Draft Analytical Document for Pacific Whiting Utilization in the At-Sea Sectors

Recent data show under attainment of fishery resources allocated in the Mothership (MS) whiting sector. Specifically, the MS sector is experiencing lower attainment of their Pacific whiting allocation compared to the Catcher/Processor (CP) and Shoreside (SS) whiting sectors. Obstacles to harvesting and processing in the MS sector have led to social and economic losses for participants; therefore, this action proposes to provide MS sector participants with greater operational flexibility by modifying specific regulations that have been identified as potentially contributing to under attainment. This document analyzes proposed management measures that would apply to the Pacific Coast Groundfish Trawl Catch Share Program participants while operating in the non-tribal whiting fishery. The measures under consideration are; adjustment to the primary whiting season start date for all sectors of the whiting fishery, removal of the catcher vessel (MSCV) processor obligation deadline, an increase or removal of the MS processor cap, and the ability to operate as a CP and an MS in the same year.

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1 Introduction

This document analyzes proposed management measures that would apply to the Pacific Coast Groundfish Trawl Catch Share Program participants while operating in the non-tribal whiting fishery. The measures under consideration are: adjustment to the primary whiting season start date for all non-tribal sectors of the whiting fishery, removal of the MS catcher vessel (MSCV) processor obligation deadline, an increase or removal of the MS processor cap of 45 percent, and the ability to act as a CP and a MS in the same year through permit transfer. The draft analyses and its appendices are provided for public review and consideration of further Council action. Please note that the salmon impact analyses contained within the main document and the Appendix A and B are preliminary and the modeling methods used are similar to those used under the 2017 Biological Opinion - Reinitiation of Section 7 Consultation Regarding the Pacific Fisheries Management Council's Groundfish Fishery Management Plan.

1.1 Purpose and Need

The Council adopted the following purpose and need statement for public review on March 8, 2021. The text is taken directly from Agenda Item G.3.a, Supplemental WDFW-ODFW Report 1, March 2021.

> This action is needed because the MS sector of the Pacific Coast Groundfish Trawl Catch Share Program is under attaining its allocations for whiting and has experienced lower average attainment than the other non-tribal whiting sectors since the start of the trawl catch share program, particularly since 2017. Causes of under attainment may include limited availability of motherships for delivery of catch due to seasonal overlap with the Alaska pollock fishery. In addition, existing regulations may be hindering some catcher vessels' opportunity to harvest or deliver fish to MS processors, by limiting the ability for available processors to accept fish from catcher vessels. In some cases, catcher vessels have been stranded without a mothership processor to deliver to for a season or year(s). These obstacles to harvest and processing in the MS sector have led to social and economic losses for participants.
>
> The purpose of this action is to identify and revise regulations that may be unnecessarily constraining, in order to provide increased operational flexibility in the Pacific whiting fishery and increase the MS sector's ability to utilize its whiting allocation, while maintaining fair and equitable access to Pacific whiting by all sectors of the program.
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> The actions identified support the economic and utilization elements of the Trawl Catch Share Program goal to "create and implement a capacity rationalization plan that increases net economic benefits, creates individual economic stability, provides for full utilization of the trawl sector allocation, considers environmental impacts, and achieves individual accountability of catch and bycatch". In addition, the action supports Management Goals 2 and 3 of the Pacific Coast Groundfish Fishery Management Plan which respectively seek to maximize the value of the groundfish resource as a whole and to achieve the maximum biological yield of the overall groundfish fishery. In addition, this action supports National Standard 1 of the Magnuson-Stevens Act to achieve the optimum yield from the fishery.

1.2 Fishery Overview

While there are similarities across the three non-tribal whiting sectors (CP, MS, and SS), there are distinct differences in their operations and regulations that may be inherent to the issues of utilization. The MS sector is made up of MSCVs, which harvest fish, and motherships, which process the fish at-sea. A cooperative system for the MS sector was created under Amendment 20 to the Pacific Coast Groundfish Fishery Management Plan (FMP). In March of 2011, the owners of all 37 MSCV permits formed a co-op called the "Whiting Mothership Cooperative (WMC)". As stated in the WMC 2019 annual report, one of the primary purposes of the WMC is to minimize the bycatch of constraining rockfish species and Chinook salmon. Multiple strategies including daily monitoring by Sea State, inseason hot spot closures, night fishing restrictions, and move-along rules are used to mitigate bycatch. One of the key features of the MS co-op is the use of seasonal pools, in which the WMC divides the whiting allocation into five pools spread across the fishing year based on the amount of whiting declared by MSCVs intending to participate in that pool. All other allocations of groundfish species (which are all managed as set asides as of 2020) are shared pro-rata to the pools. For further details on the WMC, including pool operations, recent inseason closures, bycatch rate rules, and season dates, please see Supplemental Informational Report 4, April 2021.

The CP sector has been operating under a co-op, the Pacific Whiting Conservation Cooperative (PWCC) since 1997, which was formalized for management with the implementation of Amendment 20. The CP sector utilizes similar management measures as the MS sector to mitigate bycatch, such as information sharing, use of Sea State, and move-along rules. Further details, including actions taken inseason by the co-op, can be found in Supplemental Informational Report 5, April 2021.

While there was initial consideration in the development of Amendment 20 to have the SS whiting sector be its own sector, the sector was ultimately grouped into the shorebased individual fishing quota (IFQ) program. Like all shorebased IFQ species, whiting catch and associated bycatch species that are managed with IFQ must be covered by quota pounds (QPs). About half of the SS whiting vessels also cross participate in the MS fishery as MSCVs. While not formally recognized in the groundfish regulations, like the at-sea co-ops, there is a Shoreside Whiting Cooperative that historically has had approximately two-thirds of SS whiting vessels participate (2012-2018; Agenda Item H.9. Attachment 1, November 2019).

For further details on the three whiting sectors, including descriptions of regulations, product types, and other trends, please see Agenda Item G.3, Attachment 1, March 2021.

1.3 History of this Action

The issues identified in this document were first raised in 2016 during public meetings to discuss the Council's 5-year Catch Shares Review process (Agenda Item F.6.c. Supplemental CAB Report, November 2016). However, during the development of the follow-on actions, the Council's ad hoc Community Advisory Board (CAB) did not prioritize alternatives related to this issue (Agenda Item F.2.c, Supplemental CAB Report, June 2017). In September 2018 though, the Arctic Storm Management Group provided a public comment letter to the Council for discussion and consideration proposing to increase the processing cap of 45 percent within the follow-on actions package (Agenda Item I.7.b, Supplemental Public Comment 1, September 2018). At that meeting, the Council decided not to include the request in among the issues that it addressed but asked the industry to provide some solutions to continue the discussion in the future.

In October 2018, the industry held a sector-wide meeting in Portland, OR to discuss solutions. This information was provided to the Council and its advisory bodies in November 2018 to highlight the industry's concerns as well as provide a fuller suite of potential management measures that may help address the broader issue of underutilization of the MS sector allocation (Agenda Item G.4.b., Supplemental Public Comment 2, November 2018). The Council's advisory bodies did not prioritize these issues under the Council's groundfish workload & new management measures process (Agenda Item G.4.a, Supplemental GAP Report 1, November 2018, Agenda Item G.4.a, Supplemental GMT Report 2, November 2018) on future agendas. Instead, they decided to examine all groundfish issues in March 2019 to decide what issues should move forward for further discussion and possible action. During the March 2019 meeting, the Council heard from the industry regarding MS sector utilization proposals (Agenda Item G.4., Public Comment, March 2019) and discussed the Agenda Item G.4.a., Supplemental GAP Report, March 2019 and Agenda Item G.4.a, Supplemental GMT Report 4, March 2019 reports. The Council prioritized the MS utilization issues and in November 2019, directed industry to develop the scope of action and draft purpose and need (P&N) statement for the MS sector utilization item during the GAP's March and April 2020 meetings. At its April 2020 meeting, the Council requested the GAP submit an informational report on these items for June.

In September 2020, based on Informational Report 4, June 2020, Council and NMFS staff submitted a scoping paper (Agenda Item D.2., Attachment 3, September 2020) in the advanced briefing book outlining some questions for consideration. The GMT provided a preliminary look at the data, thoughts on potential causes of under attainment, and regulatory issues (Agenda Item G.2.a, Supplemental GMT Report 3, September 2020). After considering the information provided, the Council adopted a purpose and need statement for public review and continued to scope the following issues:

1. Primary whiting season start date (which could apply to other whiting sectors),
2. Processor obligation deadline,
3. MS processor cap, and
4. MS/CP permit transfers.

The Council considered a request to allow processing south of 42° N. lat. in the at-sea sectors as a part of this action; however, due to potential interactions with salmon, the Council decided to consider the action at a later time and encouraged the industry to test the idea through future exempted fishing permit experiments.

At the March 2021 meeting, the Council adopted the following P&N statement along with the following range of alternatives (ROA) for public review (See March 2021 Decision Summary):

1. *Whiting Season Start Date (for all whiting sectors)*
    - *Status Quo: May 15*

- *Alternative 1: May 1, annual cooperative applications and Salmon Mitigation Plans due 45 days prior to the season start date.*

2. *Mothership Processor Obligation*
   - *Status Quo: Mothership processor obligation made by November 30 through mothership catcher vessel endorsed limited entry permit renewal.*
   - *Alternative 1: Remove mothership processor obligation from regulation.*

3. *Mothership Processor Cap*
   - *Status Quo: 45%*
   - *Alternative 1: 65%*
   - *Alternative 2: 85%*
   - *Alternative 3: Remove mothership processor cap from regulation.*

4. *Mothership Processor & Catcher-Processor Permit Transfer*
   - *Status Quo: A vessel cannot be registered to a mothership permit and a catcher-processor permit in the same calendar year*
   - *Alternative 1: A vessel can be registered to a mothership permit and a catcher-processor permit in the same calendar year.*

     i. *Sub-option A: A vessel can switch between the mothership sector and catcher/processor sector up to two times during the calendar year through permit transfer.*
     ii. *Sub-option B: A vessel can switch between the mothership sector and catcher/processor sector up to four times during the calendar year through permit transfer.*
     iii. *Sub-option C: Unlimited transfers.*

The proposed changes would modify federal regulations and possibly require amendment of the Groundfish FMP.

The Council is scheduled to adopt a final ROA and a preliminary preferred alternative(s) (PPA) during their September 2021 meeting and final preferred alternative(s) (FPA) during the March 2022 meeting with the intent of implementing the regulations by the 2023 fishing season.

1.4 Overview of Analysis

At the time of the drafting of this document, there has not been a determination of what kind of National Environmental Policy Act (NEPA) analysis is needed and therefore, this document is intended to provide the Council with the necessary information to support the selection of a PPA outside of the typical NEPA style template. After a PPA is selected, NMFS, in consultation with Council staff, will determine the level of NEPA analysis that is needed to complete the action. This decision will be made prior to selection of an FPA.

This analytical document splits the proposed ROA from March 2021 into two sections: Season start date change (Section 2) and other administrative alternatives (Section 3- obligation deadline, MS processor cap, and permit transfer alternatives). Each section provides a background of the proposed action alternative and an analysis of the relevant impacts.

Based on the most recent interaction data, impacts to non-salmonid protected or prohibited species (i.e., green sturgeon, eulachon, Dungeness crab, Pacific halibut, Endangered Species Act (ESA) listed species, birds or marine mammals) are not expected to change beyond what has been observed in the past under any of the proposed action alternatives since the fishery is not expected to alter its fishing operations (historic fishing location or gear used); see reports under Agenda Item G.4. in the June 2021 Briefing Book for ESA–listed species, and Groundfish FMP Amendment 29 and 2021-2022 Harvest Specifications and Management Measures for non-listed marine mammals, annual Pacific halibut impact report, and annual groundfish impact estimate report for Dungeness crab. Overall directed fishery effort for whiting may slightly increase if an additional two weeks of fishing is provided; however, we do not anticipate a substantial change in impacts beyond what was previously analyzed because incidental interactions are rare and interaction rates with non-salmonid protected or prohibited species are not directly correlated with the harvest of whiting (fishing effort, volume harvested, or area fished). Therefore, no further analysis of these species is provided in this document. Impacts to Southern Resident Killer Whales will be assessed after selection of the PPA.

There are no expected impacts to essential fish habitat (EFH) beyond what has been previously analyzed as the fisheries considered under this action utilize midwater gear which is associated with little overall impact on bottom habitat (Section 4.2 of Appendix C to the FMP). Additionally, there are no proposed changes to EFH conservation areas or gear design. Based on this information, no further analysis of EFH (bottom substrate or water column) is provided in this document.

While shortbelly rockfish is an important forage species and whiting fisheries are the largest contributors to shortbelly rockfish bycatch in recent years (Cowcod/Shortbelly RIR), it is not expected that an additional two weeks of fishing will measurably change impacts. Shortbelly rockfish bycatch is extremely variable and cannot be attributed to a specific location or time. As an ecosystem component species, shortbelly rockfish do not have harvest specifications; however, as is described in the 2021-22 Harvest Specifications Draft EA/RIR, "there is no directed fishery for shortbelly rockfish and there is a low probability of a market developing." Given these factors, the action alternatives, as proposed, would not result in the development of a shortbelly market through targeting. Fishery operations (i.e., historic fishing location or gear used) are not expected to change but we expect that annual shortbelly bycatch will continue to be variable and possibly increase with an additional two weeks.

Climate change is one important source of uncertainty for both near and far-ranging future scenarios. However, impacts to Pacific whiting, other groundfish, or salmon are not accounted for in our modeling of impacts at this time. It is not possible to predict with certainty the changes climate may have on these species coupled with the potential future impacts of this action. Instead, we qualitatively discuss the potential impacts on additional harvest of Pacific whiting and bycatch of salmon based on current research and climate change information.

An assessment of the potential impacts when combining alternatives is provided in Section 4. Further discussion will be provided after a PPA is selected.

2 Season Start Date

2.1 Background

North of 40° 30′ N. lat., the primary whiting season for all three non-tribal whiting sectors begins on May 15th. Agenda Item D.2.a, Supplement GMT Report 3, September 2020 provides a brief overview of the history of the start date:

> "The start of the Pacific whiting season has varied since the conversion of the fishery from foreign to domestic, when the start date was set at January 1. Foreign fisheries typically moved into the fishery in April when "fishable concentrations of whiting were available", and the start date was moved to April 15 in 1992 to approximate this natural start time (PFMC 2015). In 1996, the season was moved back to May 15 in some areas to minimize bycatch of Chinook salmon, which was unusually high in 1995. The dates have fluctuated between April and June in the shorebased fishery to accommodate participation in shoreside, at-sea, and Alaska fisheries. The Final Environmental Impact Statement (EIS) for Amendment 20 noted that, "the spatial/temporal overlap between the Pacific whiting fishery and the distribution of Chinook salmon... could result in incidental take of listed salmon. The season start dates are, in part, meant to limit targeting on whiting fishing when listed Chinook salmon are most likely to be taken incidentally" (PFMC 2010). The June 15 start date for shoreside whiting (North of 40° 30′ N. lat.) was moved to be consistent with the May 15 start date in the at-sea sectors in 2016. Fishing south of 40° 30′ N. lat. can start April 15 (80 FR 19034, April 9, 2015)."

While fishing south of 40° 30′ N. lat. can start April 15, as previously noted, processing vessels are not allowed to operate south of 42º N. lat., effectively restricting this early opportunity to the shoreside fleet. When considering modifying the season dates, the Council must consider the framework and criteria described in 50 CFR 660.131 (b)(2)(ii)):

> "(2) Different primary season start dates. North of 40° 30′ N. lat., different primary season starting dates may be established for the C/P Coop Program, the MS Coop Program, and the Pacific whiting IFQ fishery for vessels delivering to IFQ first receivers north of 42° N. lat. and vessels delivering to IFQ first receivers between 42° and 40° 30′ N. lat.
>
> ii. Criteria. The start of a Pacific whiting primary season may be changed based on a recommendation from the Council and consideration of the following factors, if applicable: Size of the harvest guidelines for whiting and bycatch species; age/size structure of the whiting population; expected harvest of bycatch and prohibited species; availability and stock status of prohibited species; expected participation by catchers and processors; the period between when catcher vessels make annual processor obligations and the start of the fishery; environmental conditions; timing of alternate or competing fisheries; industry agreement; fishing or processing rates; and other relevant information."

While there is no proposal within the ROA to make separate start dates for each sector, the following analyses considers the applicable criteria describe in the framework under the proposed action alternative.

2.2 Description of Alternatives

Under this item, the ROA is as follows:

No Action: Primary whiting season start date north of 40° 30' N. lat. is May 15

Under this alternative the season start date would remain as May 15 for all sectors of the non-tribal fishery (Catcher/Processor, Mothership, and Shoreside). This would not require a change to federal regulations.

Alternative 1: Primary whiting season start date north of 40° 30' N. lat. is May 1. Annual cooperative applications and Salmon Mitigation Plans due 45 days prior to the season start date.

Under this alternative the primary whiting season start date would be changed from May 15 to May 1 for all sectors of the non-tribal whiting fishery (Catcher/Processor, Mothership, and Shoreside). This would require a change to federal regulations.

2.3 Analysis

2.3.1 Pacific Whiting (Biological and Economic Related Impacts)

Under No Action, the whiting season start date north of 40° 30' N. lat. would remain May 15th and therefore recent attainment trends would be expected to continue. From 2017-2019, the SS sector averaged 92 percent, the MS sector 71 percent, and the CP sector 100 percent of the initial whiting allocations, and 83, 64, and 90 percent respectively of the post-tribal reapportionment allocation (Table 1).[1] This analysis provides information on attainment in the non-tribal whiting fisheries based on the initial and post-tribal reapportionment allocations; however, the analysis does not presuppose that tribal reapportionment will occur in the future. This three-year period is the most recent period of fishing excluding the anomalous fishing and market conditions associated with the COVID-19 pandemic in 2020.

Additionally, prior to 2017, the fisheries were operating under management conditions different from those of recent years. With respect to bycatch species previously midwater stocks (i.e., canary and widow rockfishes) were still overfished or with lower annual catch limits (ACLs) leading to limited available QPs and the at-sea fisheries operating under allocations for certain stocks (e.g., darkblotched rockfish). In more recent years, these stocks have been rebuilt, such that more QP are now available for the shoreside fishery and in the at-sea fisheries, they are now managed with set asides rather than allocations. With respect to whiting, as was noted in Agenda Item G.3, Attachment 1, March 2021, the Total Allowable Catches (TACs) for whiting in recent years have been at an historic high. Compared to previous three years, TACs for 2017-2019 increased by 24 percent. While the SS and CP sectors increased their average catch at rates higher than the TAC increase during that time, the MS sector increased their average catch by only 20

[1] Tribal reapportionment is authorized via 50 CFR 660.131(h). Whiting that is not intended to be used by the tribal fisheries can be reapportioned to the other sectors after receiving notice from the tribes or through Regional Administrator determination after September 15th. However, no reapportionments will occur after December 1 of the fishing year.

percent from the previous three-year period, which is approximately nine percent less than the allocation increase (see Table 2 in Agenda Item G.3, Attachment 1, March 2021). Excluding 2015 catch, the average catch for the MS sector declined by 2.5 percent (2014 and 2016 average catch=63,528 mt).

For the purposes of this document, the 2017-2019 period will be used as the baseline for the reasons described above; however, as TACs change, attainment percentages and actual catch amounts would change accordingly. The most recent whiting stock assessment has shown that Pacific whiting relative spawning biomass was near unfished levels in 2017 and has been declining since that time (Johnson et al. 2021). The whiting stock is predicted to continue to decline over the next two years, due in part to a lack of a strong recruitment signal in recent years. While projections are highly uncertain, this may suggest that TACs may decrease in future years. Under a lower TAC, sectors may see high attainment levels overall even if actual catch amounts decrease from the baseline (similar to 2011-2013 shown in Table 1). These impacts will be discussed qualitatively in context of the quantitative results.

Overall, there are no biological impacts to Pacific whiting expected under Alternative 1 because attainment will only approach 100 percent of the allocation for each sector—amounts that have been or will be analyzed as part of annual management actions. Pacific whiting is co-managed by the US and Canada under the Pacific Hake/Whiting Treaty. This agreement established the US's right to 73.88 percent of the overall TAC and the other 26.12 percent to Canada. As described by NMFS:

> The annual coastwide TAC-setting process begins with a stock assessment completed by the Joint Technical Committee in January. The Scientific Review Group reviews the stock assessment at their annual meeting (February or March) and provides scientific advice, which is incorporated into the final stock assessment. The Advisory Panel and Joint Management Committee meet to review the stock assessment and to provide advice to the governments of Canada and of the United States on an annual coastwide TAC by March 25th of each year. Once approved by the respective governments, the TAC advice is in turn implemented in accordance with each countries' laws and regulations.

Table 1. Total Pacific whiting total mortality a/ (mt), initial allocation and attainment, and post-reapportionment allocation and attainment by whiting sector, 2011-2020.

Year	Shoreside Whiting b/					Mothership					Catcher/Processor				
	Total Mortality (mt)	Initial Allocation (mt) and % Attain		Post-Reapp. Allocation (mt) and % Attain		Total Mortality (mt)	Initial Allocation (mt) and % Attain		Post-Reapp. All and % Attain		Total Mortality (mt)	Initial Allocation (mt) and % Attain		Post-Reapp. Allocation (mt) and % Attain	
2011	90,758	92,818	97.8%	92,818	97.8%	50,150	53,039	94.6%	53,039	94.6%	71,665	75,138	95.4%	75,138	95.4%
2012	65,416	56,902	115.0%	68,662	95.3%	38,197	32,515	117.5%	39,235	97.4%	55,668	46,064	120.9%	55,584	100.2%
2013	97,327	85,697	113.6%	98,297	99.0%	52,522	48,970	107.3%	56,170	93.5%	78,041	69,374	112.5%	79,574	98.1%
2014	98,477	108,935	90.4%	127,835	77.0%	62,038	62,249	99.7%	73,049	84.9%	103,266	88,186	117.1%	103,486	99.8%
2015	58,357	112,007	52.1%	124,607	46.8%	27,664	64,004	43.2%	71,204	38.9%	68,484	90,673	75.5%	100,873	67.9%
2016	86,176	126,727	68.0%	141,007	61.1%	65,018	72,415	89.8%	80,575	80.7%	108,804	102,589	106.1%	114,149	95.3%
2017	146,568	152,327	96.2%	169,547	86.4%	66,257	87,044	76.1%	96,884	68.4%	137,130	123,312	111.2%	137,252	99.9%
2018	130,052	152,327	85.4%	169,127	76.9%	67,163	87,044	77.2%	96,644	69.5%	116,050	123,312	94.1%	136,912	84.8%
2019	144,083	152,327	94.6%	169,126	85.2%	52,417	87,044	60.2%	96,644	54.2%	116,379	123,312	94.4%	136,912	85.0%
2020	139,478	146,567	95.2%	163,367	85.4%	37,978	83,752	45.3%	93,352	40.7%	111,144	118,649	93.7%	132,249	84.0%

a/ Mortality includes all retained catch and any discards.
b/ Includes all whiting mortality from the shorebased IFQ program.

Using 2017-2019 as a baseline, the following table summarizes the average economic impacts by sector- including production value, jobs, and income impacts (wages and salary). Production value for each sector represents the amount of revenue that processors receive for the sale of fish products, some of which would be paid to SS and MS catcher vessels in the form of ex-vessel payments for deliveries. The CP and SS sectors have averaged more than double the production value of the MS sector from 2017-2019, with income impacts seeing a similar trend. The CP sector is estimated to support nearly or over double the number of jobs as either the SS or MS sectors. The jobs related to each sector likely have different geographic distributions—particularly with respect to the CP sector.

Table 2. Average production values, jobs, and income impacts (2020$) from 2017-2019 for each whiting sector. Source: FishEye; PacFIN, Leonard and Watson (2011).

Sector	Production Value (millions of $)	Jobs a/	Income impacts (millions of $)
SS	$92.5	997	$84.5
MS	$45.3	830	$54.9
CP	$111.7	1,847	$144.1

a/ Estimated total (direct, indirect, and induced) economic impacts resulting from combined harvesting and processing.

Given that the SS and CP sectors have averaged over 90 percent attainment of their initial allocations in recent years, even in 2020 amidst pandemic conditions, it is assumed that they would likely continue to see high attainment of their allocations under No Action. Impacts would therefore be similar to those presented in Table 2 above (assuming similar allocations) under the No Action alternative. For the MS sector though, if trends in attainment under similar TACs were to continue, that would likely leave a significant portion of the allocation unharvested. From 2017-2019, the MS sector is estimated to have lost a potential opportunity of $14.5-$27.3 million in production value from unharvested whiting from the initial allocations and $21.5 to $31.8 million compared to the post-reapportionment allocations.

However, it is also important to consider that this baseline period does co-occur with a shift in attainment trends for the MS and SS sectors, given the high amount of cross participation by catcher vessels between the two sectors (75 percent from 2011-2019). From 2014-2016, the SS whiting sector averaged 70 percent attainment of the sector's initial allocation. In the following three years, catch increased by 73 percent and percent attainment by 22 percent. Comparing those two periods for the MS sector though, percent attainment of the initial MS whiting allocations declined by 6.4 percent. As described in Agenda Item G.3., Attachment 1, March 2021, "the reason behind this shift in effort may be due to a lack of capacity to process in the MS sector, the prioritization of Alaska pollock over Pacific whiting, or other factors. Also, some entities may have interests across multiple whiting sectors which may affect the prioritization in one fishery or another." Therefore, if the proposed actions were to increase opportunities in the MS sector, it could result in attainment rates in the SS sector to declining—but the degree to which is uncertain.

One of the primary benefits of moving the start date to May 1st is that it would provide additional days to harvest whiting between the Alaskan Eastern Bering Sea walleye pollock seasons. An average of 93 percent or 14 processors (both CP and MS) registered to fish in both pollock, and whiting fisheries fished in both, with the remainder only fishing pollock. Over half of the MSCVs and SS whiting catcher vessels are registered to fish or participate in both pollock and whiting fisheries (Agenda Item G.3.a, Supplemental Attachment 2, March 2021). As described in Agenda Item D.2.a, Supplemental GMT Report 4, September 2020, many vessels that fish in the Pacific whiting fishery earn the majority of their revenue in Alaska fisheries with most whiting processors processing about 60-90 percent of their annual product in Alaska each year. Given the higher volume and price of walleye pollock compared to Pacific whiting (see Table 3 of Agenda Item D.2.a, Supplemental GMT Report 4, September 2020) and as noted in public comments, vessels and processors that participate in both are likely incentivized to prioritize pollock above Pacific whiting.

Typically, "A season" fishing for pollock occurs from January 20 to early/mid-March and then starts to decrease until mid/late March to mid-April. "B season" starts on June 10, although in some years, vessels that participate in both Pacific whiting and Alaska pollock may not start fishing until later in the month.[2] For those processors that want to start fishing on opening day of B season, taking into account travel and other associated preparation time, that would mean there are only about 18 days to harvest whiting under No Action before heading to Alaska to start harvesting B season pollock.

If the whiting season start date were moved to May 1, it seems plausible that processors could be back from A season in Alaska in time to start fishing whiting. This move would provide them with an additional 15 days to participate in the whiting fishery leading to up to a month of whiting harvest opportunities between pollock seasons. MSCVs that typically participate in the first pool of the WMC would likely benefit the most from the season start date change. In 2019, there were 17 MSCVs that harvested whiting in the first pool (page 29 of Supplemental Informational Report 5, April 2020). Additionally, by moving the start of the whiting fishery season earlier, this could allow processors to get to the pollock B season by the start date, and then return to the West Coast earlier for the fall whiting fishery to provide even more opportunity to harvest whiting quota. B seasons for the Alaska pollock CP and MS fisheries typically end between August and the end of September, and the inshore CVs usually fish a little later into the season. In some years, like 2020, the Alaska pollock sectors fish until the regulatory closure at noon, November 1.[3]

Not only is it likely for vessels to be able to take advantage of the additional opportunity between Alaska pollock seasons under Alternative 1, but there is evidence to suggest that this fishing period may exhibit high effort and catch. For example, the catch per unit effort (CPUE) for the MS fishery for whiting is the highest in the first two months of the season (May/June) as shown in Figure 17 of Agenda Item G.3, Attachment 1, March 2021. Additionally, recent years have shown a general increasing trend in the percentage of total catch taken through June for all three sectors. Note that while the shoreside sector overall may appear to not be as active in the earlier months, one of the

[2] Annual inseason reports of pollock season harvest by the NMFS AK Region can be found at https://www.fisheries.noaa.gov/resource/document/alaska-inseason-management-annual-reports-north-pacific-fishery-management

[3] Historical record of fishing seasons by pollock sector and area see https://media.fisheries.noaa.gov/dam-migration/bs-pollock-seasons.pdf .

reasons is that a proportion of those vessels are fishing in the MS sector prior to the MS processors going to Alaska for pollock "B season" (Agenda Item G.3, Attachment 1, March 2021).

Looking at the whiting harvest from the adjacent period of May 15-31 may offer the best picture of how much whiting could be harvested within the two additional weeks for each sector if the season start date was moved to May 1st. Table 3 below shows the total catch (mt) and the number of processors and/or catcher vessels that delivered the harvest. Prior to 2015, the season for the shoreside sector north of 42° N. lat. was June 15th and there were no recorded landings in the shoreside whiting sector in May for the areas south of 42° N. lat. since 2011. Due to confidentiality, values for 2015 in the shoreside sector are not provided.

Table 3. Whiting catch (mt) from May 15-May 31 by sector, 2011-2020 and count of processors/dealers and catcher vessels.

Year	Catcher Processors		Mothership			Shoreside Whiting a/		
	Catch	Vessels	Catch	MS	MSCVs	Catch	Dealers	CVs
2011	21,389	7	9,701	3	8			
2012	20,341	7	4,268	3	7			
2013	23,142	8	6,434	3	9			
2014	30,315	9	16,751	4	11			
2015	32,805	9	14,657	3	9	C	C	C
2016	32,570	9	13,194	5	14	3,571	4	6
2017	25,126	8	11,876	3	8	10,215	5	15
2018	27,237	8	16,662	4	12	12,283	7	18
2019	38,046	9	25,761	6	16	12,475	7	15
2020	40,291	10	19,029	4	13	11,827	9	24

a/ Shoreside whiting landings include only those directed trips defined as shoreside whiting per 50 CFR 660.140. Minor amount of whiting caught as bycatch in the midwater rockfish or other fisheries are not included.
Note: 'C' means data is confidential and cannot be displayed.

Given the recent high attainment trends of the SS and CP sectors (Table 1), it is likely that the two additional weeks could slightly improve overall attainment leading to economic benefits to those sectors. The most likely impacts by altering the start date for these two sectors would be due to any shift in effort and seasonal differences in the co-occurring impacts to non-whiting species and particularly salmon (discussed below). For the MS sector however, these additional two weeks might provide a substantial opportunity for additional catch and economic benefits to the sector (MS and MSCVs).

Assuming no other changes, if the MS sector had retrospectively caught the same amount of whiting from May 1-15 it did from May 16-31 in the 2016-2020 period, it could have led to increases in attainment of 21 percent on average for the initial allocations and 19 percent looking at post-reapportionment attainment (Table 4). Utilizing the historical production value information from the analysis above[4], this additional catch could have been associated with $8.4 to $20.3 million in associated additional production revenue for the sector. The additional catch would have resulted in an estimated $10.5-$22.8 million in income impacts and 159 to 345 induced jobs compared to No Action. However, as will be discussed in Section 4, if Alternative 1 (May 1 start date) is combined with the ability for a processor to operate as a CP and an MS in the same season, the number of processors available in the MS sector could increase, leading to more opportunity for CVs to deliver and even greater increases in overall catch than indicated in Table 4.

Table 4. Actual, predicted additional, and total projected catch (mt) for the MS sector assuming that the amount of whiting harvested between May 15-31 was taken between May 1-14 retrospectively from 2016-2020. Actual and theoretical percent attainment of the initial and post-tribal reapportionment allocations.

Year	**Actual Catch (mt)**	**Predicted Additional Catch (mt)**	**Predicted Total Catch (mt)**	**Initial Allocation**		**Post-Tribal Reapportionment**	
				Actual	**Predicted**	**Actual**	**Predicted**
2016	65,018	13,194	78,212	89.8%	108.0%a/	80.7%	97.07%
2017	66,257	11,876	78,133	76.1%	89.8%	68.4%	80.65%
2018	67,163	16,662	83,825	77.2%	96.3%	69.5%	86.74%
2019	52,417	25,761	78,178	60.2%	89.8%	54.2%	80.89%
2020	37,978	19,029	57,007	45.3%	68.1%	40.7%	61.07%

a/ Actual attainment would not have been able to exceed 100 percent due to allocation limitations.

Overall, if the start date was moved from May 15 to May 1 during the baseline period of 2017-2019 and assuming that conditions were the same, it could have result in a net increase in revenue and economic impacts as shown in Table 5. Based on this analysis, assuming that the baseline is representative of future conditions, Alternative 1 is likely to have a positive benefit to all three whiting sectors.

Table 5. Summary table of impacts for the MS sector by adjusting the season start date to May 1 from 2017-2019

Alternative	**Whiting catch (mt)**	**Attainment % (Initial Allocation)**	**Production Value (millions 2020$)**	**Employment Impacts (Jobs)**	**Income Impacts (millions 2020$)**
No Action	61,946	71.2	$45.3	830	$54.9
Alternative 1	80,045	92.0	$63.5	1,073	$70.9
Difference	+18,099	+20.8	+$18.2	+243	+$16

[4] 2020 data was not available at the time of drafting so 2019 production value per pound was used as a proxy.

2.3.2 Non-Whiting Groundfish Impacts

This section shows that even with shifts in harvest or increases in overall whiting harvest (for the MS sector in particular), the impacts of Alternative 1 would likely still be within those described in the 2021-2022 harvest specifications as the mechanisms to control catch (e.g., IFQs, co-ops, set asides) would still be in effect preventing exceedances of allocations and ACLs.

Groundfish FMP species are managed differently between the at-sea sectors and the SS fishery. For the SS whiting fishery, all catch of any IFQ species must be covered with QPs. For the at-sea fisheries, set asides are established for select groundfish species within the biennial harvest specifications process. Set asides are managed on an annual basis unless there is a risk of exceeding a harvest specification, an unforeseen impact on other fisheries, or a conservation concern. Bycatch of groundfish in the whiting fisheries is highly variable (as can be seen in Table 4-80 of Agenda Item F.1., Attachment 8, June 2020) and is dependent on the year, timing, and location of the whiting fishery. Under No Action, the impacts to groundfish are expected to remain within the set asides adopted for the at-sea fisheries during the 2021-22 harvest specifications. The IFQ fishery would still be required to cover any catch with QPs.

Given the lack of data from May 1-14, the May 15-31 data period from 2016-2020 was used as a proxy to assess potential impacts to non-whiting groundfish species under Alternative 1. Yellowtail rockfish north of 40° 10' N. lat. and widow rockfish have the highest average bycatch for all three sectors (Table 6). Other species such as darkblotched rockfish, Pacific Ocean perch (POP), sablefish north of 36° N. lat., and rougheye rockfish also rank high in terms of average bycatch in those first two weeks of the season. Darkblotched rockfish, POP, sablefish north of 36° N. lat., widow rockfish, and yellowtail rockfish north of 40° 10' N. lat. all are managed with stock specific ACLs and have designated set asides for the at sea sectors. Rougheye rockfish is managed within the minor slope rockfish north of 40° 10' N. lat. complex (which has a set aside for the at-sea sectors). Spiny dogfish does not have any allocations or set asides and all non-tribal catch is counted against the fishery HG.

Table 6. Bycatch (mt) of select high bycatch species for three whiting sectors from May 15-31 annually and the average mortality from 2016-2020.

Sector	Species	2016	2017	2018	2019	2020	Average
CP	Darkblotched Rockfish	1.2	4.1	7.9	6.5	27.8	9.5
	POP	0.0	8.1	9.1	8.3	1.7	5.4
	Rougheye Rockfish	1.1	7.0	43.9	23.1	17.6	18.5
	Sablefish	2.1	0.6	19.7	6.4	2.9	6.3
	Spiny Dogfish	0.5	1.4	22.2	8.5	17.8	10.1
	Widow Rockfish	9.9	88.4	7.7	67.7	44.8	43.7
	Yellowtail rockfish north of 40 10 N. lat.	0.0	75.9	35.7	158.2	35.6	61.1
MS	Darkblotched Rockfish	0.3	0.7	3.9	8.7	4.5	3.6
	POP	2.0	2.5	2.4	5.4	0.3	2.5
	Rougheye Rockfish	0.9	1.0	1.0	2.4	1.0	1.2
	Sablefish	0.1	0.7	6.3	2.6	3.3	2.6
	Spiny Dogfish	0.2	2.5	7.9	2.4	2.0	3.0
	Widow Rockfish	36.5	10.5	21.7	24.6	3.9	19.4
	Yellowtail rockfish north of 40 10 N. lat.	20.2	57.5	74.4	144.7	32.2	65.8
SS	Darkblotched Rockfish	0.25	2.57	11.03	20.43	33.73	13.6
	POP	2.01	7.84	13.04	3.5	16.59	8.6
	Rougheye Rockfish	0.2	0.51	0.25	0.07	3.54	0.9
	Sablefish	NA	4.97	1.62	0.03	1.09	1.9
	Spiny Dogfish	0.02	0.16	0.51	0.25	3.16	0.8
	Widow Rockfish	16.36	54.8	37.56	61.57	77.35	49.5
	Yellowtail rockfish north of 40 10 N. lat.	18.19	47.78	97.89	110.07	57.8	66.3

However, depending on processor availability and fishing conditions, if the sectors were to shift more of their effort to the beginning of the season but not substantially increase their overall take of whiting, it would likely result in fewer overall impacts in the fall. Table 7 shows the managed groundfish species with highest average catch for each of the three sectors from the months of September-December from 2016-2020. Note that in 2020, there were fewer than three processors for the MS sector in these months and therefore the stratum is confidential.

Of note is that the average catch of yellowtail rockfish in the at-sea sectors is much higher in the spring compared to the fall, which suggests that there could be more yellowtail rockfish caught per mt of whiting under Alternative 1. For the other species though, average catch is less in the spring than the fall. For the SS sector, given the little effort seen between May 15-31 overall, it is likely that there will be minimal changes in overall bycatch estimates compared to No Action.

Table 7. Bycatch (mt) of groundfish species by year and sector from September-December, 2016-2020.

Sector	Species	2016	2017	2018	2019	2020	Average
CP	Darkblotched Rockfish	2.3	27.0	30.1	33.0	3.6	19.2
	POP	2.7	5.1	20.1	84.6	2.0	22.9
	Rougheye Rockfish	13.9	19.6	95.6	84.6	8.5	44.5
	Sablefish	16.0	56.5	70.7	46.6	2.3	38.4
	Spiny Dogfish	132.8	106.0	677.1	543.2	70.1	305.8
	Widow Rockfish	100.6	190.9	35.2	14.4	23.6	73.0
	Yellowtail rockfish north of 40 10 N. lat.	2.4	5.5	4.3	0.3	0.4	2.6
MS	Darkblotched Rockfish	0.9	6.5	16.0	15.5	C	9.7
	POP	2.0	3.0	21.7	41.6	C	17.1
	Rougheye Rockfish	2.9	2.7	2.6	5.8	C	3.5
	Sablefish	9.6	79.7	15.4	1.9	C	26.6
	Spiny Dogfish	26.3	26.2	247.9	59.4	C	90.0
	Widow Rockfish	14.1	45.9	100.4	43.9	C	51.1
	Yellowtail rockfish north of 40 10 N. lat.	8.4	29.8	50.0	0.9	C	22.3
SS	Darkblotched Rockfish	2.4	21.2	13.7	18.9	15.4	14.3
	POP	6.8	26.4	4.9	7.9	36.2	16.4
	Rougheye Rockfish	1.9	0.3	0.0	7.6	8.7	3.7
	Sablefish	0.8	20.6	15.6	19.2	4.7	12.2
	Spiny Dogfish	134.4	84.3	358.7	309.7	106.1	198.7
	Widow Rockfish	128.0	201.7	229.2	333.8	278.1	234.2
	Yellowtail rockfish north of 40 10 N. lat.	180.2	201.3	75.6	250.3	270.6	195.6

While there is considerable annual and seasonal variability in the bycatch of these species, for most of the species highlighted in the tables above, it appears as though there is less caught on average in the second half of May compared to the later months. If vessels were able to shift effort into May 1-14 and exhibit the same lower bycatch patterns as May 15-31, particularly for the MS and CP sectors, this could lead to potentially less overall bycatch in a year as there would be less bycatch in the fall. One exception may be for yellowtail rockfish with average mortality in the last two weeks of May being three to nearly 20 times higher than the fall months. For the shoreside fishery, given the recent trends and competing fishing priorities such as MS or midwater rockfish, there would likely be minimal impacts overall to other species.

2.3.3 Salmon Impacts

A primary consideration with moving the season start date earlier in the year is the potential interactions with salmon. Fisheries in the groundfish FMP currently operate under the 2017 Biological Opinion (2017 BiOp). All Pacific whiting fisheries (tribal and non-tribal) operate within a guideline of 11,000 Chinook salmon and 494 coho salmon. Table 8 describes the catch of Chinook and coho salmon by sector from 2016-2020 and the overall percent of the whiting sector guideline taken for each year. Overall, the combined sector bycatch has been well within the guideline, with the highest bycatch of Chinook salmon in 2018 and 2019 the highest take of coho salmon. While these data may represent the best estimate of salmon bycatch under current conditions, future bycatch of salmon in whiting fisheries depends upon the spatial and population dynamics of both species, with the added layer of climate effects upon each. For an in-depth discussion on climate impacts to Chinook salmon and whiting, please see Appendix A.

Table 8. Chinook and coho salmon bycatch by whiting sector, 2016-2020. Source: PacFIN

Species	Sector	2016	2017	2018	2019	2020
Chinook salmon	SS	734	1,396	1,334	2,147	1,724
	MS	369	721	2,572	791	67
	CP	2,683	3,048	2,951	2,648	668
	Tribal	201	560	169	13	8
	Total	3,987	5,725	7,026	5,599	2,467
	% of guideline (11,000)	36.2%	52.0%	63.9%	50.9%	22.4%
Coho salmon	SS	5	27	11	168	86
	MS	0	0	0	4	2
	CP	2	0	0	5	0
	Tribal	1	6	1	4	0
	Total	8	33	12	181	88
	% of guideline (494)	1.6%	6.7%	2.4%	36.6%	18.6%

Alternative 1 would allow for two weeks of fishing during a time of year where there has been no fishing by the at-sea sectors in over two decades and little to no activity in the shoreside sector in the areas north of 40° 30’ N. lat. over that same time. The 2017 BiOp stated that:

> "Significant uncertainty exists in the magnitude of evolutionarily significant unit (ESU)-specific impacts for fisheries in locations or time periods outside the available data. Areas south of 42° N. latitude and during the January-to-May period have particularly limited information. For example, ESUs with early freshwater entry timing, like Upper Willamette spring and Snake River spring/summer stocks, may be underrepresented in the genetics data. These stocks are thought to be present in ocean areas in the winter period; however, whiting fisheries have not occurred in the January- to mid-May period since the mid-1990s. Historical CWT [Coded Wire Tag] recoveries indicate that about one third of the recoveries for the Upper Willamette Chinook were prior to the current May 15th start date for the fishery" (page 189).

Term and Condition 2.d. of the 2017 Salmon Incidental Take Statement (ITS) states that "The Council and NMFS shall retain the following restrictions to minimize Chinook bycatch for the duration of this opinion: …. The delay of the start of the primary Pacific whiting season until May 15th for all sectors, north of 40° 30′ N. latitude". Therefore, central to this action is the determination of what impacts would occur to salmon during the additional two weeks under the proposed alternative start date.

As described in the 2015 Environmental Assessment (EA) to support the change in the shoreside whiting fishery start date to be May 15th for all areas north of 40° 30' N. lat., "With respect to salmon bycatch rates in the early season, the 1997 whiting season EA observed that prediction of bycatch rates by season is difficult, and the greatest risk of elevated salmon bycatch for the shorebased whiting fishery appeared to be in late April and early May." (PFMC, 2015) Ultimately, the 2015 EA concluded the same as the 1997 EA in that "It would be difficult to predict the impact of changing season timing on salmon bycatch, especially on a year-to-year basis, as could occur under the proposed framework."[5]

The following section attempts to predict the potential changes in salmon bycatch in the non-tribal whiting fisheries in relation to the 2017 BiOp and ITS. Note that under both No Action and Alternative 1, management measures, such as salmon mitigation plans (SMPs) and block area closures (BACs), would still be actionable. Further, required sampling protocols, including the gathering of genetic information, would continue to be collected under Alternative 1 which would reduce the uncertainty of stock composition (discussed in Appendix B) within the May 1-14 time period.

For coho salmon, given the low take over a five-year period for the at-sea sector (Table 8) and considering fewer than three were taken by the SS fishery in May from 2016-2019, it is likely that there will be minimal to no additional impact to coho salmon by moving the start date to May 1st. Even if there were additional impacts in the May 1-14 period, the whiting sector as a whole has averaged 19.2 percent of the guideline since the ITS was issued in 2017 suggesting that there would be negligible risk to the guideline with an extension of the season. No further discussion will therefore be discussed related to season start date impacts to coho salmon.

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[5] The proposed framework referenced here is that of the framework to change the season start date described in Section 2.1.

In the proposed action for the 2017 BiOp, estimates of Chinook salmon bycatch for the non-tribal whiting sectors were produced for each sector using a simulation-based bootstrap model. Estimates were projected based on a TAC of 500,000 mt and assumed an average percent attainment (2008-2016) and full attainment for each sector as well as a northern and southern distribution scenario for the at-sea fleets and the influence of tribal whiting fisheries on Chinook salmon impacts. Based on those projections, it was concluded that the whiting sectors would likely stay within the 11,000 Chinook salmon threshold under a northern distribution, but may be more likely to access the 3,500 Chinook salmon reserve under the southern distribution.

For this analysis, estimates of potential total Chinook salmon impacts from the additional two weeks of fishing were produced for each of the three non-tribal whiting sectors using the same simulation-based bootstrap model developed during the 2017 BiOp. For full details on the methods, assumptions, and results, see Appendix A. In terms of Chinook bycatch in the May 1-14 period, the analysis shows that higher whiting harvest is associated with higher Chinook bycatch, and the scenario with more southern effort by the CP sector produced somewhat higher projected bycatch than an assumption of northern effort for that sector (Figure 1).[6]

[6] Substantial latitudinal variation in effort among years was only apparent for the CP sector (see Appendix A for further details).

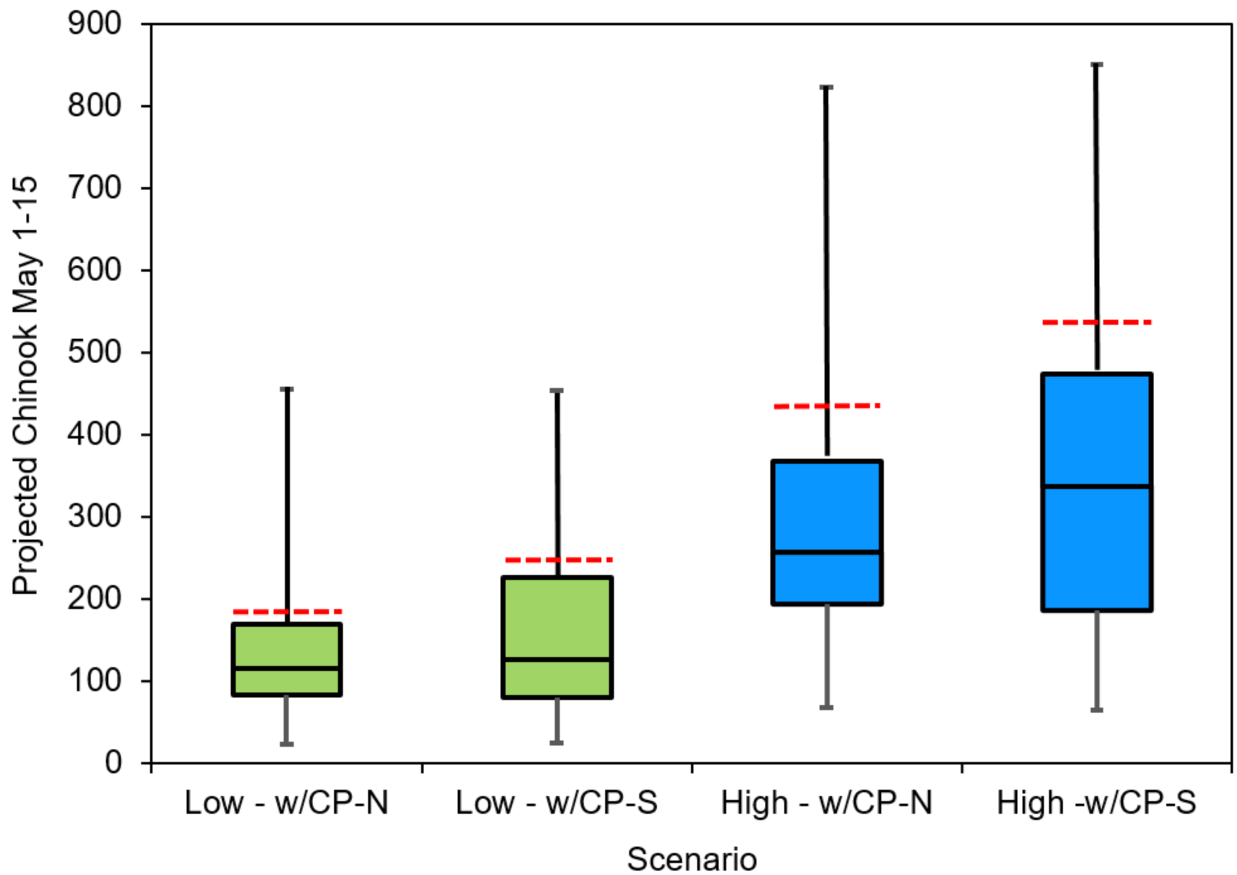

Figure 1. Quartile box plot of projected total Chinook bycatch counts, for each of four fishery-level scenarios modeled, summed across the three whiting fishery sectors. The red dashed lines show the 80th percentile of the projected distribution. The black line in the center of each box shows the median, the top boundary of the boxes show the 75th percentile, the bottom boundary shows the 25th, and whiskers show minimum and maximum values of the predicted distribution. Each box plot includes projections for the MS, SS, and CP sectors. The abbreviation "w/CP-N" means including an assumption of a northern effort distribution in the CP sector, and "w/CP-S" means including an assumption of southern effort distribution for the CP sector.

In order to understand the impacts of the season start date change within the results of the 2017 BiOp, a range of possible outcomes for the non-tribal whiting fishery was developed and is expressed using an aggregate of the results by adding the low, middle, and high total fishery projections from the four scenarios modeled (using 80th percentile projections for the May 1-15 period, Table A-1 from Appendix A), to the low, middle, and high values among the most recent five years of annual whiting fishery bycatch (2016, 2017, and 2018 respectively). The results ranged between 3,977 and 7,381 total Chinook salmon per year, with a middle value of 5,538 per year which represents a relatively modest increase in annual bycatch, of between 5 and 7.6 percent, and a median increase of 6.4 percent.

In terms of the overall risk to the guideline and need to access the Reserve in a given year, impacts from tribal fisheries must also be considered. Estimates of total Chinook salmon bycatch with the additional two weeks of fishing for the entire whiting fishery (tribal and non-tribal) are between 4,178 and 7,550 Chinook salmon with a middle value of 6,098 per year. These estimates are still well below the whiting bycatch threshold of 11,000 fish (from 38 to 69 percent), suggesting that the impacts from Alternative 1 would still be within those analyzed within the BiOp in terms of overall Chinook salmon harvest.

One of the key assumptions of the analyses is that the change in season start date would result in an overall net increase in effort and harvest across the three modeled sectors, rather than a shift toward fishing earlier in the year. However, given the attainment trends seen in Table 1, it is likely that there may be some degree of a shift in effort rather than a strict increase in effort for some or all sectors. Any shift in effort toward early season catch is likely to decrease total Chinook bycatch numbers, if it trades off with fall effort, when most of the Chinook salmon bycatch typically occurs. The likelihood for each sector to (or ability to) shift effort, depends largely on their current attainment trends and resulting ability to accommodate the expected additional early May catch, with the available allocation. Higher attainment leaves a lower remainder unharvested and the expectation for more shifting of effort to accommodate additional expected early May catch.

For the CP sector, an average attainment of 90 percent of the post-reapportionment allocation has left an average of 13,839 mt of whiting unharvested from 2017-2019 (or nearly 21,000 mt if 2017 is excluded where attainment was 99.9 percent). Yet, even if tribal reapportionment were not to be issued, with the exception of 2015, the CP sector has left less than 8,000 mt of the initial allocation unharvested with the majority of years being fully harvested (i.e., taken the full allocation plus some portion of the reapportioned allocation). Therefore, if the sector were to harvest 25,000 to 45,000 mt during the first two weeks as simulated in the bootstrap analysis, it would mean that a similar amount of fish would need to go unharvested in the later part of the year. As shown in Figure 2 below, the majority of salmon caught in the CP sector occurs in the latter half of the season. From 2016-2019, the sector took an average of 2,390 salmon (or 84 percent of the total take) after September (i.e., when B season in AK typically concludes; see Section 2.3.1 for more details); yet only an average of 34 percent of the whiting catch occurred within that same time frame. Therefore, it is likely that under Alternative 1, the CP sector will see less overall salmon bycatch if they choose to fish early; although, it is possible that the impacts to individual ESUs may be different as interactions can vary by season and latitude.

For the SS fishery, as efforts and landings earlier in the season have been increasing (Table 3), some effort shift for select vessels earlier in the season may also be likely depending on the portfolios of those vessels and what opportunities are available at that time. The SS sector has averaged approximately 12,000 mt of unharvested allocations between 2017-2019 and are projected to take between 5,000-15,000 mt in the additional two weeks. This suggests that on the fleet level, assuming that effort patterns stay the same, the salmon impacts are likely to be additive rather than an overall shift. If there is a continued shift to fishing earlier in the year, then overall salmon impacts may be lower with stock-specific impacts changing due to a shift in timing.

For the MS fishery, under recent attainment trends, it is possible (and likely) that there will be a net increase in effort and harvest under Alternative 1 compared to No Action; therefore, salmon bycatch estimates could be additive to recent bycatch amounts. The average whiting amount unutilized from the initial MS allocation has averaged nearly 20,000 mt from 2017-2019. Yet, the two-week addition to the season would likely result in a projected additional whiting harvest ranging from 10,000 to 30,000 mt. If the sector were able to take the higher end estimate, then it is likely that a shift in overall effort would need to occur as catch would be higher than the average unharvested amount (in order to stay within the recent allocation levels). Therefore, if a shift in effort did occur, it is likely accommodative of the allocation and the impacts to overall Chinook salmon bycatch and to specific stocks encountered may still vary within the range projected for the MS sector described in Appendix A. However, if whiting catch only increased by 10,000 mt, then effort in the fall may stay similar to recent years, leading to overall net increase in salmon bycatch as described above. Even with the potential for shift in effort or additional effort compared to recent years, estimates are still within those produced for the 2017 BiOp.

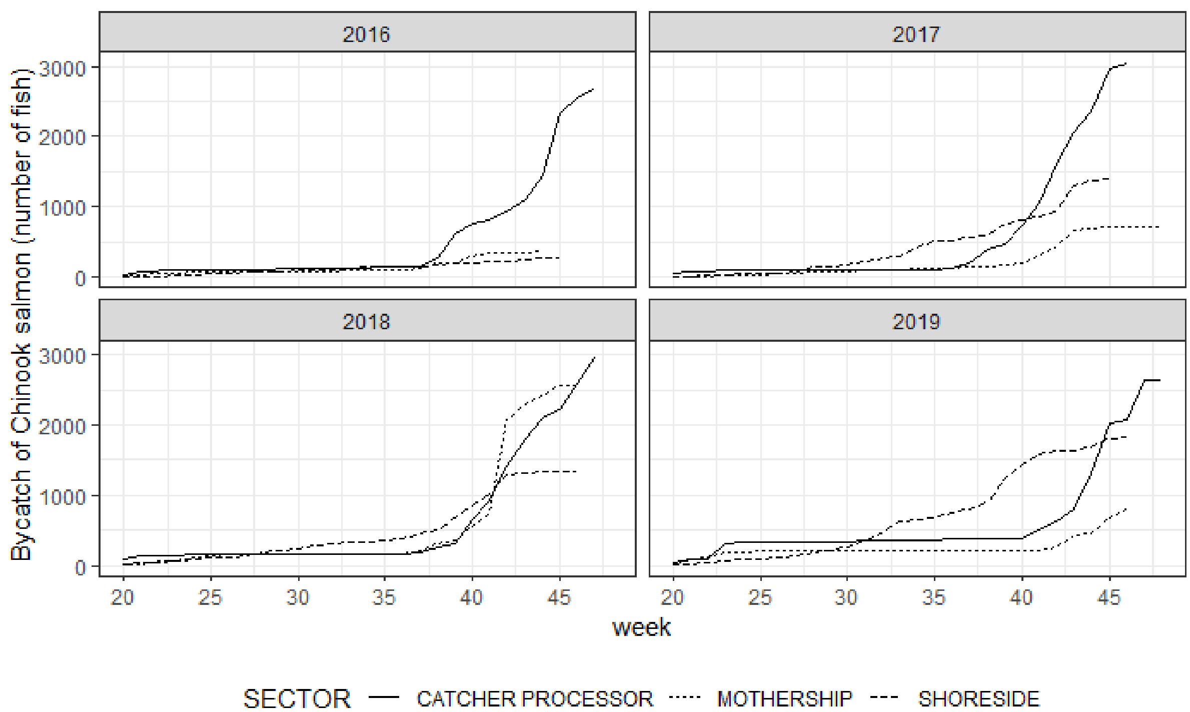

Figure 2. Cumulative Chinook salmon bycatch by week and whiting sector,2016-2019. Source: PacFIN and WCGOP

In addition to considering overall impacts to Chinook, the impacts to individual ESUs must also be considered as the stock composition of bycatch changes depending on where and when the Chinook salmon are caught. We provide some preliminary analysis and general conclusions in this document; a detailed summary of the methods and additional data summaries for this analysis will be provided prior to final action that is scheduled for March 2022..

Using the 80th percentile estimates from Figure 1 above, Table 9 below shows the estimated ESU specific impacts in the May 1-14 period. As in Figure 1, four sets of impacts are presented based on the distribution of the CP fleet (north/south; MS and SS are coastwide projections) and catch (low/high) scenarios described above. ESA-listed ESUs are shown in bold. With a more northerly distribution by the CP fleet, the estimated catch of certain stocks such as Lower Columbia and Puget Sound may be higher. If the CP sector fishes in a more southerly pattern, catch of California Coastal Chinook may be higher. Yet, given that the overall amount of Chinook salmon harvest under Alternative 1 is estimated to be within the levels produced from the 2017 BiOp and the

Chinook salmon threshold from the whiting sector and that the composition of stocks expected to be caught in the May 1-14 are the same as those examined in the BiOp, the overall impacts are still likely to be within those described in the 2017 BiOp (See Appendix B for draft initial findings and conclusions). Council and NMFS staff are working on supplemental analysis to assess the ESU impacts in the context of the abundance of the population using exploitation rates as was done in the 2017 BiOp and described on page 2-154 (NMFS, 2017).

Table 9. Combined Dirichlet and multinomial logistic regression predictions for Chinook salmon bycatch (counts for individual ESUs) across sectors from May 1-14 under various scenarios of catch/effort distribution and harvest level.

Number of Chinook from 80th Percentile	**Scenario (Distribution/Effort)**	**Sacramento Winter**	**Central Valley Spring**	Central Valley Fall	**California Coast**	Klamath/Trinity	S Oregon/N California	Oregon Coast	Washington Coast	**L Columbia R**	**U Willamette R**	Mid-Columbia R Spring	**U Columbia R Spring**	Deschutes R Summer/Fall	U Columbia R Summer/Fall	**Snake R Spring/Summer**	**Snake R Fall**	**Puget Sound**	Southern BC	Central BC-AK
188	North/Low	**0**	**1**	8	**8**	45	36	25	1	**12**	**1**	1	**1**	2	7	**1**	**3**	**11**	20	3
421	North/High	**0**	**2**	18	**17**	98	79	56	3	**28**	**3**	2	**2**	6	17	**3**	**8**	**26**	47	6
244	South/Low	**0**	**1**	10	**13**	95	70	19	1	**6**	**1**	1	**1**	2	4	**1**	**2**	**6**	10	1
523	South/High	**0**	**2**	22	**26**	189	140	46	2	**18**	**2**	2	**2**	4	12	**2**	**5**	**17**	30	4

Note: Bolded stocks are ESA listed ESUs.

3 Administrative Alternatives

The other three items included in the range of alternatives are administrative in nature and are likely to have no biological or physical impacts beyond those disclosed in the 2015-2016 EIS and the 2021-22 harvest specifications tiered EA.

Mothership Processor Obligation

- Status Quo: Mothership processor obligation made by November 30 through mothership catcher vessel endorsed limited entry permit renewal.
- Alternative 1: Remove mothership processor obligation from regulation.

Mothership Processor Cap

- Status Quo: 45%
- Alternative 1: 65%
- Alternative 2: 85%
- Alternative 3: Remove mothership processor cap from regulation.

Mothership Processor & Catcher-Processor Permit Transfer

- Status Quo: A vessel cannot be registered to a mothership permit and a catcher-processor permit in the same calendar year
- Alternative 1: A vessel can be registered to a mothership permit and a catcher-processor permit in the same calendar year.

    i. Sub-option A: A vessel can switch between the mothership sector and catcher-processor sector up to two times during the calendar year through permit transfer.
    ii. Sub-option B: A vessel can switch between the mothership sector and catcher-processor sector up to four times during the calendar year through permit transfer.
    iii. Sub-option C: Unlimited transfers.

3.1 MS Obligation

3.1.1 Background

During the development of Amendment 20, the Council initially proposed that the MS co-op would operate similar to the Alaska fisheries in that a MSCV would be tied to a processor and in order to obligate to another MS, a CV would have to enter the open access or non-co-op fishery for a year. However, the Council chose to forgo the processor tie or linkage provision alternative and instead adopted the obligation deadline.[7] Each year by November 30th, a MSCV must declare to NMFS whether they would be participating in the co-op or non-co-op fishery and to which processor they are obligating their catch history assignment (CHA).[8] CHAs cannot be divided or separated from the initial permit it was issued to under Amendment 20. A MSCV can be released

[7] For history of dates, see Agenda Item G.3, Attachment 1, March 2021.
[8] This date aligns with the limited entry permit renewal process.

from a processor obligation through a mutual exception agreement (MEA) and commit to a new MS permit.

This management measure was "intended to provide for some certainty to the mothership on a short-term basis without raising some of the legal complexities that were raised by National Oceanic and Atmospheric Administration (NOAA) General Counsel (GC) over the linkage provision." (Appendix B to Amendment 20 FEIS) It also avoided some of the penalty components associated with the linkage provision (i.e., having to go into the non-co-op fishery for a year before committing to a new processor) but provided some short-term certainty for MS companies in business planning for the upcoming fishing season. Furthermore, it was intended to provide an opportunity for motherships to benefit from rationalization, or at least minimize some potentially adverse impacts on motherships that may occur as a result of rationalization. Specifically, the "Council heard substantial amounts of testimony and considered analysis which indicated that rationalization would tend to benefit harvesters but without a provision to specifically address the interest of processors, opportunism existed to shift the balance of power in the industry toward harvesters' favor at the expense of processors. The processor tie was viewed as one mechanism which may work at striking a balance between the harvester and the processor when a fishery moves to rationalization." (Appendix B to Amendment 20 FEIS)

3.1.2 Description of Alternatives

Under this item, the ROA adopted by the Council is:

No Action: Mothership processor obligation made by November 30 through mothership catcher vessel endorsed limited entry permit renewal.

Under No Action, MSCVs would still be required to obligate their CHA to a MS permit by November 30 during the limit entry permit renewal process. This would not require a change in federal regulations.

Alternative 1: Remove mothership processor obligation from regulation.

Under this alternative, MSCVs would no longer be required to notify NMFS of the MS permit that they would obligate their CHA to in the following year. MSCVs would instead obligate their CHAs to a MS through individual agreements or within the WMC. This would require a change in federal regulations. Vessels would still be required to notify NMFS of their participation in the co-op or non-coop fishery.

3.1.3 Analysis

Under No Action, CVs would still be required to obligate their CHA to a MS by November 30th of the prior fishing year. Previous comments by industry have mentioned how this can cause some discomfort for some MSCVs in having to obligate in the current year for the following fishing year. An example might be that a MSCV is in a situation where they are wanting to deliver to another vessel or company while still obligated to a different company. As noted earlier, under

No Action, MS and MSCV contracts can be modified to release a vessel from its obligation through an MEA.

Currently, there are administrative costs associated with No Action that are cost recoverable; however, these costs are likely negligible as the obligation process co-occurs with the LEP renewal process (which would still be required for MSCVs) and inseason changes to processor obligations are not specifically tracked by NMFS.

Alternative 1 would remove the MS processor obligation deadline from federal regulations and MS and MSCVs could work independently of the government to ensure MSCVs have a platform for delivery. It's likely that MSCV endorsed LEPs would obligate their CHA through private arrangements or within the WMC. There would be no longer be a requirement for MSCV-endorsed permit owners to notify NMFS of an MEA nor require NMFS to track the obligations. Additionally, if a MSCV wanted to change the obligation mid-season through an MEA, for example, if a MS was unable to process that catch, no additional paperwork processing would be required by harvesters, processors, or NMFS. Several comments by industry and in public comment[9] have noted the occurrences of MSCVs being unable to deliver to a processor for a season or multiple years. Therefore, this may have an indirect benefit of security for MSCVs to find a processor that could take their catch as well as flexibility to change processors inseason without regulatory delay. While not a part of the initial suite of alternative obligation deadlines to be considered in this process, the GAP supported eliminating other potential date changes in favor of having this internal process between MSCVs and MS companies or within the WMC (Agenda Item G.3.a, Supplemental GAP Report, March 2021).

There is likely little to no change in administrative costs that would be cost recoverable under Alternative 1 compared to No Action. MSCVs would still be required to renew their LEPs each year, which includes the co-op declaration for the following year. Co-op(s) would also still be required to submit their annual application per 660.150(d)(1)(iii)(A). The most direct benefit would likely be in fewer administrative costs to the industry in needing to notify the NMFS of MEAs inseason. Quantitative summaries of the cost savings to NMFS or the industry is not possible since these particular transactions are not tracked via the cost recovery itemization methods within NMFS.

3.2 MS Processor Cap

3.2.1 Background

Under Amendment 20, accumulation limits were imposed to prevent excessive concentration of catch allocations. Accumulation limits for the whiting sector include processing caps, ownership limits, and harvest limits. The Council set a processing cap for the MS sector at 45 percent, which was intended to inhibit consolidation by ensuring that at least three MS companies would participate in the fishery. As described in Agenda Item G.4.a, Supplemental WDFW Report 1, November 2018, it was thought at the time that even if two MS companies processed 45 percent,

[9] Link to record on page 32 of https://www.pcouncil.org/documents/2018/09/september-2018-meeting-record.pdf/

the remaining ten percent available for processing would provide enough incentive for a third MS company to participate in the fishery.

The MS permit usage limit (i.e., processing cap) is defined as "the maximum amount of the annual mothership sector Pacific whiting allocation that a person owning an MS permit may cumulatively process, no more than 45 percent, as described at §660.150(f)(3)(i)." A "person" is defined as "any individual, corporation, partnership, association or other entity (whether or not organized or existing under the laws of any state), and any Federal, state, or local government, or any entity of any such government that is eligible to own a documented vessel under the terms of 46 U.S.C. 12103(b).". As the word "person" is typically associated with only an individual, the following discussion will use the word "entity" to describe the individuals, corporations, and other groups in which the regulations pertain.

The processing limit is assessed via the "individual and collective" rule as outlined at 50 CFR 660.150(f)(3). In simple terms, entities are held to the 45 percent processing limit based on how much they own of the permit(s) that is used for processing. For example, in Figure 3, permit MS0001 processes 40 percent of the whiting allocation in a year. Permit MS0001 is owned by Company A, which is owned equally by Individuals B and C. Therefore, company A would have processed 40 percent, and Individuals B and C would have processed 20 percent. However, the evaluation of the accumulation limit must also take into consideration each entity's ownership of other permits- in this example, MS0002, which processed 20 percent of the allocation. Company B owns 100 percent of MS0002 and Company B is owned by Individuals D and C equally. Individual D would therefore be associated with processing 10 percent of the allocation and Individual C would be associated with 10 percent. Overall, this means that Individual C would have processed a total of 30 percent of the whiting allocation in a year.

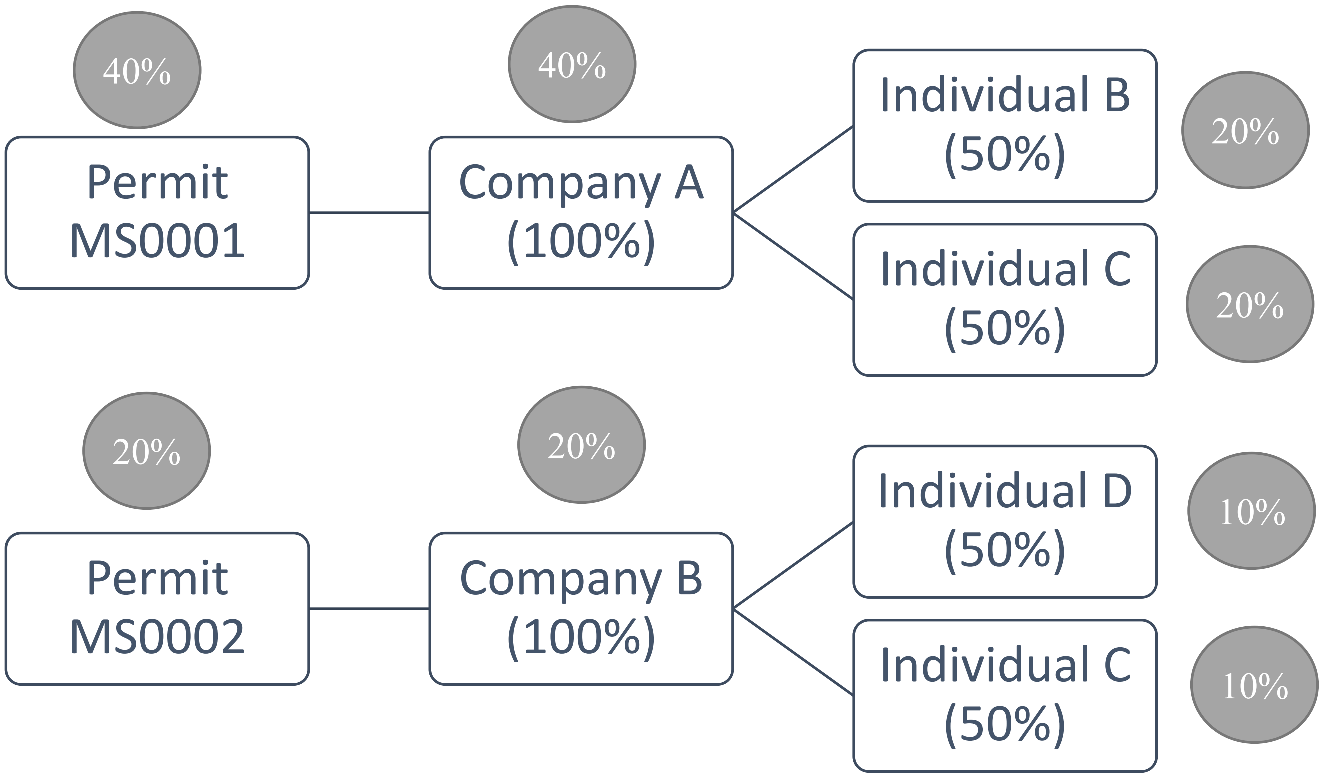

Figure 3. Diagram of individual and collective rule for MS processing limit. Percent of whiting processed shown in grey circles. Ownership of permit/entity shown in boxes.

As a reminder, the MS sector is the only sector with a processing limit. There are also two additional accumulation limits in the MS fishery as MSCVs are held to a 20 percent accumulation limit of the whiting CHA and a catch limit of 30 percent of the allocation. As noted in Appendix B of Amendment 20, "Since motherships and catcher vessels are both dependent on the fishery, accumulation limits for both catcher vessels and motherships were set while taking into account the balance of power between catcher vessels and motherships and the relationships that may be established and changed through fleet consolidation." A processing limit was considered for the CP sector as a part of the follow-on catch share actions; however, it was rejected in favor of an ownership limit. For the shoreside IFQ program, first receivers are not restricted on the amount of IFQ fish they can process, although are subject to the same QS ownership restrictions as other IFQ participants (10 percent for Pacific whiting). Shoreside vessels are also restricted to annual vessel limits, which is 15 percent for Pacific whiting.

3.2.2 Description of Alternatives

The Council adopted the following as the ROA in March 2021 for the MS processing limit:

No Action: 45 percent
Under No Action, no entity could process more than 45 percent of the MS sector allocation. This would not require a change in federal regulations.

Alternative 1: 65 percent

Under this alternative, no entity or individual could process more than 65 percent of the MS sector allocation. This would require a change in federal regulations.

Alternative 2: 85 percent
Under this alternative, no entity or individual could process more than 85 percent of the MS sector allocation. This would require a change in federal regulations.

Alternative 3: Remove mothership processor cap from regulation.
Under this alternative, the mothership processor cap would be removed from regulation and there would be no restrictions on the amount of the MS sector allocation that an entity could be processed. This would require a change in federal regulations.

3.2.3 Analysis

As described in Appendix B to Amendment 20,

> "A usage limit affects the amount of consolidation that can occur in the mothership processing portion of the whiting fishery. Consolidation can affect ex-vessel price negotiations and/or revenue sharing. The fewer mothership processors, the more leverage each mothership processor has in negotiating over exvessel prices or profit sharing arrangements. In addition, consolidation can improve the efficiency of the mothership processing sector. If greater quantities per mothership vessel result in greater cost efficiencies, then consolidation may result in a more efficient use of capital resources and greater net benefits to society. Consolidation also depends on fluctuations in the whiting [optimum yield] OY. During a low OY year, it may be appropriate to allow fewer motherships to process whiting compared to a year when the whiting OY is relatively high."

Since 2011, based on publicly available data, there appears to have been no consolidation of the six MS permits, with two companies owning two permits each and two companies owning a single permit. With the exception of 2015, five to six permits were used to process whiting each year since 2008 (see Table 12 in Agenda Item G.3., Attachment 1, March 2020), however, the amount of processing varies by permit and company.

Figure 4 evaluates the amount of whiting an entity has processed at the individual and collective level from 2015-2020. The left panel shows the processing percentage for all groups (corporations, not for profits, etc.) where the right panel is for all individuals. Entities could be represented multiple times in the same column (if processed the same range of whiting each year) or could be represented in multiple columns.

From 2015-2020, there were only six instances (year/entity combination) where a group processed more than 20 percent of the allocation (i.e., around half of the processing limit; Figure 4). No individuals have exceeded a processing percentage of more than 16 percent in that same time period. Therefore, it does not appear that there is a current problem in terms of entities being constrained by the processing limit. However, what is not captured in this figure is the potential impacts of the processing limit in the future and how it may continue to limit overall attainment of the MS allocation.

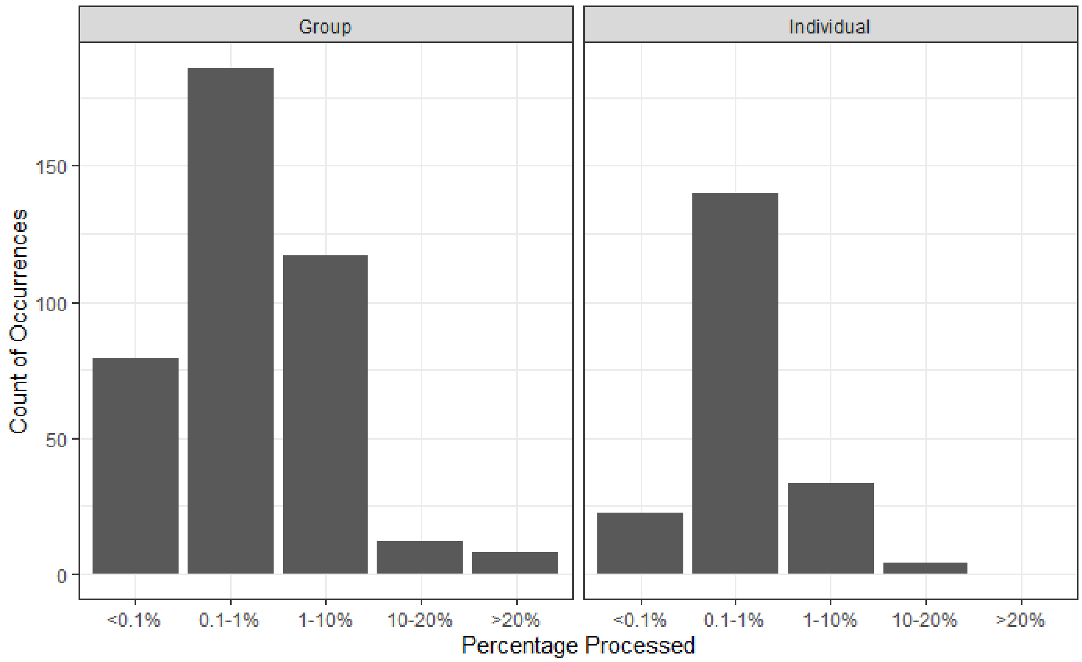

Figure 4. Count of number of occurrences from 2015-2020 by the amount of the whiting allocation processed by an entity. Groups include all corporations, not for profits, businesses, etc.

Appendix B to Amendment 20 noted that it "During a low OY year, it may be appropriate to allow fewer motherships to process whiting compared to a year when the whiting OY is relatively high". While recent years TACs have been at recent historical maximums (~450,000 mt), it was less than a decade ago that the TAC was at ~186,000 mt, or approximately 1/3 of the recent levels (see Figure 1 of Agenda Item D.2.a, Supplemental GMT Report 3, September 2020). Further, recent stock assessments have shown a decline in the whiting population due in part to a lack of strong recent recruitment suggesting that TACs may continue to decrease as well. We note that when the Council was developing Amendment 20, the Council initially considered a range of processing limits from 20 to 50 percent under US whiting TACs ranging from 170,000 to 300,000 mt, which at the time, these were considered reasonable high and low bounds.

Table 10 below shows the associated processing limits under a range of allocations between 2011-2019, including the minimum and maximum initial allocations and the 2015 allocation which represents close to the average allocation across the time series. Annual processing amounts by entity (processing percentage times the allocation in that year) during the baseline period (2017-2019) were then compared to amounts associated with the alternative processing limits under the lowest (2012), average (2015) and highest (2019) TAC scenarios. There were ten instances (year/entity combinations) between 2017-2019 where an entity was associated with greater than more than the 45 percent processing limit (14,632 mt), under the lowest TAC scenario. There were also four occurrences where an entity processed more than the 65 percent limit under alternative 1 (21,135 mt) under the lowest (2012) allocation. Looking at just the MS vessels themselves (not taking into account ownership), there have been five instances (year/vessel combination) over the baseline period where a single vessel has processed more than 45 percent of the lower TAC processing limit. Therefore, it appears as though the current MS fleet has participants with the ability to process more than 45 percent under a lower TAC, such as in 2012. Processing capacity is dependent on several factors, including available fishing time, market demand, storage capacity, and labor availability. While a vessel may not have been able to actually process recent levels of whiting in 2012 due to lack of whiting abundance, processing limits, etc., the analysis does show what MS vessels could have been able to potentially process in a season under the various proposed limits and under various TAC scenarios, if regulations would have allowed for increased flexibility or with future expected capacity changes (such as a vessel being able to stay the entire season on the West Coast). Additionally, while Alaska pollock is primary revenue component for these vessels currently (described in Section 2.3.1), the impacts of climate change on both stocks are uncertain. If Alaska pollock fisheries were to decline due to changing ocean conditions and whiting opportunities persisted, processors may shift their operations to focus more on whiting leading to increased attainments of the processing cap.

Table 10. Processing cap alternatives retrospectively applied to four allocations

Processing Cap Alternative	**MS Initial Allocation**		
	32,515 (2012- low in IFQ)	**64,004 (2015)**	**87,044 (2019- max)**
No Action: 45%	14,632	28,802	39,170
Alternative 1: 65%	21,135	41,603	56,579
Alternative 2: 85%	27,638	54,403	73,987
Alternative 3: Unlimited	32,515	64,004	87,044

Under No Action, it is likely that few, if any entities will come up against the current processing limit under average or higher TAC levels. However, as TACs decline or if market conditions change (e.g., pollock opportunities decline) or a new MS vessel allows for more sustained participation throughout the season, entities may start increasingly coming up against the processing cap. As noted in the Appendix B excerpt above, it may be appropriate for fewer than three motherships to participate when TACs are lower, as it would be too costly for three or more MS processors to participate.

If the processing limit was increased (Alternative 1 or 2) or removed (Alternative 3), it is still likely that more than one MS would continue to participate in the fishery. Several factors including Alaska pollock fishery opportunities and actual capacity of a single MS vessel suggest that it would be unlikely and probably not feasible for one vessel to process the entire allocation-particularly under recent high TAC levels.

Overall, the action alternatives are likely to increase benefits to processing entities who choose to participate as it could allow for higher overall profits compared to No Action. However, other processing entities could be outcompeted by another and therefore be negatively impacted. The impact to MSCVs under No Action compared to the action alternatives are less clear. On one hand, under Alternatives 1-3, MSCVs without a processor may be able to deliver to a processor that would have been previously unavailable due to the processing limit. These benefits may be greater under lower TAC conditions when it may not be as profitable for MS vessels to process in favor of other opportunities (e.g., pollock) and there are fewer MS processors available. Alternatively, No Action may promote more competition, which could lead to higher prices being paid to MSCVs compared to Alternative 3, where a single entity could theoretically control the pricing structure for the fishery.

3.2.4 Excessive Shares Consideration

The proposed alternatives for changes to the processing cap for the MS sector would allow for as few as one to two MS processing entities to process the entirety of the allocation. During Council discussion in March 2021, the question was raised about the consideration of excessive shares by making the processing cap unlimited. The Council may want to consider this in selecting the PPA and if it comports with National Standard 4 that outlines the factors for consideration in making allocations:

(3) *Factors in making allocations.* An allocation of fishing privileges must be fair and equitable, must be reasonably calculated to promote conservation, and must avoid excessive shares. These tests are explained in paragraphs (c)(3)(i) through (c)(3)(iii) of this section:

(i) *Fairness and equity.* (A) An allocation of fishing privileges should be rationally connected to the achievement of OY or with the furtherance of a legitimate FMP objective. Inherent in an allocation is the advantaging of one group to the detriment of another. The motive for making a particular allocation should be justified in terms of the objectives of the FMP; otherwise, the disadvantaged user groups or individuals would suffer without cause. For instance, an FMP objective to preserve the economic status quo cannot be achieved by excluding a group of long-time participants in the fishery. On the other hand, there is a rational connection between an objective of harvesting shrimp at their maximum size and closing a nursery area to trawling.

(B) An allocation of fishing privileges may impose a hardship on one group if it is outweighed by the total benefits received by another group or groups. An allocation need not preserve the status quo in the fishery to qualify as “fair and equitable,” if a restructuring of fishing privileges would maximize overall benefits. The Council should make an initial estimate of the relative benefits and hardships imposed by the allocation and compare its consequences with those of alternative allocation schemes, including the status quo. Where relevant, judicial guidance and government policy concerning the rights of treaty Indians and aboriginal Americans must be considered in determining whether an allocation is fair and equitable.

(ii) *Promotion of conservation.* Numerous methods of allocating fishing privileges are considered “conservation and management” measures under section 303 of the Magnuson-Stevens Act. An allocation scheme may promote conservation by encouraging a rational, more easily managed use of the resource. Or it may promote conservation (in the sense of wise use) by optimizing the yield in terms of size, value, market mix, price, or economic or social benefit of the product. To the extent that rebuilding plans or other conservation and management measures that reduce the overall harvest in a fishery are necessary, any harvest restrictions or recovery benefits must be allocated fairly and equitably among the commercial, recreational, and charter fishing sectors of the fishery.

(iii) *Avoidance of excessive shares.* An allocation scheme must be designed to deter any person or other entity from acquiring an excessive share of fishing privileges, and to avoid creating conditions fostering inordinate control, by buyers or sellers, that would not otherwise exist.

(iv) *Other factors.* In designing an allocation scheme, a Council should consider other factors relevant to the FMP's objectives. Examples are economic and social consequences of the scheme, food production, consumer interest, dependence on the fishery by present participants and coastal communities, efficiency of various types of gear used in the fishery, transferability of effort to and impact on other fisheries, opportunity for new participants to enter the fishery, and enhancement of opportunities for recreational fishing.

The Council could consider whether there would be excessive shares on two levels: either within the MS sector alone or across the whiting fishery. If the Council is only concerned about the ability for a single owner to process the entirety of the MS allocation, again, it is likely that more than one vessel (and owner) would likely participate in the fishery. While the processing cap may limit a MS to process a certain amount, it does not ensure that they would have the MSCVs to deliver that amount in a certain year. A processing entity would also still be held to the other accumulation limits regulating the MS sector, including the 20 percent ownership limit and the 30 percent harvest limit. This would be similar to the shorebased sector, where there are no processing limits and first receivers compete to purchase products at different times and locations and can only own up to a QS limit for each species.

If instead the Council was more concerned about the changing of the processing limits in the scope of the broader whiting allocation, the discussion from PFMC (2018) on considering processing limits and the issue of excessive shares for the CP sector under Amendment 21-4 may provide some insight:

"The impacts of a processing limit will likely be distributional and may also impact net benefits if efficiency could be increased through higher levels of processing consolidation without adversely impacting efficiently functioning product markets (i.e., without creating market power that interfered with competitive market functions) …. Given that a permit owner in the CP sector also competes with harvesters in the IFQ sector and processors in the MS sector, even a 100 percent accumulation limit in the CP sector might not give the permit holder unlimited control of the product market because of competition from entities in the shorebased and MS sectors, as well as other sources of whitefish that substitute for whiting in the market. However, because ownership extends across sectors, the possibility for more extensive control exists, which could be inhibited by processing or ownership accumulation limits. "

The same logic holds true for the MS sector. Even if an entity was able to process the entirety of the MS allocation under Alternative 3, there would still be competition from other owners across the other whiting sectors and other fisheries that produce whitefish. Additionally, as described above, the other accumulation limits for the MSCVs would remain in place.

3.3 MS Processor & CP Permit Transfer

3.3.1 Background

Currently, there is a prohibition for processors in the at-sea Pacific whiting fishery from operating as both an MS and CP during the same calendar year. The origin of this prohibition dates to the implementation of the whiting sector allocations in 1997. At that time, specific limitations were placed on CP vessels to prevent these higher capacity vessels from harvesting other sector's allocations. During the development of Amendment 20, there was extensive consideration of permitting a processor to operate as a CP and an MS in the same fishing year. Specifically, in the initial ROA, the Council considered prohibiting a processor from acting as both a CP and a MS in the same month or at the same time (Appendix B to the Amendment 20 FEIS). The Council ultimately decided to maintain the original prohibition within Amendment 20. As noted in 85 FR 37027, the initial prohibition was implemented "to help ensure market stability in the separate sectors." Restricting CPs from also engaging in MS activity also was intended to protect existing MS processors in the sector and help ensure that they benefit from rationalization in addition to MSCVs.

Additionally, as described in 50 CFR 660.25, CP or MS endorsed permits are only allowed two transfers within their respective sectors in a calendar year, and the second transfer can only be back to the original vessel. Under Amendment 20, the Council considered having zero or only one transfer allowed (Appendix B to the Amendment 20 FEIS). However, the Council chose a two-transfer allowance to provide flexibility if a MS were unable to process catch (e.g., due to fire or a breakdown) or if unexpected opportunities arose in other fisheries (such as pollock) and another MS would be able to fill that role. The Council noted in Appendix B that, "A restriction on the number of transfers ensures that participation in the mothership processing portion of the fishery remains limited. This helps maintain stable relations between motherships and catcher vessels. In a fishery managed with processor linkages, stable relations between processors and catcher vessels translate into more stable operation of cooperatives." For the CP sector, a limit of two transfers was also recommended as part of the FPA in November 2008 which was a change from the single transfer recommended in June 2008.[10]

In April of 2020, the Council recommended that NMFS implement an emergency rule suspending this prohibition after one company that owned a MS permit would not be able to process as a MS in the 2020 season due to unforeseen health, economic, and safety risks and would be operating only as a CP (85 FR 37027). This left three MSCVs who had previously committed to this MS from having a platform to deliver their catch. Under this emergency rule, a processor could be *dual registered* to a MS and a CP-endorsed permit within the calendar year and would declare into one of the fisheries prior to leaving port. Note that the dual registration is different than the proposed mechanism for transfer between fisheries described in the alternatives section below. Council staff clarified the description of alternatives in Section 3.3.2 with the intent that vessels could not be dual registered (i.e., both MS and CP permits on a vessel at the same time) as this was the intent of the industry proposals. Further discussion is needed by the Council and the industry to ensure this is the intent of these alternatives.

[10] https://www.pcouncil.org/documents/2020/02/f-groundfish-management-november-2008.pdf/

One vessel did dual register to both a MS and CP-endorsed permit in 2020; however, that vessel only participated in the CP sector based on the annual co-op reports (Supplemental Informational Report 4, April 2021 and Supplemental Informational Report 5, April 2021). A second emergency rule was implemented in May 2021 which again suspended the prohibition on dual registration (86 FR 26439). At the time of the drafting of this document, no vessel appears to have been dual registered.

3.3.2 Description of Alternatives

No Action: A vessel cannot be registered to a mothership permit and a catcher/processor permit in the same calendar year.

Under No Action, a vessel could not be registered to a MS permit and a CP endorsed permit in the same calendar year. This would not require a change in federal regulations.

Alternative 1: A vessel can be registered to a mothership permit and a catcher/processor permit in the same calendar year.

Under this alternative, a vessel could be registered to a MS permit and a CP permit in the same year, but not at the same time (i.e., a vessel cannot dual register). This would require a change in federal regulation.

> Sub-option A: A vessel can switch between the mothership sector and catcher/processor sector up to two times during the calendar year through permit transfer.
>
> Sub-option B: A vessel can switch between the mothership sector and catcher/processor sector up to four times during the calendar year through permit transfer.
>
> Sub-option C: Unlimited transfers.

3.3.3 Analysis

Under No Action, a vessel could not operate as a MS and a CP in the same year, and both MS and CP-endorsed permits would be restricted to only two within sector transfers per year (i.e., could be transferred to another vessel and then the second transfer would have to be back to the original vessel as shown in Figure 5). Under No Action, attainment trends for both sectors described under Section 2.3.1 would likely continue or could even decline for the MS sector in the situation that was seen in 2020.

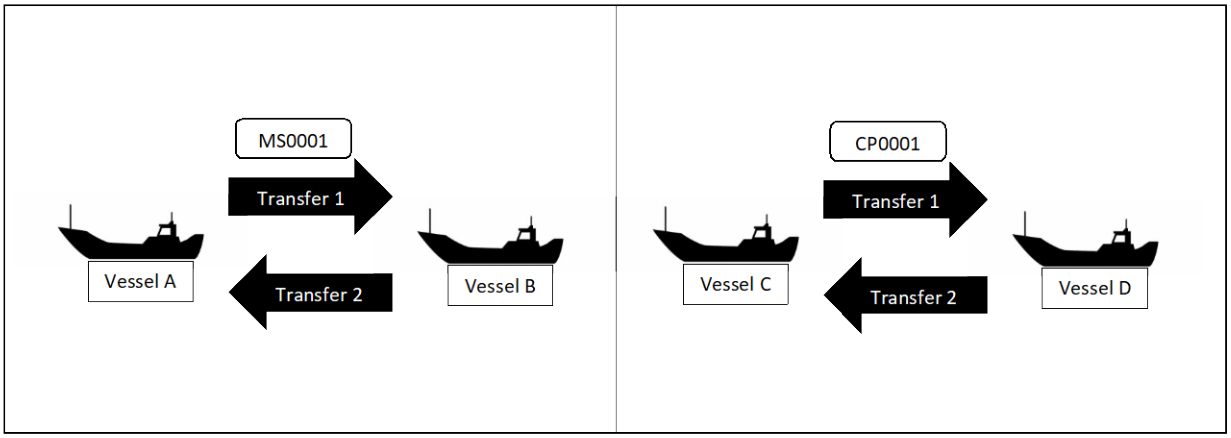

Figure 5. Diagram of No Action Permit Transfer Regulations

One of the primary issues under No Action is the lack of processing capacity in the MS sector. As noted in Agenda Item G.3., Attachment 1, March 2021 , there appears to be a significant issue of vessels being unable to harvest their CHAs due to the lack of processors. While there are typically five or six MS vessels that process in a given year, MS vessels do not typically remain on the fishing grounds throughout the entire season so there may not be processors available during optimum delivery times. As shown in Table 8 of Agenda Item G.3., Attachment 1, March 2021 , the average number of processors typically declines over the season.

Under Alternative 1, a processor could operate as a MS and a CP in the same year. Appendix B to Amendment 20 states that by allowing CPs to operate as MS (and vice versa) "effectively means that rationalization will allow consolidation to occur across the catcher-processor and mothership sectors rather than remaining within each of the two sectors. Over time, theory would suggest that (if catcher processors are allowed to operate as a mothership) the differentiation of catcher-processor and motherships would no longer exist. Instead, the fishery may be made up of several vessels which do a combination of catcher-processor and mothership activity in order to reach a more efficient point of production." The analysis speaks to several factors that could influence the impact of allowing CPs to act as MS, including the economic impact to the sector. For example, in theory, a vessel that engages as both a CP and a MS may be able to pay more to a MSCV than a typical MS vessel and still generate more revenue overall. This is because of the difference in cost structure of the two processor types. Assuming that the CP and MS are made up of the same capital, MS operations have higher costs than CP operations because MS processors must pay MSCVs for the fish to process, while CPs harvest and process the fish themselves.

Another consideration for this alternative is that of the six MS vessels that are linked to a current MS permit, only three are licensed as a CP in Alaska and therefore could also potentially participate as a CP in the whiting fishery. The three remaining MS vessels are not set up to operate as a CP and therefore would be unable to participate in the CP sector. For these vessels, there would not be the same opportunity to decrease average costs compared to those that could operate within both sectors. However, as noted by the GAP in March 2021, it was thought that the likelihood of a typical MS processor moving to operate as a CP would be low. While there have been limited instances of latent CP-endorsed permits, the likelihood of accessing a permit to operate in the CP sector may be limited unless there was common ownership of both permit types.

Within Alternative 1, there are three sub-options for the number of sector transfers that would be allowed based on the number of permit transfers- two, four, and unlimited. In other words, under sub-option A, a vessel could move into the other sector via permit transfer (i.e., transfer #1) and then return to its original sector (i.e., transfer #2). Figure 6 below provides a graphical representation of an example of sub-options A and B. Sub-option C would allow unlimited transfers.

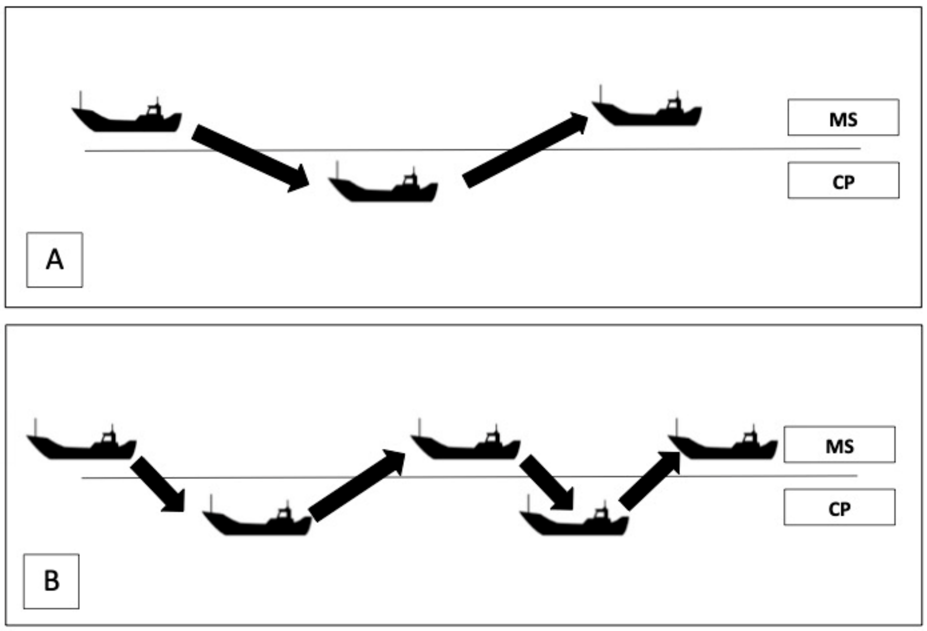

Figure 6. Diagram of proposed transfer limits sub-options A (top panel) and B (lower panel) between at-sea sectors under Alternative 1.

There are a few main factors that the Council needs to consider under this alternative: the actual number of transfers that are likely to occur between the sectors, the number of permits that may be transferred between vessels, and if by allowing more than two transfers would it create any unintended consequences. Based on industry input, the movement between fisheries would not be a logistically quick movement as the operations of the vessels (e.g., crew size, fishing set up) are not the same for a vessel in the CP sector and the MS sector. Given the prioritization of the Alaska pollock fisheries for B season, it may be unlikely for a vessel to participate as a CP and an MS prior to leaving for B season due to the seasonal timing constraints. This would mean that a transfer between sectors would likely occur when the vessels return to the West Coast in the late summer or fall. At that time, a vessel may be able to fish in the other sector and then return to the original sector to round out the season late in the year. However, if pollock opportunities were to decline or another factor led to vessels staying longer on the West Coast fishing for whiting, there could be a situation in which a vessel would want to operate more times within each sector.

As described above, the initial idea behind the two-permit transfer limit *within* the sector was to create a stable pool of MS processing vessels and relationships between MS and MSCVs. Opening the pool of potential processors in the MS sector by allowing typical CP vessels to operate as a

MS in the same year may provide additional processing capacity for MSCVs that have been without a processor. However, as described above, there could be economic impacts to historical MS processors if typical processors from the CP sector were able to pay higher price to MSCVs.

One thing that may need to be considered along with this alternative is a change to the current regulations on within-sector permit transfers. As shown in Figure 5, a permit can only be transferred twice- from a vessel to another vessel and then back to the original vessel. If the permit is taken off a vessel and unregistered, then there is no transfer counted. Under the proposed action alternative, if a company owns both a MS and CP permit and would only be using each permit on a single vessel (i.e., would have one of the permits unregistered at all times), then there would be no issue on the permit transfer limit (Figure 7).

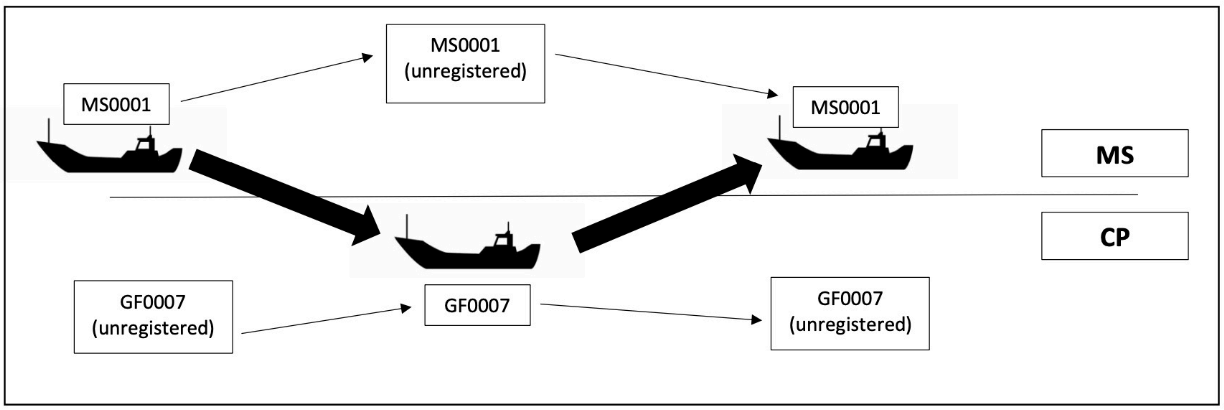

Figure 7. Diagram of a vessel transferring between the CP and MS sector through permit transfer utilizing an unregistered permit.

However, a situation could arise where a permit may not be eligible to be transferred if the within sector permit regulations are not modified. Figure 8 below provides an example of this situation. Vessel A (black vessel) begins the season operating as a CP and wants to lease an MS permit (MS00001) that was already registered to another MS vessel (Vessel B) at the beginning of the season. Vessel A then would unregister its CP permit and register under MS0001. However, if Vessel A broke down and couldn't process (shown in the red cross), then the MS0001 permit could only go back to Vessel B (original vessel) and could not be transferred to another vessel (Vessel C) to act as a processor. While this situation may be unlikely given the current state of ownership and the pool of potential processing vessels, there may need to be consideration of whether modifications to the within sector permit transfer regulations are needed if the action alternative is recommended.

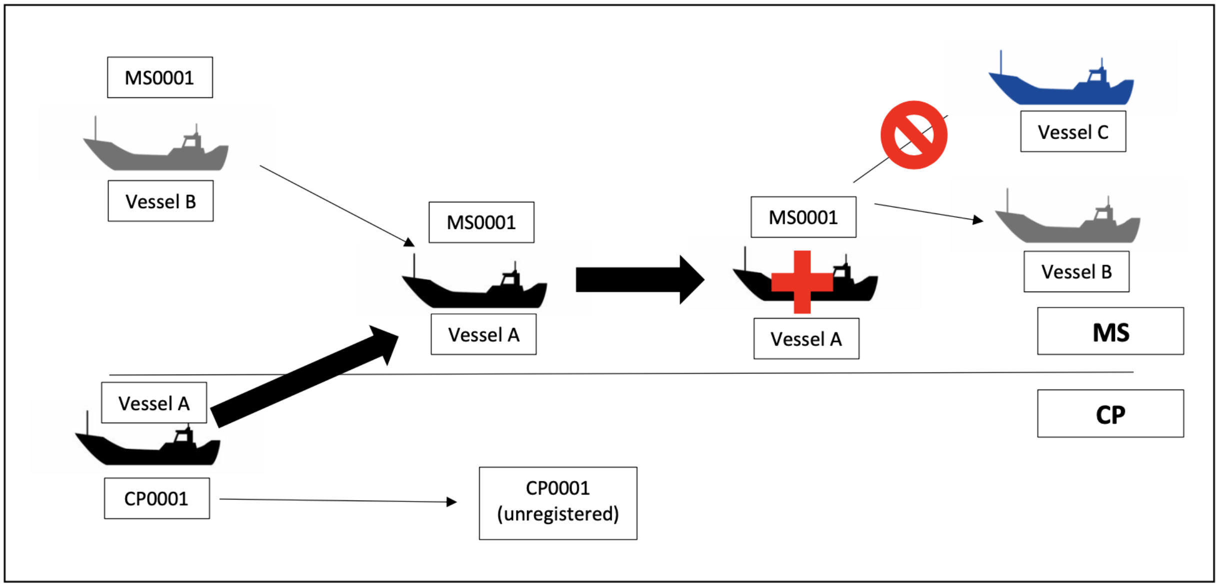

Figure 8. Diagram of processing vessel transferring between at-sea sectors and potential issue with current regulations regarding permit transfer limits.

Under No Action, processing entities would likely see no change in benefits. Impacts to MSCVs may be neutral to negative depending on the processing capacity available in a given year. Under Alternative 1, there could be a range of impacts. For those entities that would be able to process as both MS and CPs, the overall benefit would likely increase as vessels would be able to profit in both sectors. For vessels that only process in a single sector, impacts could be neutral (if they are able to maintain their processing level) or slightly negative (if a typical MS vessel lost deliveries to a vessel that typically harvests in the CP sector who could pay a higher price). For MSCVs, impacts could be neutral to positive. If overall processing capacity is not increased, then there is likely no change for MSCVs. If processing capacity is increased though, then there is likely positive impact to MSCVs. Additional benefits could also be seen if a typical CP vessel is able to process and pay an increased amount to MSCVs. Administrative costs of Alternative 1 are expected to be higher than No Action, although it is likely negligible. Overall, there may be slightly higher administrative costs (and therefore cost recovery) associated with the unlimited permit transfers (sub-option C) compared to the four-permit transfer option (sub-option B). Both sub-options are likely to be associated with higher administrative costs than sub-option A- i.e., two permit transfer.

4 Synergy Analysis

The above sections provide an assessment of the impacts of each of the alternatives individually. This section attempts to discuss some of the potential impacts of the Council selecting multiple action alternatives. A fuller discussion of the interactions between the alternatives will be provided after the selection of a PPA at the September 2021 meeting.

4.1 Economic Impacts

When considering all the action alternatives in combination, it is likely that the overall attainment will increase, particularly for the MS sector. The MS sector has been under-attaining its initial allocations by 28.8 percent and its post-reapportionment allocations by 36 percent since 2017. As noted in the purpose and need, and referenced throughout the document, reasons for this include limited availability of motherships for delivery of catch due to seasonal overlap with the Alaska pollock fishery and existing regulations may be hindering some catcher vessels' opportunity to harvest or deliver fish to MS processors. While the movement of the primary season start date would likely provide the most benefit in terms of harvest opportunities when both MS and MSCVs can be on the fishing grounds, the increased flexibility to have more processors (via the permit transfer) or have processors accept and potentially process higher amounts of catch (processor cap) would in combination provide the most opportunity to increase attainment and economic benefits for all sectors.

4.2 Salmon Impacts

While the majority of the impacts to salmon would come from the movement of the start date from May 15 to May 1, there could be additional impacts if the permit transfer alternative were also selected and utilized. That is, by implementing an alternative to allow permit transfers, the availability of processors throughout the season for the CP and MS sectors could change when and where effort is placed. However, as described in Section 2.3.3, we expect the overall amount of bycatch to be within those described in the 2017 BiOp. The 2017 BiOp assumed both 100 percent attainment of the sector allocations under a 500,000 mt TAC. While these alternatives, in combination, are likely to increase attainment for the MS sector overall, these levels of harvest in the BiOp are still higher than those in the current fishery. The same conclusions would still hold that the fishery is likely to stay within the 11,000 Chinook guideline under a northern distribution of the at-sea fleet but may have a higher risk of exceeding the guideline and accessing the Reserve with a southern distribution.

4.3 Processing Opportunities

By allowing a vessel to operate as a MS and CP in the same year and removing the processing limit, this would potentially allow an entity to process the entirety of both its MS and CP whiting allocations. Similar considerations of excessive shares as described in Section 3.2.4 may need to be considered depending on the Council's PPA.

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7 Appendix A

Projecting total Chinook bycatch impacts of a May 1 season start date, in West Coast, Pacific whiting fishery sectors

August 5, 2021

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7.1 Executive Summary

In this analysis, we estimated the potential impact on Chinook salmon bycatch of moving the whiting season start date two weeks earlier to May 1, versus the current date of May 15. We produced model-based projections of total bycaught Chinook for each of three non-tribal whiting fishery sectors, with separate projections for scenarios of northern and southern effort, in cases where a latitudinal pattern in effort distribution among years was apparent in the recent data.

We used a simulation-based, bootstrap model (Matson and Erickson 2018, Doerpinghaus 2016, Mirick et al. 2015, Stohs 2015) to project distributions of bycaught Chinook salmon counts for the additional two-week period, across a range of sector-specific scenarios of whiting catch, and we discuss the distributions of those results in light of recent annual bycatch in the fishery. Our results were then passed to a second projection model, with Dr. Paul Moran in the Northwest Fishery Science Center (NWFSC), to predict the stock composition of that bycatch (Appendix B), and ultimately yield Evolutionary Significant Unit (ESU)-specific projections of Chinook bycatch.
In terms of total Chinook bycatch, we found that in addition to the intuitive result of higher whiting harvest being associated with higher Chinook bycatch, the scenario with more southern effort by the CP sector produced somewhat higher projected bycatch than an assumption of northern effort for that sector (Figure A-1, Table A-1). Substantial latitudinal variation in effort among years was only apparent for the CP sector (Table A-2).

In order to express our aggregate results as a range of possible outcomes for the whole fishery (Figure A-1), if we add low, middle, and high total fishery projections from the four scenarios modeled (using 80th percentile projections for the May 1-15 period, Table A-1), to the low, middle, and high values among the most recent five years of annual whiting fishery bycatch (2016, 2017, and 2018 respectively), our result ranges between 3,977 and 7,381 total Chinook per year, with a middle value of 5,538 per year; far below the fishery threshold of 11,000 fish. This represents a relatively modest increase in annual bycatch, between 5 and 7.6 percent, and a median change of 6.4 percent. This interpretation assumes a conservative net increase in effort for all sectors, as a result of an earlier season start date, rather than a shift toward fishing earlier in the year.

These annual sums, which include our two-week projections for early May, combined with the range of annual bycatch in the past five years, are well within that analyzed for the commercial non-tribal whiting fishery in the 2017 BiOp, and do not represent additional take of Chinook salmon (total counts) beyond it. They lie well within the guideline and threshold specified in the terms and conditions of Section 2.9.1 for the whiting fishery, that “the sector will take actions to reduce bycatch to remain within the guideline of 11,000 Chinook per year”, and that “bycatch will not exceed 14,500 Chinook per year including a Reserve of 3,500 Chinook per year in the event that bycatch increases unexpectedly” (NMFS 2017); particularly considering the mitigation measures that were developed, including use of the reserve.

Adding tribal Chinook bycatch estimates from whiting fisheries, for the same three years, our total result ranges between 4,178 and 7,550 total Chinook per year, with a middle value of 6,098 per year. These estimates are still well below the fishery guideline of 11,000 fish (from 38 to 68 percent), and still well within the range analyzed in the 2017 BiOp. Again, this assumes a net increase in effort and harvest across the modeled sectors, (with corresponding future allocations which would allow that level of catch) rather than a shift toward fishing earlier in the year. In Section 2.3.3, we deliberate about how much of the projected bycatch may translate into either simply seasonally shifted effort, versus increased attainment, according to recent fleet behavior, allocation remainder, potential for reapportionment, number of vessels likely to fish early in the year, and other factors.

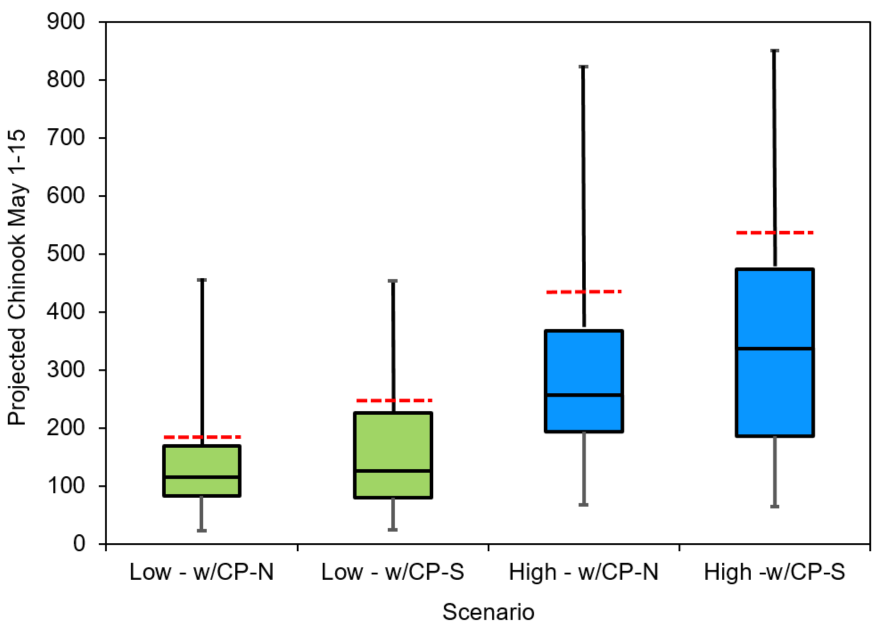

Figure A-1. Quartile box plot of projected total Chinook bycatch counts, for each of four fishery-level scenarios modeled, summed across the three whiting fishery sectors. The red dashed lines show the 80th percentile of the projected distribution. The black line in the center of each box shows the median, the top boundary of the boxes show the 75th percentile, the bottom boundary shows the 25th, and whiskers show minimum and maximum values of the predicted distribution. The abbreviation “w/CP-N” means including an assumption of a northern effort distribution in the Catcher-Processor sector (CP), and “w/CP-S” means including an assumption of southern effort distribution for the CP sector.

Table A-1. Projected total Chinook bycatch counts, aggregated to the fishery level, by scenario modeled. Each column includes projections for Mothership (MS), versions for northern and southern effort assumptions of CP, and Shorebased Whiting (SS).

Harvest	Low catch		High catch	
Quantiles	**w/CP=N**	**w/CP=S**	**w/CP=N**	**w/CP=S**
0%	22.9	24.9	66.7	63.7
1%	40.4	38.4	100.2	94.2
5%	52.2	49.2	117.9	110.9
25%	82.2	79.2	193.8	185.8
50%	**115.1**	**125.1**	**256.8**	**337.3**
75%	168.5	225.5	367.7	473.7
80%	**187.6**	**243.6**	**421.1**	**523.1**
95%	259.0	306.0	552.9	637.9
99%	314.5	350.5	635.5	702.5
100%	454.0	453.0	821.7	849.7
Mean	**131.0**	**155.4**	**289.3**	**335.0**

Table A-2. Projected total Chinook bycatch counts, for each of eight sector-level scenarios modeled, summed across the three whiting fishery sectors.

Sector	**MS**		**CP**				**SS**	
Data years	**2015-19**		**2015-19**		**2015-19**		**2016-19**	
Effort dist.	**Coastwide**		**North**		**South**		**Coastwide**	
Exp. harvest	**Low: 10k mt**	**High: 30k mt**	**Low: 25k mt**	**High: 45k mt**	**Low: 25k mt**	**High: 45k mt**	**Low: 5k mt**	**High: 15k mt**
Quantiles	**Bycatch**		**Bycatch**				**Bycatch**	
0%	0.0	1.0	22	56.0	24.0	53.0	0.9	9.7
1%	1.0	7.0	36	77.0	34.0	71.0	3.4	16.2
5%	3.0	10.0	44	88.0	41.0	81.0	5.2	19.9
25%	16.0	59.0	58	108.0	55.0	100.0	8.2	26.8
50%	**28.0**	**83.0**	**76**	**140.0**	**86.0**	**220.5**	**11.1**	**33.8**
75%	46.0	132.0	108	194.0	165.0	300.0	14.5	41.7
80%	**56.3**	**170.4**	**116**	**207.0**	**172.0**	**309.0**	**15.3**	**43.7**
95%	83.4	234.7	156	266.0	203.0	351.0	19.6	52.1
99%	100.4	262.7	191	314.0	227.0	381.0	23.2	58.8
100%	139.0	308.0	279	443.0	278.0	471.0	36.0	70.7
Mean bycatch	**33.4**	**99.2**	**86.0**	**155.4**	**110.4**	**201.1**	**11.6**	**34.6**
Mean latitude	**46.4203**	**46.3875**	**45.6605**	**45.6113**	**42.4090**	**42.4050**	**46.1860**	**46.1865**
Bycatch range	139.0	330.8	257.0	387.0	254.0	418.0	35.1	61.0
Bycatch SD	25.24	69.47	35.87	57.96	59.19	104.34	4.48	10.01
Bycatch CV	0.76	0.70	0.42	0.37	0.54	0.52	0.39	0.29

7.2 Introduction

7.2.1 Purpose and need

The portion of the proposed action discussed in this appendix, to change the whiting season start date north of 40° 30' N. lat., from May 15 to May 1 for all non-tribal whiting sectors, was adopted as part of the ROA at the March 2021 meeting (Agenda Item G.3., Council Motion). The overall purpose and need of the comprehensive proposed action was identified in Agenda Item G.3.a Supplemental WDFW-ODFW Report 1, March 2021, and adopted by Council at the March 2021 meeting; to

> "*identify and revise regulations that may be unnecessarily constraining, in order to provide increased operational flexibility in the Pacific whiting fishery and increase the MS sector's ability to utilize its whiting allocation, while maintaining fair and equitable access to Pacific whiting by all sectors of the program.*"

Recent annual retained catches (mt), post-reapportionment allocations (mt), and attainment of sector allocations in West Coast whiting fishery sectors for recent years are provided in Table A-3 for context.

Table A-3. Recent annual retained catch (mt) and attainment of sector (post-reapportionment) allocations in Pacific coast whiting fishery sectors for recent years. Note that SS includes all whiting catch from Shorebased IFQ participants.

Year	Retained catch (mt)			Post-reapportion allocation (mt)			Post-reapportion attainment		
	SS	MS	CP	SS	MS	CP	SS	MS	CP
2015	58,011	27,544	68,435	124,607	71,204	100,873	47%	39%	68%
2016	85,499	64,597	108,781	141,007	80,575	114,149	61%	80%	95%
2017	144,440	65,358	137,104	169,547	96,884	137,252	85%	67%	100%
2018	129,403	65,997	116,005	169,127	96,644	136,912	77%	68%	85%
2019	143,757	51,829	116,352	169,126	96,644	136,912	85%	54%	85%

7.2.2 Analytical objective

The specific objective of this analysis is to estimate the additional impact on Chinook salmon bycatch (both as total counts of Chinook, and of ESA-listed ESUs), of extending the whiting season by two weeks earlier than the current season (May 1 start date versus current start date of May 15).

7.3 Methods

7.3.1 Approach

Our analytical approach is to produce simulation model-based projections of Chinook bycatch, as total count distributions, for the May 1-14 period, in the three non-tribal commercial whiting sectors. Due to the long-standing season start date of May 15 for directed whiting, data are not available for the first two weeks of May. Thus, the model is informed by data from the immediately adjacent time period of May 15-31, in the most recent available five-year period for the at-sea sectors (2015-2019) and four-year period for SS (2016-2019) for reasons discussed below. We explored other alternative data sources, including historical data from the at-sea whiting fishery in the 1990s, and potentially borrowing data from the midwater rockfish sector, but ultimately rejected those sources as unrepresentative for this analysis, as explained in Section 8.3.6.

The projected total counts are subsequently used to inform model-based predictions of ESU-specific counts (Moran et al., attachment). Projections of bycatch from the additional two-week period are combined with recent, annual bycatch estimates to inform likely full-season bycatch under the new proposed season start date. Those full-season projected bycatch amounts are also discussed briefly here, and more broadly within the sections above, in context with the existing annual take limits, and the full-season projections from the 2017 BiOp for ESA listed salmon. The assumptions of target catch (whiting) used in the BiOp were highly optimistic, according to a conservative approach for meeting ESA mandates. Both full attainment of sector allocations, and recent average attainment of the whiting allocations were assumed in the 2017 BiOp. However, recent attainment levels for the MS sector in particular, have been considerably lower than assumed in the BiOp analysis (Table A-2).

The status quo alternative (SQ) is represented by recent annual bycatch estimates over 2015-2019 (same years informing model input data). Projections are made for Alternative 1 using both low and high expected whiting catch values for the additional two weeks of fishing season proposed, for each whiting fishery sector.

7.3.2 Data

Model input data include the most recent five years of combined observer and Electronic Monitoring (EM) data (haul-level) currently available; 2015-2019. Data for the Shorebased Whiting Sector (SS) is combined from the West Coast Groundfish Observer Program (WCGOP) and EM programs according to current methods used by WCGOP, in annual groundfish mortality and salmon bycatch reporting. Data to inform the model for SS in 2015 are currently unavailable due to complications with the availability of haul-distributed data for EM in that year only. However, as described in Section 2.1, there was little to no activity in May 2015 for the SS sector and therefore excluding it likely did not impact the results. Data for the year 2020 were not available for the SS sector at the time of this analysis. Additionally, fishing operations and markets were severely impacted by the COVID-19 pandemic, making 2020 likely unrepresentative of future fishing years, and 2020 data are also not used for the at-sea sectors for this reason. North Pacific Groundfish and Halibut Observer Data (NORPAC) data are used to inform modeling of at-sea sectors (CP and MS), queried from the NORPAC Comprehensive table in the Pacific Fisheries

Information Network (PacFIN) database. Representativeness of fishery effort distribution in the model data was explored and considered before analysis. See Section 8.3.6, "Other data considered but rejected". Haul counts during May for each year in the whiting sectors ranged between 440 and 567, with a median of 545 for CP; between 232 to 533, with a median of 326 in MS; and from 66 to 203, with a median of 170 for SS.

7.3.3 Modeling

Projected distributions of total Chinook counts, and latitude for the May 1-14 period are produced using the same simulation-based (bootstrap) model used in the analysis for the 2017 BiOp (Matson and Erickson 2018), and recommended by the Science and Statistical Committee (SSC). This same modeling approach has been used several times in the Pacific Fishery Management Council to predict fishery bycatch for highly migratory species (HMS) and groundfish, including ESA salmon. It was applied to analyze use of hard caps to manage bycatch of sea turtles and marine mammals in the drift gillnet fishery (Stohs 2015), set-asides for rockfish bycatch in the whiting fisheries (Doerpinghaus, 2016), Chinook bycatch for the 2017 salmon BiOp (Matson and Erickson 2018), subsequent similar analyses of Chinook bycatch for developing mitigation measures in the groundfish fishery, and for analysis of various bycatch species in groundfish harvest specifications in biennial harvest specifications cycles since then. The approach was presented for use in projecting bycatch in whiting fisheries in November of 2015 (Mirick et al. 2015), and reviewed/endorsed by the SSC, with specific recommendations for its configuration, which we follow in this analysis. The model was subsequently recommended by the SSC for use in bycatch analysis for the 2017 salmon BiOp during scoping of that item (Agenda Item I.1.a, Supplemental SSC Report, March 2017); and it was used to analyze the suite of catch assumptions recommended by the Council as the FPA, representing the future groundfish fishery for that purpose (Matson and Erickson 2018).

The bootstrap method we employ is a non-parametric simulation-based approach that builds empirical distributions of one or more specified statistics, by resampling actual data within stated parameters; it does not rely on any assumptions about the distribution of the data. Thus, it is appropriate for non-standard distributions often seen in fishery data (highly skewed, multimodal, etc.). Forcing an assumption of a particular distribution upon an analysis which does not fit the data well can introduce error (not easily predicted or corrected) and have important consequences on analytical conclusions and downstream decision making.

The basic approach of the bootstrap model we use is to simulate 10,000 seasons of fishing under a set of conditions that characterize each desired scenario, for each sector. Those conditions are set by specifying the years, sector, and season to be used for input, how each year of data should be weighted, and the amount of target catch (whiting) to accumulate before stopping the model.
Each fishery sector is modeled separately, and each year of data is weighted equally. One season is simulated by first randomly selecting a data year to sample from, then randomly resampling fishery observer/EM data haul-by-haul, with replacement, until a designated amount of retained Pacific whiting catch accumulates (mt). At this point, the model stops and records the number of corresponding bycaught Chinook salmon. This process is repeated 10,000 times for each model run, and a distribution of the results among simulated seasons is built, the quantiles of which are used to inform probabilities of bycatch levels for Chinook salmon as total count. The quantiles of

the distribution generated by the bootstrap routine can be used as reasonable approximations of probabilities, under the implicit and explicit conditions and assumptions of a particular model run, and the input data used (Davidson and Hinkley 1997).

Model output includes distributions of Chinook counts, latitude, haul counts, summary quantile tables, and histograms for each predicted variable. The 80th quantile value of predicted Chinook counts and mean latitude for each scenario modeled are produced for use together with genetic-based mixed stock assignments, to inform subsequent model-based predictions of ESU-specific Chinook counts (NOAA 2017 and Moran et al., in review, *Fisheries*).

The risk-averse approach used in the 2017 BiOp, and in this analysis, identified the 80th percentile of the projection distribution as the preferred estimate of Chinook salmon bycatch, given the protected or endangered status of ESUs. The bootstrap distribution can be taken to approximate probabilities of the expected results. In this case, the 80th percentile value corresponds to an 80 percent probability that the number of bycaught Chinook salmon are expected to occur at or beneath this level (given the data, and model assumptions). A risk-averse approach such as using the 80th percentile is customary for endangered species management, and contrasts with a more typical risk-neutral approach for groundfish management, which uses the median or mean as the point prediction, and surrounding percentiles to express uncertainty (e.g., interquartile range, etc.).

The quantiles of each sector, and scenario-specific projected distribution are calculated for each sector, and then those same quantiles are summed across the three sectors (within a particular scenario, i.e., latitudinal effort pattern) to generate aggregated prediction statistics for the whole commercial directed (non-tribal) whiting fishery.

7.3.4 Expected range of target catch

We identified a range of whiting catch expected to occur within the May 1-14 period, by examining historical whiting catch data from the May 15-31 period and soliciting industry input. Low and high catch scenarios were used as model stop points in the bycatch projection model (total counts) for each of the three whiting sectors. The low and high values identified for each sector are: 10,000 mt and 30,000 mt for the MS sector; 25,000 mt and 45,000 mt for the CP sector; 5,000 mt and 15,000 mt for the SS sector (Table A-4). Thus, there is one low and one high projected bycatch distribution produced (for the May 1-14 date range) for each sector, under each set of conditions (e.g., alternative latitudinal effort distributions).

Table A-4. Expected retained whiting catch amounts for the first two weeks of May (model catch caps) by sector, in metric tons.

Catch Expectation Level	Sector		
	CP	MS	SS
High	45,000	30,000	15,000
Low	25,000	10,000	5,000

7.3.5 Fishery spatial effort distribution

The whiting fishery has shown fairly regular seasonal effort distributions, but the pattern is not invariable among years. Pacific whiting migrate seasonally off the U.S. West Coast, northward in the spring from southern spawning grounds, to as far north as southeast Alaska; and in summer, environmental conditions affect the distribution of hake off the U.S. West Coast, suggesting warmer ocean conditions drive a more northern distribution of hake (Malick et al. 2020, Benson et al., 2002; Ressler et al., 2007; Agostini et al., 2008; Dorn, 1995; Ware and McFarlane, 1995). This is important for making accurate ESU-specific predictions, given that latitude is the most important predictor of stock composition (Moran et al. in review). Thus, where data from the recent past reveal substantial variability in seasonal effort distribution among years, we run the model with separate northern and southern scenarios for each alternative, for affected sectors. The current approach assumes a relatively stable future seasonal distribution pattern of whiting fishery effort among years, for a particular scenario modeled.

7.3.6 Other data considered but rejected

We considered but rejected two other potential data sources available for the May 1-14 time period. First, we considered informing projected total bycatch in the SS sector from data in the midwater trawl rockfish fishery. However, as described in the Agenda Item G.3., Attachment 1, March 2021, "*While these vessels [midwater rockfish] and whiting vessels both use midwater gear for targeting rockfish and whiting respectively, the operations are different in terms of salmon interactions and areas fished between the midwater rockfish fisheries and the whiting fisheries (and then within the whiting fisheries themselves).*" Further, *"midwater rockfish vessels possess about 36 percent less horsepower than the SS whiting vessels (and thereby MSCVs) and based on previous analyses, fish stocks targeted by midwater rockfish vessels (e.g., canary, yellowtail, and widow rockfishes) are typically found closer to shore and in shallower depths than whiting.*"

We also considered but rejected using early 1990s NORPAC data (May 1-14) to inform alternative predictions of total Chinook counts in the at-sea sectors (CP, MS). Several issues were identified with using those data: 1) substantial differences in historical salmon abundance including total and ESU-specific abundance, as well as compositions (Ford et al. 2011), 2) historical groundfish fishery conditions from the 1990s are quite different from current conditions, limiting their analytical usefulness for this exercise (participation, effort and management/regulations), and 3) concerns that ocean conditions were likely meaningfully different between the 1990s and now (NOAA 2021).

7.4 Results and discussion

7.4.1 Fishery effort distribution

Since latitude is a strong predictor of stock composition in Chinook salmon bycatch (Moran et al. in review), we examined whiting fishery spatial effort distribution among sectors and years, to determine how years should be grouped for analysis within each sector and scenario. The model was run with separate northern and southern scenarios for each alternative, for affected sectors.

To expeditiously screen for differences in spatial effort patterns among years, we scrutinized aggregated whiting catch by latitude; mean whiting catch per haul, by latitude and longitude; and smoothed haul density, weighted by whiting catch. Retained whiting catch was used to represent effort (and a common denominator in expressing bycatch rates) in the analysis for the 2017 BiOp and we use it again here, both for reasons discussed in Matson and Erickson (2018), and for analytical continuity and comparability between this analysis and the 2017 BiOp. Results of the screening are shown in Figure A-2 through Figure A- 4; axis labels and scale legend are absent to preserve confidentiality. Ranges in figures are sufficient to capture effort during the period; latitude ranges from approximately 42° to 48° N. lat. among most figures.

For the MS and SS sectors, we found that spatial effort distribution patterns were similar among years, with a mixed northern and southern component within each year (Figure A-2 through A- 4, axis labels and the scale legend are not shown to preserve confidentiality; ranges are sufficient to capture effort during the period.) Therefore, we chose to use 2015-2019 data for the MS sector and 2016-2019 for the SS sector together to inform model runs and did not justify separate northern and southern analyses.

In the CP sector however, spatial plots (Figure A-2 and Figure A- 3, axis labels and the scale legend are not shown to preserve confidentiality; ranges are sufficient to capture effort during the period) show a strikingly different pattern among years, with a southern effort distribution in 2015-2016, and a mixed but predominantly northern latitudinal effort pattern in 2017-2019, within May of each year. This suggests a need to produce separate projections for both northern and southern effort scenarios for the CP sector.

Along with bycatch estimates themselves, range and standard deviation of the predicted bycatch distributions scaled primarily with the amount of assumed target catch (Table A- 5).

7.4.2 Chinook bycatch projections

7.4.2.1 Combined projection results

In terms of total Chinook bycatch, we found that in addition to the intuitive result of higher whiting harvest being associated with higher Chinook bycatch, the scenario with more southern effort by the CP sector produced somewhat higher projected bycatch than an assumption of northern effort for that sector (Figure A-5, Table A-1). Substantial latitudinal variation in effort among years was only apparent for the CP sector (Table A- 5).

In order to express our aggregate results as a range of possible outcomes for the whole fishery, if we add low, middle, and high total fishery projections from the four scenarios modeled (using 80^{th} percentile projections for the May 1-15 period, Table A-1), to the low, middle, and high values among the most recent five years of annual whiting fishery bycatch (2016, 2017, and 2018 respectively), our result ranges between 3,977 and 7,381 total Chinook per year, with a middle value of 5,538 per year; all still far below the fishery threshold of 11,000 fish. This represents a relatively modest increase in annual bycatch, of between 5 and 7.6 percent, and a median change of 6.4 percent. This interpretation assumes a net increase in effort (whiting harvest) for all sectors, as a result of an earlier season start date, rather than a shift toward fishing earlier in the year.

These annual sums, which include our two-week projections for early May, combined with the range of annual bycatch in the past five years, are well within that analyzed for the commercial non-tribal whiting fishery in the 2017 biological opinion, and do not represent additional take of Chinook (total counts) beyond it. They lie well within the guideline and threshold specified in the terms and conditions of Section 2.9.1 for the whiting fishery, that “the sector will take actions to reduce bycatch to remain within the guideline of 11,000 Chinook per year”, and that “bycatch will not exceed 14,500 Chinook per year including a Reserve of 3,500 Chinook per year in the event that bycatch increases unexpectedly” (NMFS 2017); particularly considering the 11,000 fish guideline, and mitigation measures that were developed since the opinion, including use of the reserve.

Adding tribal Chinook bycatch estimates from whiting fisheries, for the same three years, our total result ranges between 4,178 and 7,550 total Chinook per year, with a middle value of 6,098 per year. These estimates are still well below the fishery guideline of 11,000 fish (from 38 to 68 percent), and within the range analyzed in the 2017 BiOp. Again, this assumes a net increase in effort and harvest across the modeled sectors, (with corresponding future allocations which would allow that level of catch) rather than a shift toward fishing earlier in the year.

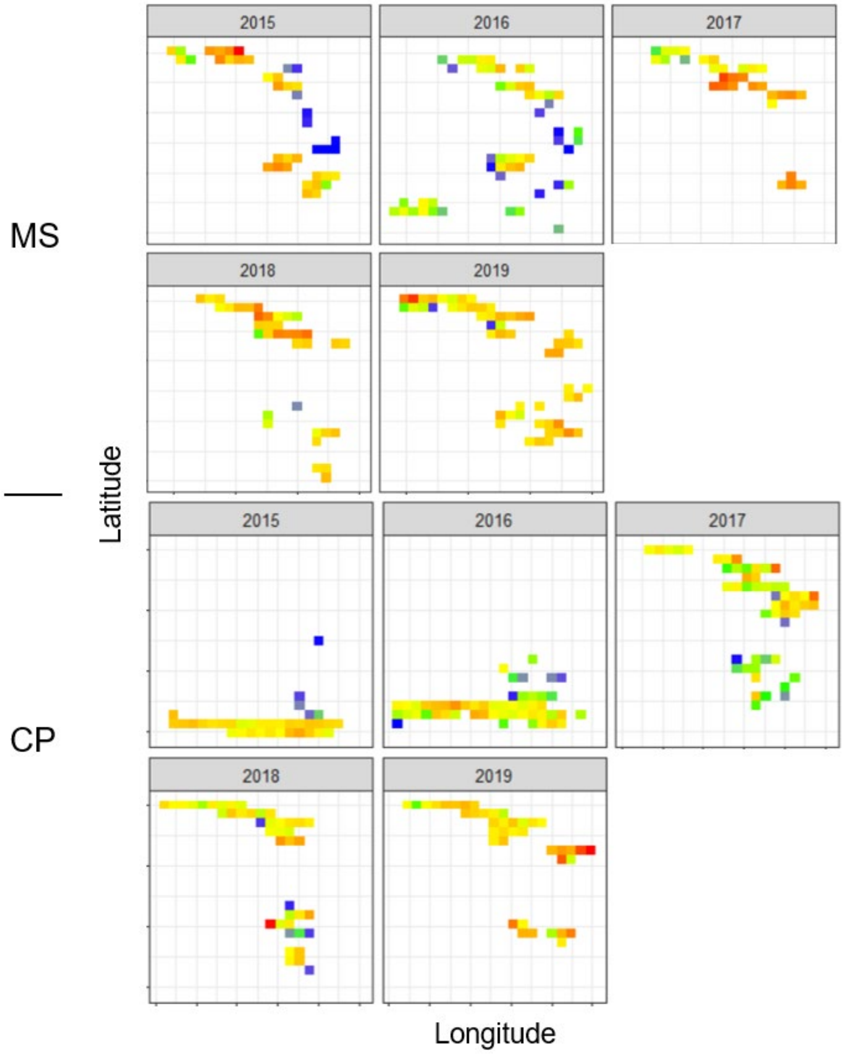

Figure A-2. Heatmap plot (mean retained hake/haul in mt) summarizing annual spatial effort distribution by latitude and longitude, for the **Mothership sector** (MS) and **Catcher-Processor sector** (CP), in the at-sea whiting fishery, during May, 2015-2019. For MS (top panels), the plot shows a similar pattern among years, with both northern and southern components within May of each year, and does not suggest need to produce separate projections for both northern and southern effort scenarios. For the CP (bottom panels), the plot shows a strikingly different pattern among years, with a southern effort distribution in 2015-2016, and a mixed N-S pattern in 2017-2019, within May of each year. This does suggest a need to produce separate projections for both northern and southern effort scenarios for the CP sector. **Axis labels and scale legend are absent to preserve confidentiality.** Ranges are sufficient to capture effort during the period.

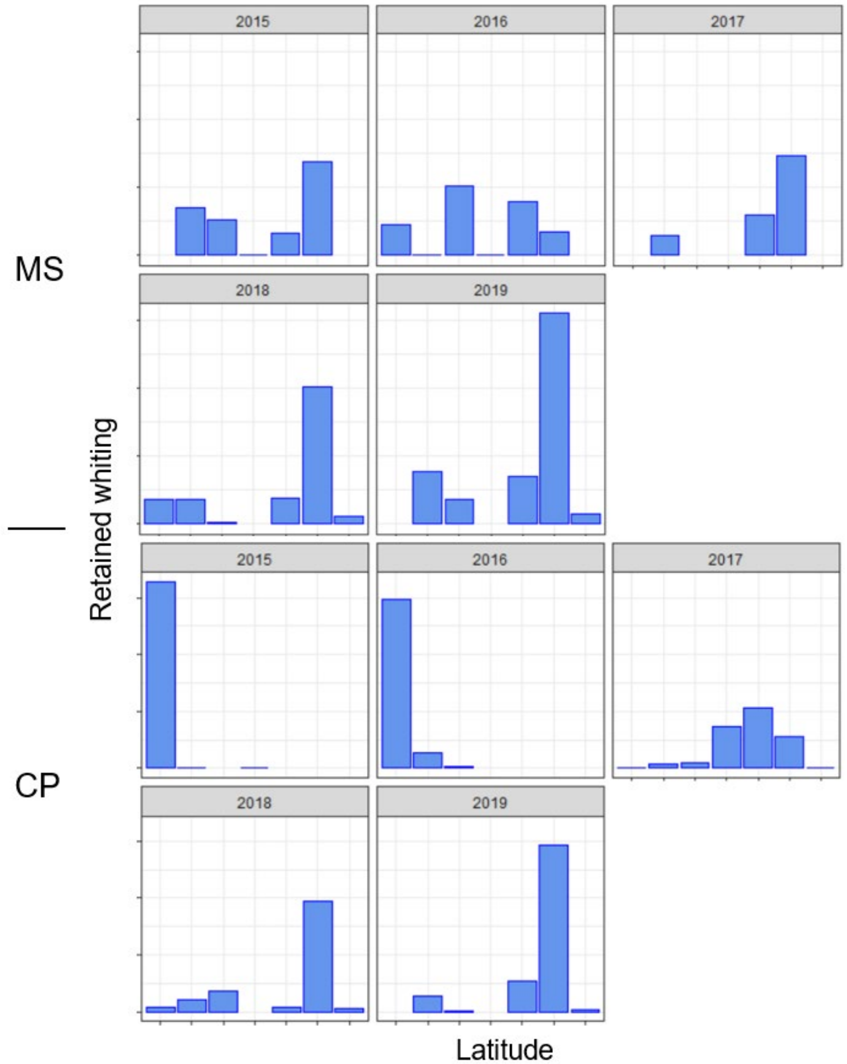

Figure A- 3. Column plot of sum retained hake by latitude bin, and year, for the **Mothership sector** (MS) and **Catcher-Processor sector** (CP), in the at-sea whiting fishery, during May, 2015-2019. For MS (top panels), the plot shows a similar pattern among years, with both northern and southern components within May of each year, and does not suggest need to produce separate projections for both northern and southern effort scenarios. For the CP (bottom panels), the plot shows a strikingly different pattern among years, with a southern effort distribution in 2015-2016, and a mixed N-S pattern in 2017-2019, within May of each year. This does suggest a need to produce separate projections for both northern and southern effort scenarios for the CP sector. **Axis labels and scale legend are not shown to preserve confidentiality.** Ranges are sufficient to capture effort during the period.

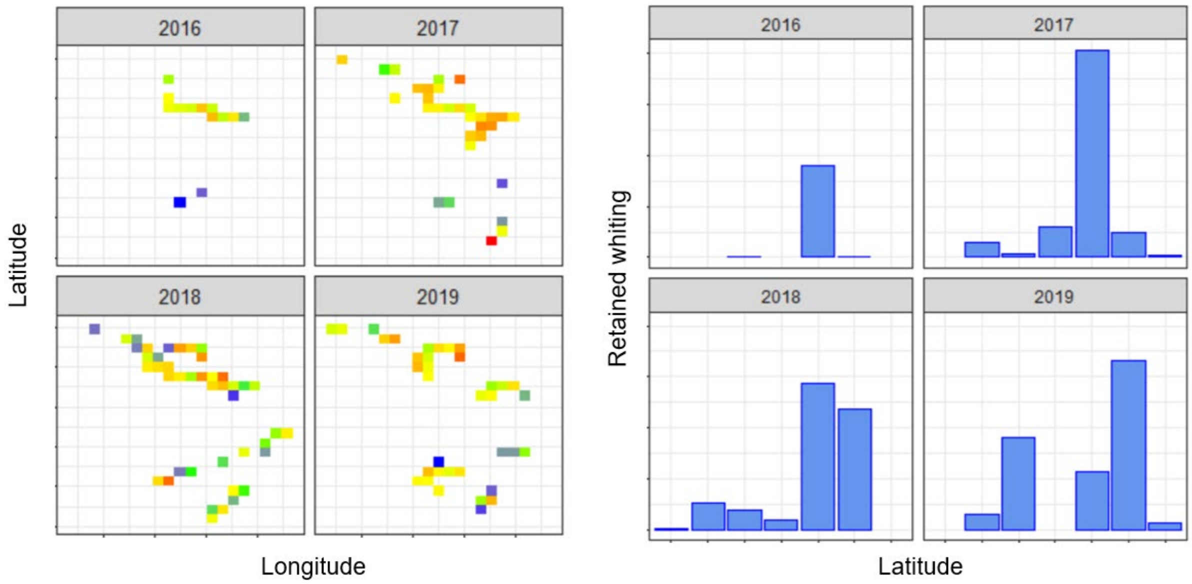

Figure A- 4. Heatmap plot (left, mean retained hake/haul in mt), and column plot (right, sum retained hake by latitude bin), summarizing annual spatial effort distribution for the **Shorebased whiting** (SS) fishery sector, during May, 2015-2019. The plots show a similar pattern among years, with both northern and southern components within May of each year, and do not suggest a need to produce separate projections for both northern and southern effort scenarios. **Axis labels and the scale legend are not shown to preserve confidentiality.** Ranges are sufficient to capture effort during the period.

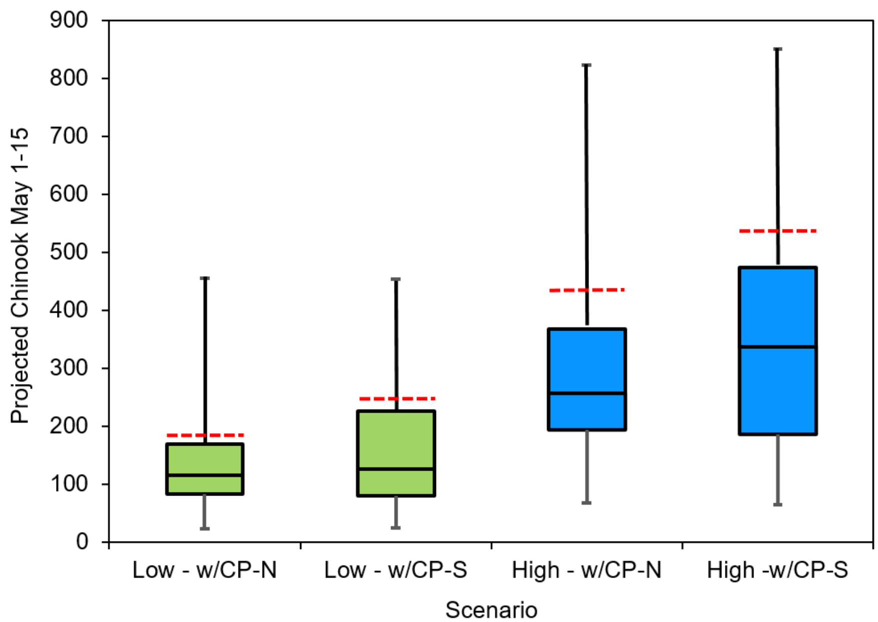

Figure A-5. Quartile box plot of projected total Chinook bycatch counts, for each of four fishery-level scenarios modeled, summed across the three whiting fishery sectors. The red dashed lines show the 80th percentile of the projected distribution. The black line in the center of each box shows the median, the top boundary of the boxes show the 75th percentile, the bottom boundary shows the 25th, and whiskers show minimum and maximum values of the predicted distribution. The abbreviation "w/CP-N" means including an assumption of a northern effort distribution in the Catcher-Processor sector (CP), and "w/CP-S" means including an assumption of southern effort distribution for the CP sector.

Table A- 5. Projected total Chinook bycatch counts, aggregated to the fishery level, by scenario modeled. Each column includes projections for MS, versions for northern and southern effort assumptions of CP, and SS.

Harvest	**Low catch**		**High catch**	
Quantiles	**w/CP=N**	**w/CP=S**	**w/CP=N**	**w/CP=S**
0%	22.9	24.9	66.7	63.7
1%	40.4	38.4	100.2	94.2
5%	52.2	49.2	117.9	110.9
25%	82.2	79.2	193.8	185.8
50%	**115.1**	**125.1**	**256.8**	**337.3**
75%	168.5	225.5	367.7	473.7
80%	**187.6**	**243.6**	**421.1**	**523.1**
95%	259.0	306.0	552.9	637.9
99%	314.5	350.5	635.5	702.5
100%	454.0	453.0	821.7	849.7
Mean	**131.0**	**155.4**	**289.3**	**335.0**

Table A-6. Projected total Chinook bycatch counts, for each of eight sector-level scenarios modeled, summed across the three whiting fishery sectors.

Sector	**MS**		**CP**				**SB**	
Data years	2015-19		2015-19		2015-19		2016-19	
Effort dist.	**Coastwide**		**North**		**South**		**Coastwide**	
Exp. harvest	**Low: 10k mt**	**High: 30k mt**	**Low: 25k mt**	**High: 45k mt**	**Low: 25k mt**	**High: 45k mt**	**Low: 5k mt**	**High: 15k mt**
Quantiles	Bycatch		Bycatch				Bycatch	
0%	0.0	1.0	22	56.0	24.0	53.0	0.9	9.7
1%	1.0	7.0	36	77.0	34.0	71.0	3.4	16.2
5%	3.0	10.0	44	88.0	41.0	81.0	5.2	19.9
25%	16.0	59.0	58	108.0	55.0	100.0	8.2	26.8
50%	**28.0**	**83.0**	**76**	**140.0**	**86.0**	**220.5**	**11.1**	**33.8**
75%	46.0	132.0	108	194.0	165.0	300.0	14.5	41.7
80%	**56.3**	**170.4**	**116**	**207.0**	**172.0**	**309.0**	**15.3**	**43.7**
95%	83.4	234.7	156	266.0	203.0	351.0	19.6	52.1
99%	100.4	262.7	191	314.0	227.0	381.0	23.2	58.8
100%	139.0	308.0	279	443.0	278.0	471.0	36.0	70.7
Mean bycatch	**33.4**	**99.2**	**86.0**	**155.4**	**110.4**	**201.1**	**11.6**	**34.6**
Mean latitude	**46.4203**	**46.3875**	**45.6605**	**45.6113**	**42.4090**	**42.4050**	**46.1860**	**46.1865**
Bycatch range	139.0	330.8	257.0	387.0	254.0	418.0	35.1	61.0
Bycatch SD	25.24	69.47	35.87	57.96	59.19	104.34	4.48	10.01
Bycatch CV	0.76	0.70	0.42	0.37	0.54	0.52	0.39	0.29

7.4.2.2 Projection results by sector

Analysis of the MS sector was performed with an assumption of a coastwide effort distribution. Projection results (Table A-6, Figure A- 6) for the MS sector show estimates of 28 Chinook as the median, and 56.3 fish for the, 80th percentile, under the low catch scenario of 10,000 mt of retained whiting. The high catch scenario results for the MS sector are 83 Chinook as the median, and 107 Chinook as the, 80th percentile, with retained catch of 30,000 mt of whiting (Table A-4, Figure A-7).

Table A-7. Chinook salmon bycatch in groundfish fisheries from 2015 to 2019 (years used as model input), with annual distribution by sector (B). Values from commercial sectors are from the 2019 WCGOP salmon report, tribal values are from PacFIN. Whiting fishery sectors together take on average 90 percent of the Chinook bycatch each year in commercial groundfish fisheries. The bottom row shows the percent of the 11,000 fish management threshold.

Sector	2015	2016	2017	2018	2019
SS	1,806	734	1,396	1,334	2,147
MS	261	369	721	2,572	791
CP	1,545	2,683	3,048	2,951	2,648
Tribal	3	201	560	169	13
Sum	3,615	3,987	5,725	7,026	5,599
Percent of 11,000 fish threshold	33%	36%	52%	64%	51%

Due the very different latitudinal effort distribution during May, among years in the CP sector, we performed two projections (northern and southern) for each hake catch assumption, for four model runs in all (High-South, High-North, Low-South, and Low-North).

Projection results (Table A-6,Figure A-8) for the CP sector, with a northern effort distribution, under the low catch scenario (retained catch of 25,000 mt whiting) are 76 fish as the median, and 116 fish as the 80th percentile. The northern effort, high catch scenario (45,000 mt whiting) results are 140 fish as the median, and 207 fish as the 80th percentile (Table A-6, Figure A-9).

Results for the CP sector, with a southern effort distribution, under a low catch scenario are 86 Chinook as the median, and 172 fish for the 80th percentile (Table A-6,Figure A-10). Projection results (Table A-6,Figure A-11) assuming a southern effort distribution, under the high catch scenario, show 221 Chinook as the median, and 309 fish as the 80th percentile.

Finally, analysis of the SS sector was, like the MS sector, performed with an assumption of coastwide effort distribution. Projection results (Table A-6,Figure A- 12) for the SS sector show estimates of 11 Chinook as the median, and 15 fish for the 80th percentile, under the low catch scenario of 5,000 mt of retained whiting. The high catch scenario results for the SS sector are 34 Chinook as the median, and 44 Chinook as the 80th percentile, with retained catch of 15,000 mt of whiting (Table A-6, Figure A-13).

Summary tables of full projection results, for number of Chinook, mean latitude, and number of hauls are shown in the Section 8.5.

7.4.2.3 Uncertainty

In developing predictions of Chinook bycatch for the whiting sectors, we handled uncertainty in several ways. We produced simulated empirical distributions of projected bycatch based on fishery data which incorporated cumulative haul-level variability into the outcomes. This provided probabilities of bycatch amounts among quantiles, in each scenario. We incorporated variability due to year effects (each simulated season was produced using a randomly selected data year, see Section 7.3), and accounted for variation by fishery sector with separate, sector-specific projections. Where it was evident in the recent past, we made separate projections to account for interannual differences in latitudinal fishery effort distribution.

Range, standard deviation, and coefficient of variation of the predicted bycatch distributions are shown in Table A-6. Standard deviations of the projected distributions are scaled primarily with the amount of assumed target catch (and amounts of accompanying bycatch). Standard deviation values were also higher for the southern effort scenario, given the same level of expected whiting catch in the CP sector; this accompanied a slightly wider range of projected bycatch for the southern effort scenario, within the high whiting catch expectation in the CP sector.

Values of coefficient of variation (CV, standard deviation expressed as percent of the mean) were very similar in most cases, but were noticeably higher for the southern scenario, for the same level of expected whiting catch (both low and high), in the CP sector. Overall, the southern projections for CP were both noticeably higher, and showed more variability than the northern ones (mean latitude approximately 45.6° vs 42.4° N. lat.).

7.4.2.4 Climate considerations

Not all identifiable sources of uncertainty could be accounted for. Climate change is one important source of uncertainty for both near and far-ranging future scenarios, not accounted for in our predictions.

As climate change progresses, oceans continue to absorb heat, warm, current and upwelling patterns may be altered, anomalous ocean and climate conditions are becoming more frequent, and even novel phenomena, such as the Marine Heat Wave (MHW) (a.k.a. "warm blob") of 2014-16 have appeared off the U.S. West Coast (Petersen et al. 2015), the dynamics, and impacts of which (biological, as well as weather, upwelling, El Nino, decadal oscillations) scientists are still working to understand (Chen et al. 2021).

Crozier (2016), in a thorough review of the relevant literature on climate change and Pacific salmon, noted that frequency of large-scale climate anomalies like the “warm blob” in 2014 are projected to increase, which dramatically alter the marine environment. Factors like loss of snowpack, declines in summer runoff, warming rivers and streams, changes in climate-adapted vegetation, fires, changes in coastal upwelling, and ocean acidification paint a complex, and challenging future for Pacific salmon in particular.

Climate change has been projected to influence Pacific salmon is through both survivorship (through both freshwater and ocean phases of their life cycle) and ocean phase spatial redistribution. Climate change has also been predicted to have potentially substantial distributional effects on Pacific whiting, and the future of Chinook bycatch in the whiting fishery comes at the complex intersection of the two.

Chinook salmon abundance has been revealed as strongly related to sea surface temperature (SST), a readily available environmental indicator. For example, Crozier et al. 2021 found that Chinook salmon "*populations rapidly declined in response to increasing sea surface temperatures and other factors across diverse model assumptions and climate scenarios", and that SST was "an important component of most relevant indices. ...SST reflects complex interactions between atmospheric forcing, wind strength, upwelling, and mixing of ocean layers, all of which affect ecosystem productivity throughout the California Current*". Their results also indicated that "*as one symptom of a changing ocean, rising SST puts all of our study populations at high risk of extinction, despite actions within the hydrosystem to speed juvenile travel and increase in-river survival*".

Shelton et al. (2020) predicted substantial ocean redistribution in response to changes in sea surface temperature, but the situation was complex. Rather than simply shifting northward, net movement was predicted into some ocean regions (British Columbia, central California) while out of others (northern California, Washington). The analysis predicted little change for Oregon, southern B.C., and Alaska.

Environmental conditions influence the summer distribution of Pacific whiting along the U.S. and Canadian West Coast (Malick et al 2020, Resler 2007), and studies suggest ocean temperature as a predictor of whiting distribution off the West Coast of North America. Thermal conditions in particular have been positively associated with the proportion of the whiting population in Canada, with warming driving the stock northward (Dorn, 1995; Ware and McFarlane, 1995). More specifically, thermal conditions were shown to exert a spatially variable effect on whiting distribution, with strong positive correlations with hake biomass north of Vancouver Island, and strong negative associations off Vancouver Island and Washington (Malick et al., 2020).

Future bycatch levels of Chinook salmon in whiting fisheries depend on the combined effects of spatial and population dynamics of both species (and Chinook ESUs), climate effects upon each, as well as fleet effort distribution and behavior. Future patterns in species-specific spatial redistributions and their degree of overlap, combined with changes in relative abundance, increases the complexity for bycatch prediction and its uncertainty, particularly while environmental predictors of Chinook bycatch are still in development.

7.5 Additional Figures and Tables

Sector and scenario-specific results summaries of bycatch projections by sector.

Table A- 8. Bycatch projection results for the **Mothership sector** in the at-sea whiting fishery, **assuming a retained whiting harvest of 30,000 mt ("High" scenario).** These results show quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date. Quantiles typically important to management are shown in bold font. The 80th percentile was used in the 2017 biological opinion as a risk averse metric to characterize the projected distribution.

Quantiles	Chinook (count)	Hake (mt)	Latitude (mean)	Hauls (count)
0%	1	30,000	44.1284	565
1%	7	30,000	44.6037	579
5%	10	30,000	44.9242	586
25%	59	30,000	45.9706	595
50%	**83**	**30,000**	**46.3988**	**605**
75%	132	30,000	46.9503	635
80%	**170.4**	**30,000**	**47.2089**	**648**
95%	234.7	30,000	47.5050	766
99%	262.7	30,000	47.6617	778
100%	308	30,000	47.9750	793
Mean	**99.2**	**30,000**	**46.3875**	**634.83**

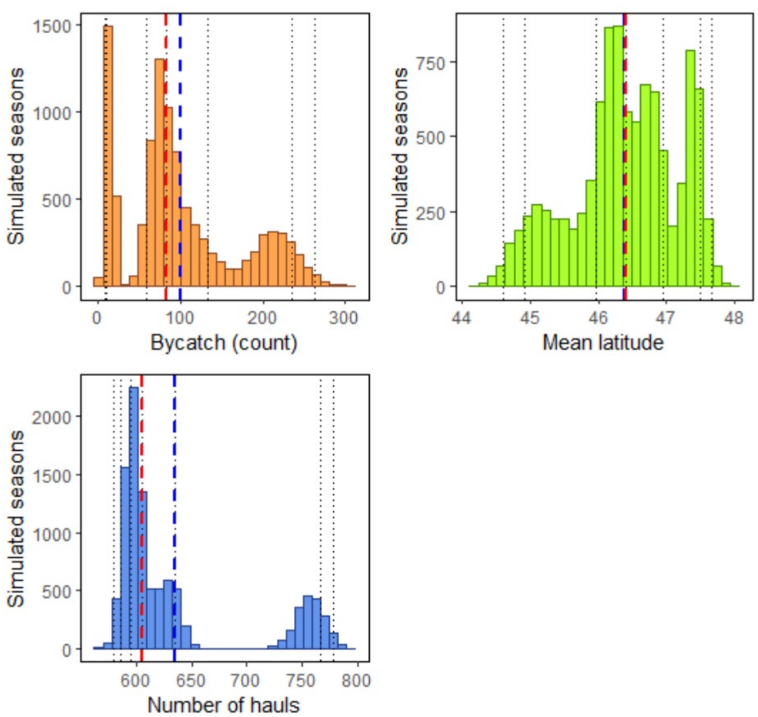

Figure A- 6. Bycatch projection results for the **Mothership sector** in the at-sea whiting fishery, **assuming a retained whiting harvest of 30,000 mt ("High" scenario)**. These results show histograms and quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date from May 15 to May 1. Select quantiles are shown as dashed lines; from the left, they are: 0.01, 0.05, 0.25, 0.5 (median, red), 0.75, 0.95, and 0.99 (the mean appears in blue).

Table A- 9. Bycatch projection results for the **Mothership sector** in the at-sea whiting fishery, **assuming a retained whiting harvest of 10,000 mt ("Low" scenario).** These results show quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date. Quantiles typically important to management are shown in bold font. The 80th percentile was used in the 2017 biological opinion as a risk averse metric to characterize the projected distribution.

Quantiles	Chinook (count)	Hake (mt)	Latitude (mean)	Hauls (count)
0%	0	10,000	42.9925	182
1%	1	10,000	44.2115	189
5%	3	10,000	44.7237	193
25%	16	10,000	45.9213	198
50%	**28**	**10,000**	**46.5078**	**203**
75%	46	10,000	47.1273	214
80%	**56.3**	**10,000**	**47.2327**	**237**
95%	83.4	10,000	47.5939	258
99%	100.4	10,000	47.8395	265
100%	139	10,000	47.9750	283
Mean	**33.4**	**10,000**	**46.4203**	**212.44**

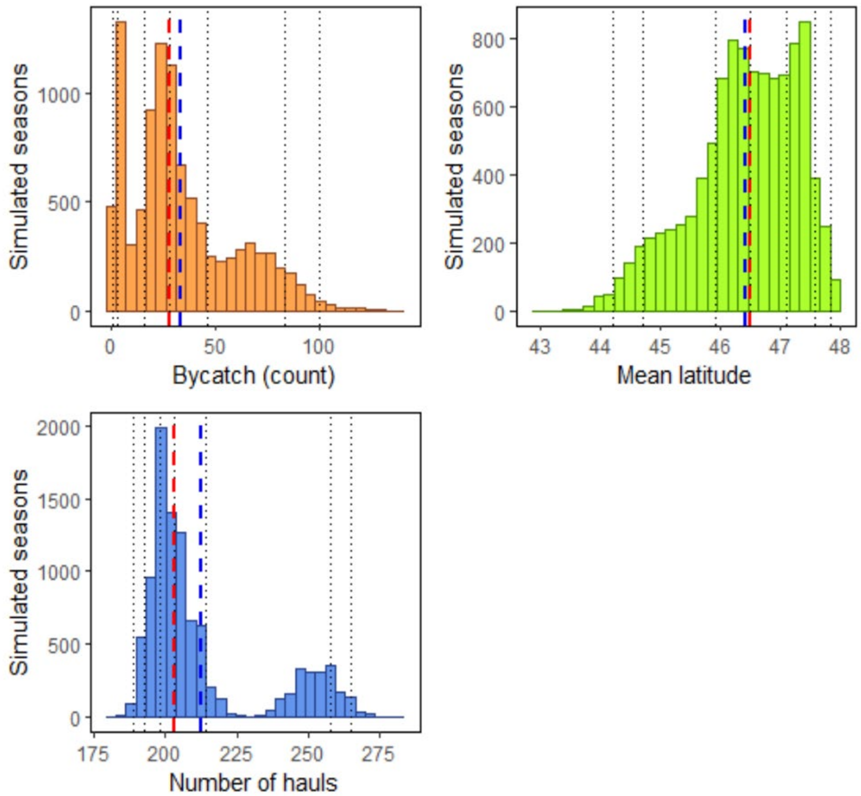

Figure A-7. Bycatch projection results for the **Mothership sector** in the at-sea whiting fishery, **assuming a retained whiting harvest of 10,000 mt ("Low" scenario)**. These results show histograms and quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date from May 15 to May 1. Select quantiles are shown as dashed lines; from the left, they are: 0.01, 0.05, 0.25, 0.5 (median, red), 0.75, 0.95, and 0.99 (the mean appears in blue).

Table A-10. Bycatch projection results for the Catcher Processor sector in the at-sea whiting fishery, assuming a retained whiting harvest of 25,000 mt ("Low" scenario) and a northern effort distribution (years 2015-2016). These results show quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date. Quantiles typically important to management are shown in bold font. The 80th percentile was used in the 2017 biological opinion as a risk averse metric to characterize the projected distribution.

Quantiles	Chinook (count)	Hake (mt)	Latitude (mean)	Hauls (count)
0%	22	25,000	43.3837	347
1%	36	25,000	43.8539	358
5%	44	25,000	44.1358	365
25%	58	25,000	44.7160	378
50%	**76**	**25,000**	**45.3957**	**436**
75%	108	25,000	46.8936	446
80%	**116**	**25,000**	**46.9895**	**448**
95%	156	25,000	47.2654	458
99%	191	25,000	47.4234	465
100%	279	25,000	47.7110	491
Mean	**86.0**	**25,000**	**45.6605**	**419.4**

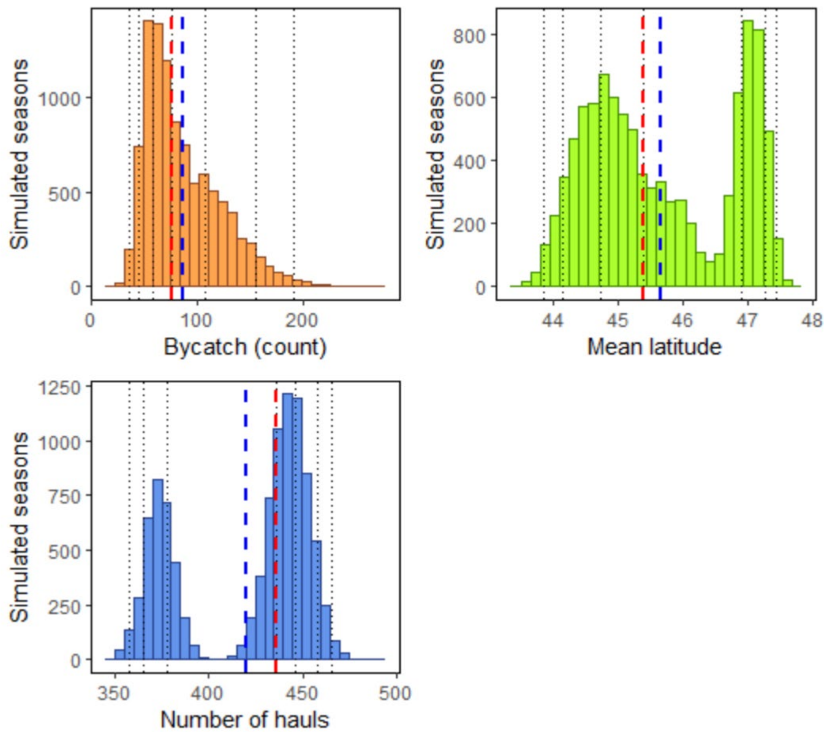

Figure A-8. Bycatch projection results for the Catcher Processor sector in the at-sea whiting fishery, assuming a retained whiting harvest of 25,000 mt ("Low" scenario), and a northern effort distribution (years 2015-2016). These results show histograms and quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date from May 15 to May 1. Select quantiles are shown as dashed lines; from the left, they are: 0.01, 0.05, 0.25, 0.5 (median, red), 0.75, 0.95, and 0.99 (the mean appears in blue).

Table A- 11. Bycatch projection results for the Catcher Processor sector in the at-sea whiting fishery, assuming a retained whiting harvest of 45,000 mt ("High" scenario) and a northern effort distribution (years 2015-2016). These results show quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date. Quantiles typically important to management are shown in bold font. The 80th percentile was used in the 2017 biological opinion as a risk averse metric to characterize the projected distribution.

Quantiles	Chinook (count)	Hake (mt)	Latitude (mean)	Hauls (count)
0%	56	45,000	43.6106	634
1%	77	45,000	44.0201	651
5%	88	45,000	44.2624	660
25%	108	45,000	44.7139	679
50%	**140**	**45,000**	**45.2024**	**787**
75%	194	45,000	46.9284	802
80%	**207**	**45,000**	**46.9972**	**805**
95%	266	45,000	47.2088	818
99%	314	45,000	47.3336	828
100%	443	45,000	47.5272	850
Mean	**155.4**	**45,000**	**45.6113**	**755.1**

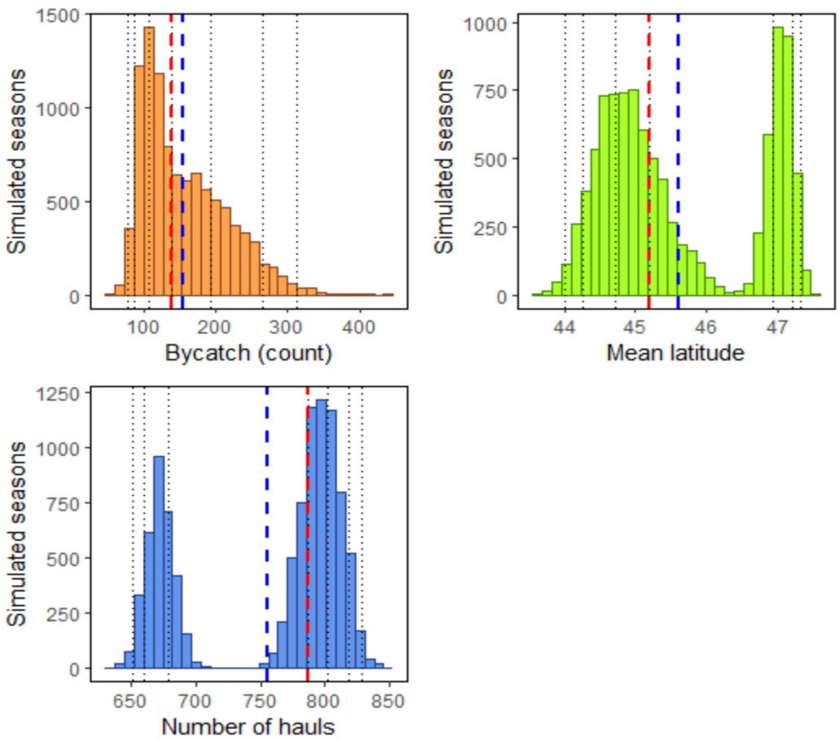

Figure A-9. Bycatch projection results for the Catcher Processor sector in the at-sea whiting fishery, assuming a retained whiting harvest of 45,000 mt ("High" scenario), and a northern effort distribution (years 2015-2016). These results show histograms and quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date from May 15 to May 1. Select quantiles are shown as dashed lines; from the left, they are: 0.01, 0.05, 0.25, 0.5 (median, red), 0.75, 0.95, and 0.99 (the mean appears in blue).

Table A-12. Bycatch projection results for the Catcher Processor sector in the at-sea whiting fishery, assuming a retained whiting harvest of 25,000 mt ("Low" scenario) and a southern effort distribution (years 2015-2016). These results show quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date. Quantiles typically important to management are shown in bold font. The 80th percentile was used in the 2017 biological opinion as a risk averse metric to characterize the projected distribution.

Quantiles	Chinook (count)	Hake (mt)	Latitude (mean)	Hauls (count)
0%	24	25,000	42.0955	396
1%	34	25,000	42.1204	402
5%	41	25,000	42.1333	407
25%	55	25,000	42.1614	416
50%	**86**	**25,000**	**42.5372**	**431**
75%	165	25,000	42.6471	447
80%	**172**	**25,000**	**42.6620**	**449**
95%	203	25,000	42.7272	458
99%	227	25,000	42.7842	464
100%	278	25,000	42.9575	479
Mean	**110.4**	**25,000**	**42.4090**	**431.6**

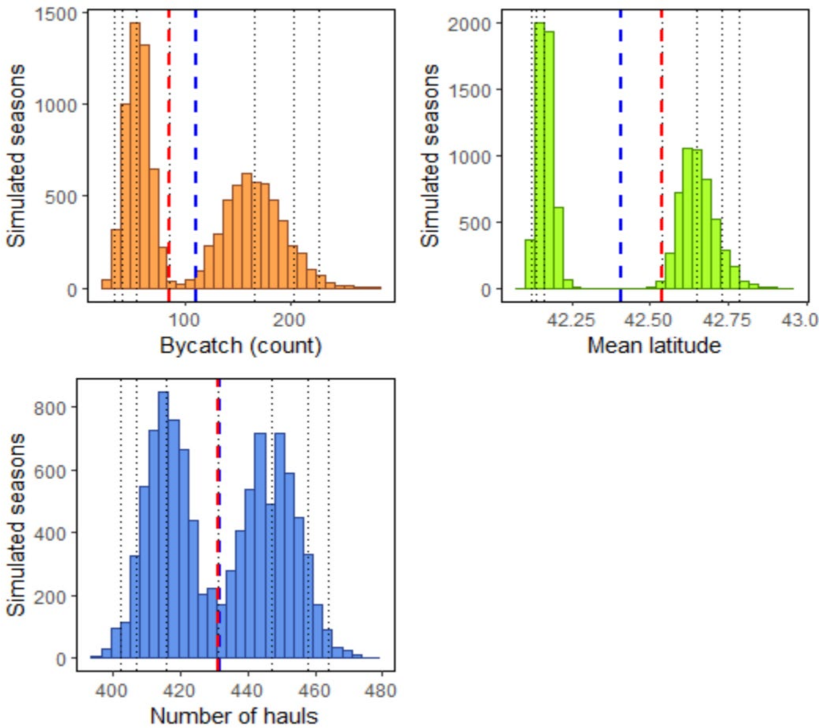

Figure A-10. Bycatch projection results for the Catcher Processor sector in the at-sea whiting fishery, assuming a retained whiting harvest of 25,000 mt ("Low" scenario), and a southern effort distribution (years 2015-2016). These results show histograms and quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date from May 15 to May 1. Select quantiles are shown as dashed lines; from the left, they are: 0.01, 0.05, 0.25, 0.5 (median, red), 0.75, 0.95, and 0.99 (the mean appears in blue).

Table A-13. Bycatch projection results for the Catcher Processor sector in the at-sea whiting fishery, assuming a retained whiting harvest of 45,000 mt ("High" scenario) and a southern effort distribution (years 2015-2016). These results show quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date. Quantiles typically important to management are shown in bold font. The 80th percentile was used in the 2017 biological opinion as a risk averse metric to characterize the projected distribution.

Quantiles	Chinook (count)	Hake (mt)	Latitude (mean)	Hauls (count)
0%	53	45,000	42.11243	711
1%	70.99	45,000	42.12849	729
5%	81	45,000	42.14076	736
25%	100	45,000	42.16267	748
50%	**220.5**	**45,000**	**42.20707**	**770**
75%	300	45,000	42.64945	805
80%	**309**	**45,000**	**42.66016**	**808**
95%	351	45,000	42.70721	818
99%	381	45,000	42.74786	827
100%	471	45,000	42.87296	845
Mean	**201.15**	**45,000**	**42.40503**	**776.059**

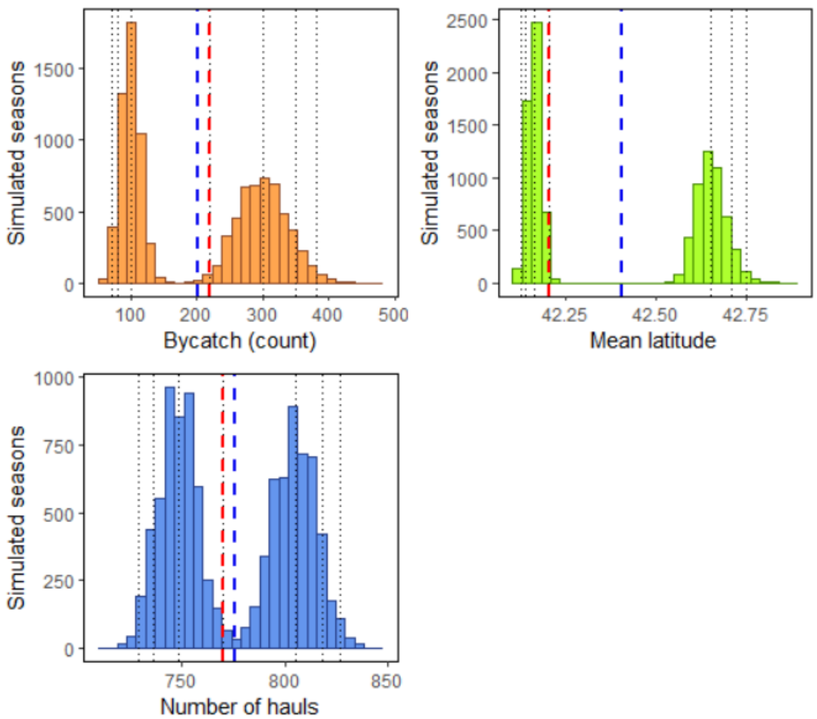

Figure A-11. Bycatch projection results for the Catcher Processor sector in the at-sea whiting fishery, assuming a retained whiting harvest of 45,000 mt ("High" scenario), and a southern effort distribution (years 2015-2016). These results show histograms and quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date from May 15 to May 1. Select quantiles are shown as dashed lines; from the left, they are: 0.01, 0.05, 0.25, 0.5 (median, red), 0.75, 0.95, and 0.99 (the mean appears in blue).

Table A- 14. Bycatch projection results for the **Shorebased Whiting sector**, **assuming a retained whiting harvest of 5,000 mt ("Low" scenario), based on data years 2016-2019).** These results show quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date. Quantiles typically important to management are shown in bold font. The 80th percentile was used in the 2017 biological opinion as a risk averse metric to characterize the projected distribution.

Quantiles	Chinook (count)	Hake (mt)	Latitude (mean)	Hauls (count)
0%	0.9	5,000	43.9856	53
1%	3.4	5,000	44.4183	61
5%	5.2	5,000	44.7652	64
25%	8.2	5,000	45.6583	70
50%	**11.1**	**5,000**	**46.5182**	**76**
75%	14.5	5,000	46.6839	85
80%	**15.3**	**5,000**	**46.7356**	**88**
95%	19.6	5,000	47.1015	97
99%	23.2	5,000	47.2560	105
100%	36.0	5,000	47.6645	125
Mean	**11.6**	**5,000**	**46.1860**	**78.0**

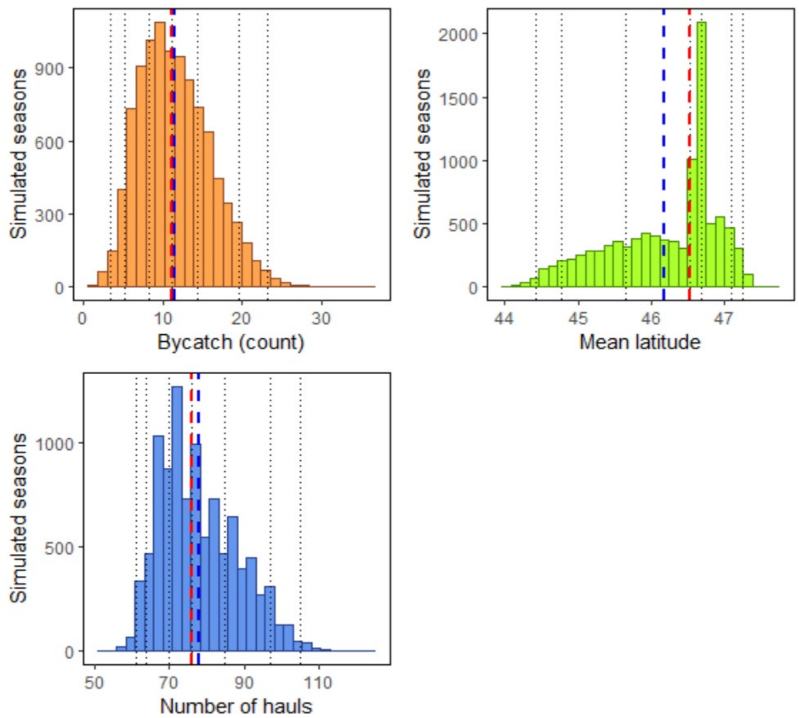

Figure A- 12. Bycatch projection results for the **Shorebased Whiting sector**, **assuming a retained whiting harvest of 5,000 mt ("Low" scenario), using data years 2016-2019)**. These results show histograms and quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date from May 15 to May 1. Select quantiles are shown as dashed lines; from the left, they are: 0.01, 0.05, 0.25, 0.5 (median, red), 0.75, 0.95, and 0.99 (the mean appears in blue).

Table A-15. Bycatch projection results for the **Shorebased Whiting sector**, **assuming a retained whiting harvest of 15,000 mt ("High" scenario), based on data years 2016-2019).** These results show quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date. Quantiles typically important to management are shown in bold font. The 80th percentile was used in the 2017 biological opinion as a risk averse metric to characterize the projected distribution.

Quantiles	Chinook (count)	Hake (mt)	Latitude (mean)	Hauls (count)
0%	9.7	15,000	44.4860	182
1%	16.2	15,000	44.7259	192
5%	19.9	15,000	44.9508	198
25%	26.8	15,000	45.6538	209
50%	**33.8**	**15,000**	**46.5992**	**226**
75%	41.7	15,000	46.6853	254
80%	**43.7**	**15,000**	**46.7855**	**262**
95%	52.1	15,000	47.0157	283
99%	58.8	15,000	47.1178	294
100%	70.7	15,000	47.3049	315
mean	**34.6**	**15,000**	**46.1865**	**232.5**

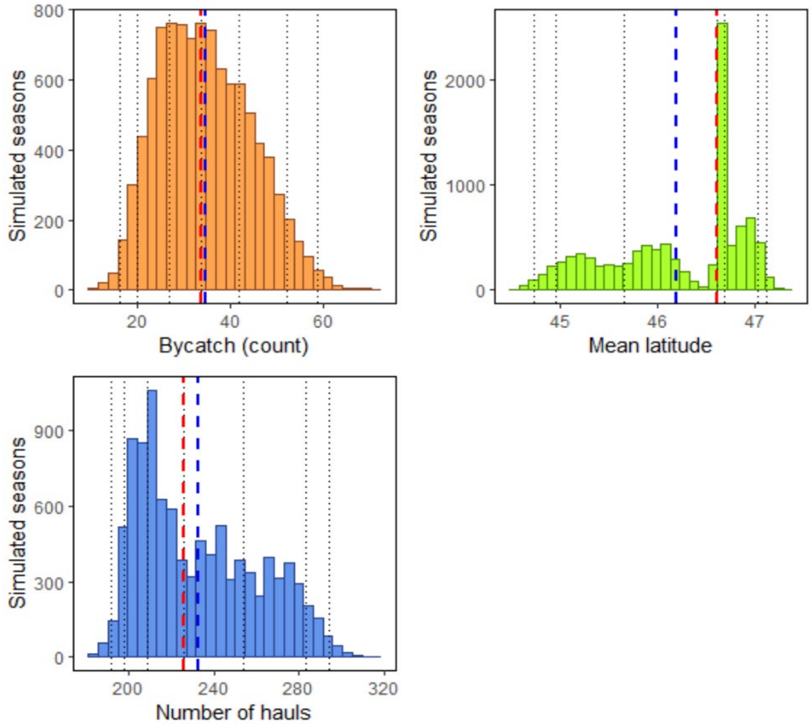

Figure A-13. Bycatch projection results for the **Shorebased Whiting sector**, **assuming a retained whiting harvest of 15,000 mt ("High" scenario), using data years 2016-2019)**. These results show histograms and quantiles of the projected distribution, for additional Chinook bycatch (count) taken as a result of moving the whiting season start date from May 15 to May 1. Select quantiles are shown as dashed lines; from the left, they are: 0.01, 0.05, 0.25, 0.5 (median, red), 0.75, 0.95, and 0.99 (the mean appears in blue).

8 Appendix B

Chinook salmon ESU-specific bycatch forecasts for proposed Pacific hake/whiting management action: existing data and compositional forecasts

Paul Moran, Sean Matson, Jessi Doerpinghaus, Brett Wiedoff, and Stacey Miller
16 Aug 2021

Summary
The goal of this analysis was to evaluate potential impacts on Chinook salmon ESUs associated with opening the Pacific hake/whiting mid-water trawl fisheries 2 weeks earlier than current regulations allow. Because this action seeks to facilitate attainment, we assume that overall Chinook bycatch numbers will not increase relative to the impacts estimated in the most recent Biological Opinion (BiOp, NMFS—WCR 2017). Instead, the question here was whether the ESU compositional forecasts in the BiOp would sufficiently represent take of particular ESUs in this early period. California Coastal was the only listed ESU that showed early impacts that were notably higher than full year. That pattern was evident in shoreside genetic data, but not in at-sea data. Finding no other evidence from either coded-wire tags or genetic data to doubt overall representativeness, we used existing genetic models to enumerate expected take by ESU that might be added to recent observed numbers as a result of the proposed rule change. Recognizing the limitations of conclusions drawn from lack of evidence, continued monitoring is clearly appropriate.

Introduction and Methods
Part 1—Evaluation of incomplete temporal representation in genetic data
We were concerned that sensitive stocks might not be reflected in genetic models (2008 - 2015) that were used in the BiOp (described below) because no genetic data were available for a time when the season started before 15 May. To address that concern we conducted a series of analyses of historical coded-wire-tag (CWT) data and contemporary genetic stock identification (GSI) data. We compared early-year ESU proportions versus proportions over the entire period. To the extent possible, we looked within data sets for signals of early stocks, and we compared across data sets to determine what the GSI data might miss in predicting early season impacts. If we saw suggestions of large impacts in that early period on sensitive spring-run ESUs like Upper Willamette Spring or Snake River Spring/Summer that were not reflected in genetic data, then we would seek to somehow incorporate that information, despite uncertainty as to how that could be done (see *Complications for combining CWT and GSI data* below). If genetic models seemed to capture those ESUs, then we would not expect BiOp estimates to change. In the second part of the study, we estimated ESU-specific bycatch for this 2-week period.

A query of the Regional Mark Identification System databases returned only 44 records for all CWT recoveries from 1991-1995, 1 May - 31 Dec, and north of latitude 41 for at-sea and shore-based fisheries (all Pacific hake mid-water trawl). We compared ESU origins for **early CWT recoveries 1-14 May (N=32) versus all May through Dec (N=44)**. ESU proportions were estimated from observed CWT counts, and we calculated errors (95% CI) from the multinomial distribution. We used the MultinomCI() function in the DescTools R package with the "sisonglaz" method (Glaz and Sison 1999) based on recommendation of May and Johnson (2000). We analyzed both **at-sea and shore-based CWT recoveries comparing 1-14 May versus May-December.**

Lacking GSI data before 15 May, we tried to approximate the CWT data by selecting **an early period, 15 -31 May (N=682) and comparing to the entire period, May-December**. Again, we sought to evaluate whether our genetic models might miss those sensitive stocks passing through the fishery earlier in the year, and whether our predictions might require incorporation of CWT data. The temporal mismatch with shore-based CWT and GSI data was even more acute. Contemporary shore-based fisheries don't begin until June, so those were the only genetic data available. Nevertheless, we divided shore-based GSI data into early and full data sets as with the other comparisons.

Early May versus all May - December
The models for the at-sea fleet (CP and MS sectors) were trained on observed bycatch in these fisheries from 2008 - 2015 and implemented in two different statistical models, DR and MLR of ESU composition/origin as a function of latitude. The goal was to compare how early May predictions might differ from predictions based on current models from available genetic data. Each data set was divided into an early period and a full period (CWT data were too sparse to allow a comparison of early versus late (only 12 CWT recoveries after May 15th from 1991-1995). GSI data are lacking before 15 May because the primary whiting fisheries have not fished in this earlier time period (May 1-14) since the early 1990's. We therefore selected a two-week early period, 15 -31 May (N=682) and compared to the entire period, May-December (N=4304).

Shore-based sector impacts were modeled on observed bycatch composition from 2013 – 2016, including 2 additional years of data relative to the 2017 BiOp. Latitude was not used for the less mobile shore-based sector. We refer to this static model—specific to the shore-based sector—as simply SB to distinguish from the spatially-explicit DR and MLR models used in the at-sea sectors.

Evaluation of CWT recoveries was essential before moving ahead with compositional forecasts for early May based on currently available genetic data from contemporary fisheries that do not begin fishing until 15 May. The second part of our report, the predictive forecasts, will include estimates for all the sectors and fishery management scenarios shown in Table ES2, along with estimated latitudes and numbers that were to be our model inputs. Shore-based latitudes are provided here for comparison with other sectors, but were not used as model inputs.

Part 2—Compositional forecasting and the 2017 BiOp
To estimate the number of fish taken in bycatch from each ESU in this early period, we conducted compositional forecasting nearly identical to that described in the 2017 US West Coast groundfish Biological Opinion. In both cases we employed genetic mixture modeling conditioned on allele frequencies of potential source populations in a coast-wide reference collection of known-origin individuals. For the reference baseline, we used the standardized microsatellite data set produced by the international consortium, Genetic Analysis of Pacific Salmonids (GAPS, Moran et al. 2005; Seeb et al 2007; Appendix). Much useful background information and detail is available regarding the general approach used for this analysis in the 2017 BiOp and in Moran et al. (unpubl., included with this report).

One difference in the current effort from the 2017 BiOp was in the statistical models used for multinomial forecasting. A great deal of subsequent model evaluation and cross validation since the BiOp significantly increased our understanding of the performance of Dirichlet regression (DR) and multinomial logistic regression (MLR) in this context. At the time of the 2017 BiOp, very limited cross validation suggested that our ad hoc method actually outperformed accepted DR and ML methods. Further characterization of DR and MLR in Chinook salmon genetic data (Moran et al. unpubl.) led to a better understanding of the relative strength and weakness of those methods (Fig. 1). Ultimately, the decision was made for this analysis that a simple unweighted combining of model estimates from Dirichlet and multinomial logistic regression would give the most accurate and statistically supported approach to this problem. Both classes of model estimates are included here for information.

Genetic mixture analysis
The genetic analyses that form the core of this report relied on conditional maximum likelihood mixture modeling (CMLMM) and produced two classes of genetic allocation to source populations—direct estimation of mixture proportions and probabilistic assignment of individual fish (Rannala and Mountain 1998; Koljonen et al. 2005; rubias package in R, Moran, and Anderson 2019). CMLMM is also referred to as genetic mixture analysis or modeling, individual assignment, and often, genetic stock identification (GSI).

Latitude was known to be the strongest single predictor of ESU composition (Fig. 2, scatter plot included here from Moran et al. unpubl.). So, our forecasting model used DR on proportions of ESUs as a function of the mean latitude for the group of fish sampled. As an additional predictor we used individual assignments and MLR of that fish's latitude and it's ESU of origin (Fig. 3, illustrates those regressions). Thus, the model inputs for our predictive forecast regression models would be 1) the mean latitude of anticipated bycatch and 2) total number of Chinook salmon potentially taken in the period of interest for a given fishery sector or scenario (conservatively estimated by using the 80% quantile, see Table E2S above). Our analysis included two different geographic distributions (north and south) for the catcher/processor (CP) sector and two levels of harvest for all three Pacific hake mid-water trawl sectors, including shore based (SB). Latitude is highly relevant to bycatch impacts because of the high mobility of the at-sea fleet. The shore-based fleet is much more consistent in latitudinal distribution and so we apply a static model that does not include latitude (although it is listed in Table E2S for comparison to other sectors).

Results and Discussion
We conducted this analysis in two parts, 1) preliminary evaluation of available CWT and GSI data (descriptive) and, 2) application of compositional forecasting models to estimate take associated with this proposed rule change for each Chinook salmon ESU (predictive). Although Part 1) ended up being subsidiary to the final report, the concern it addressed for temporally limited GSI data was sufficient for that part of our analysis to be essential and remain prominent.

We concluded from our preliminary analysis that CWT data were too sparse and not sufficiently different from genetic data for us to change our fundamental approach using genetic modeling. It was clearly essential to make this preliminary assessment before applying genetic models that did not include data for the first 2 weeks in May. In presenting these results, we begin by showing comparisons within and between CWT and GSI data sets for at-sea and shore-based sectors. After showing why CWT would not be used, we then proceed with observations from compositional forecasting and the ESU-specific take tables they produced when multiplied by total numbers of predicted Chinook salmon anticipated with the proposed rule change (see ***Conclusions--compositional forecasts of ESU bycatch***).

Coded-wire-tag recoveries and comparison to GSI observations
The confidence limits on ESU proportions from CWTs were extremely broad because the number of tag recoveries is quite small to estimate proportions for 19 categories, especially for sparse at-sea recoveries (Table 1, Fig. 4). It's also worth noting that the categories include all ESUs (and a couple of northern groups). Zeros in the CWT plot might be for ESUs with no tag releases (e.g., California Coast) whereas all ESUs are assayed genetically. Because of the interdependent nature of proportional data, the mismatch of multinomial classes is a fundamental and potentially irreconcilable problem in combining data sets.

CWT recoveries in at-sea sectors
In the 1990s, most bycatch came before May, with very little throughout the summer, and a few more tag recoveries in fall or winter. The temporal distributions of at-sea CWT and GSI bycatch samples were almost non-overlapping. For example, only one Willamette CWT was taken from May 1st to the 15th and none thereafter. CWTs from other ESUs, such as Central Valley Fall, Klamath/Trinity, Oregon Coast, and Deschutes ESUs (and Southern BC) were also relatively more abundant in bycatch before 15 May, which would decrease the relative proportion of Willamette ESU. By contrast, a few ESUs were relatively less abundant in early May CWT recoveries (S OR/N Cal, Lower Columbia River, Upper Columbia River Summer/Fall). Puget Sound CWTs were conspicuously absent in the early period, despite being abundant in GSI throughout the season between 2008 and 2015.

For the subset of ESUs that is represented in CWT data, the estimated proportions and their confidence intervals were fully contained in the 95% confidence intervals for the GSI estimates (Fig. 5 and 6). This was despite the fact that proportions are scaled differently because there are fewer ESUs represented in CWTs than for GSI, where every fish from every ESU is genetically "tagged." Proportions are higher on average when there are fewer classes to fall into (see Complications below).

We found that **Upper Willamette River ESU, which was a principal concern in this exercise, was well represented in early GSI data**. Approximately two thirds of all Willamette fish from 2008 to 2015 were taken in May. Again, as in CWT data described above, many other ESUs were also abundant in bycatch in early May, e.g., Oregon Coast, Lower Columbia River, Mid-Columbia Spring, Deschutes, and Snake R Fall (to a lesser degree), and U Columbia Summer/Fall ESUs, (and Southern BC and Central BC-AK non-ESU reporting groups). However, some ESUs were less abundant in early bycatch, e.g., Central Valley fa, California Coast, Klamath/Trinity, S Oregon/N California, Puget Sound ESUs, but it is important to note that ESU composition in at-sea bycatch is driven primarily by latitude (NMFS—WCR 2017, Moran et al. unpubl.). The composition is therefore confounded here by migration of the at-sea fleet from north to south over the course of the season. This underscores the importance of models that accommodate latitude.

CWTs in the shore-based sector
CWT recoveries of Central Valley Fall ESU in the shore-based sector were higher in early May than from May – December (Fig. 7). Over the entire year Southern Oregon/Northern California ESU was the largest contributor to CWT recoveries, whereas for contemporary GSI data Klamath/Trinity, Southern Oregon/Northern California, and Oregon Coast ESUs are large, relatively equal contributors to bycatch in the SB sector. In general, **CWT recoveries suggested little or no impact or no change for listed ESUs**. A few appear later in the season, but that is likely due to increasing sample size.

The GSI results in this case were based on very few samples (N=15) because most shore-based Chinook bycatch occurs later in the year, as noted above. Nevertheless, we saw **similar signals to those from CWT recoveries** (Fig. 8). The largest contributing ESUs overlapped, and both data sets showed an early abundance of Central Valley Fall ESU (Fig. 9) with a shift toward Klamath/Trinity ESU in the later season. California Coastal was the only listed ESU that showed a trend for early season abundance that might translate to larger than expected bycatch, relative to the proportion forecast in the BiOp for the full year (Fig 8). However, proportions from early-season CWTs were similar to GSI's early-season proportions, suggesting current genetic models are capturing this effect.

Complications for combining CWT and GSI data
There are a number of significant problems with directly combining CWT and genetic data. In addition to the fact that not all ESUs are tagged (above), only specific hatchery populations are tagged, and rates of tagging within those programs vary from year to year. The amount of natural production relative to hatchery production at the ESU level varies widely. There's also the disparate sample size to reconcile, 41 at-sea tag recoveries versus 4,304 genetic samples and 167 shore-based CWTs versus 345 genetic samples. Beyond creating a thorny weighting problem, the larger genetic samples from the at-sea sector allow a dynamic predictive model with respect to latitude (Fig. 3), a critical factor in ESU composition and a necessity in evaluating the highly mobile CP sector. Such a spatially explicit model would obviously not be possible from 41 tag recoveries over 5 years.

Because of the high level of uncertainty in the CWT data and potential pitfalls of combining them with GSI, we chose to focus our compositional forecasting efforts on the genetic data alone, despite the potential shortcomings we identified with respect to representativeness of early May timing. Fortunately, it doesn't seem necessary to rely on CWT data. The **signal that is evident does not differ significantly from genetic mixture modeling** (Fig. 6 and 9). We find no compelling evidence that genetic models will underestimate any ESUs, at least not relative to the BiOp. Even if California Coast is underestimated by a factor of two in all sectors, that's 52 fish total in the worst-case scenario, only ~10% of the BiOp estimate. Finally, even where CWT recoveries might suggest genetic data underestimate or overestimate proportions (e.g., Puget Sound), it seems unwise to change our forecasts given the challenges described above.

Conclusions--compositional forecasts of ESU bycatch
The 2017 BiOp seems robust to the proposed rule change. We therefore moved on in the second part of our study to show exactly what we think those impacts might be, by ESU. We described

the application of DR and MLR compositional forecasting models for at-sea sectors, and the static SB model from previous ESU composition in observed shore-based bycatch. Those analyses became central to our report of ESU-specific impacts, once we ruled out excessive differences in early May composition and a need to incorporate CWT recoveries in predictive modeling.

Our previous cross validation analyses of compositional predictions gave important insight into accuracy and relative performance of the DR and MLR models (Moran et al. unpubl.). For example, we knew that DR more accurately estimated abundant ESUs but systematically overestimated rare ones. By contrast, MLR more accurately predicted rare ESUs but consistently overestimated southern ESUs, especially the very abundant Klamath/Trinity ESU. In general, MLR estimates tended to be higher for some southern ESUs and lower for northern, relative to DR.

With those characteristics in mind, the MLR estimates obtained here are likely overestimates for Klamath/Trinity ESU. When we compare divergence of the model estimates, mean squared errors (MSEs) were extremely large (error metrics not shown but see Table 3 for model comparisons). However, when the error metric was scaled to the size of the contributing ESU, Klamath fell in the middle of the distribution (i.e., mean absolute arctangent percent error, MAAPE). Moreover, the small ESUs have very large MAAPE values, reflecting scaling and the DR over-estimation bias noted in Moran et al. (unpubl.). A prediction of 189 Klamath fish in this 2-week period is certainly higher than expected. However, we note that the 80% quantile was chosen to be conservative and is obviously higher than expected bycatch.

Because DR and MLR each have distinct predictive strengths and limitations, and because neither is clearly more accurate for the application at hand, we favor combining the two estimates as an unweighted arithmetic mean for each sector/scenario (Table 5 and 6, Fig. 10).

In addition to the averaging of models, several other factors exert a dampening effect on bycatch forecasts for ESU impacts. For example, there can be pulses of fish—for example returning adults—that are hard to capture in predictive models, due to insufficient scale and density of temporal sampling (exactly the problem we faced here). However, because those same populations are sampled at different times of the year as migrating and feeding sub-adults, those unsampled impacts are mitigated to some extent. Also, in multinomial data, errors are distributed among classes, and well-characterized classes (ESUs) inform the less certain classes. In general, these effects and others serve to reduce the sensitivity to inputs for these forecasts. There's no question that this exercise pushed the margin of statistically sound compositional forecasting, however, we believe that by thoroughly mining both CWT and GSI data and by using conservative inputs and interpretation we have derived estimates that are consistent with obligations to apply the best available science and to reasonably evaluate impacts on listed and other sensitive ESUs. **Despite considerable effort, we found little if any evidence of impacts on listed ESUs that would not have been captured in the 2017 BiOp.**

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Tables and Figures

Table 1. CWT recoveries 1991-1995 by Chinook salmon ESU in at-sea sectors comparing **1-14 May versus all of May-December**

ESU	May 1-14	May-Dec
Sacramento Wi	0	0
Central Valley Sp	0	0
Central Valley Fa	1	1
California Coast	0	0
Klamath/Trinity	7	8
S Oregon/N California	9	11
Oregon Coast	2	2
Washington Coast	0	0
L Columbia R	3	7
U Willamette R	1	1
Mid-Columbia R Sp	0	0
U Columbia R Sp	0	0
Deschutes R Su/Fa	2	2
U Columbia R Su/Fa	1	2
Snake R Sp/Su	0	0
Snake R Fa	2	3
Puget Sound	0	0
Southern BC	3	3
Central BC-AK	1	1
	32	41

Table 2. CWT recoveries 1991-1995 by Chinook salmon ESU in shore-based sectors comparing **1-14 May (N=39) versus all of May-December (N=167)**

ESU	May 1-14	May-Dec
Sacramento Wi	0	0
Central Valley Sp	0	0
Central Valley Fa	11	25
California Coast	0	0
Klamath/Trinity	9	31
S Oregon/N California	11	70
Oregon Coast	6	27
Washington Coast	0	0
L Columbia R	0	6
U Willamette R	0	0
Mid-Columbia R Sp	0	1
U Columbia R Sp	0	0
Deschutes R Su/Fa	0	0
U Columbia R Su/Fa	0	1
Snake R Sp/Su	0	0
Snake R Fa	2	5
Puget Sound	0	1
Southern BC	0	0
Central BC-AK	0	0
	39	167

Table 3. Predicted proportions of Chinook salmonbycatch by Evolutionarily Siginificant Unit for each Pacific whiting sector under different scenarios of effort distribution and harvest level (DR Dirichlet Regression, MLR multinomial logistic regression, MS Mothership, CP Catcher Processor, SB Shore-based model and sector)

Model	Sector	Effort dist.	Exp. Harvest	Latitude	Sacramento Wi	Central Valley Sp	Central Valley Fa	California Coast	Klamath/Trinity	S Oregon/N California	Oregon Coast	Washington Coast	L Columbia R	U Willamette R	Mid-Columbia R Sp	U Columbia R Sp	Deschutes R Su/Fa	U Columbia R Su/Fa	Snake R Sp/Su	Snake R Fa	Puget Sound	Southern BC	Central BC-AK
DR	MS	Coastwide	Low	46.420	0.000	0.009	0.022	0.032	0.126	0.131	0.110	0.014	0.093	0.013	0.012	0.010	0.022	0.053	0.013	0.030	0.107	0.177	0.024
DR	MS	Coastwide	High	46.388	0.000	0.009	0.023	0.032	0.128	0.133	0.111	0.014	0.092	0.013	0.012	0.010	0.022	0.052	0.013	0.030	0.106	0.174	0.024
DR	CP	North	Low	45.661	0.000	0.010	0.029	0.041	0.190	0.187	0.121	0.013	0.063	0.012	0.012	0.010	0.021	0.045	0.012	0.026	0.073	0.114	0.020
DR	CP	North	High	45.611	0.000	0.010	0.029	0.042	0.195	0.190	0.121	0.013	0.061	0.012	0.012	0.010	0.021	0.044	0.012	0.026	0.071	0.110	0.020
DR	CP	South	Low	42.409	0.000	0.005	0.032	0.049	0.442	0.339	0.070	0.004	0.005	0.004	0.005	0.005	0.006	0.009	0.004	0.006	0.006	0.007	0.004
DR	CP	South	High	42.405	0.000	0.005	0.032	0.049	0.442	0.339	0.069	0.004	0.005	0.004	0.005	0.005	0.006	0.009	0.004	0.006	0.006	0.007	0.004
MLR	MS	Coastwide	Low	46.420	0.000	0.000	0.035	0.037	0.229	0.158	0.135	0.004	0.087	0.003	0.001	0.001	0.007	0.040	0.003	0.016	0.076	0.156	0.012
MLR	MS	Coastwide	High	46.388	0.000	0.000	0.036	0.038	0.234	0.162	0.136	0.004	0.085	0.002	0.001	0.001	0.007	0.039	0.003	0.016	0.073	0.151	0.012
MLR	CP	North	Low	45.661	0.000	0.000	0.046	0.054	0.340	0.234	0.132	0.002	0.045	0.001	0.001	0.001	0.003	0.024	0.001	0.010	0.030	0.068	0.007
MLR	CP	North	High	45.611	0.000	0.000	0.046	0.054	0.346	0.239	0.131	0.002	0.043	0.001	0.001	0.001	0.003	0.023	0.001	0.010	0.028	0.064	0.007
MLR	CP	South	Low	42.409	0.000	0.003	0.039	0.074	0.504	0.344	0.033	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000
MLR	CP	South	High	42.405	0.000	0.003	0.039	0.074	0.504	0.344	0.033	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000
MLR	SB	Coastwide	Low	46.186	0.000	0.000	0.129	0.032	0.260	0.207	0.204	0.005	0.056	0.000	0.000	0.000	0.013	0.055	0.000	0.003	0.008	0.028	0.001
MLR	SB	Coastwide	High	46.187	0.000	0.000	0.129	0.032	0.260	0.207	0.204	0.005	0.056	0.000	0.000	0.000	0.013	0.055	0.000	0.003	0.008	0.028	0.001

Table 4. Predicted number of Chinook salmon at the 80% quantile expected in bycatch for each Pacific whiting sector under different scenarios of effort distribution and harvest level (DR Dirichlet Regression, MLR multinomial logistic regression, MS Mothership, CP Catcher Processor, SB Shore-based model and sector)

Model	Latitude	N	Sector	Effort dist.	Exp. Harvest	**Sacramento Wi**	**Central Valley Sp**	Central Valley Fa	**California Coast**	Klamath/Trinity	S Oregon/N California	Oregon Coast	Washington Coast	**L Columbia R**	**U Willamette R**	Mid-Columbia R Sp	**U Columbia R Sp**	Deschutes R Su/Fa	U Columbia R Su/Fa	**Snake R Sp/Su**	**Snake R Fa**	**Puget Sound**	Southern BC	Central BC-AK
DR	46.420	56	MS	Coastwide	Low	0	1	1	2	7	7	6	1	5	1	1	1	1	3	1	2	6	10	1
MLR	46.420	56	MS	Coastwide	Low	0	0	2	2	13	9	8	0	5	0	0	0	0	2	0	1	4	9	1
DR	46.388	170	MS	Coastwide	High	0	2	4	5	22	23	19	2	16	2	2	2	4	9	2	5	18	30	4
MLR	46.388	170	MS	Coastwide	High	0	0	6	6	40	28	23	1	15	0	0	0	1	7	1	3	12	26	2
DR	45.661	116	CP	North	Low	0	1	3	5	22	22	14	2	7	1	1	1	2	5	1	3	8	13	2
MLR	45.661	116	CP	North	Low	0	0	5	6	39	27	15	0	5	0	0	0	0	3	0	1	3	8	1
DR	45.611	207	CP	North	High	0	2	6	9	40	39	25	3	13	3	3	2	4	9	3	5	15	23	4
MLR	45.611	207	CP	North	High	0	0	10	11	72	49	27	0	9	0	0	0	1	5	0	2	6	13	1
DR	42.409	172	CP	South	Low	0	1	5	8	76	58	12	1	1	1	1	1	1	2	1	1	1	1	1
MLR	42.409	172	CP	South	Low	0	1	7	13	87	59	6	0	0	0	0	0	0	0	0	0	0	0	0
DR	42.405	309	CP	South	High	0	1	10	15	137	105	21	1	1	1	2	2	2	3	1	2	2	2	1
MLR	42.405	309	CP	South	High	0	1	12	23	156	106	10	0	0	0	0	0	0	0	0	0	0	0	0
SB/SB/H	46.186	15	SB	Coastwide	Low	0	0	2	0	4	3	3	0	1	0	0	0	0	1	0	0	0	0	0
SB/SB/H	46.187	44	SB	Coastwide	High	0	0	6	1	11	9	9	0	2	0	0	0	1	2	0	0	0	1	0

Table 5. Predicted number of Chinook salmon derived from combined Dirichlet regression and multinomial logistic regression, reported by Evolutionarily Siginificant Unit expected in bycatch for each Pacific whiting sector under different scenarios of harvest level and effort distribution (MS Mothership, CP Catcher Processor, SB Shore-based)

Latitude	N	Sector	Effort dist.	Exp. Harvest	**Sacramento Wi**	**Central Valley Sp**	Central Valley Fa	**California Coast**	Klamath/Trinity	S Oregon/N California	Oregon Coast	Washington Coast	**L Columbia R**	**U Willamette R**	Mid-Columbia R Sp	**U Columbia R Sp**	Deschutes R Su/Fa	U Columbia R Su/Fa	**Snake R Sp/Su**	**Snake R Fa**	**Puget Sound**	Southern BC	Central BC-AK
46.420	56	MS	Coastwide	Low	**0**	**0**	2	**2**	10	8	7	0	**5**	**0**	0	**0**	1	3	**0**	**1**	**5**	9	1
46.388	170	MS	Coastwide	High	**0**	**1**	5	**6**	31	25	21	1	**15**	**1**	1	**1**	2	8	**1**	**4**	**15**	28	3
45.661	116	CP	North	Low	**0**	**1**	4	**5**	31	24	15	1	**6**	**1**	1	**1**	1	4	**1**	**2**	**6**	11	2
45.611	207	CP	North	High	**0**	**1**	8	**10**	56	44	26	2	**11**	**1**	1	**1**	2	7	**1**	**4**	**10**	18	3
42.409	172	CP	South	Low	**0**	**1**	6	**11**	81	59	9	0	**0**	**0**	0	**0**	1	1	**0**	**1**	**0**	1	0
42.405	309	CP	South	High	**0**	**1**	11	**19**	146	105	16	1	**1**	**1**	1	**1**	1	2	**1**	**1**	**1**	1	1
46.186	15	SB	Coastwide	Low	**0**	**0**	2	**0**	4	3	3	0	**1**	**0**	0	**0**	0	1	**0**	**0**	**0**	0	0
46.187	44	SB	Coastwide	High	**0**	**0**	6	**1**	11	9	9	0	**2**	**0**	0	**0**	1	2	**0**	**0**	**0**	1	0

Table 6. Predicted number of Chinook salmon (counts) derived from combined Dirichlet and multinomial logistic regression predictions across sectors and under various scenarios of effort distribution and harvest levels.

N	Effort dist.	Exp. Harvest	**Sacramento Wi**	**Central Valley Sp**	Central Valley Fa	**California Coast**	Klamath/Trinity	S Oregon/N Calfornia	Oregon Coast	Washington Coast	**L Columbia R**	**U Willamette R**	Mid-Columbia R Sp	**U Columbia R Sp**	Deschutes R Su/Fa	U Columbia R Su/Fa	**Snake R Sp/Su**	**Snake R Fa**	**Puget Sound**	Southern BC	Central BC-AK
188	North	Low	**0**	**1**	8	**8**	45	36	25	1	**12**	**1**	1	**1**	2	7	**1**	**3**	**11**	20	3
421	North	High	**0**	**2**	18	**17**	98	79	56	3	**28**	**3**	2	**2**	6	17	**3**	**8**	**26**	47	6
244	South	Low	**0**	**1**	10	**13**	95	70	19	1	**6**	**1**	1	**1**	2	4	**1**	**2**	**6**	10	1
523	South	High	**0**	**2**	22	**26**	189	140	46	2	**18**	**2**	2	**2**	4	12	**2**	**5**	**17**	30	4

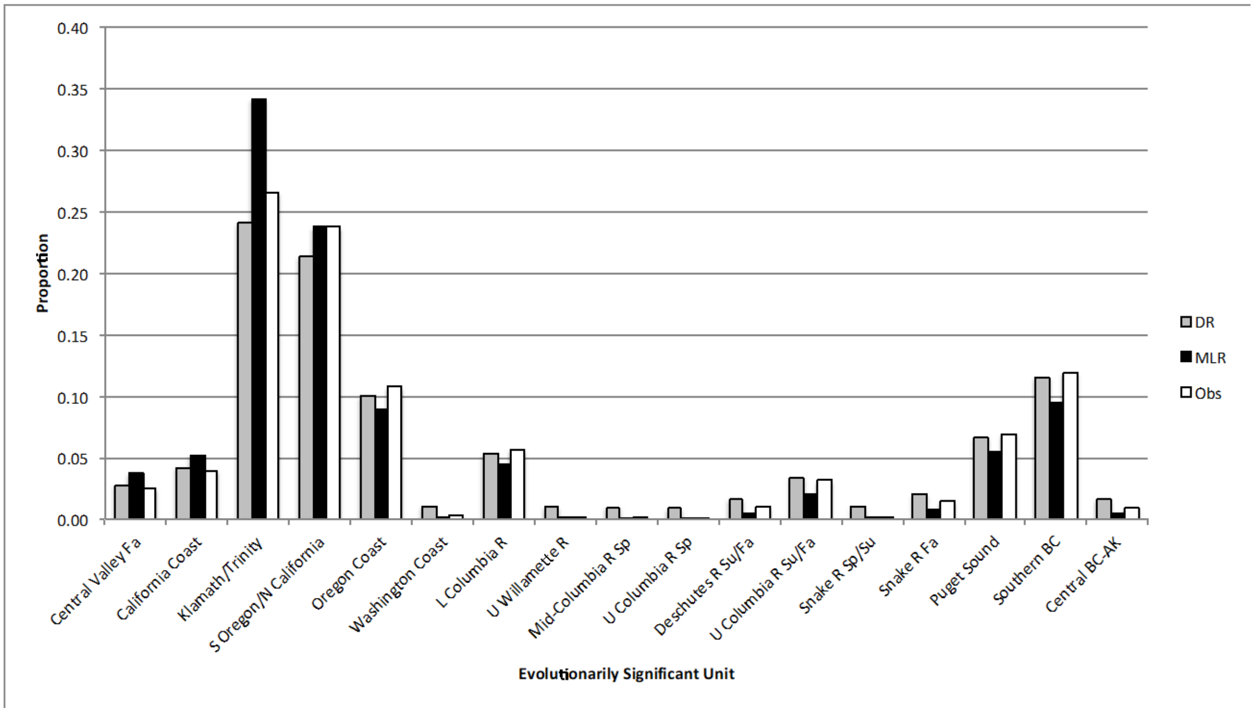


Figure 1. Model cross validation, summarized from predictions across 8 years of genetic mixture analysis. ESU proportions (south to north) estimated from observed samples (Obs) compared with values predicted from Dirichlet regression (DR) and multinomial logistic regression (MLR), independent of observed training data. Sacramento Winter and Central Valley Spring ESUs were not included in leave-one-out cross-validation because no Sacramento fish was ever observed, and Central Valley Spring was only observed in a single year (reproduced from Moran et al. unpubl.).

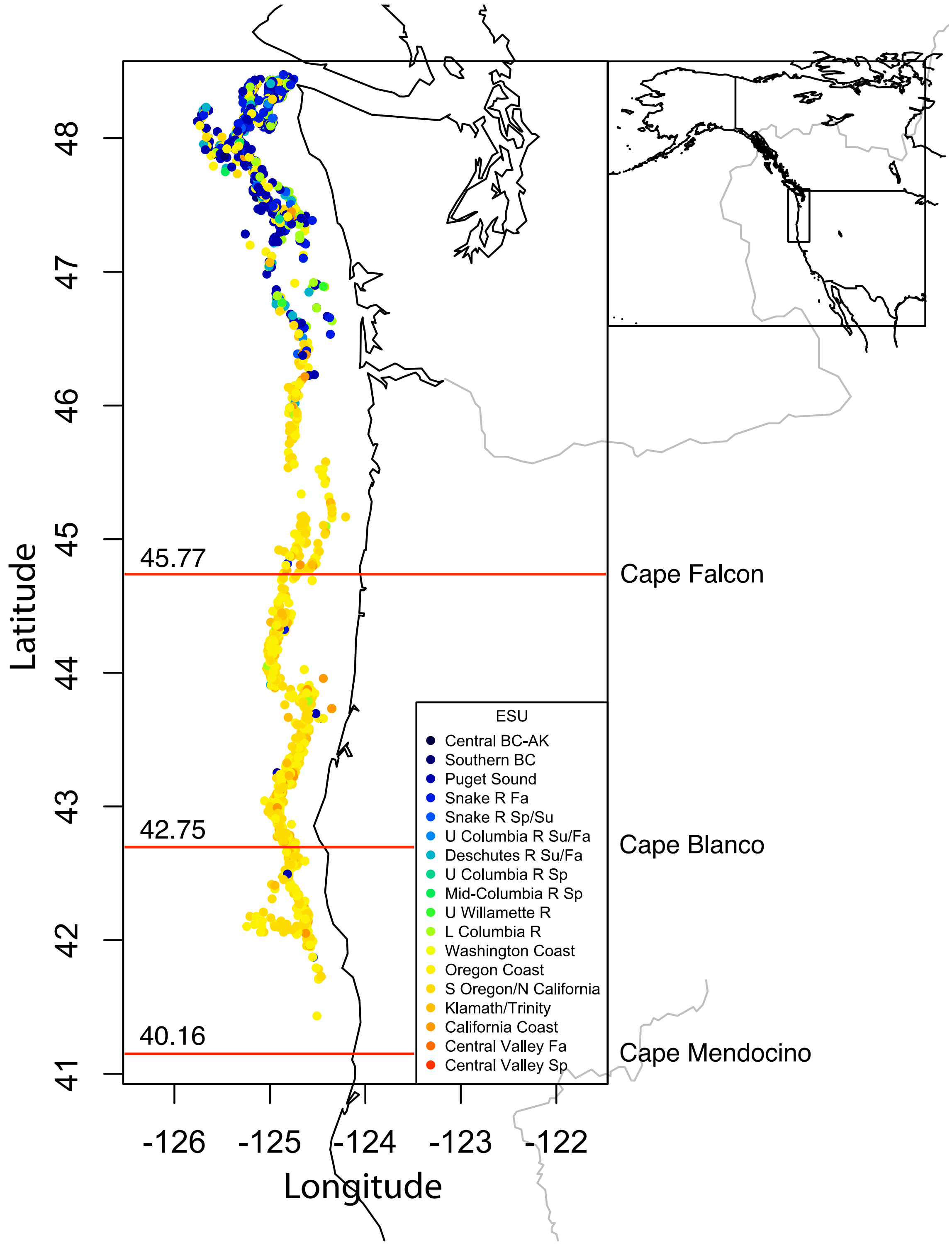


Figure 2. Individual Chinook Salmon taken in bycatch color coded by most likely ESU of origin, from red in the south to blue in the north. Fishery management area boundaries are shown as red lines with associated latitudes (reproduced from Moran et al. unpubl.).

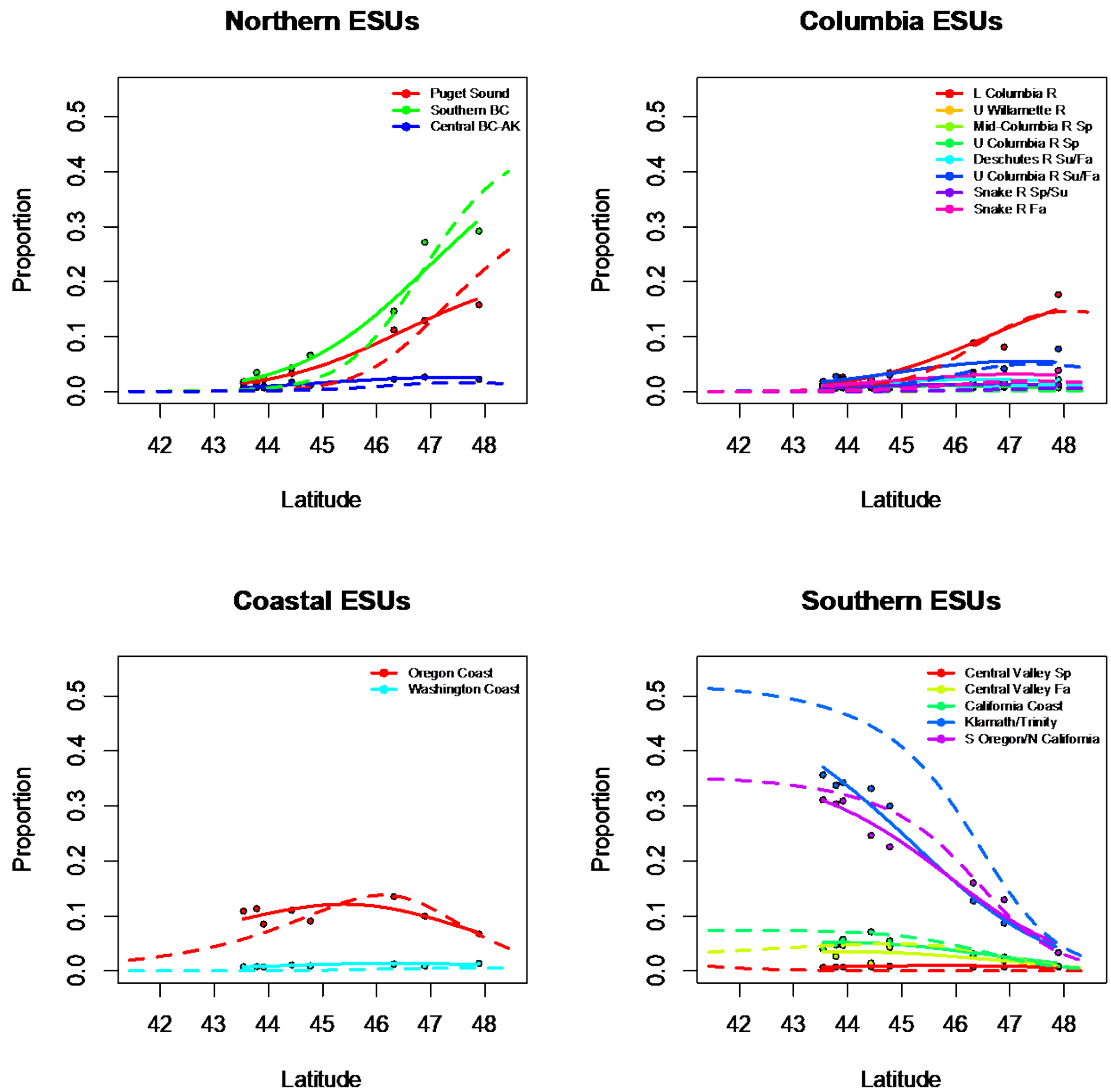
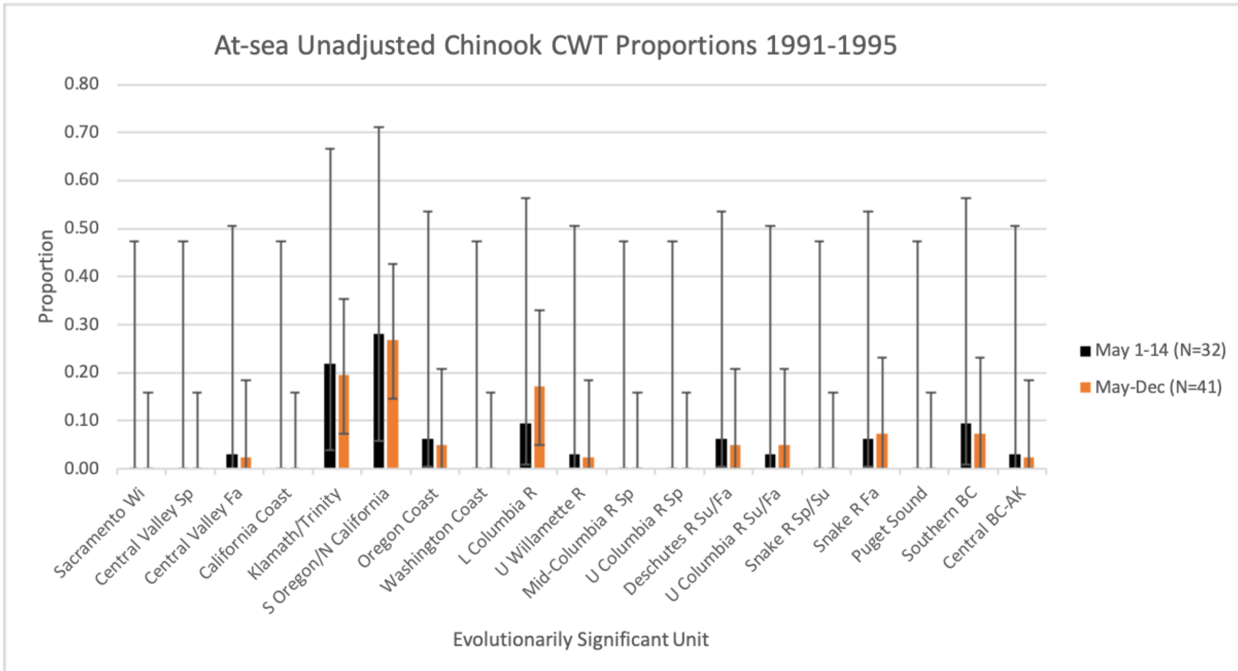


Figure 3. Dirichlet regression (solid) and multinomial logistic regression (dashed) with observed proportions (summing to one over all four panels) and mean latitudes of annual samples (points). Data ranges differ because DR is based on mean latitudes, whereas MLR is fitted to individual fish, their observed latitude, and the ESU to which they were assigned (reproduced from Moran et al. unpubl.).



[Author's note: Multinomial errors are incorrect because non-existent classes are included, e.g., Cal Coast. Not clear how to easily determine which ESUs were not tagged in the 1990s]

Figure 4. Bar plot at-sea early/all CWT proportions

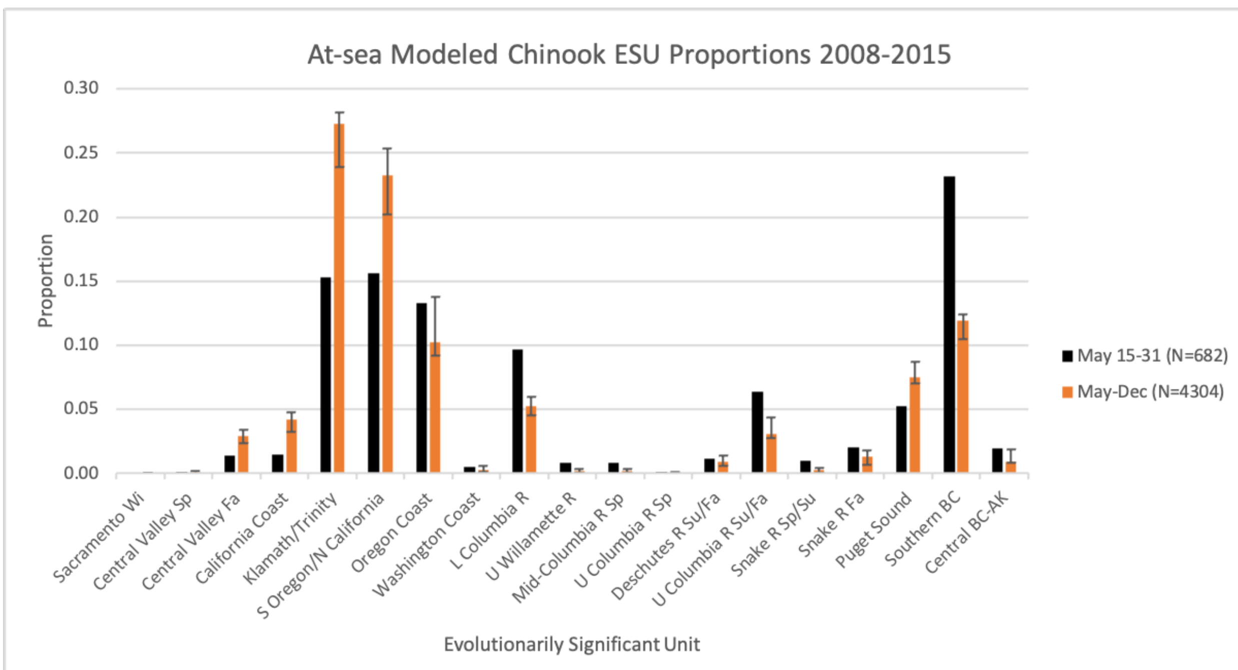


Figure 5. Bar plot at-sea early/all modeled GSI proportions

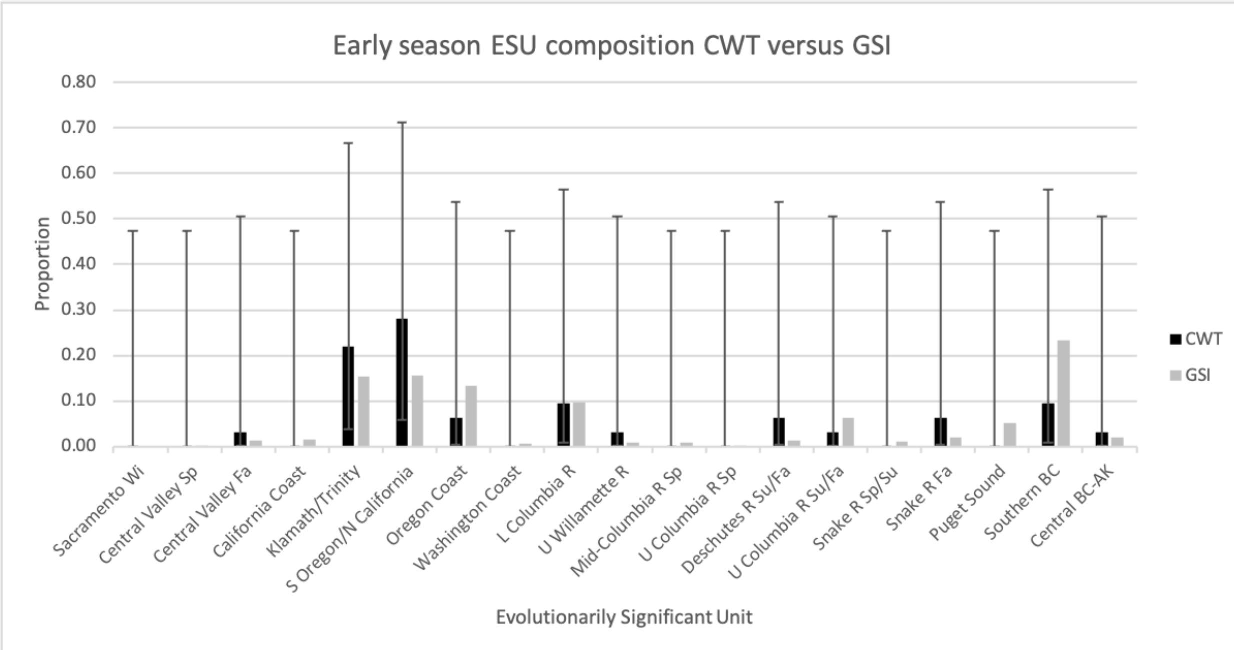


Figure 6. Bar plot at-sea early CWT/early GSI proportions

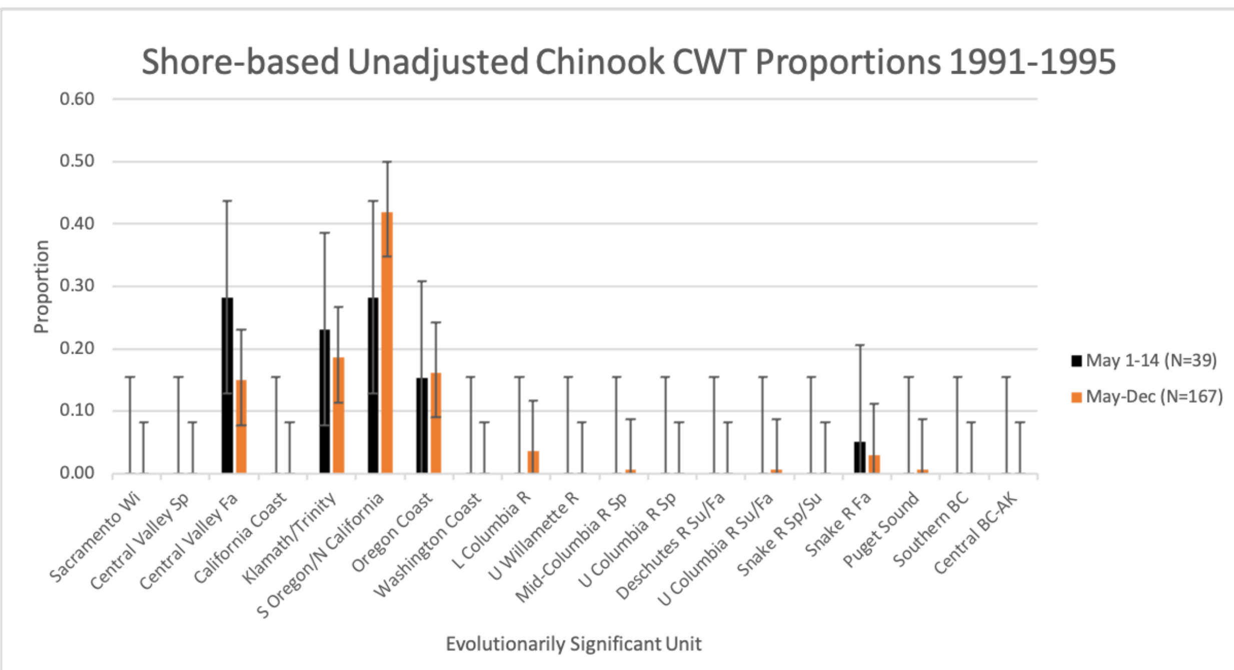


Figure 7. Bar plot shore-based early/all CWT proportions

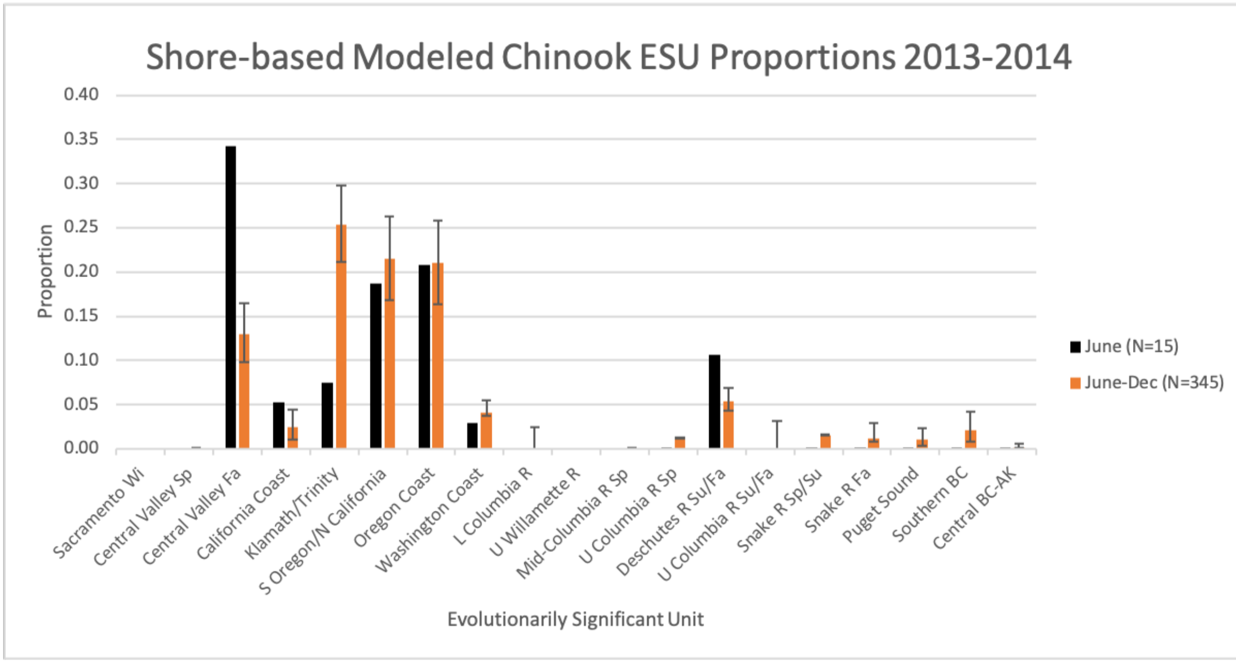


Figure 8. Bar plot shore-based early/late GSI proportions

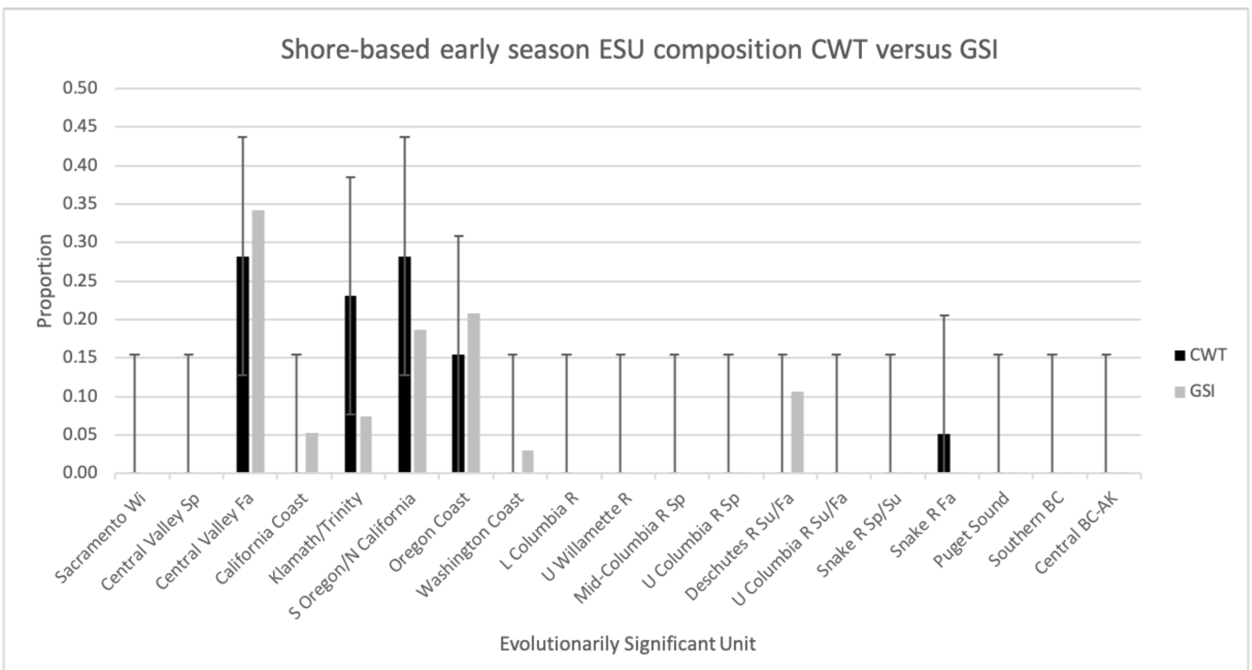


Figure 9. Bar plot shore-based early CWT/”early” GSI (June in this case)

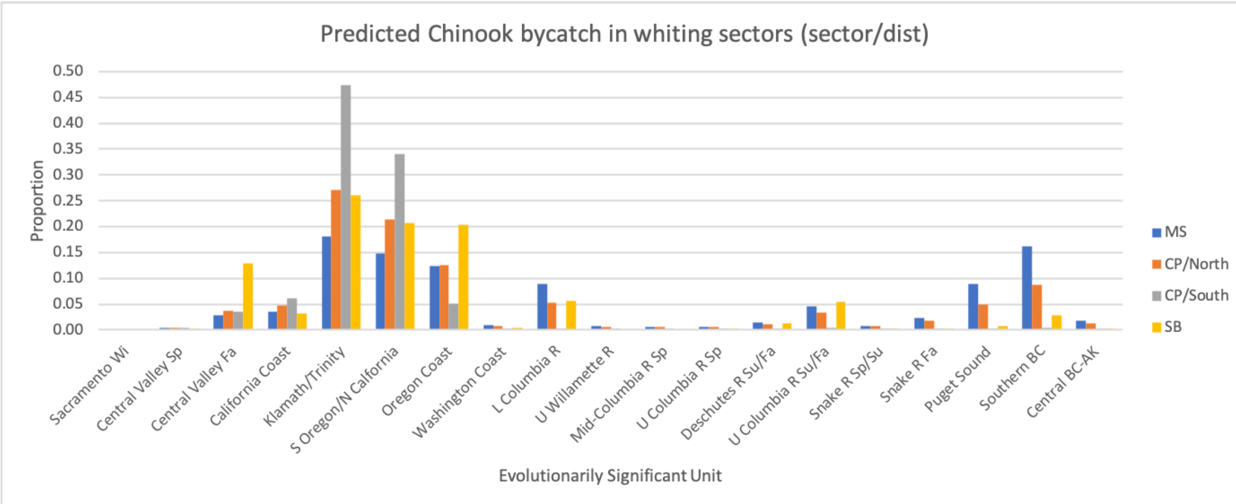


Figure 10. Chinook salmon ESU proportions predicted from latitude, by sector and distribution (DR and MLR model estimates combined for at-sea sectors). High and low harvest levels have quite similar (but not identical) proportions--only high series plotted (see Table 4 and 5 for detail).

APPENDIX—compositional forecasting

Reference populations and reporting group structure for genetic mixture analysis based on Evolutionarily Significant Units (J. Myers, pers. comm. January 2016). Populations modified from Seeb et al. (2007). Status: E = Endangered, T = Threatened, C = Candidate, NW = Not Warranted, N/A = Not Applicable, stock aggregates that are not ESUs, which are only defined for the conterminous, US West Coast states. Carson Hatchery is a mixed-origin broodstock that is not listed under the ESA.

Genetic baseline population	ESU reporting group	Status
Sacramento Hatchery	Sacramento Winter	E
Butte Creek sp	Central Valley Spring	T
Deer Creek sp	Central Valley Spring	T
Mill Creek sp	Central Valley Spring	T
Feather Hatchery sp	Central Valley Fall	C
Feather Hatchery fa	Central Valley Fall	C
Butte Creek fa	Central Valley Fall	C
Stanislaus River	Central Valley Fall	C
Battle Creek	Central Valley Fall	C
Russian River	California Coastal	T
Eel River	California Coastal	T
Trinity Hatchery fa	Upper Klamath-Trinity Rivers	NW
Trinity Hatchery sp	Upper Klamath-Trinity Rivers	NW
Klamath River fa	Upper Klamath-Trinity Rivers	NW
Chetco River	S. Oregon and N. California Coastal	NW
Applegate Creek	S. Oregon and N. California Coastal	NW
Cole Rivers Hatchery	S. Oregon and N. California Coastal	NW
Elk Hatchery	Oregon Coast	NW
Sixes River	Oregon Coast	NW
Coquille River	Oregon Coast	NW
Coos Hatchery	Oregon Coast	NW
S Umpqua Hatchery	Oregon Coast	NW
Umpqua Hatchery	Oregon Coast	NW
Siuslaw River	Oregon Coast	NW
Alsea River	Oregon Coast	NW
Yaquina River	Oregon Coast	NW
Siletz River	Oregon Coast	NW
Salmon River fa	Oregon Coast	NW
Nestucca Hatchery	Oregon Coast	NW
Trask River	Oregon Coast	NW
Wilson River	Oregon Coast	NW
Kilchis River	Oregon Coast	NW
Nehalem River	Oregon Coast	NW

Genetic baseline population	ESU reporting group	Status
Necanicum Hatchery	Oregon Coast	NW
Forks Creek Hatchery	Washington Coast	NW
Humptulips Hatchery	Washington Coast	NW
Queets River	Washington Coast	NW
Hoh River	Washington Coast	NW
Sol Duc Hatchery	Washington Coast	NW
Makah Hatchery	Washington Coast	NW
Lewis Hatchery sp	Lower Columbia River	T
Kalama Hatchery sp	Lower Columbia River	T
Cowlitz Hatchery sp	Lower Columbia River	T
Cowlitz Hatchery fa	Lower Columbia River	T
Sandy River	Lower Columbia River	T
Lewis River fa	Lower Columbia River	T
Spring Creek Hatchery	Lower Columbia River	T
McKenzie Hatchery	Upper Willamette River	T
N Santiam Hatchery	Upper Willamette River	T
Warm Springs Hatchery	Mid-Columbia River Spring	NW
John Day River	Mid-Columbia River Spring	NW
U Yakima Hatchery	Mid-Columbia River Spring	NW
Wenatchee River sp	Upper Columbia River Spring	E
Wenatchee Hatchery sp	Upper Columbia River Spring	E
Carson Hatchery	Upper Columbia River Spring	N/A
U Deschutes River	Deschutes River Summer/Fall	NW
L Deschutes River	Deschutes River Summer/Fall	NW
Hanford Reach	Upper Columbia River Summer/Fall	NW
Wenatchee River su/fa	Upper Columbia River Summer/Fall	NW
Wells Hatchery	Upper Columbia River Summer/Fall	NW
Methow River	Upper Columbia River Summer/Fall	NW
Lyons Ferry Hatchery	Snake River Fall	T
EF Salmon River	Snake River Spring/Summer	T
WF Yankee Fork	Snake River Spring/Summer	T
Secesh River	Snake River Spring/Summer	T
Rapid River Hatchery	Snake River Spring/Summer	T
Minam River	Snake River Spring/Summer	T
Imnaha River	Snake River Spring/Summer	T
Newsome Creek	Snake River Spring/Summer	T
Tucannon Hatchery	Snake River Spring/Summer	T
Tucannon River	Snake River Spring/Summer	T

Genetic baseline population	ESU reporting group	Status
Clear Creek Hatchery	Puget Sound	T
Voights Hatchery	Puget Sound	T
S Prairie Creek	Puget Sound	T
Soos Hatchery	Puget Sound	T
George Adams Hatchery	Puget Sound	T
Hamma Hamma River	Puget Sound	T
Snoqualmie River	Puget Sound	T
Samish Hatchery	Puget Sound	T
Elwha Hatchery	Puget Sound	T
Elwha River	Puget Sound	T
Dungeness River	Puget Sound	T
NF Nooksack Hatchery	Puget Sound	T
White Hatchery	Puget Sound	T
Hatchery Supp Sp Hatchery	Puget Sound	T
Skykomish River	Puget Sound	T
Wallace Hatchery	Puget Sound	T
NF Stillaguam Hatchery	Puget Sound	T
Skagit River	Puget Sound	T
U Sauk River	Puget Sound	T
Suiattle River	Puget Sound	T
L Sauk River	Puget Sound	T
Marblemount Hatchery sp	Puget Sound	T
Marblemount Hatchery su	Puget Sound	T
U Cascade River	Puget Sound	T
U Skagit River	Puget Sound	T
W Chilliwack Hatchery	Southern BC	N/A
Maria Slough	Southern BC	N/A
Birkenhead Hatchery	Southern BC	N/A
M Shuswap Hatchery	Southern BC	N/A
L Thomson River	Southern BC	N/A
L Adams Hatchery	Southern BC	N/A
Clearwater River	Southern BC	N/A
Riveraft River	Southern BC	N/A
Spius Hatchery	Southern BC	N/A
Nicola Hatchery	Southern BC	N/A
Louis Creek	Southern BC	N/A
Deadman Hatchery	Southern BC	N/A
U Chilcotin River	Southern BC	N/A
Chilko River	Southern BC	N/A
Quesnel River	Southern BC	N/A
Nechako River	Southern BC	N/A
Stuart River	Southern BC	N/A

Genetic baseline population	ESU reporting group	Status
Swift River	Southern BC	N/A
Morkill River	Southern BC	N/A
Salmon River sp	Southern BC	N/A
Cowichan Hatchery	Southern BC	N/A
Nanaimo Hatchery fa	Southern BC	N/A
Big Qualicum Hatchery	Southern BC	N/A
Puntledge Hatchery fa	Southern BC	N/A
Quinsam Hatchery	Southern BC	N/A
Nitinat Hatchery	Southern BC	N/A
Sarita Hatchery	Southern BC	N/A
Tranquil River	Southern BC	N/A
Robertson Hatchery	Southern BC	N/A
Conuma Hatchery	Southern BC	N/A
Tahsis River	Southern BC	N/A
Marble Hatchery	Southern BC	N/A
Porteau Cove Hatchery	Southern BC	N/A
Klinaklini River	Southern BC	N/A
Wannock Hatchery	Central BC-AK	N/A
Atnarko Hatchery	Central BC-AK	N/A
Kitimat Hatchery	Central BC-AK	N/A
Ecstall River	Central BC-AK	N/A
L Kalum River	Central BC-AK	N/A
Bulkley River	Central BC-AK	N/A
Sustut River	Central BC-AK	N/A
Kincolith River	Central BC-AK	N/A
Kwinageese River	Central BC-AK	N/A
Damdochax River	Central BC-AK	N/A
Owegee River	Central BC-AK	N/A
L Tahltan River	Central BC-AK	N/A
Nakina River	Central BC-AK	N/A
Kowatua Creek	Central BC-AK	N/A
Tatsatua Creek	Central BC-AK	N/A
U Nahlin River	Central BC-AK	N/A
Chickamin/White Hatchery	Central BC-AK	N/A
Chickamin Hatchery	Central BC-AK	N/A
Chickamin River	Central BC-AK	N/A
Keta River	Central BC-AK	N/A
King Creek	Central BC-AK	N/A
Clear Creek	Central BC-AK	N/A
Creekipple Creek	Central BC-AK	N/A
Andrew Creek	Central BC-AK	N/A
Andrew/Mac Hatchery	Central BC-AK	N/A

Genetic baseline population	ESU reporting group	Status
Andrew/Med Hatchery	Central BC-AK	N/A
Andrew/Cry Hatchery	Central BC-AK	N/A
King Salmon River	Central BC-AK	N/A
Big Boulder Creek	Central BC-AK	N/A
Tahini River	Central BC-AK	N/A
Tahini/Mac Hatchery	Central BC-AK	N/A
Klukshu River	Central BC-AK	N/A
Situk River	Central BC-AK	N/A

[1]Feather River spring run brood stock was extensively hybridized with fall run in that program and the two are now genetically indistinguishable.
[2]Brood stock from Cole M. Rivers Hatchery on the Rogue River in Southern Oregon is currently propagated and released in Young's Bay at the mouth of the Columbia River.