yet are visually indistinguishable. The first four dashed vertical lines, moving from left to right, represent the catch sizes corresponding to the 0.75, 0.99, 0.999, and 0.9995 quantiles (calculated on the sectors combined). The fifth displays the general size of the largest haul in the data but is itself outside the range.



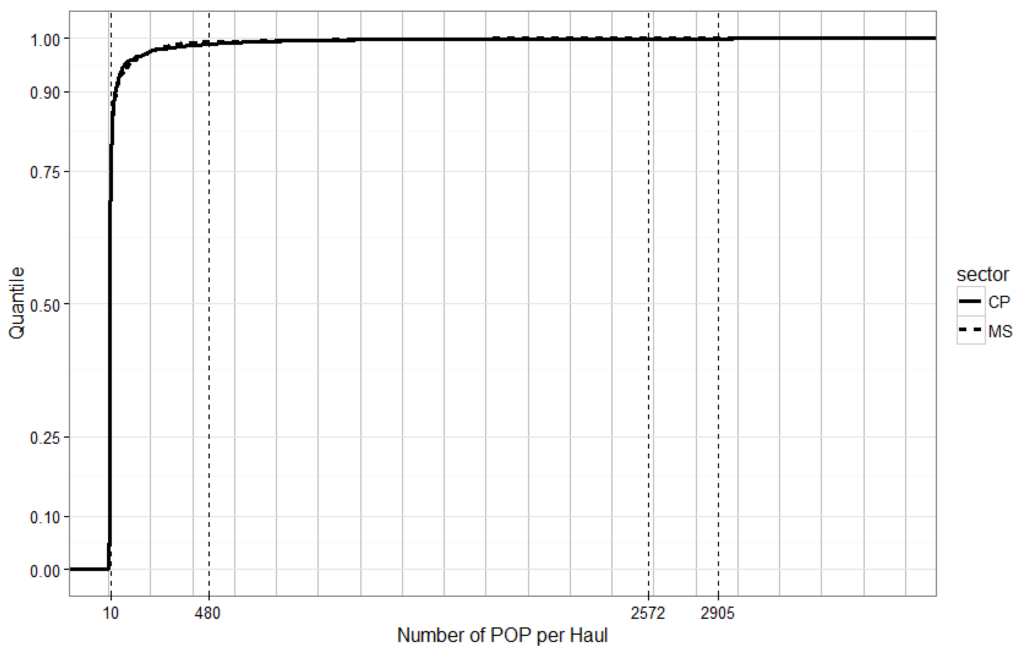


Figure 6: Cumulative Distributions of Darkblotched Rockfish Positive Hauls, 2000-2015 (top panel (metric tons) and bottom panel (numbers of fish). The distributions of both sectors are plotted separately yet are visually indistinguishable. The first four dashed vertical lines, moving from left to right, represent the catch sizes corresponding to the

0.75, 0.99, 0.999, and 0.9995 quantiles (calculated on the sectors combined). The fifth displays the general size of the largest haul in the data but is itself outside the range.

4.3.3.2 Summarizing the Bootstrap Simulation Results by Size Bin

This section provides a series of looks at the simulation results, using the size bins and other metrics, to explore the conditions that lead to overages of darkblotched and POP.

The first focuses on the top ten highest simulated season catches of darkblotched and POP in the bootstrap simulation for each sector. It is clear that these extreme outcomes arise when the bootstrap resampling draws multiple low frequency but large impact hauls from bin 6, and to a lesser but still significant part from, bin 5 as well. These runs are by definition rare—they make up the highest 10 out of 10,000 runs—because the bootstrap resampling draws hauls in proportion to their frequency in the data. More details on how rare these season structures are can be found in Section 4.3.4.1, where recent trends in hauls are discussed. Figure 7 shows the results for darkblotched and Figure 8 for POP (mt). They underscore the largest hauls as a key source of variability in total catch and major causes of these relatively implausible catch levels.

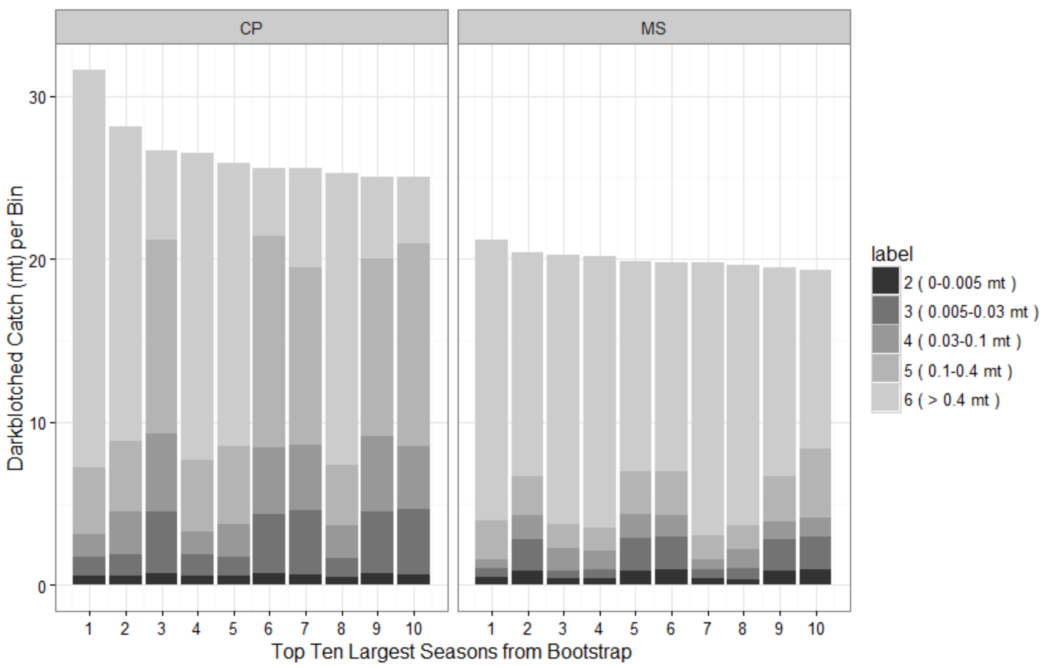


Figure 7: Contribution of Darkblotched Catch in Top Ten Highest Catch Seasons in Bootstrap, broken down by the five non-zero size bins (bin 1 = zero darkblotched caught)

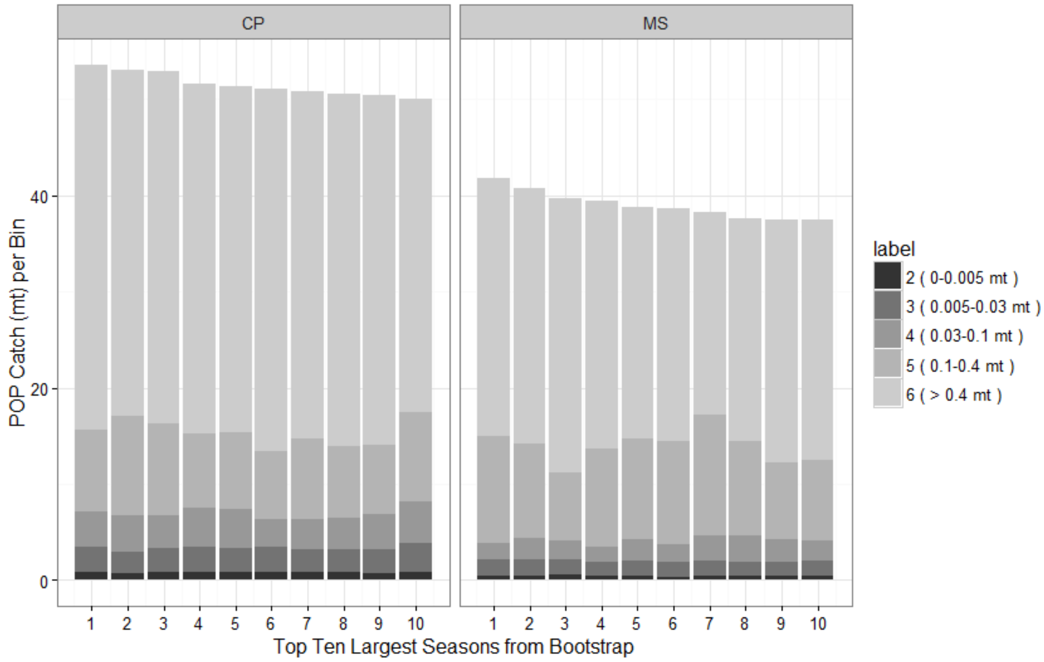


Figure 8: Top Ten Largest Simulated Seasons of POP Catch from Bootstrap by size bin broken down by the five non-zero size bins (bin 1 = zero POP caught)

The following section provides a means of quick visual comparison of the impact that the size bins have across all simulation results (Figure 9-Figure 12). This impact can be visually examined by comparing the change in magnitudes in the x-axis and y-axis across size bins.

In the following four figures, the x-axis displays the proportion of hauls that occurred in the bin while the y-axis displays the amount of simulated catch that came from hauls within the size bin. For example, in Figure 9, it can be seen that hauls in bin 2 (0-0.005 mt) ranged from close to zero to greater than 15 percent of the total simulated hauls per season and yet contributed less than 1 mt overall when they occurred most frequently. Bin 6 in that same figure, in contrast, appeared in zero to around 0.8 percent of the total hauls in a simulated season and yet contributed upwards of 25 mt of darkblotched catch even in the middle range of the x-axis.

These patterns again underscore the point that the lower frequency hauls of bins 5 and 6 have a disproportionate impact to the risk of overages. The next set of analyses provides more detail on the different patterns apparent between simulations that reached overages.

Before moving to that more detailed analysis, Figure 9-Figure 12 can also be used to examine the behavior of the simulation results. Each gray point represents a simulated season. The cluster pattern provides some indication of how simulated seasons reached certain levels of catch in each bin. Two model fit lines are plotted for visual aid: a standard linear regression line (dashed line) and a loess trend line (solid line) that will more flexibly follow non-linear patterns in the data. To use one of the extreme examples to illustrate, the two lines diverge in Figure 9 at the upper end of the x-axis in bin 6, which shows that total catch of darkblotched in the bin was lower in many runs at a higher frequency than at more intermediate levels. This pattern is probably a result of the wide range of haul sizes, anything exceeding 0.4 mt, covered by bin 6.

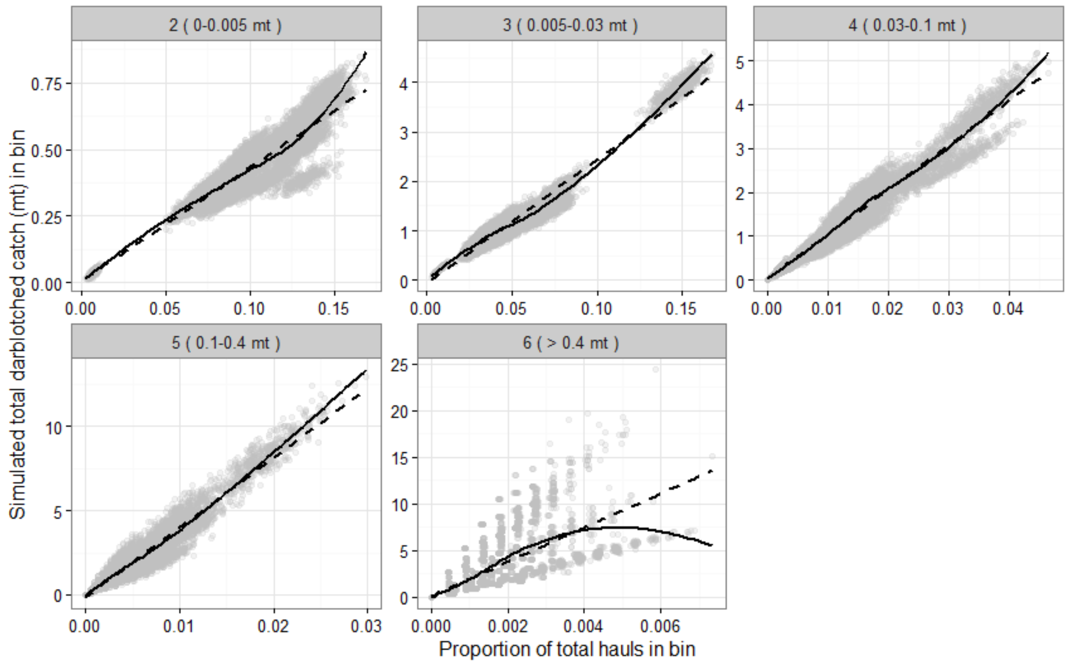


Figure 9: Comparison of Proportion of Hauls and the Corresponding Amount of Simulated Darkblotched Catch (mt) in Bins 2-5 for the CP Sector. Solid line represents linear regression fit. Dashed line is a loess trend line.

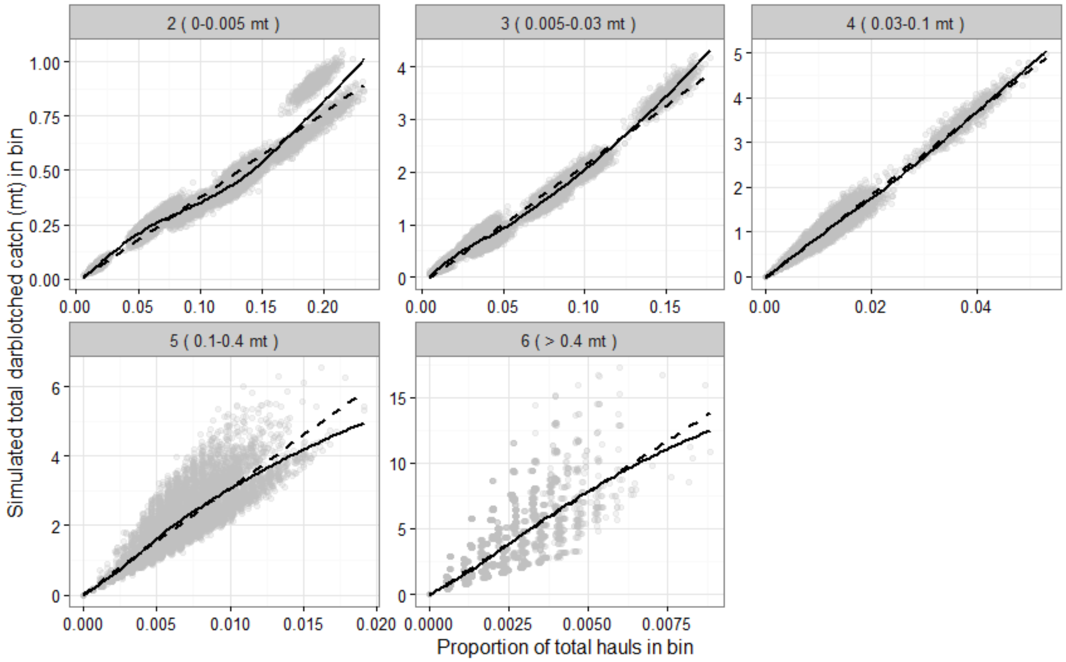


Figure 10: Comparison of Proportion of Hauls and the Corresponding Amount of Simulated Darkblotched Catch (mt) in Bins 2-5 for the MS Sector. Solid line represents linear regression fit. Dashed line is a loess trend line.

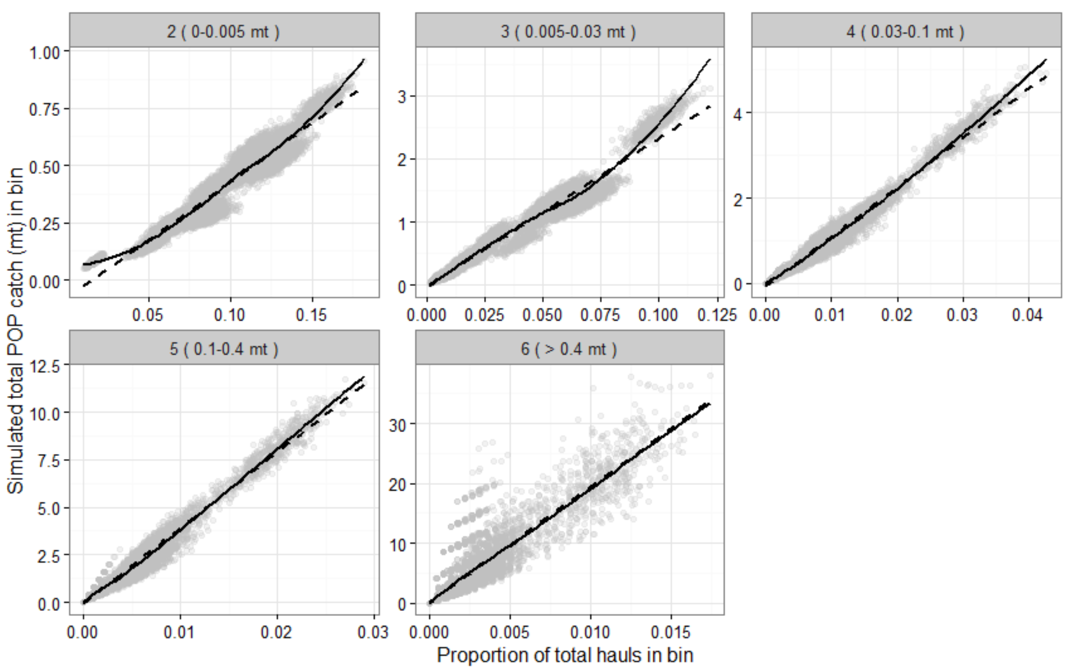


Figure 11: Proportion of Total Hauls in Bins and Corresponding Amount of Simulated POP Catch, CP sector. Solid line represents linear regression fit. Dashed line is a loess trend line.

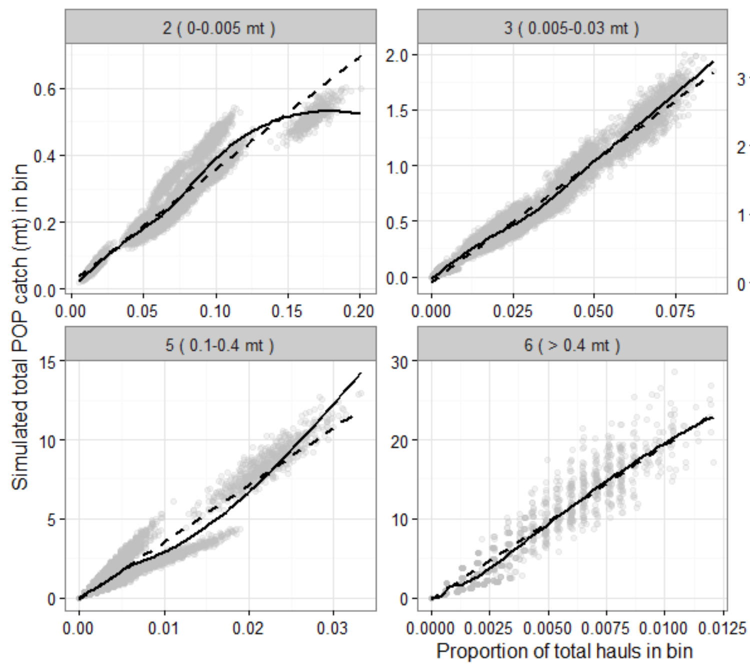


Figure 12: Proportion of Total Hauls In Bins and Corresponding Amount of Simulated POP Catch, MS sector. Solid line represents linear regression fit. Dashed line is a loess trend line.

For that more detailed look, Table 11 and Table 12 break down the simulated seasons under Scenario 4 for the CP and MS sectors for darkblotched based on the six size bins and three categories related to overage status (first discussed in Section 4.3.3.1). Table 13 and

Table 14 report the corresponding information for POP. As a reminder, Scenario 4 has no triggers for closure except for reaching the whiting allocation. The three categories of seasons are:

a. seasons with simulated catch under the darkblotched or POP allocation,
b. seasons that reached or exceeded the allocation by less than one metric ton, and
c. seasons that exceed the allocation by one metric ton or more.

Again, the risk posed by catches of a certain size is a product of the frequency with which they happen and their size. The tables reports summary statistics that allow for comparison of the risk associated with each size bins across the three categories of season. These summary statistics include the minimum, average, 95th percentile, and maximum for the number of hauls within each size bin, the simulated darkblotched or POP catch attributed to that bin, the percentage of hauls within each bin, and the amount of darkblotched or POP per haul.

While the tables can be used to make a number of comparisons, only a few key comparisons are highlighted here for the purpose of illustrating the suggested factors for weighing the risk of overages. The primary focus of these comparisons is on the size bins and on the amount of catch each contributes in simulated seasons that did not exceed their allocation compared to simulated seasons where overages did occur. The main factors driving the total catch amount are: (1) the proportion of hauls drawn from the bin (i.e. their frequency); and, (2) the average size of a haul in the bin.

Starting with bin 2 in Table 11, it shows that the frequency of CP catches of darkblotched of this size does change markedly between overages and underages. The frequency jumps from 0.2 percent in seasons under the allocation up to 6.8 percent and 5.9 percent (a ~300 fold increase) in the two overage categories. However, the corresponding change in the average total catch in the bin only increases from 0.41 mt in seasons simulated to catch less than the allocation to 0.59 mt and 0.67 mt in the overage seasons. Catches in this bin—which again, represent hauls of individual fish and not shoals— do not appear to add much to the risk of overages. The average size of catch in the bin is 0.002 mt in all three season categories.

Bin 6 in Table 11 shows the opposite extreme. It shows relatively small changes in average frequency between overages and underages, rising from 0.1 percent in seasons under the allocation to 0.2 percent and 0.3 percent in seasons with overages. However, the change in the average total contribution of darkblotched in the bin increases from 1.43 mt to 7.33 mt and 5.85 mt in the overage categories.

The key factor is, again, the total impact that the various size bins can be expected to have on the risk of overages. Comparing the average total catch in each bin, and weighing the size against the total allocation, is one way of gauging this impact. Using Table 11 again as an example, looking at seasons with overages of more than 1 mt, it is the one case where bin 5 that has the highest impact. In those simulated seasons, bin 5 contributed 7.29 mt of total catch on average. This equates to 44.5 percent of the CP's 2017 allocation of darkblotched of 16.4 mt. The average contribution of bin 6 was 5.85 mt, or 35.7 percent of the allocation level.

One final observation is that hauls in bins 2, 3, and 4 do not appear to have enough impact on their own to reach overages of the 2017 recommended allocation levels. To illustrate, the maximum values for POP in the MS sector (Table 14) for these three bins in seasons of overages is, in order: 0.54 mt, 1.99 mt, and 3.24 mt. The sum of these amounts is 5.8 mt, which is below the 9 mt allocation level. The same applies across all sectors and both stocks. Catches in bin 5 and bin 6 are what pushed the sectors into overage levels.

Table 11: Summary Metrics of Bootstrap Simulated Darkblotched Catch in CP Sector under Scenario 4

Category	**Under Allocation**						**Less than 1 mt Over Allocation**						**1 mt or more Over Allocation**					
Simulated Seasons in Category	9222						100						678					
Haul Size Bin	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Number of Hauls																		
Min	1180	6	7	0	0	0	1314	154	58	5	5	1	1276	131	46	5	5	0
Average	1676	185	83	23	10	1	1675	267	148	42	24	5	1459	285	251	62	35	7
95th percentile	2054	279	144	49	22	5	1854	312	310	78	37	7	1800	317	329	86	49	11
Max	2729	331	341	79	38	11	2050	324	330	86	39	9	2012	348	351	95	60	14
Simulated Total Darkblotched Catch in Bin																		
Min	0.00	0.01	0.07	0.00	0.00	0.00	0.00	0.33	0.68	0.21	1.08	0.60	0.00	0.28	0.51	0.25	0.85	0.00
Average	0.00	0.41	1.01	1.21	1.84	1.43	0.00	0.59	1.85	2.30	4.89	7.33	0.00	0.67	3.20	3.35	7.29	5.85
95th percentile	0.00	0.64	1.76	2.62	4.24	6.64	0.00	0.76	4.03	4.20	7.53	11.72	0.00	0.77	4.25	4.64	10.40	14.43
Max	0.00	0.81	4.32	4.06	7.49	13.09	0.00	0.81	4.27	4.57	7.84	14.50	0.00	0.85	4.61	5.19	12.98	24.40
Percentage of Total Hauls																		
Min	64.1%	0.2%	0.3%	0.0%	0.0%	0.0%	64.2%	6.8%	2.6%	0.2%	0.2%	0.0%	62.5%	5.9%	2.1%	0.2%	0.2%	0.0%
Average	84.3%	9.6%	4.3%	1.2%	0.5%	0.1%	77.3%	12.4%	7.0%	2.0%	1.1%	0.2%	69.3%	13.6%	12.1%	3.0%	1.7%	0.3%
95th percentile	90.1%	14.3%	7.7%	2.7%	1.1%	0.2%	83.5%	15.0%	15.1%	3.7%	1.8%	0.3%	81.6%	15.3%	15.9%	4.1%	2.4%	0.5%
Max	99.1%	16.9%	16.4%	4.2%	1.9%	0.6%	89.1%	15.5%	15.8%	4.2%	1.9%	0.5%	90.0%	16.5%	16.7%	4.7%	3.0%	0.7%
Darkblotched per Haul																		
Min	0.000	0.001	0.009	0.031	0.101	0.420	0.000	0.002	0.011	0.042	0.170	0.453	0.000	0.002	0.010	0.040	0.141	0.430
Average	-	0.002	0.012	0.053	0.190	0.950	-	0.002	0.012	0.055	0.209	1.391	-	0.002	0.013	0.054	0.211	0.805
95th percentile	-	0.002	0.014	0.064	0.263	1.980	-	0.002	0.013	0.062	0.240	1.985	-	0.003	0.013	0.059	0.239	1.813
Max	0.000	0.003	0.015	0.076	0.383	2.618	0.000	0.003	0.013	0.065	0.280	2.618	0.000	0.003	0.014	0.067	0.318	2.379

Table 12: Summary Metrics of Bootstrap Simulated Darkblotched Catch in MS Sector under Scenario 4

Category	**Under Allocation**						**Less than 1 mt Over Allocation**						**1 mt or more Over Allocation**					
Simulated Seasons in Category	9484						227						289					
Haul Size Bin	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Number of Hauls																		
Min	1033	9	7	0	0	0	1100	18	16	4	2	0	1065	24	21	3	4	0
Average	1407	163	85	19	9	2	1259	249	143	27	13	5	1252	281	138	21	11	6
95th percentile	1662	341	253	60	19	5	1558	375	271	76	26	9	1393	372	206	31	19	10
Max	1720	413	303	92	31	10	1627	392	304	88	29	14	1601	398	276	79	33	15
Simulated Total Darkblotched Catch in Bin																		
Min	0.00	0.01	0.05	0.00	0.00	0.00	0.00	0.04	0.20	0.18	0.23	0.00	0.00	0.06	0.22	0.17	0.67	0.00
Average	0.00	0.36	1.02	1.01	1.57	1.28	0.00	0.59	1.66	1.50	2.44	5.86	0.00	0.69	1.50	1.14	2.29	8.92
95th percentile	0.00	0.80	3.37	3.22	3.66	5.20	0.00	0.96	3.65	4.16	4.17	9.33	0.00	0.97	2.26	1.79	3.92	13.71
Max	0.00	1.05	4.22	4.98	6.55	8.74	0.00	1.01	4.17	4.79	5.41	10.12	0.00	1.02	3.84	4.45	5.56	17.26
Percentage of Total Hauls																		
Min	63.3%	0.6%	0.5%	0.0%	0.0%	0.0%	64.1%	1.1%	1.0%	0.2%	0.1%	0.0%	65.2%	1.4%	1.3%	0.2%	0.2%	0.0%
Average	83.5%	9.8%	5.0%	1.1%	0.5%	0.1%	74.7%	14.5%	8.2%	1.6%	0.8%	0.3%	73.7%	16.2%	7.8%	1.2%	0.7%	0.4%
95th percentile	97.1%	19.5%	14.6%	3.5%	1.1%	0.3%	94.7%	20.3%	15.7%	4.4%	1.5%	0.5%	83.2%	20.3%	11.2%	1.7%	1.1%	0.6%
Max	98.3%	23.3%	17.4%	5.3%	1.8%	0.6%	95.6%	21.1%	17.7%	5.1%	1.7%	0.8%	95.3%	21.4%	16.1%	4.6%	1.9%	0.9%
Darkblotched per Haul																		
Min	0.000	0.001	0.006	0.034	0.109	0.403	0.000	0.002	0.008	0.041	0.116	0.609	0.000	0.002	0.009	0.039	0.127	0.689
Average	-	0.002	0.011	0.051	0.180	0.838	-	0.002	0.011	0.055	0.191	1.346	-	0.002	0.011	0.054	0.201	1.455
95th percentile	-	0.003	0.014	0.062	0.270	1.885	-	0.003	0.014	0.062	0.269	2.209	-	0.003	0.013	0.064	0.268	2.355
Max	0.000	0.003	0.017	0.082	0.361	2.878	0.000	0.003	0.016	0.071	0.318	2.878	0.000	0.003	0.016	0.072	0.324	2.878

Table 13: Summary Metrics of Bootstrap Simulated POP Catch in CP Sector under Scenario 4

Category	**Under Allocation**						**Less than 1 mt Over Allocation**						**1 mt or more Over Allocation**					
Simulated Seasons in Category	9170						76						754					
Haul Size Bin	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Number of Hauls																		
Min	1285	27	3	0	0	0	1331	171	25	8	1	4	1327	158	23	7	0	4
Average	1724	174	64	13	5	3	1634	216	85	21	9	8	1480	292	172	51	32	18
95th percentile	2044	281	129	32	16	8	2022	254	134	32	18	11	1999	346	224	74	49	28
Max	2708	326	159	48	28	15	2043	276	140	39	22	13	2043	380	253	88	59	36
Simulated Total POP Catch in Bin																		
Min	0.00	0.05	0.02	0.00	0.00	0.00	0.00	0.35	0.29	0.37	0.11	8.15	0.00	0.34	0.23	0.35	0.00	4.87
Average	0.00	0.37	0.73	0.71	0.90	2.57	0.00	0.47	0.94	1.26	1.86	12.35	0.00	0.69	2.14	2.91	6.29	18.77
95th percentile	0.00	0.61	1.49	1.79	3.32	8.94	0.00	0.57	1.48	2.08	4.18	15.05	0.00	0.83	2.88	4.26	9.95	28.79
Max	0.00	0.73	1.81	2.71	7.00	14.59	0.00	0.59	1.62	2.66	4.59	15.29	0.00	0.96	3.23	5.08	11.75	38.00
Percentage of Total Hauls																		
Min	74.0%	1.0%	0.1%	0.0%	0.0%	0.0%	74.9%	7.7%	1.1%	0.4%	0.0%	0.2%	65.5%	7.6%	1.0%	0.4%	0.0%	0.2%
Average	86.8%	8.8%	3.3%	0.7%	0.2%	0.1%	82.3%	11.2%	4.6%	1.1%	0.5%	0.4%	72.4%	14.3%	8.4%	2.5%	1.6%	0.9%
95th percentile	95.2%	13.4%	6.9%	1.6%	0.8%	0.4%	89.0%	14.0%	7.5%	1.8%	1.0%	0.6%	88.4%	16.6%	10.9%	3.6%	2.4%	1.4%
Max	98.6%	15.4%	8.7%	2.4%	1.6%	0.8%	89.4%	14.6%	7.9%	2.2%	1.2%	0.7%	89.8%	18.2%	12.2%	4.3%	2.9%	1.7%
POP per Haul																		
Min	0.000	0.001	0.005	0.030	0.107	0.410	0.000	0.002	0.010	0.045	0.111	0.740	0.000	0.002	0.009	0.043	0.111	0.487
Average	-	0.002	0.011	0.052	0.200	0.976	-	0.002	0.011	0.058	0.189	1.734	-	0.002	0.012	0.057	0.196	1.182
95th percentile	-	0.003	0.013	0.066	0.397	1.881	-	0.002	0.012	0.065	0.248	2.789	-	0.003	0.013	0.064	0.238	2.622
Max	0.000	0.003	0.017	0.077	0.397	4.241	0.000	0.003	0.013	0.068	0.291	3.356	0.000	0.003	0.014	0.070	0.286	4.241

Table 14: Summary Metrics of Bootstrap Simulated POP Catch for MS Sector under Scenario 4

Category	**Under Allocation**						**Less than 1 mt Over Allocation**						**1 mt or more Over Allocation**					
Simulated Seasons in Category	9363						3						634					
Haul Size Bin	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Number of Hauls																		
Min	1214	9	0	0	0	0	1349	83	31	6	3	6	1382	130	98	22	23	4
Average	1514	107	41	8	5	1	1355	86	35	8	6	6	1443	176	126	42	41	12
95th percentile	1683	196	88	23	15	3	1362	88	39	10	7	7	1479	198	143	53	51	19
Max	1738	332	124	43	30	8	1363	88	39	10	7	7	1516	215	159	65	62	22
Simulated Total POP Catch in Bin																		
Min	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.18	0.30	0.32	0.44	10.15	0.00	0.34	1.12	1.02	4.47	2.95
Average	0.00	0.23	0.47	0.42	0.88	0.47	0.00	0.19	0.37	0.37	0.74	10.33	0.00	0.44	1.54	2.13	8.50	13.54
95th percentile	0.00	0.41	1.10	1.30	2.88	2.50	0.00	0.19	0.42	0.43	0.92	10.64	0.00	0.50	1.79	2.71	11.08	21.14
Max	0.00	0.60	1.68	2.42	6.13	10.15	0.00	0.19	0.43	0.44	0.93	10.70	0.00	0.54	1.99	3.24	12.95	28.58
Percentage of Total Hauls																		
Min	75.2%	0.5%	0.0%	0.0%	0.0%	0.0%	90.2%	5.6%	2.1%	0.4%	0.2%	0.4%	75.6%	7.1%	5.3%	1.2%	1.3%	0.2%
Average	90.4%	6.4%	2.4%	0.5%	0.3%	0.0%	90.6%	5.8%	2.4%	0.5%	0.4%	0.4%	78.4%	9.6%	6.8%	2.3%	2.2%	0.7%
95th percentile	98.3%	11.3%	5.1%	1.4%	0.9%	0.2%	90.8%	5.9%	2.6%	0.6%	0.5%	0.5%	79.9%	10.7%	7.8%	2.9%	2.8%	1.0%
Max	99.4%	20.1%	8.0%	2.7%	1.9%	0.5%	90.8%	5.9%	2.6%	0.7%	0.5%	0.5%	81.6%	11.7%	8.7%	3.5%	3.3%	1.2%
POP per Haul																		
Min	0.000	0.002	0.005	0.031	0.105	0.406	0.000	0.002	0.010	0.043	0.124	1.528	0.000	0.002	0.011	0.042	0.175	0.582
Average	-	0.002	0.011	0.056	0.195	0.780	-	0.002	0.010	0.049	0.134	1.637	-	0.002	0.012	0.050	0.209	1.096
95th percentile	-	0.003	0.014	0.075	0.331	1.919	-	0.002	0.011	0.058	0.144	1.691	-	0.003	0.013	0.054	0.234	1.474
Max	0.000	0.004	0.020	0.092	0.395	1.919	0.000	0.002	0.011	0.059	0.145	1.691	0.000	0.003	0.014	0.057	0.258	1.940

4.3.4 Examining Recent Patterns of Darkblotched and POP Bycatch

This section focuses on bycatch patterns in the at-sea sectors from the 1990s through the 2015 season, with some information displayed for the ongoing season in 2016. There are two purposes of this section. First, describing the actual history of the fishery adds to the understanding of the impact that various sized catch events have had in the past and could reasonably be expected to have in the future and brings further insight to the evaluation of overage risk. Secondly, the evaluation provides a complementary angle from which to explore some of the bootstrap simulation's underlying assumptions.

Section 4.3.4.1 first looks at the patterns across size bins over the same 2000-2015 period used in the bootstrap simulation. Section 4.3.4.2 then uses the six haul size bins and classifies their frequency and impact in the actual data back to 1991. The actual bycatch patterns can be used to further gauge the plausibility of some of the more extreme overages produced in the bootstrap simulation. And more fundamentally, it provides an approach for considering the question posed in Section 4.2.1.1 on the degree to which changed incentives under Alternative 1 might affect fishing behavior, and in turn, the risk of overages.

One key assumption of the bootstrap simulation is that the data it uses contains the largest value, i.e. the largest catch of darkblotched or POP, possible on a haul. The data shows this to be untrue. The 2000-2015 period used in the bootstrap was chosen for several reasons (e.g. consistent sampling protocols). Yet this time period does not contain the largest catch events recorded by observers. Observer coverage and sampling protocols were different in the 1990s, and sampling error is a possible source of the larger recorded hauls; however, it is highly certain that larger catch events than seen over 2000-2015 have happened and could happen again.

The analysis in Section 4.3.4.3 explores the effect of that possibility. The approach is to vary the average size of the catch in bin 6 (hauls exceeding 0.4 mt) to show how expectations of total catch from that bin would change over a range of frequencies (i.e. the probability that a haul in bin 6 occurs). Again, the total impact from this largest class of hauls depends on the number that happen each season and their average size. This is true for all the size bins, but bin 6 is the only one that has no outer limit on size.

4.3.4.1 Haul Size Bin Patterns, 2000-2015

Table 15 and Table 16 display the pattern of darkblotched bycatch over 2000-2015 broken out into the five size bins (i.e the sixth bin of zero catch is omitted). Table 17 and

Table **18** show the corresponding information for POP. These tables summarize the data from same time period used in the bootstrap, and so not surprisingly, they reflect the same general pattern seen in the bootstrap results. The high impact of the infrequent catches in bin 6 across both sectors and species, and of bin 5 for CPs and darkblotched, are clearly apparent. In addition it can be seen ~60 percent of the catches of darkblotched and ~65 percent of catches of POP fall within bin 2—the catches of individual fish instead of shoals—and yet they only accounted for between ~6 to 7 percent of the total catch over this period.

Figure 13 and Figure 14 plot the size bin pattern for each year for darkblotched and POP, respectively. They provide for a quick visual examination of the impact of catch across the different size bins have in both high and low catch years. It can also be seen that bins 2, 3, and 4 did not reach levels that would pose overage risks based on the 2017 allocations levels (identified in Table 4 and Table 6) on their own during these year. The bootstrap results support the conclusion that it would be highly unlikely for catch in these bins to reach the overage levels of the 2017 allocation levels on their own.

Some noteworthy comparison can be made between the data in Table 15 through

Table **18** and the bootstrap results. For example, the data underscores the relatively low plausibility of the extreme bootstrap results shown in Figure 7 and Figure 8 (i.e. the top 10 largest simulated catch seasons of darkblotched and POP). For instance, for darkblotched, one of the largest simulated seasons in the MS sector drew 15 hauls from bin 6. Table 16 identifies that there were only 16 hauls observed in bin 6 in total over 2000-2015.

Table 15: Bycatch of Darkblotched Rockfish on Positive CP Hauls, 2000-2015

Bin Number	2	3	4	5	6
Bin (mt)	0-.005	0.005-0.03	0.03-0.01	0.1-0.4	> 0.4
Hauls	2,061	1,005	272	118	19
Total Catch (mt)	4.53	12.26	14.53	22.96	17.74
Average Catch Per Haul	0.002	0.012	0.053	0.195	0.934
Percent of Total Positive Hauls	59.3%	28.9%	7.8%	3.4%	0.5%
Percent of Catch	6.3%	17.0%	20.2%	31.9%	24.6%

Table 16: Bycatch of Darkblotched Rockfish on Positive MS Hauls, 2000-2015.

Bin Number	2	3	4	5	6
Bin (mt)	0-.005	0.005-0.03	0.03-0.01	0.1-0.4	> 0.4
Hauls	1,650	830	186	78	16
Total Catch (mt)	3.49	9.82	9.52	14.39	14.50
Average Catch Per Haul	0.002	0.012	0.051	0.185	0.907
Percent of Total Positive Hauls	59.8%	30.1%	6.7%	2.8%	0.6%
Percent of Catch	6.8%	19.0%	18.4%	27.8%	28.0%

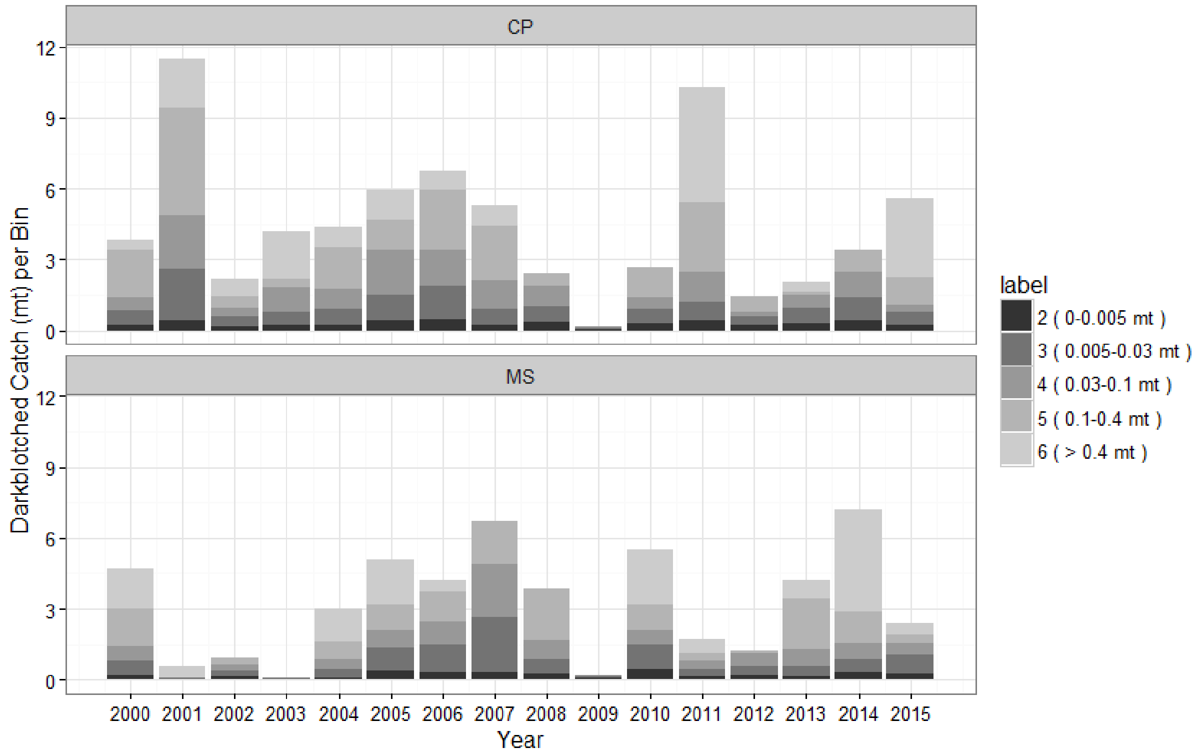


Figure 13: Annual darkblotched catch (mt) by haul size bin, 2000-2015

Table 17: Bycatch of POP on Positive CP Hauls, 2000-2015

Bin Number	2	3	4	5	6
Size Range (mt)	0-.005	0.005-0.03	0.03-0.01	0.1-0.4	> 0.4
Hauls	1,937	766	170	71	40
Total Catch (mt)	4.11	8.91	9.16	13.94	39.86
Average Catch Per Haul	0.002	0.012	0.054	0.196	0.997
Percent of Total Positive Hauls	64.9%	25.7%	5.7%	2.4%	1.3%
Percent of Catch	5.4%	11.7%	12.1%	18.3%	52.5%

Table 18: Bycatch of POP on Positive MS Hauls, 2000-2015

Bin Number	2	3	4	5	6
Size Range (mt)	0-.005	0.005-0.03	0.03-0.01	0.1-0.4	> 0.4
Hauls	1,115	438	87	60	11
Total Catch (mt)	2.19	5.31	4.65	11.65	10.77
Average Catch Per Haul	0.002	0.012	0.053	0.194	0.980
Percent of Total Positive Hauls	65.2%	25.6%	5.1%	3.5%	0.6%
Percent of Catch	6.3%	15.4%	13.5%	33.7%	31.2%

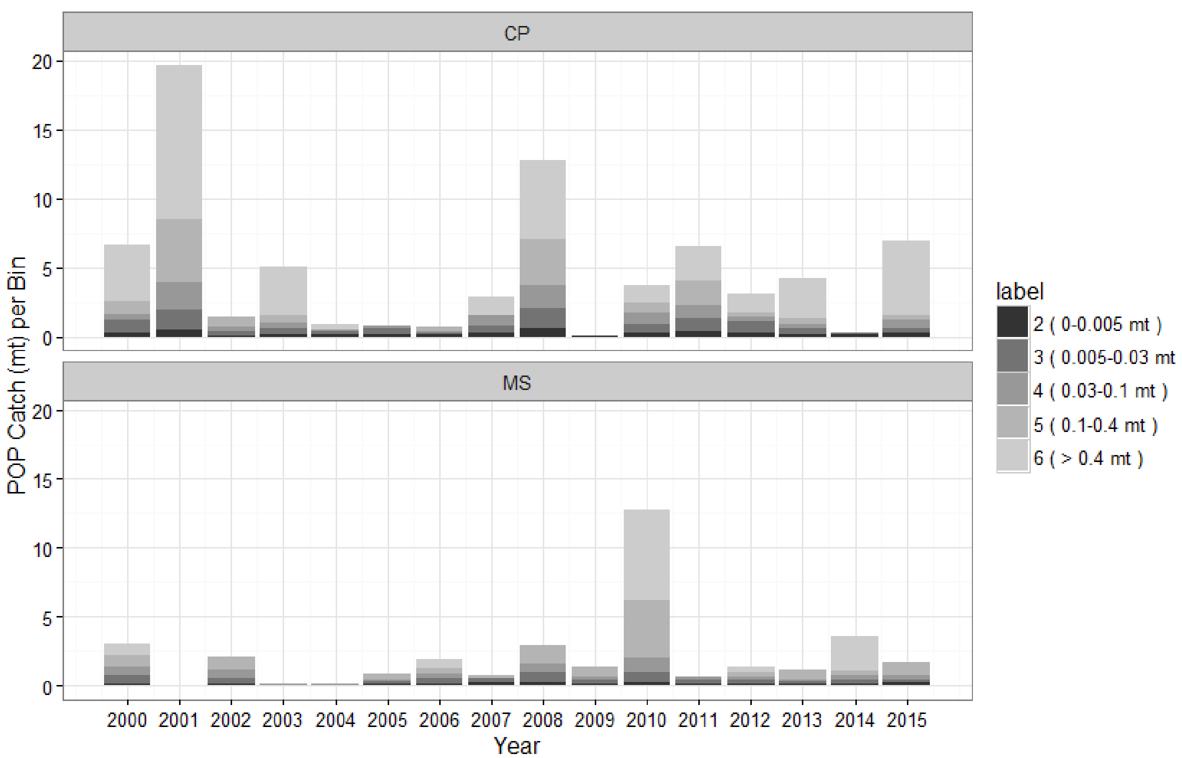


Figure 14: Annual POP catch (mt) by haul size bin, 2000-2015

4.3.4.2 Comparing Patterns in Haul Size Bins between Time Periods

As concluded in Section 4.3.2, the bootstrap results do not show Alternative 1 causing substantial changes in the frequency with which overages occur. However, as with many of the statistical techniques used by the Council to forecast catch, the bootstrap assumes that bycatch patterns in the future will continue to resemble those observed in the data. Given the level of variability in bycatch and the relatively long time series used in the bootstrap, this assumption does not appear to be unreasonable. Yet to the degree that Alternative 1 causes major changes in fishing behavior, then the bootstrap results would be expected to less accurately reflect catch patterns under set aside management.

In addition, Section 4.2.1.2 posed the question of how much fishing behavior has mattered to the risk of overages. In brief, bycatch outcomes may only be weakly tied to incentives and behavior when the factors that lead to large bycatch years are mostly random in nature. A high degree of randomness in bycatch patterns means that the same fishing behaviors could result in a wide range of bycatch outcomes.

To explore this issue, this section compares patterns over the 2009-2016 period of co-op bycatch management to past periods when the at-sea sectors may have been less focused on bycatch of darkblotched and POP. Like the bootstrap, this data cannot definitely answer the questions of how the efforts of the co-ops have influenced the risk of overages or how that risk might change under Alternative 1. However, the evaluation of frequency and impact of the size bins over different time periods in the fishery may offer some indications of the range of total catches that could be plausibly be expected under Alternative 1.

Figure 15 and Figure 16 provide the same look at the haul size bin pattern as Figure 13 and Figure 14 but do for the period 1991-1999. One of the first patterns to stand out comes from the large catches of darkblotched and POP that happened over 1991-1995. The bin 5 and 6 catches show substantial contributions to the catch, the catches in bin 4 also appear significant in those years as well, especially for POP in the MS sector.

This analysis does not go much into detail on the history of the at-sea whiting sectors, but for several reasons, focuses on catches after 1997 as being more representative of current operations of the co-ops and of the observer coverage and sampling protocols. For example, 1991 was the first year that fishery was conducted solely by U.S. vessels. That year saw a large increase in effort that dropped the season length down from eight months in previous years to three months. The at-sea sectors took 91 percent of the total whiting catch that year. [26] The years 1994 through 1996 were managed under a common pool of whiting where the CP and MS vessels competed for the catch. The current allocation scheme went into place in 1997 and reduced the competition between the at-sea sectors.[27] While the following analysis focuses on 1997 onward, the catch of darkblotched and POP in the early 1990s could be informative of what is possible with extreme changes in the fishery.

[26] See discussion of the fishery in early 1990s given by Gil Sylvia, H.M, Mann, and C. Pugmire, 2008. Achievements of the Pacific whiting conservation cooperative: rational collaboration in a sea of irrational competition. FAO Fisheries Technical Paper. http://agris.fao.org/agris-search/search.do?recordID=XF2008435481.
[27] PFMC EA on Pacific Whiting Allocations and Seasons (1997): http://www.pcouncil.org/wp-content/uploads/02_1997_EA_RIR_Whiting.pdf.

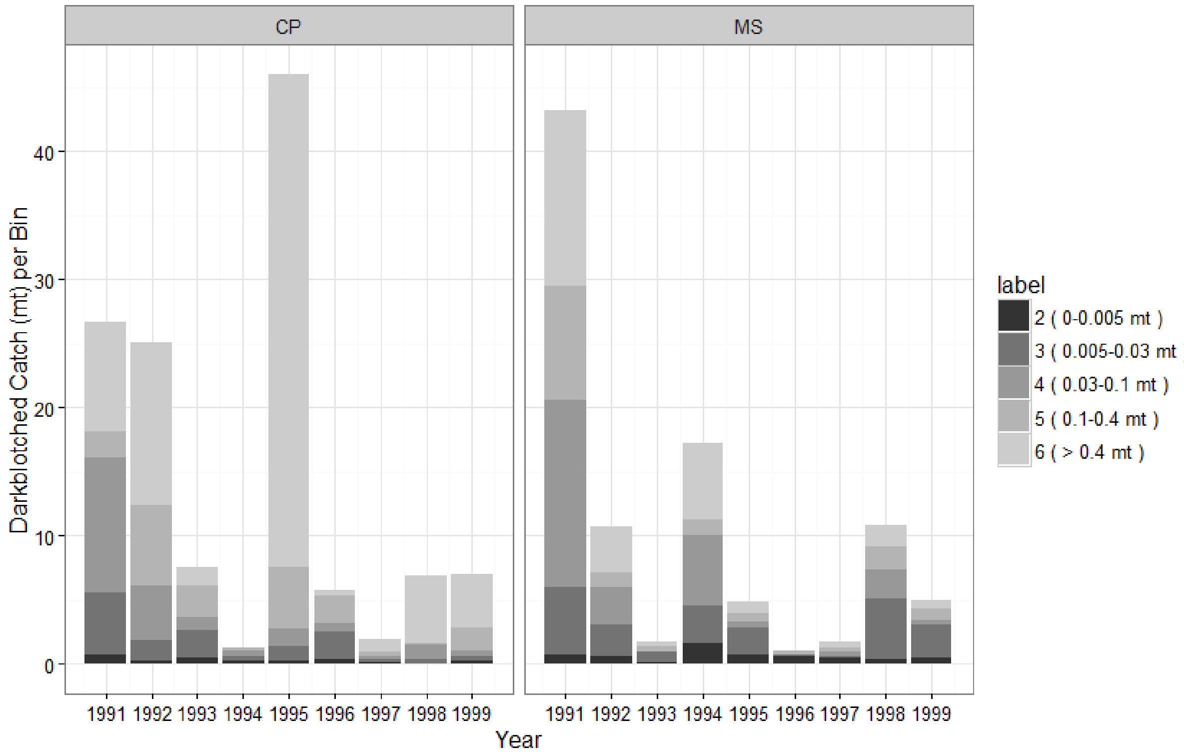


Figure 15: Annual darkblotched catch (mt) per haul size bin, 1991-1999

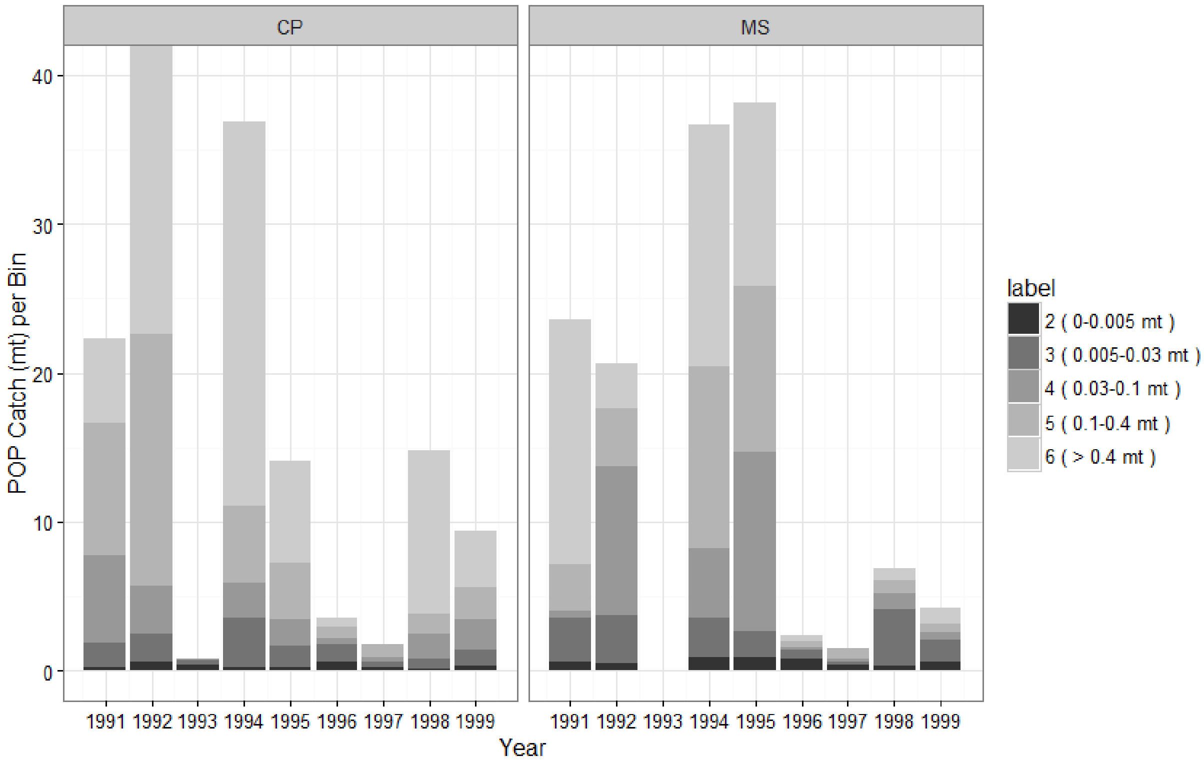


Figure 16: Annual POP catch (mt) by size bin, 1991-1999. Note: the y-axis is truncated because of extreme catch by the CP sector in 1992 would obscure the size bin patterns in the other years. The catch in 1992 was 331.9 mt, with bin 6 extending to that level from the range displayed above.

Table 19 and

Table **20** compare the size bin pattern for darkblotched across three time periods of the fishery: 1997-2008, 2009-2015, and 2011-2015. The latter two represent the years of most active bycatch management of darkblotched and POP. The co-op programs began in 2011 but the co-ops had been give sector specific bycatch caps starting in 2009. The years 2007-2008 were managed under pooled bycatch caps for all three whiting sectors, which may have caused a "race for bycatch" dynamic, and so those years are included as part of the earlier period. Table 21 and Table 22 show the corresponding information for POP.

There are a number of patterns that could be noted. Foremost, the average frequency of hauls in bin 6 does not change substantially between the three time periods, either remaining identical or changing by 0.1 percent. It appears to be the average size of catch in the bin that leads to differences in the total expected catch in that bin. Bins 5 and 6 contributed the most impact in all periods with the exception of 1997-2008 period for darkblotched and the MS sector. During that period, the bin 3 catches had the largest impact in the MS sector.

Table 19-Table 22 also provide a standardized means of comparing the time periods based on the total estimated catch on a per 1,000 basis. The catch per 1,000 hauls was calculated by multiplying the frequency of the hauls in each bin times 1,000, multiplying by the average size of catch in each bin, and then summing the product of all bins together. In all cases but POP in the MS sector, the expected catch per 1,000 hauls was higher in the 1997-2008 period. These tables can also be used to explore the change in expected total catch if various changes in the frequency and average catches by bin were to occur. For example, if the frequency of bin 5 for darkblotched in the CP sector increased to the level seen in 1997-2008 but the other bins stayed at their 2011-2015 averages, the expected total catch per 1,000 hauls would increase 18.9 percent to 4.08 mt.

Figure 17–Figure 20 provide a time series view of the frequency of catches in each bin, and go all the way back through 1991 and include data through the current 2016 season (through July 25). The time series show considerable variation between across most every bin. The horizontal bars display average frequencies calculated over various time periods, identified in the figure captions, as well as “grand mean” over the full time series. These various references should help in the evaluation of how bycatch patterns have changed over the time series. The high variability makes drawing statistically significant differences challenging.

In general, even with individual years showing spikes in the proportions hauls contributing from each bin for both darkblotched and POP, the shorter time period averages (“group means”) have varied little. However, in Bin 6, there is a steeper decline in the average from 1991-1996 to the later periods for both CP and MS for both darkblotched and POP. As previously mentioned, A-SHOP data from this time period experienced lower sampling coverage, therefore the higher average may be true of the behavior during this time period or may simply be the result an extrapolation of one catch event to the fleet.

While sector specific bycatch caps may have provided an incentive to avoid bycatch starting in 2009, the inter annual variation of the proportion of hauls in each bin over the entire time series shows similar levels pre and post bycatch caps, suggesting the randomness of some of the larger hauls that may not be able to be avoided. Furthermore, the average proportions of hauls (and corresponding levels catch) suggest that the both fleets can experience higher magnitude haul events at a greater frequency, and yet remain at a low total catch tonnage. However, the differences in averages have not been tested for statistical significance.

Table 19: Darkblotched Average Frequency and Per Haul magnitude by bin size for 1997-2008, 2009-2015, and 2011-2015 for the CP Sector. Total Catch refers to total catch in each bin per 1,000 hauls.

Bin	1997-2008			2009-2015			2011-2015		
	% of Hauls	mt per Haul	Total Catch	% of Hauls	mt per Haul	Total Catch	% of Hauls	mt per Haul	Total Catch
1	82.6%	--	--	85.9%	--	--	84.7%	--	--
2	9.8%	0.002	0.20	9.2%	0.002	0.18	10.2%	0.002	0.20
3	5.2%	0.012	0.62	3.6%	0.012	0.43	3.7%	0.012	0.44
4	1.6%	0.053	0.85	0.8%	0.053	0.42	0.9%	0.053	0.48
5	0.7%	0.190	1.33	0.4%	0.210	0.84	0.4%	0.215	0.86
6	0.1%	1.088	1.09	0.1%	1.446	1.45	0.1%	1.446	1.45
Total Catch (mt) Per 1000 Hauls			4.09			3.33			3.43

Table 20: Darkblotched Average Frequency and Per Haul magnitude by bin size for 1997-2008, 2009-2015, and 2011-2015 for the MS Sector. Total Catch refers to total catch in each bin per 1,000 hauls.

Bin	1997-2008			2009-2015			2011-2015		
	% of Hauls	mt per Haul	Total Catch	% of Hauls	mt per Haul	Total Catch	% of Hauls	mt per Haul	Total Catch
1	75.0%	--	--	83.0%	--	--	84.5%	--	--
2	13.5%	0.002	0.27	11.1%	0.002	0.22	10.1%	0.002	0.20
3	9.4%	0.013	1.22	4.5%	0.011	0.50	3.8%	0.012	0.46
4	1.4%	0.056	0.78	1.0%	0.051	0.51	1.0%	0.051	0.51
5	0.6%	0.174	1.04	0.4%	0.207	0.83	0.4%	0.203	0.81
6	0.1%	0.795	0.80	0.1%	0.945	0.95	0.1%	0.887	0.89
Total Catch (mt) Per 1000 Hauls			4.12			3.00			2.87

Table 21: POP: Average Frequency and Per Haul magnitude by bin size for 1997-2008, 2009-2015, and 2011-2015 for the CP Sector. Total Catch refers to total catch in each bin per 1,000 hauls.

Bin	1997-2008			2009-2015			2011-2015		
	% of Hauls	mt per Haul	Total Catch	% of Hauls	mt per Haul	Total Catch	% of Hauls	mt per Haul	Total Catch
1	83.4%	--	--	87.5%	--	--	87.1%	--	--
2	10.1%	0.002	0.20	8.4%	0.002	0.17	8.9%	0.002	0.18
3	4.5%	0.012	0.54	3.1%	0.011	0.34	3.0%	0.011	0.33
4	1.3%	0.055	0.72	0.7%	0.050	0.35	0.6%	0.050	0.30
5	0.5%	0.197	0.99	0.2%	0.196	0.39	0.2%	0.199	0.40
6	0.2%	1.213	2.43	0.2%	0.964	1.93	0.2%	1.024	2.05
Total Catch (mt) Per 1000 Hauls			4.87			3.18			3.25

Table 22: POP: Average Frequency and Per Haul magnitude by bin size for 1997-2008, 2009-2015, and 2011-2015 for the MS Sector. Total Catch refers to total catch in each bin per 1,000 hauls.

Bin	1997-2008			2009-2015			2011-2015		
	% of Hauls	mt per Haul	Total Catch	% of Hauls	mt per Haul	Total Catch	% of Hauls	mt per Haul	Total Catch
1	81.0%	--	--	87.8%	--	--	89.4%	--	--
2	12.7%	0.002	0.25	7.9%	0.002	0.16	7.7%	0.002	0.15
3	5.2%	0.014	0.73	3.1%	0.012	0.37	2.3%	0.012	0.28
4	0.7%	0.051	0.36	0.6%	0.052	0.31	0.4%	0.056	0.22
5	0.3%	0.174	0.52	0.5%	0.210	1.05	0.2%	0.202	0.40
6	0.04%	0.628	0.25	0.1%	1.044	1.04	0.1%	0.959	0.96
Total Catch (mt) Per 1000 Hauls			2.11			2.94			2.02

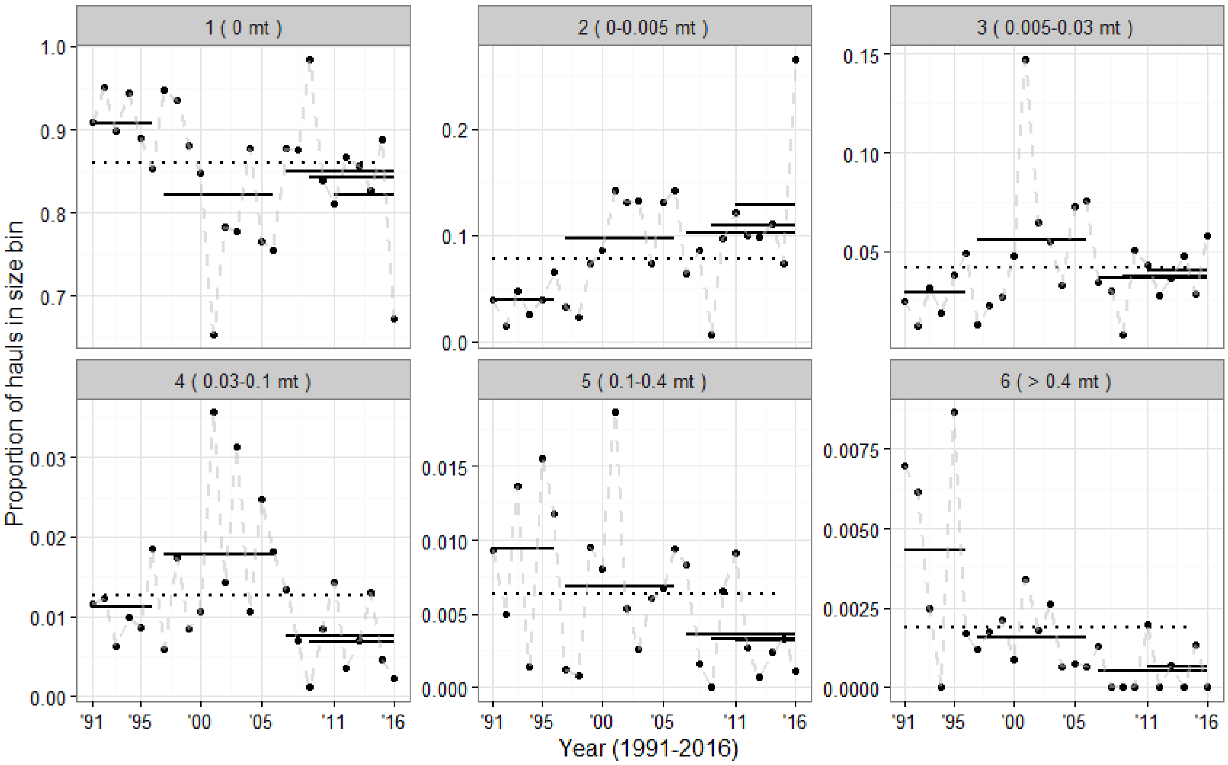


Figure 17: Darkblotched CP Sector. Proportion of Hauls Within Size Bin from 1991-2016, with Grand Mean over Time Series, and Group Means for 1991-1996, 1997-2006, 2007-2016, 2009-2016, and 2011-2016. Yearly proportion shown by dashed line with black dots, grand mean shown by dotted line, and group means shown by solid black line over time periods.

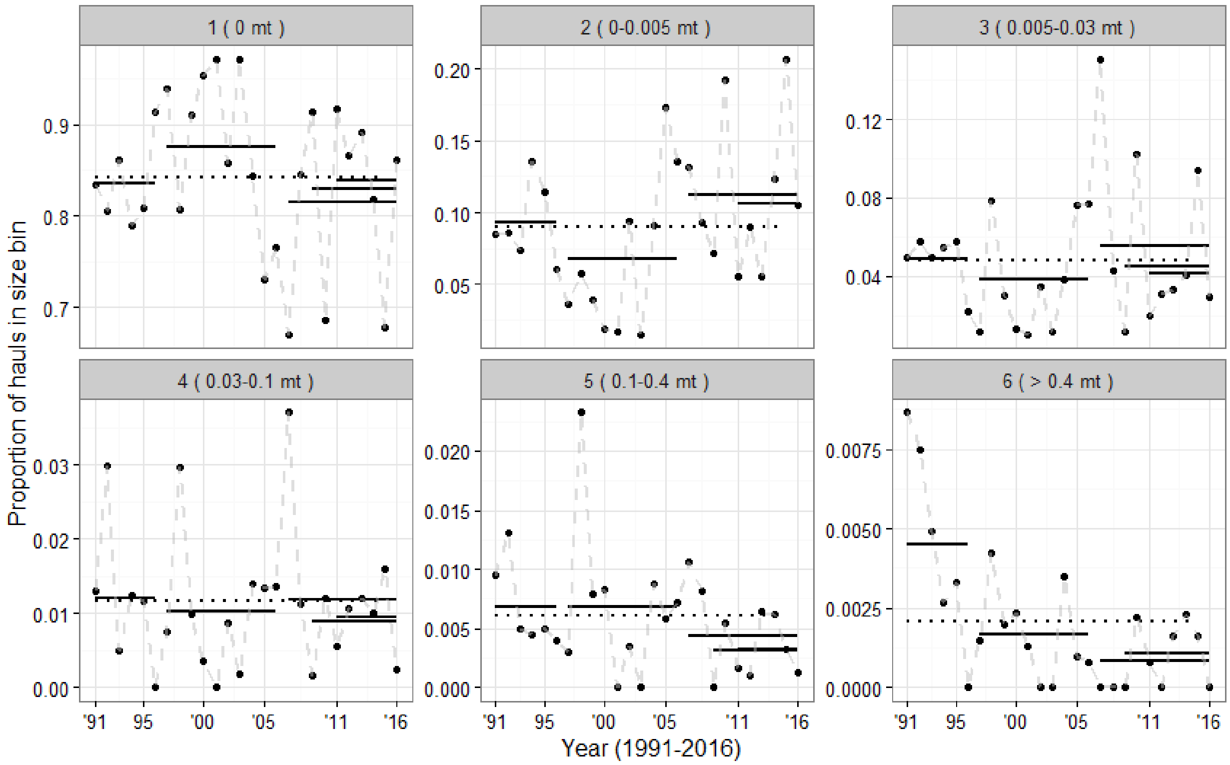


Figure 18: Darkblotched MS Sector. Proportion of Hauls Within Size Bin from 1991-2016, with Grand Mean over Time Series, and Group Means for 1991-1996, 1997-2006, 2007-2016, 2009-2016, and 2011-2016. Yearly proportion shown by dashed line with black dots, grand mean shown by dotted line, and group means shown by solid black line over time periods.

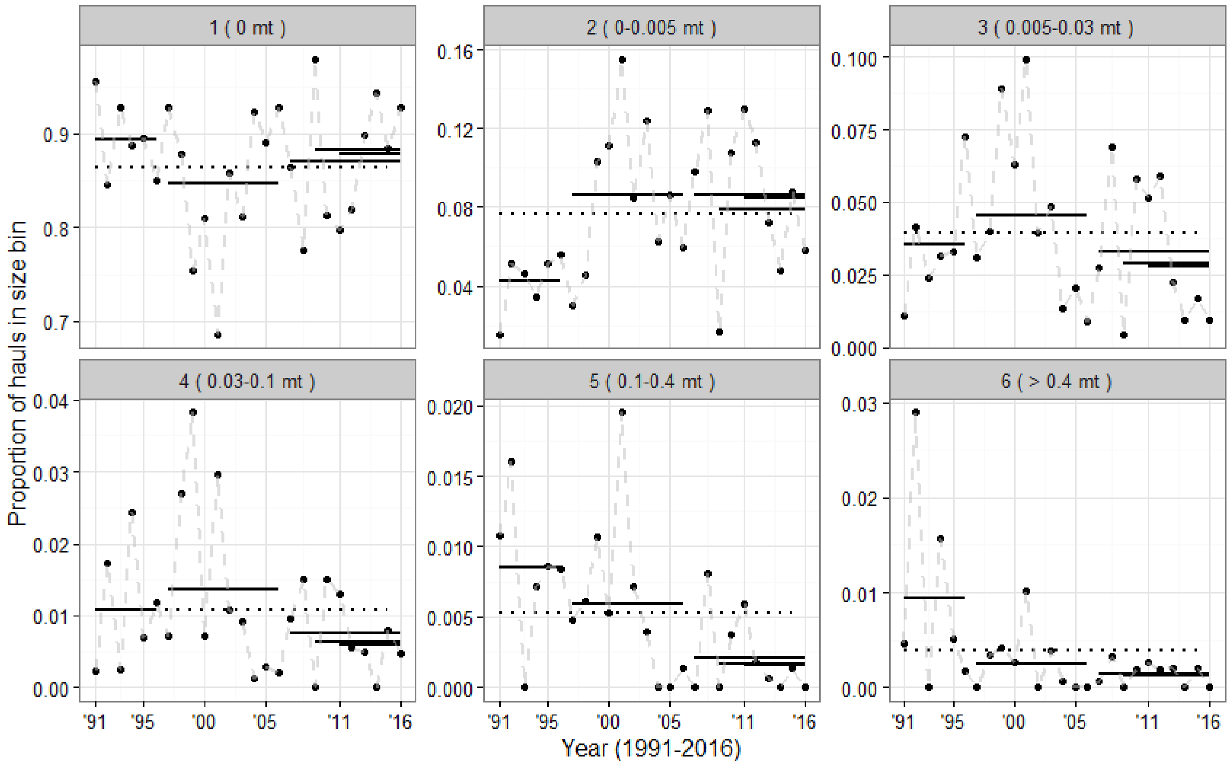


Figure 19: CP Sector POP. Proportion of Hauls Within Size Bin from 1991-2016, with Grand Mean over Time Series, and Group Means for 1991-1996, 1997-2006, 2007-2016, 2009-2016, and 2011-2016. Yearly proportion shown by dashed line with black dots, grand mean shown by dotted line, and group means shown by solid black line over time periods.

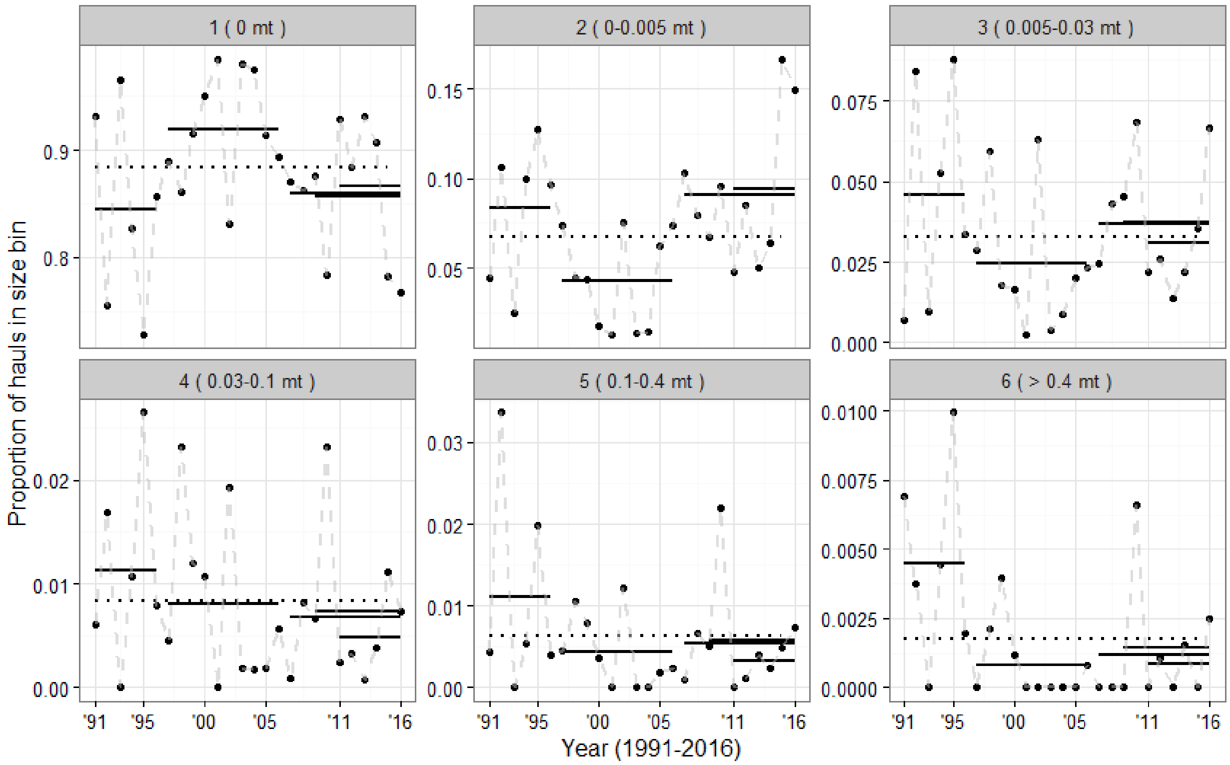


Figure 20: MS Sector POP. Proportion of Hauls Within Size Bin from 1991-2016, with Grand Mean over Time Series, and Group Means for 1991-1996, 1997-2006, 2007-2016, 2009-2016, and 2011-2016. Yearly proportion shown by dashed line with black dots, grand mean shown by dotted line, and group means shown by solid black line over time periods.

4.3.4.3 Basic Risk Assessment of the Impact of Largest Catch Events

As noted above, one assumption of the bootstrap simulation is that the data used contains the largest catch possible, which is known to not be true for the 2000-2015 data. As just seen in Section 4.3.4.2, the "bin 6" catches have been larger in the pre-2000 time frame. Table 23 and Table 24 offer a very simple method of gauging the effect of this assumption.

In brief, Table 23 uses the binomial probability distribution to show the number of bin 6 hauls that could be expected under a range of probabilities of occurrence (i.e. the probability that a bin 6 size catch comes up in any one haul). This table illustrates the behavior of randomness in that a different number of hauls could be observed based on a given probability of occurrence. For example, if the probability of a bin 6 catch is 0.002 (i.e. 2 out of 1,000), then the most frequently observed number of bin 6 hauls would be 1 or 2 per 1,000 hauls. However, 6 hauls would be expected to occur 1.2 percent of the time. This range of probabilities is based on the frequencies seen across the bin 6s shown in Figure 17-Figure 20.

Table 24 then simply multiples a number of hauls by a range of average weights. The range of average weights is representative of those seen in the 1991-2016 data but does not cover the largest values.

This information is intended to illustrate a simple method for evaluating the number of hauls that can be expected per 1,000 hauls based on a plausible range of probabilities of occurrence. More evaluation to use in informing plausible combinations of the expected number of bin 6 hauls and their average size may be provided in a supplemental report.

Table 23. Probabilities Of Observing A Given Number of Bin 6 Sized Hauls Expected per 1,000 Hauls Based on a Range Of Probabilities of a Bin 6 Catch Occurring on any One Haul (Based on Binomial Probability Distribution).

	Probability of Occurrence							
Bin 6 Hauls Per 1000 Hauls	**0.0005**	**0.001**	**0.002**	**0.003**	**0.004**	**0.005**	**0.006**	**0.007**
0	60.6%	36.8%	13.5%	5.0%	1.8%	0.7%	0.2%	0.1%
1	30.3%	36.8%	27.1%	14.9%	7.3%	3.3%	1.5%	0.6%
2	7.6%	18.4%	27.1%	22.4%	14.6%	8.4%	4.4%	2.2%
3	1.3%	6.1%	18.1%	22.4%	19.6%	14.0%	8.9%	5.2%
4	0.2%	1.5%	9.0%	16.8%	19.6%	17.6%	13.4%	9.1%
5	0.0%	0.3%	3.6%	10.1%	15.7%	17.6%	16.1%	12.8%
6	0.0%	0.1%	1.2%	5.0%	10.4%	14.7%	16.1%	14.9%
7	0.0%	0.0%	0.3%	2.2%	5.9%	10.5%	13.8%	15.0%
8	0.0%	0.0%	0.1%	0.8%	3.0%	6.5%	10.3%	13.1%
9	0.0%	0.0%	0.0%	0.3%	1.3%	3.6%	6.9%	10.2%
10	0.0%	0.0%	0.0%	0.1%	0.5%	1.8%	4.1%	7.1%
11	0.0%	0.0%	0.0%	0.0%	0.2%	0.8%	2.2%	4.5%
12	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	1.1%	2.6%

Table 24. Total Catch in Bin 6 Expected By Change in Average Weight Per Haul Over a Range Bin 6 Hauls.

	Average Weight of Catch (mt)												
Hauls Occurring per Season	**0.50**	**0.75**	**1.00**	**1.25**	**1.50**	**1.75**	**2.00**	**2.25**	**2.50**	**2.75**	**3.00**	**3.25**	**3.50**
1	0.5	0.8	1.0	1.3	1.5	1.8	2.0	2.3	2.5	2.8	3.0	3.3	3.5
2	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
3	1.5	2.3	3.0	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5
4	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0
5	2.5	3.8	5.0	6.3	7.5	8.8	10.0	11.3	12.5	13.8	15.0	16.3	17.5
6	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0
7	3.5	5.3	7.0	8.8	10.5	12.3	14.0	15.8	17.5	19.3	21.0	22.8	24.5
8	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0
9	4.5	6.8	9.0	11.3	13.5	15.8	18.0	20.3	22.5	24.8	27.0	29.3	31.5
10	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0
11	5.5	8.3	11.0	13.8	16.5	19.3	22.0	24.8	27.5	30.3	33.0	35.8	38.5
12	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	33.0	36.0	39.0	42.0

4.4 Indirect Impacts on Endangered Species

The main analysis of direct effects of Alternative 1 considered the potential for increased bycatch of darkblotched or POP. This section considers the potential for indirect impacts on endangered species. Chinook salmon and eulachon are both ESA listed species that have Biological Opinions (BiOps) for interaction with the groundfish fisheries. Currently, Chinook salmon is undergoing consultation and the eulachon incidental take statement is being updated to better reflect the current and future status of the groundfish fleet. Alternative 1 could marginally increase effort in the at-sea fleet, and therefore could marginally increase encounters with these species. However, the uncertainty in the degree to which effort would increase and the large variation in areas fished makes it challenging to draw definitive conclusions.

4.4.1 Chinook Salmon

In June, NMFS presented concerns that current fishing operations that are actively avoiding bycatch may shift focus to optimizing harvest of whiting, leading to potential increases in Chinook salmon landings (Agenda Item G.2.a, Supplemental NMFS Report). As there is currently an ongoing re-consultation on ESA salmon within the groundfish fishery, any actions taken under this item could be further evaluated through that process.

In general, the conclusion of this analysis is that it would be difficult to conclude or rule out that Alternative 1 would increase Chinook bycatch. This section provides a thorough look at the bycatch patterns of Chinook.

The conclusion is based on the limited main effect of Alternative 1 on fishing effort. The main effect of Alternative 1 is that it would not shut down the at-sea sectors automatically for closures. In those years, which would be expected at a rate of roughly 1-in-10 seasons, Alternative 1 would increase the number of hauls conducted by the at-sea sectors compared to No Action (this assumes that the Council would be unable to reopen the sectors after a closure) . While the number of hauls may increase in this way, the added flexibility with darkblotched and POP may lead to more time fishing off the continental slope. This could reduce Chinook encounters, as they are thought to occur more frequently in the shallower waters over the continental shelf. However, this depth relationship may also be uncertain.

The current biological opinion specifies a bycatch threshold of 11,000 Chinook for the Pacific whiting midwater trawl fishery, with a bycatch rate of 0.05 Chinook per mt of whiting. However, the thresholds and rates apply to the at-sea sectors together with the shoreside and tribal whiting fisheries. Figure 21 shows the total number of Chinook caught by each of the at-sea fleets from 2006-2015, with the combined total caught between the two sectors. Catch has varied over the years, with 2014 being the highest take by both sectors (and the year the re-initiation was triggered).

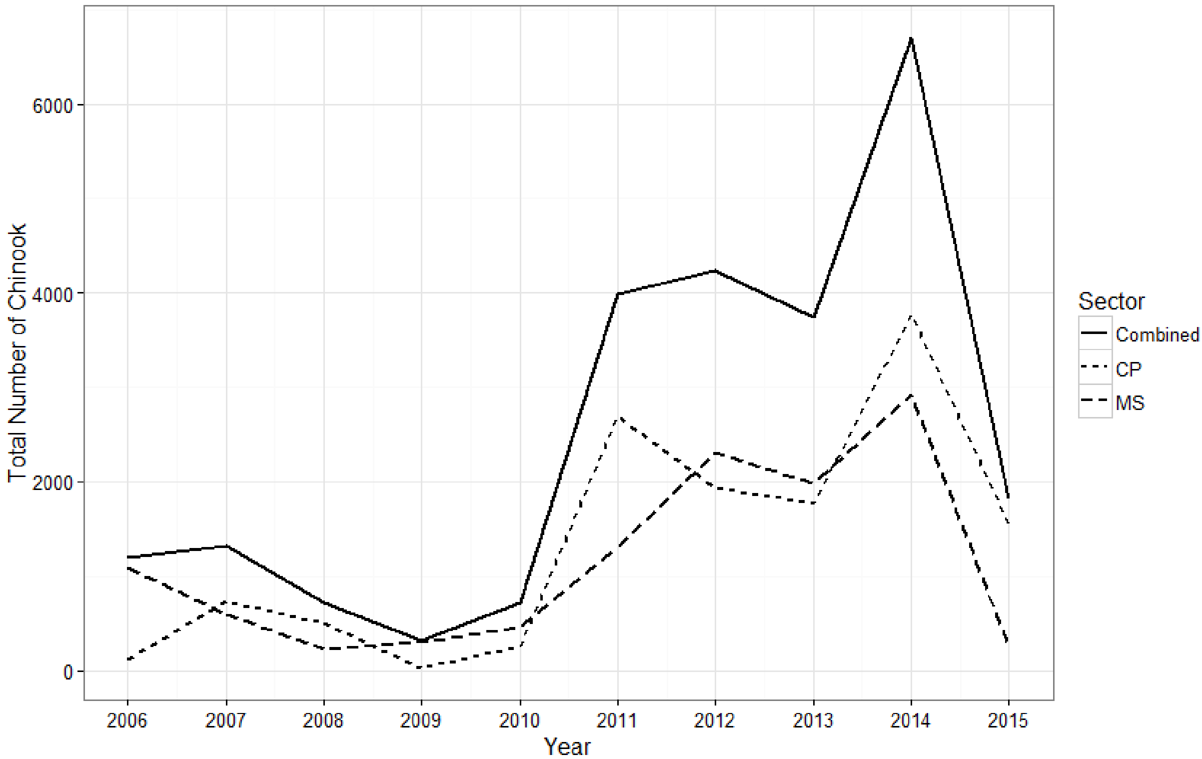


Figure 21: At-Sea Sectors Landings of Chinook, 2006-2015

Looking at the sectors individually, there also appears to be no correlation between the catch of Chinook and the total catch of Pacific whiting. Figure 22 and Figure 23 below show the total number of Chinook caught on the y-axis versus the total catch of Pacific whiting (mt) on the x-axis for 2000-2015 for the CP and MS sectors respectively. The dashed line represents the linear trend line for the data, with the 95 percent confidence interval (CI) shaded in grey. Both sectors' trendlines show poor fit to the data, with R-squared values of 0.2705 for the CP sector and 0.1073 for the MS sector. The addition of further variables into the regression analysis may change this relationship, but it would appear that there suggesting that there is not a strong correlation between whiting catch and bycatch of chinook.

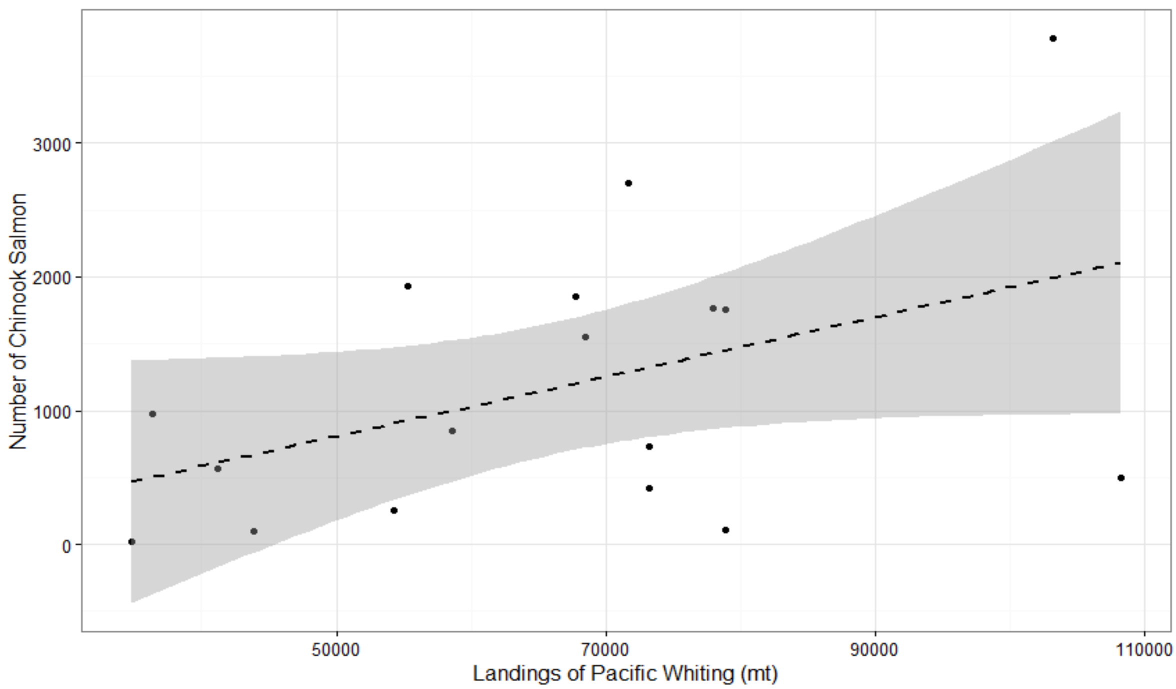


Figure 22: Total Chinook salmon (number) versus Pacific whiting catch (mt) in the CP Sector, 2000-2015, with linear trendline and 95% CI

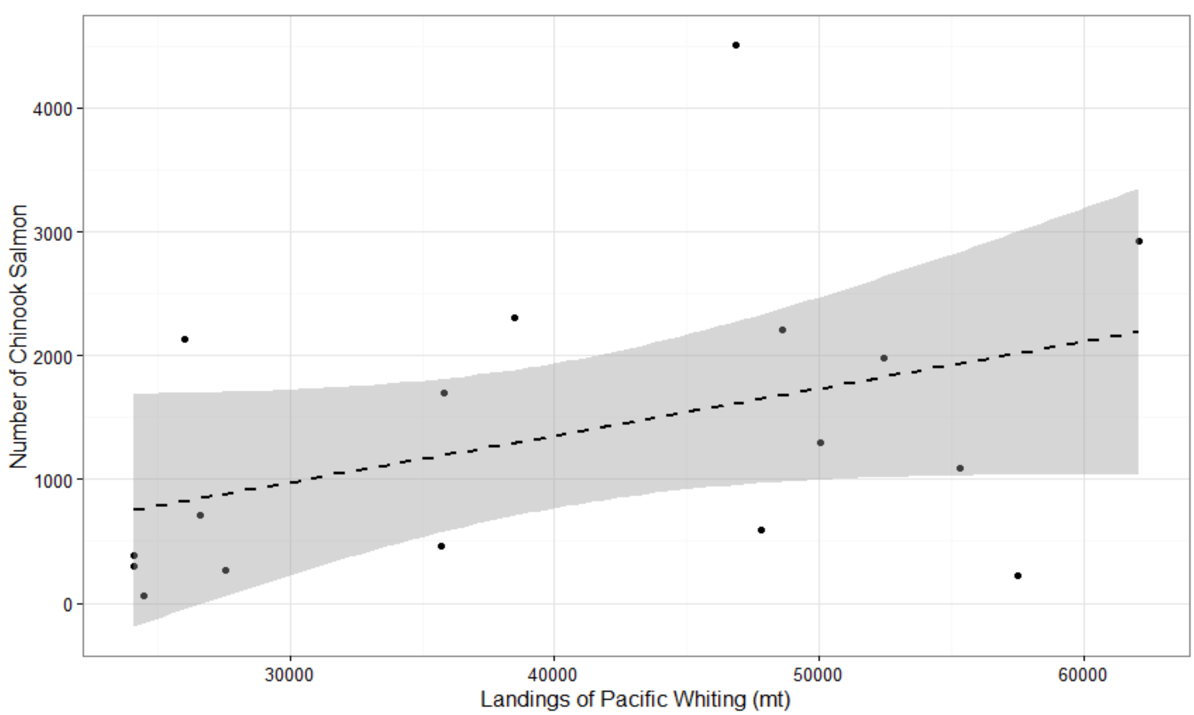


Figure 23: Total Chinook salmon (number) versus Pacific whiting catch (mt) in the MS Sector, 2000-2015, with linear trendline and 95% CI

Figure 24 below shows the bycatch ratio of Chinook to whiting for both sectors from 2006-2015. Due to the variations in TACs, the pattern is different than that seen in Figure 21. While there were higher bycatch rates of Chinook in 2012 for the CPs compared to 2014, the whiting allocation was less than half of what it was in 2014 and therefore fewer overall salmon (i.e. numerator) needed to be taken to have a higher bycatch rate. In 2015, there was little whiting activity overall, which resulted in low amounts of chinook caught, and therefore low bycatch rates.

Figure 24: Bycatch ratio of Chinook salmon in the at-sea fleets, 2006-2015

Furthermore, over the ten year period, the majority of positive Chinook hauls in both sectors had low bycatch rates. Figure 25 and Figure 26 show the cumulative distribution of bycatch rates on positive chinook hauls in the CP and MS sectors from 2006-2015, with the bycatch ratio on the x-axis and the quantile on the y-axis. In the CP sector, 95 percent of positive hauls land less than 1 Chinook per every metric ton of whiting compared to over 96 percent in the MS sector.

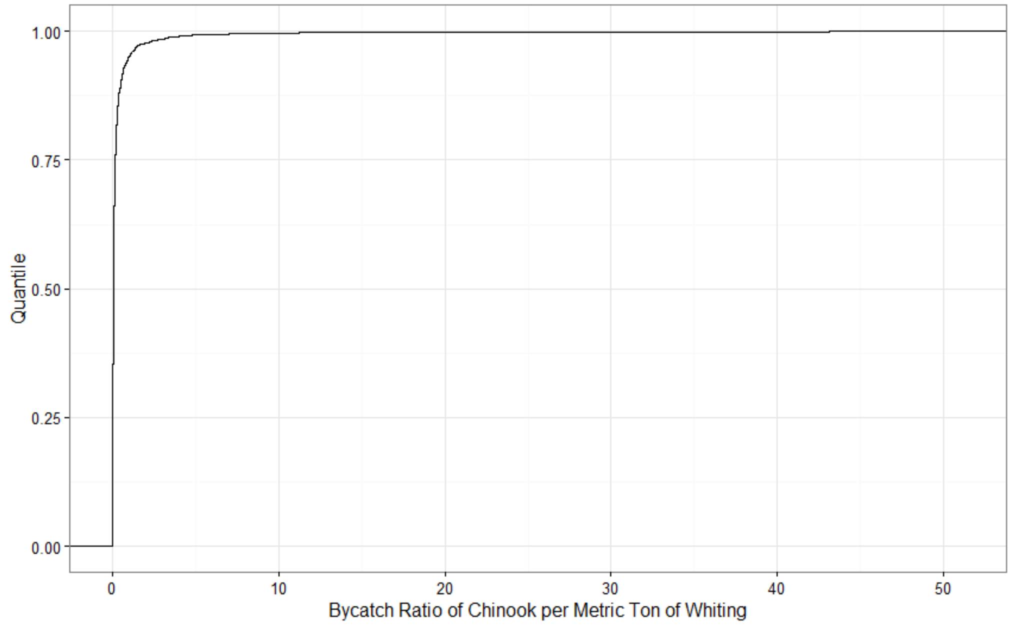


Figure 25: Cumulative Distribution of Bycatch Ratio on Positive Chinook Hauls in the CP Sector, 2006-2015.

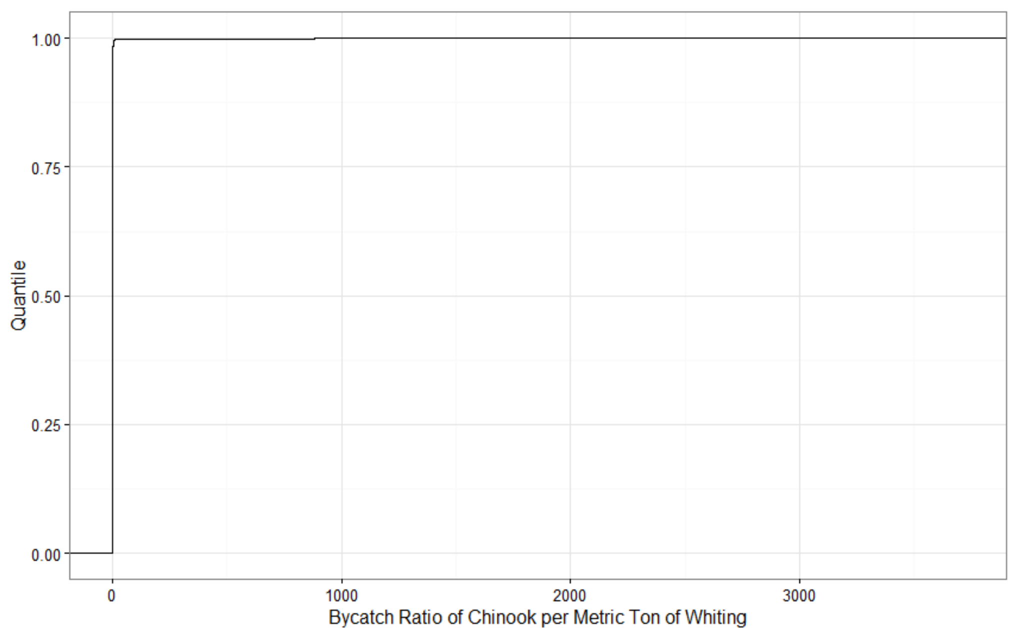


Figure 26: Cumulative Distribution of Bycatch Ratio on Positive Chinook Hauls in the MS Sector, 2006-2015

Similar to darkblotched and POP as shown in June 2016 Agenda Item G.2.a., Supplemental WDFW Report 2, catch of Chinook can accumulate rapidly over a few hauls. Figure 27 shows the cumulative catch by haul from 2006 to June 14, 2016. Looking at 2014 again, the graph shows where catch of salmon escalated quickly for the MS sector early in the season and later for the CP sector.

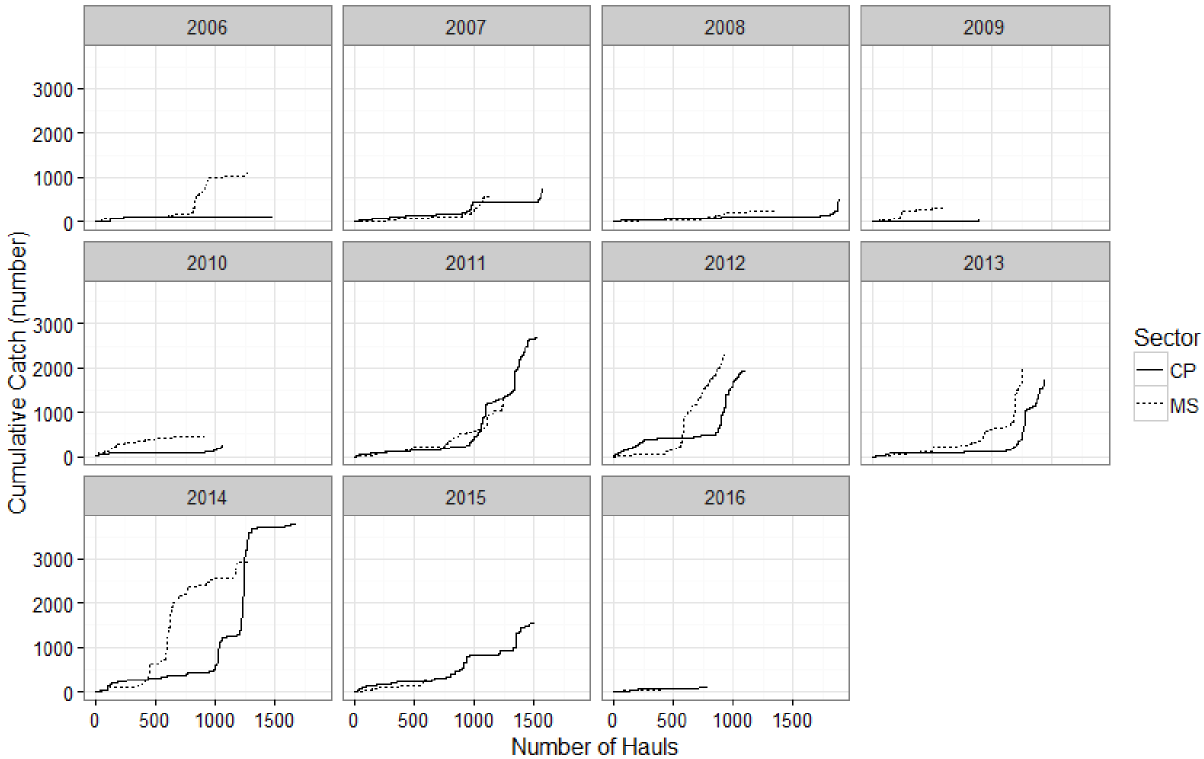


Figure 27: Cumulative Catch (number) by Sector of Chinook Salmon, 2006-2015 with preliminary 2016 data included through June 14, 2016.

While there appears to be little correlation between catch of whiting and bycatch of salmon (as shown above), there have been concerns about correlations between depth of fishing and catch of salmon. Currently, NMFS can institute the ocean salmon conservation zone and force all fishing activities to occur outside of 100 fm.[28] Figure 28 and Figure 29 below show boxplots of the bycatch rate of the number of Chinook per metric ton of whiting landed on positive hauls in both sectors from 2006-2015 by depth bin. The x-axis displays the bottom depth recorded in fathoms while the bycatch rate is on the y-axis; mean bycatch rates are shown by the diamond shape point in each bind. Note that not all hauls had depths or locations recorded and therefore, this only represents those hauls with recorded bottom depth. Furthermore, to preserve confidentiality, outliers were removed (but included in mean calculation).

For the CP sector, the highest mean and median bycatch occurred in the 0-50 fm bottom depth bin, which suggests that the ocean salmon conservation zone at 100 fm may limit some of the higher bycatch areas. However, the 101-150 fm bottom depth bin still sees an average of 1 Chinook per every metric ton of whiting with a median value of 0.07. This means that more than half of the hauls made in this depth range exceeded the 0.05 bycatch rate threshold; again though, the threshold applies currently to the whiting sectors as a whole. The MS sector exhibits more similar spreads of bycatch rates across bins in comparison. However, the averages for both the 51-100 fm and 101-150 fm bin were too large to fit on

[28] The ocean salmon conservation zone can be implemented by automatic authority when the 11,000 Chinook threshold is projected to be caught by all Pacific whiting fisheries combined. (50 CFR 660, Subpart D 248 § 660.131 (c)(4))

the graph below (with being able to show the boxplots effectively). Averages for those bins were 15 and 4.3 Chinook per mt of whiting.

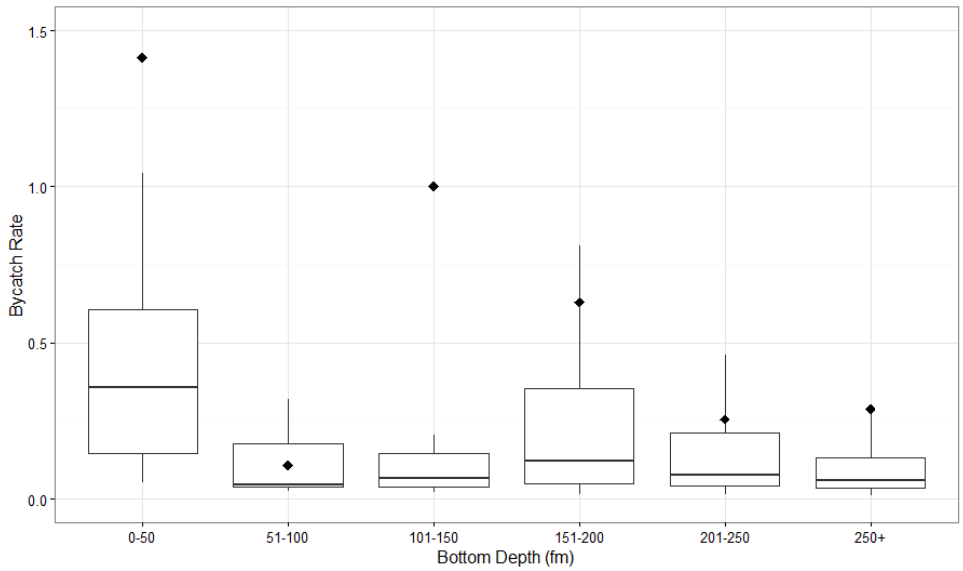


Figure 28: Boxplots of Bycatch Rates of Chinook per Metric Ton of Whiting landed on Positive Hauls, by Bottom Depth, for the CP Sector 2006-2015

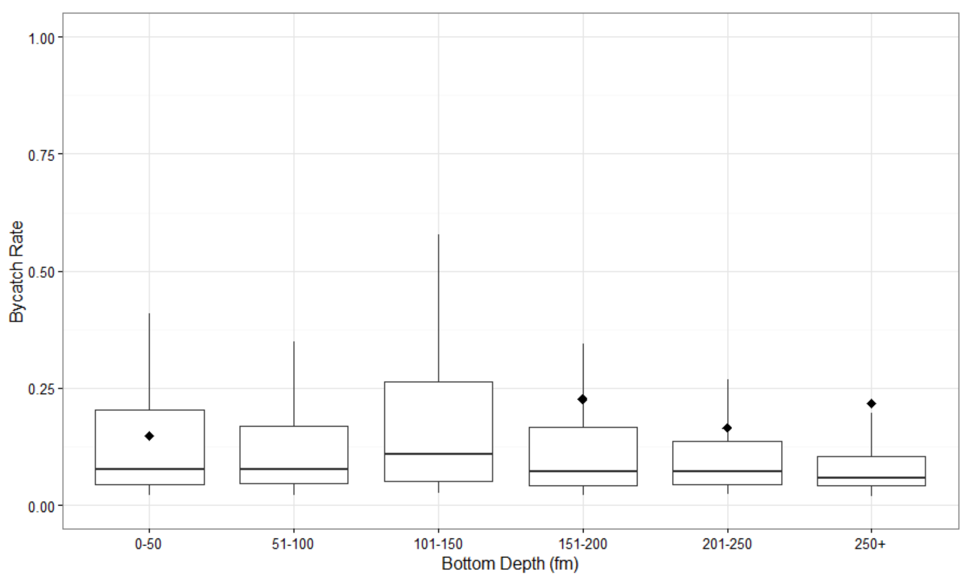


Figure 29: Boxplots of Bycatch Rates of Chinook per Metric Ton of Whiting landed on Positive Hauls, by Bottom Depth, for the MS Sector 2006-2015

While there is no particular allocation of Chinook that would result in the closure of one of the at-sea sectors (currently), the overall risk of the magnitude of Chinook that could be taken under No Action compared to Alternative 1 (if NMFS allowed the sectors to exceed their allocations without concern for the ACL) can be examined with the bootstrap analysis. Table 25 below shows the results of the bootstrap analysis for Chinook salmon for both the CP and MS fleets; note that values are in numbers of Chinook, not metric tons.

Table 25: Bootstrap Analysis for Chinook Salmon for both CP and MS

Sector	**Scenario**	**Percentage of Simulated Seasons**					
		0.01	0.25	0.5	0.75	0.95	0.9999
CP	1	58	496	1,424	2,750	4,048	5,281
	2	58	532	1,645	2,793	4,049	5,281
	3	58	496	1,438	2,788	4,079	5,281
	4	58	532	1,740	2,820	4,081	5,281
MS	1	212	896	1,912	3,313	6,581	9,688
	2	241	933	1,912	3,317	6,600	9,688
	3	212	900	1,920	3,341	6,614	9,688
	4	241	942	1,921	3,344	6,644	9,688

Table 25 shows that under all four scenarios, the relative magnitude of the catch of Chinook salmon is similar for both CP and MS. However, the risk-neutral estimate does provide some variation in that for the CP sector, when POP is a bycatch trigger, less salmon are caught compared to when POP is unrestricted.

Instead of having the bootstrap model simulate a “closed” season based on reaching a bycatch or whiting allocation, it can instead be modified to run for a specific number of hauls. In the bootstrap above, the number of hauls required to meet the trigger for a closure is dependent on the hauls that are randomly selected (i.e. fewer number of hauls if hauls have larger landings of a particular species). Figure 30 below shows the same quantiles as shown in Table 25, but shows the simulated total number of Chinook salmon (y-axis) landed based on the number of hauls (x-axis). As shown on the left panel for the MS sector, the “worst case” scenario (i.e. 0.9999 quantile) has a much steeper slope than the CP sector. In other words, in 1 in 10,000 runs, there are more Chinook caught per haul in the MS sector than the CP sector. The MS sector could take over 15,000 Chinook in 3,000 hauls.

Table 26 below shows the number of hauls per sector from 2011-2015 and the average number across those years with the final allocation (post-apportionment) and the total catch of whiting (mt).

Table 26: At-Sea sector Number of Hauls, Allocation and Catch from 2011-2015

Year	**CP**			**MS**		
	Number of Hauls	**Allocation**	**Catch**	**Number of Hauls**	**Allocation**	**Catch**
2011	1534	75,138	71,679	1248	53,039	50,051
2012	1102	55,584	55,263	949	39,235	38,480
2013	1442	79,574	77,950	1256	56,170	52,472
2014	1684	103,486	103,203	1306	73,049	62,098
2015	1507	100,873	68,484	627	71,204	27,586
Average	**1454**			**1077**		

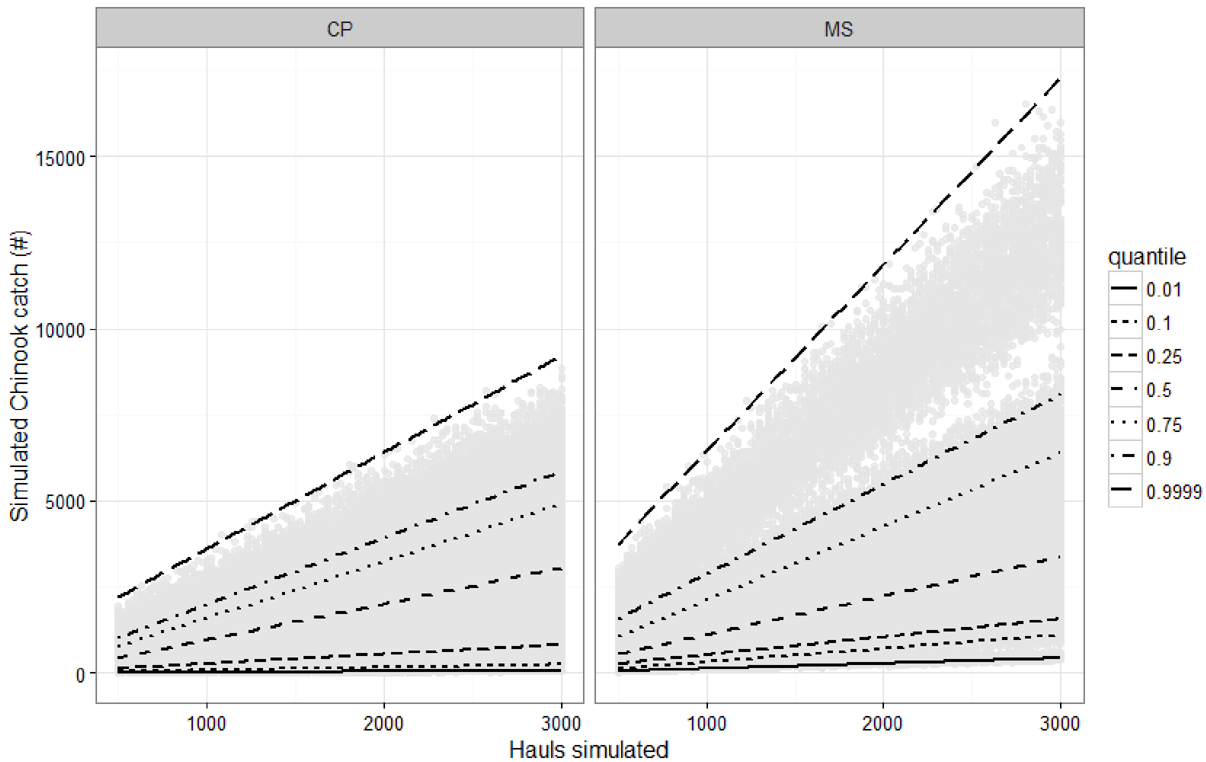


Figure 30: Bootstrap Simulation for Chinook Salmon Based on Number of Hauls

4.4.2 Eulachon

As with Chinook, minimal expected changes to the bycatch of eulachon would be expected under Alternative 1. The main effect, as discussed in more detail above, is that Alternative 1 would allow for more fishing effort in the at-sea sectors in the seasons that would be closed under No Action for overages of the darkblotched or POP allocations.

At the allocation levels associated with the 2017 ACLs, such overage years would be relatively unlikely to occur. As suggested by the bootstrap simulation analysis in Section 4.3.2, such overages would be expected on the order of 1-in-10 seasons. So in most seasons, no change in fishing effort would be expected. These estimates, as in the main analysis, are based are on the at-sea sectors conducting the number of hauls needed to fully harvest their 2016 allocations of whiting. As also concluded in the main analysis, changes in fishing behavior and fishing areas cannot be quantitatively ruled out.

For eulachon, new evidence suggests that bycatch is more of a factor of the eulachon population size and that the current incidental take amount may not reflect the best estimates of bycatch when eulachon are abundant.[29] The current incidental take level was derived in a 2011 NMFS BiOp and is set at a limit of 1,004 fish per year for all commercial groundfish sectors combined.

Table **27** shows the bycatch by sector of eulachon (numbers of fish) from 2002-2013.

The CP sector alone exceeded the entirety of the incidental take statement (ITS) in 2011, but most other years have seen minimal take of eulachon. This includes years in which there were and were not sector specific bycatch allocations. The MS sector saw its highest level of bycatch in 2013, when the shoreside sector also caught over four times the ITS amount at effort levels similar to 2011 and 2012 (Gustafson, 2016). While uncertain, this spike in 2013 in both sectors could be based on the fishing patterns of the catcher vessels that participated in both sectors. The possibility was not investigated here.

In general, the bycatch patterns across all sectors indicate that there are either limited interactions with eulachon or that they are able to escape through the mesh. There may be more encounters with eulachon that are not captured by observer data as the only time that they would be observed in the net would be if the net was clogged. Limited research is available on the actual mortality of these encountered, but not caught, fish (Gustafson, 2016).

[29] http://www.pcouncil.org/wp-content/uploads/2015/06/D4a_Sup_GF_ESA_WrkgrpRpt_JUN2015BB.pdf

Table 27: Bycatch of eulachon by sector, 2002-2013 in numbers of fish (As seen in Table 14 in Gustafson (2016)).

	Non-hake bottom and midwater groundfish fisheries			Shoreside Hake[a]	At-sea hake fisheries			Total Estimate
Year	WA	OR	CA		Tribal MS	Non-Tribal MS	CP	
2002	0	783	0		0	0	0	783
2003	0	52	0		0	0	0	52
2004	0	0	5		0	0	0	5
2005	0	0	0		0	0	0	0
2006	0	0	0		0	0	147	147
2007	0	72	0		0	4	6	82
2008	0	0	0		0	6	37	43
2009	0	67	0		32	6	30	135
2010	0	0	22		0	0	0	22
2011	12	127	0	0	160	54	1,271	1,624
2012	1	167	0	0	0	7	16	191
2013	137	522	0	4,139	n/a	278	39	5,115

[a] WCGOP did not start monitoring bycatch of eulachon in the shoreside hake fleet until 2011.

4.5 Impacts of Alternatives on Socioeconomic Environment

The importance of costs and economic considerations to the comparison of Alternative 1 to No Action is discussed in Section 1.4. In short, NS7 and NS8 require consideration of costs to the at-sea sectors and any other relevant entities as well as adverse economic impacts to fishing communities. The guidelines on those National Standards recommend that additional costs associated with an alternative should be justified in terms of expected improvements to the conservation and management goals.

In general, Alternative 1 would be expected to reduce costs and adverse economic impacts relative to No Action in two ways. First, it would reduce the chances that the sectors would be closed inseason for overages of darkblotched and POP before they are able to fully harvest their marketable whiting (i.e. reducing the chances of lost or forgone yield). And second, it would allow the at-sea co-ops to relax the measures the co-ops are taking to avoid darkblotched and POP. Each is discussed separately below. While the general conclusion about reduced costs is clear, the exact reductions that would be expected can only be considered qualitatively.

In terms of their importance to fishing communities, the economic contributions of the at-sea sectors are taken into account each biennial cycle, and most recently as part of the 2017-2018 Groundfish Harvest Specifications and Management Measures Description and Analysis for Decision Making.[30] That analysis uses the input-output model tailored to Pacific Coast fisheries (IO-PAC). While the IO-PAC most thoroughly describes economic impact of the at-sea sector, it does not take into account the effects of inseason closures for exceeding any bycatch allocation, including darkblotched or POP. Instead, the model assumes that the at-sea sectors take the entirety of the Pacific whiting allocations.

[30] Final version is in progress. Current version at time of writing is available: http://www.pcouncil.org/wp-content/uploads/2016/06/G4_Att2_Analysis_Doc_JUN2016BB.pdf

The Northwest Fisheries Science Centers Economic Data Collection reports show that the at-sea sectors earn some of largest commercial revenues among the groundfish sectors.[31] As to the specific fishing communities most directly affected by the activities of these sectors, all of the MS and CP processor vessels list Seattle and the Greater Puget Sound areas as their homeport, and deliver their products to Blaine, Bellingham, Tacoma, and Seattle. The sector employs people from those communities as well as from around the country and other nations. According to the EDC data, catcher vessels that participate in the MS fishery in 2014 listed their homeports as Puget Sound, Newport, and Brookings.[32] Therefore, any potential cost burdens or savings discussed below would filter down to communities in these areas.

Before beginning the discussion, it is worth noting that the issue of lost yield from closures could also be framed and considered as a matter of achieving conservation objectives. The core conservation goal of NS1 is the achievement of optimum yield. Providing the sectors with the opportunity to fully prosecute their fisheries is how optimum yield is achieved. Framed either way, the effect of Alternative 1 on the at-sea sector's harvest of whiting is a key factor for the Council's consideration.

4.5.1 Potential Benefit from Reduced Chance of Inseason Closure

There are two main sources of information for considering the costs that could be avoided by the reduced chances of bycatch closures under Alternative 1. First, the bootstrap simulation calculates the amount of whiting that went unharvested during seasons closed because of overages of darkblotched or POP. As with the information on the general size of potential overages, this information gives a range of plausible amounts of harvest that could be lost. Second, in terms of the value of that potential forgone yield, the EDC program provides information on variable costs and total cost net revenue based on data collected from both sectors.

Table 28 and Table 29 below show the results of the bootstrap simulation for Pacific Whiting for the CP and MS sectors, reporting both the amount of whiting that was attained and forgone in the simulated seasons.

As with the analysis of potential darkblotched and POP overages, the extreme results of the bootstrap are used as a plausible upper bound. As a note on the interpretation of the quantiles, they are typically ordered in terms of highest to lowest. Here forgone values are ordered as negative numbers/deficits (the negative signs are omitted) so that they align with the corresponding attainment values (i.e. the value for a full attainment season is aligned with a value of zero forgone yield). The 0.0001 quantile for forgone whiting is therefore equivalent to the 0.9999 quantile used to discuss the largest overages in the bootstrap results reported in Section 4.3.

Table 28 shows that for the CP sector, under Scenarios 1 and 3, there is between a ~1-in-100 and ~1-in-10,000 chance that the sector would forgo 75 to 90 percent of their whiting allocation in a closure scenario. As a general caveat to the results, as described below, it is possible that the at-sea sectors could be reopened after a closure as was done by emergency meeting in 2014. With Scenario 2 (when only darkblotched and whiting allocations are used for closures), the possible forgone whiting is almost half the amount compared to Scenarios 1 and 3. For the MS sector, there is similar risk in leaving a majority

[31] The EDC reports and FISHeyE data portal can be accessed here: https://www.nwfsc.noaa.gov/research/divisions/fram/economic/overview.cfm

[32] Prior to 2014, there were vessels also operated out of Alaska, Astoria, and San Francisco.

of the whiting unharvested. This suggests that POP (used in both Scenarios 1 and 3 as a bycatch allocation) is more constraining than darkblotched in the simulated seasons to both sectors in attaining their respective whiting allocations.[33]

Scenario 4 simulates closures only when the whiting allocation is reached. By definition, there are no instances of forgone whiting under this scenario. The results are still reported for consistency. However, as noted above, a caveat of the analysis is that lost yield could still be possible under Alternative 1. As noted in Section 4.3, there may be some extraordinary overages under set aside management that would warrant inseason closure. Although the type of extraordinary overage that might warrant closure has not been discussed by the Council, they would still be less common than the overages that would cause closures under No Action.

Table 28: CP Bootstrap Analysis for Pacific Whiting

Pacific Whiting	Scenario	Allocation (mt)	Percentage of Simulated Seasons					
			0.0001	**0.01**	**0.25**	**0.5**	**0.75**	**0.95**
Attained	1	102,589	12,870	28,992	102,589	102,589	102,589	102,589
	2		45,678	72,902	102,589	102,589	102,589	102,589
	3		12,870	29,031	102,589	102,589	102,589	102,589
	4		102,589	102,589	102,589	102,589	102,589	102,589
Forgone	1		89,719	73,597	0	0	0	0
	2		56,911	29,687	0	0	0	0
	3		89,719	73,558	0	0	0	0
	4		0	0	0	0	0	0

Table 29: MS Bootstrap Analysis for Pacific Whiting

Pacific Whiting	Scenario	Allocation (mt)	Percentage of Simulated Seasons					
			0.0001	**0.01**	**0.25**	**0.5**	**0.75**	**0.95**
Attained	1	72,415	8,967	18,149	72,415	72,415	72,415	72,415
	2		17,810	54,309	72,415	72,415	72,415	72,415
	3		8,967	18,182	72,415	72,415	72,415	72,415
	4		72,415	72,415	72,415	72,415	72,415	72,415
Forgone	1		63,448	54,266	0	0	0	0
	2		54,605	18,106	0	0	0	0
	3		63,448	54,233	0	0	0	0
	4		0	0	0	0	0	0

In terms of the economic values associated with the forgone yield scenarios, Table 30 below shows the total cost net revenue for an average CP and MS processing vessel, as well as the catcher vessels who

[33] To conclude that POP is more constraining in actuality, the assumptions of the bootstrap would need to be examined more closely. For example, there is some indication that POP can be avoided more easily by moving areas.

participate in the MS fishery, for the season and per day and per ton of whiting as taken from the EDC data. Due to the characteristics of the vessels, there are different reporting groups for per ton of whiting for each vessel type. CP vessels both catch and process Pacific Whiting, MS vessels can purchase whiting (from catcher vessels) or process whiting, and catcher vessels harvest whiting.

Total cost net revenue is defined as the revenue minus any variable and fixed costs and can be view as a measure of long-term profitability over many years.[34] In considering trends in total cost net revenue, they can be affected negatively if a large fixed cost (e.g., a new engine) were purchased within that year. However, some of the trends seen above can also be due to the allocations resulting from the TAC. For example, 2012 was the lowest TAC that has been seen in recent years and has a resulting lower total cost net revenue. Under Alternative 1, the sectors could have less forgone whiting due to more flexibility to be able to access their target without the threat of immediate closure and not forced to move as frequently, thereby reducing their variable costs (discussed below).

Using a real example, the MS sector ceased fishing in 2014 under the terms of their co-op agreement after hitting their darkblotched allocation. It took action an emergency meeting of the Council and follow-up inseason action at the November meeting to reopen the fishery. Had the Council not been able to reopen the fishery, the economic impact would have been considerable.

At the time of the closure, the sector had 14,680.5 mt of whiting to potentially harvest of their initial whiting allocation. In 2014, the average total cost net revenue per metric ton of whiting produced for a MS vessel was $121 and $27 for the catcher vessels harvesting in the MS sector. If the fishery had not been reopened, the loss in net revenues would have been roughly $2.2 million. Again, net revenues are the best available estimate of profit to the sector. This figure does not capture the total economic contribution of the sector (e.g. the indirect losses to employees or business that rely on the MS sector for employment or products).

If the at-sea sectors had been operating under Alternative 1 in 2014, the MS sector could have continued fishing with NMFS approval and therefore would have not incurred losses due to being closed automatically. The Council could then have assessed the situation in November under inseason adjustments and taken any routine action necessary. While a relatively minor consideration, the administrative costs of the emergency council meeting are relevant under NS7 and would have been avoided as well.

[34] https://dataexplorer.northwestscience.fisheries.noaa.gov/fisheye/NetRevExplorer/

Table 30: Average Vessel Total Cost Net Revenue for the At-Sea Sector per Year, per Day, and per Metric Ton of Whiting, 2011-2014

	2011	2012	2013	2014
Catcher Processor				
Per Year	$ 2,170,000	$ 1,740,000	$ 3,130,000	$ 5,400,000
Per Day	$ 41,300	$ 39,700	$ 62,000	$ 89,600
Per Ton				
Harvested	$ 226	$ 209	$ 297	$ 460
Produced	$ 656	$ 613	$ 894	$ 1,225
Mothership				
Per Year	$ 920,000	$ (290,000)	$ 260,000	$ 650,000
Per Day	$ 7,600	$ (11,600)	$ 5,100	$ 7,500
Per Ton				
Produced	$ 114	$ (796)	$ 12	$ 121
Purchased	$ 28	$ (501)	$ (5)	$ 43
Mothership Catcher Vessels				
Per Year	$ 157,600	$ (3,900)	$ 146,900	$ 200,200
Per Day	$ 3,932	$ 135	$ 3,423	$ 4,605
Per Ton				
Harvested	$ 54	$ 3	$ 31	$ 27

4.5.2 Relaxation of Bycatch Avoidance

The cost savings to the fleet that may be occur under Alternative 1 may be greatest in terms of relaxing the measures they have taken to avoid being closed for exceeding darkblotched and POP. For instance, with Alternative 1, vessels may not be forced to move as frequently to avoid bycatch species as the risk of immediate closure due to exceeding the allocation is not as great. Under No Action, vessels move more than required by co-op agreement due to concerns about exceeding base rates, pool allocations, or overall sector allocations and then being forced to cease fishing activities. Vessels may be able move less frequently under Alternative 1 as exceeding the set aside would not result in an automatic closure.

While these costs savings are potentially the most significant, they are difficult to quantify. For one, as discussed above in Section 4.2, the degree to which the co-ops would relax their bycatch avoidance measures is uncertain. Currently, the at-sea co-ops operate under agreements that include requirements for vessels to move when certain bycatch rates thresholds are exceeded or avoid certain “hotspot” areas in order to stay within their bycatch allocations.

Cost savings would also be expected under No Action compared to recent years, including the current year. As sector representatives have testified to several times, their bycatch rules focus on the catch of individual darkblotched and POP. As was submitted in written public comment to the Council in June 2016:

> While lightning strikes have been avoided, an even greater problem is caused by low level, chronic catches of darkblotched rockfish and POP. We estimate that if each tow had four

> darkblotched rockfish we would attain our darkblotched rockfish allocation well before we catch our whiting.[35]

At the allocation levels associated with the 2017-2018 ACLs, the analysis above in Sections 4.3.3 and 4.3.4 would suggest that the chronic catches would not reach overage levels on their own. The avoidance of lightning strikes would be sufficient to keep the risk of closure low.

However, with the continued need to move and avoid certain species, as well as the need to find Pacific whiting to harvest (as patterns are variable), this can lead to increases in variable costs (e.g. fuel). Table 31 shows the average variable cost per day for all three at-sea vessel types. The more days that vessels have to spend on the water, the more that is ultimately taken from the revenue. If the sectors were managed under set asides for darkblotched and POP, vessels may be more willing to stay in locations longer as the risk of immediate closure is no longer present.

Table 31: Average Variable Cost per Day in the At-Sea Sector, 2011-2014

	2011	2012	2013	2014
CP	$ 67,900	$ 83,200	$ 63,800	$ 76,800
MS	$ 86,400	$ 93,100	$ 93,000	$ 113,800
Catcher Vessels	$ 8,002	$ 9,415	$ 9,951	$ 10,073

[35] Letter from Pacific Whiting Conservation Cooperative, PFMC Briefing Book June 2016 Agenda Item G.2.b, Supplemental Public Comment 2.