GROUNDFISH MANAGEMENT TEAM REPORT ON INSEASON ADJUSTMENTS
FINAL ACTION

The Groundfish Management Team (GMT) discussed the current status of bycatch in the at-sea whiting sectors and the need for some additional information stemming from Pacific Fishery Management Council (Council) discussion during the June 2023 Council meeting. Bycatch in the shoreside whiting sector is also a matter of interest and therefore included where practicable; however, detailed spatial data from this sector is not available in-season, so this analysis does not include spatial elements of 2023 bycatch in the shoreside sector. Below, the GMT provides an informational report that details the 2023 Spring season bycatch in the Pacific whiting fishery. Effort was made to keep the two at-sea sectors separate for analysis while still maintaining data confidentiality.

Contents

Executive Summary

Spring 2023 Pacific whiting attainments for both at-sea sectors are well below the 5-year average spring attainments of their initial Pacific whiting allocations. Both at-sea sectors saw high encounter rates throughout the entire Spring fishery, and all three Pacific whiting sectors saw increases in Chinook bycatch compared to their respective recent averages. Haul-level analysis demonstrates that 2023 appears to be an anomalous year. Although Chinook bycatch in Spring 2023 was atypically high, the first two weeks of 2023 (May 1-14) did not appear to drive the increased encounters nor the higher proportion of moderate to large sized hauls. Based on the low Pacific whiting catch scenario for both sectors, the mothership (MS) sector's Chinook salmon bycatch in the first two weeks of 2023 exceeded the 80th percentile projection in the Whiting Utilization

Analysis and the catcher-processor (CP) sector's bycatch exceeded the 100th percentile projections for both southern and northern effort distribution scenarios. However, the Whiting Utilization Analysis projections could not have accounted for the atypically high encounters, haul sizes, and bycatch rates experienced in Spring 2023.

A bootstrap projection was used to model two different Pacific whiting attainment scenarios for the at-sea sectors against two different shoreside whiting scenarios to evaluate the risk of exceeding the 11,000 Chinook bycatch threshold. The GMT ran similar bootstrap projections of at-sea bycatch under low and average Pacific whiting attainment scenarios for darkblotched rockfish, widow rockfish, yellowtail rockfish north of 40° 10′ N. lat., sablefish north of 36° N. lat, and canary rockfish. We evaluated the risk to the ACL for those stocks, with the exception of canary rockfish, by combining the 80th percentile of the at-sea projections with three alternative scenarios of mortality in all other sectors. None of the ACLs for the stocks evaluated appeared to be at risk of being exceeded under any of the scenarios, but the widow rockfish mortality is projected at 95 percent of the ACL under the highest mortality scenario.

At-sea Whiting Catch

Spring 2023

The Pacific whiting fishery season opened on May 1, 2023, two weeks earlier than prior years (May 15), as a result of the Council's Whiting Utilization action (87 FR 77000). Each company has their own plans, but in general, before the CP and MS at-sea sectors start fishing in the West Coast Pacific whiting fishery, they fish in the walleye pollock (also known as Alaska pollock) "A Season" starting in early January. After the Alaska pollock "A Season," they fish in the West Coast Pacific whiting fishery until June before again leaving for Alaska to fish Alaska pollock in the Summer "B Season." This year, vessels wrapped up Spring fishing in the Pacific whiting fishery by June 4. The following section provides a characterization of the Pacific whiting fishery in Spring 2023.

Table 1 indicates that even with the two extra weeks in May, both at-sea sectors are well below the 5-year average spring attainment of their initial Pacific whiting allocations. The MS sector's 2023 percent attainment was about a third of their recent five-year average (15 percent vs. 42 percent), and the CP percent attainment was about two-thirds of their recent five-year average (31 percent vs. 45 percent). It should be noted that the date at which the at-sea sectors have fully

transitioned from the Spring Pacific whiting fishery to the Alaska pollock "B Season" varies year-to-year, so the attainments in Table 1 are not entirely comparable. To provide a more direct comparison, the GMT truncated the Spring fishery into a snapshot of the same three weeks in Table 2.

Table 2 compares total Pacific whiting catch and attainment in the at-sea sectors from the same three calendar weeks (weeks 20-22 or May 15 - June 4) from the last five years, compared to 2023. During that three week period, CP catch in 2023 was ~6,000 mt higher than the five-year average, and CP attainment was 2 percent higher in 2023 than the average. The MS sector caught ~7,600 mt less than their five-year average, and 2023 MS attainment was exactly half of the five-year average. The shoreside whiting sector has attained 13 percent less of their initial allocation than the recent six-year average, as of August 17th (Table 3). The 2023 shoreside whiting attainment to date is equivalent to 2022, which is when the sector also experienced their lowest year-end attainment in the last 6 years.

Table 1. Sum of Pacific whiting catch by at-sea sector for full Spring season in metric tons (mt), with the caveat that the 2023 year started on May 1 as opposed to May 15 for all other years. The end of the Spring season was characterized as June 30th for all years, but fishing concluded prior to then in many past years. Source: NorPac 7/17/2023, End of Year GEMM product was used

	Spring Season				***End of Year***	
	Pacific Whiting Catch (mt)		**Attainment of Initial Allocation**		***Attainment of Initial Allocation***	
	CP	**MS**	**CP**	**MS**	***CP***	***MS***
2018	51,655	39,151	42%	45%	94%	77%
2019	69,846	48,226	57%	55%	94%	60%
2020	64,230	32,437	54%	39%	94%	46%
2021	28,644	23,563	28%	32%	100%	49%
2022	48,496	31,395	43%	39%	112%	75%
Average of past 5 years	52,574	34,955	45%	42%	99%	61%
2023	40,030	14,135	31%	15%		
Ratio of 2023: 5 year average	0.76	0.40	0.69	0.36		

Table 2. At-sea Pacific whiting catch (mt) in weeks 20 through 22 (May 15-June 4) since 2018. Source: NorPac 7/17/2023

	Pacific Whiting Catch (mt)		Attainment of Initial Allocation	
	CP	**MS**	**CP**	**MS**
2018	29,326	19,201	24%	22%
2019	38,706	27,072	31%	31%
2020	38,721	18,249	33%	22%
2021	9,587	9,883	9%	14%
2022	23,554	15,127	21%	19%
Average of past 5 years	27,979	17,906	24%	22%
2023	34,046	10,385	26%	11%
Ratio of 2023: 5 year average	1.22	0.58	1.12	0.53

Chinook Salmon Bycatch

Spring 2023

The GMT investigated Chinook salmon bycatch throughout the Spring 2023 season, including any possible influence on bycatch amounts and/or rates from the earlier season start date. Appendix A of the Whiting Utilization Analysis (Table A-2; Analytical Document for Regulatory Amendment) projected Chinook salmon bycatch under four possible scenarios: low or high Pacific whiting catch as well as southern or northern CP effort distribution. The low and high Spring catch scenarios for the CP sector are defined as 25,000 mt and 45,000 mt of Pacific whiting, respectively. In the first two weeks this year, the CP sector caught ~8,000 mt of Pacific whiting (Table A 7 in Appendix 1). The low and high Spring catch scenarios for the MS sector are defined as 10,000 mt and 30,000 mt, respectively. The MS sector caught ~4,000 mt of Pacific whiting in the first two weeks of 2023. For both at-sea sectors, the "low catch" scenario is still roughly 2-3 times the actual amount of Pacific whiting catch in the first two weeks of 2023.

Given that bycatch rates tend to be higher in the southern portion of the at-sea fishing grounds, projections under the southern CP effort distribution tend to be higher than the northern distribution. Spatial differences in the MS sector were explored as part of the Whiting Utilization Analysis but were deemed not substantial enough to warrant different distribution scenarios for that sector. In the first two weeks of 2023, the average haul latitude in the CP sector was 43.9, which is squarely in the middle of the southern and northern scenario mean latitudes, indicating a mixed or coastwide distribution.

Appendix 1 evaluates how Chinook salmon bycatch in the at-sea sectors during the first two weeks compares to projections in the Whiting Utilization Analysis. In summary, actual Chinook bycatch during the first two weeks of the 2023 season (68 fish; Table A 7 in Appendix 1) in the MS sector was at the 86.5th percentile of the projected distribution under the low catch scenario, just over the 80th percentile, which is the preferred, risk-averse estimate identified in the 2017 biological opinion. Actual bycatch during the first two weeks in the CP sector (383 fish) exceeded the 100th percentile of the low catch, southern distribution scenario by 105 fish, as well as the 100th

percentile of the low catch, northern distribution scenario by 104 fish. However, while the bycatch amounts in the first two weeks were at the upper limits or exceeded the limits of the distributions projected in the Whiting Utilization Analysis, Chinook bycatch rates were even higher during the remainder of Spring, indicating that the addition of May 1-14 was likely not a driving factor for the unusually high Spring bycatch but rather that there was a more systemic bycatch anomaly this year.

In the first two weeks of the 2023 Pacific whiting season, the shoreside whiting sector caught ~7,700 mt of Pacific whiting, which is slightly higher than the low catch scenario of 5,000 mt used for projections in the Whiting Utilization Analysis. In the first two weeks, the shoreside sector caught 42 Chinook salmon, which is 6 fish higher than the upper limit of the low catch scenario projections and just within the 80th percentile of the high catch scenario (15,000 mt of Pacific whiting). Therefore, the shoreside sector also exceeded expectations for Chinook bycatch under a low catch scenario. Figure 1 shows Chinook salmon bycatch in the shoreside whiting sector by week, where weeks 18 and 19 correspond to May 1-14. The rate of Chinook salmon landed per 1 mt of Pacific whiting was highest in weeks 20 and 21 at roughly 2 Chinook per mt of Pacific whiting. Rates then declined and generally stayed below 1 Chinook per mt of Pacific whiting for the remainder of the time series.

Again, the addition of the first two weeks to the Pacific whiting season does not appear to be driving the high rates and amounts of Chinook bycatch in 2023. While the actual Chinook bycatch amounts for all three Pacific whiting sectors exceeded projections in the Whiting Utilization Analysis, this does not necessarily indicate that the projections were inaccurate. Analysis in the following sections demonstrates that 2023 appears to be an anomalous year, and the Whiting Utilization Analysis projections could not have accounted for the atypically high encounters, haul sizes, and bycatch rates experienced in Spring 2023.

Shoreside Sector Year-to-Date Analysis

As of August 17, 2023, the shoreside whiting sector also experienced higher than average catch of Chinook salmon. The total catch of 819 Chinook as of August 17th is 1.7 times higher than the recent six-year average through that same date (Table 3). However, this value is potentially inflated by a few hauls with very high Chinook salmon bycatch that accounted for more than half of the total bycatch. In the shoreside whiting sector 90 percent of the trips have a bycatch of four Chinook or fewer. For both 2022 and 2023 from January 1 through August 17, the sector caught 0.014 Chinook salmon per 1 mt of Pacific whiting, which is 2.1 times the recent six-year average (Table 3).

Table 3. Shoreside whiting data presented as Year-to-date (YTD) or 8/17 for 2017 through 2023. Data Source: YTD data from FOS_GROUNDFISH_SECTOR_CODES "Midwater Hake EM" and "Midwater Hake" Pulled from PacFIN on 8/17/2023, End of Year GEMM product was used.

	YTD				***End of Year***		
Year	**Chinook Catch (#)**	**Whiting catch (mt)**	**Attainment of Initial Allocation**	**Chinook per 1 mt Whiting**	***Chinook Catch (#)***	***Whiting Total mortality (mt)***	***Attainment of Initial Allocation***
2017	288	86,907	51%	0.003	*1,394*	*145,916*	*96%*
2018	321	83,823	50%	0.004	*1,330*	*129,443*	*85%*
2019	630	84,190	50%	0.007	*2,141*	*144,083*	*95%*
2020	764	88,893	54%	0.009	*1,717*	*138,503*	*95%*
2021	208	75,485	53%	0.003	*538*	*126,110*	*99%*
2022	755	55,775	36%	0.014	*2,333*	*104,803*	*75%*
Average of past 6 years	494	79,179	49%	0.007	*1,576*	*131,476*	*91%*
2023	819	58,199	36%	0.014			
Ratio of 2023: 6 year average	1.7	0.74	0.74	2.1			

Spring Analysis by Week

As shown in Figure 1& Figure 2, higher Pacific whiting catch in a single Spring 2023 week generally equated to higher Chinook salmon bycatch in that week. In week 21, the number of Chinook salmon bycatch almost doubled for the CP sector even though Pacific whiting catch dropped slightly, which could indicate select tows with above average bycatch of Chinook during that week. When reviewing haul by haul data, it does appear that there have been a few instances of unusually high bycatch in the CP sector that were mostly found in week 21.

Compared to 2016-2022, the number of Chinook salmon per 1 mt of Pacific whiting per week in Spring of 2023 was uncharacteristically high for both at-sea sectors (Figure 3and Figure 4). During week 20 in 2023, the MS sector experienced the highest weekly bycatch rate from 2016 between weeks 20 through 22.

Spring At-Sea Analysis by Haul

Figure 5 shows the cumulative distribution of haul-level bycatch rates of Chinook salmon per mt of Pacific whiting in all positive Chinook salmon hauls from Spring 2023, by at-sea sector. The CP sector experienced a much wider range of haul rates than the MS sector, and the MS sector's largest bycatch hauls contributed more to their overall bycatch than the CP sector's. The largest

four Chinook hauls in the CP sector make up 439 fish or 20 percent of that sector's total Spring 2023 Chinook bycatch. The largest four Chinook hauls in the MS sector make up 145 fish or 32 percent of that sector's total Spring 2023 Chinook bycatch. In addition, the largest MS bycatch haul contributes twice as much to the proportion of total bycatch compared to the CP sector's largest haul.

In Spring 2023, the CP sector tended to encounter Chinook salmon more than the MS sector, with 40 percent of all CP hauls and 25 percent of all MS hauls catching some amount of Chinook salmon (Table 4 and Table 5). Both sectors encountered salmon at roughly five times their recent averages[1]. The CP sector spent 489 more hours with gear in the water than their recent average, and the MS sector spent 76 fewer hours. Figure 5 shows that Chinook salmon bycatch rates in 2023 tended to be highest in the southern portion of the fishing grounds for both sectors. Bycatch and effort data were aggregated into 1° by 1° cells for visualizations.

Table 3and Table 4 use 2011-2023 haul-level data from hauls through June 4th to show the annual proportion of haul sizes in each sector, out of all positive Chinook hauls. Only hauls through June 4th were included in order to compare to 2023 proportions. The majority of Spring at-sea hauls catch only 1-3 Chinook salmon, with the recent average proportion at about 80 percent for both sectors. However, in 2023 the proportions of hauls with 1-3 fish dropped to 52 percent in the CP sector and 59 percent in the MS sector. Consequently, there were a larger proportion of moderate to large bycatch hauls in 2023 than in recent years. In the CP sector, the proportion of hauls with more than 7 Chinook salmon in 2023 was roughly 5 times that of the recent average, and the proportion of hauls with more than 3 Chinook salmon in the MS sector was roughly twice the recent average.

The first two weeks of 2023 (May 1-14) did not appear to drive the increased encounters nor the higher proportion of moderate to large sized hauls. Both sectors saw high encounter rates throughout the entire Spring fishery. In the CP sector, the haul size proportions were roughly equivalent between the first two weeks of 2023 and the remainder of the Spring fishery. While we do not show a similar breakout for the MS sector in Table 5 due to data confidentiality, the MS sector in fact experienced a substantially larger proportion of small (1-3 fish) hauls in the first two weeks than in the remainder of the Spring fishery. There do not appear to be any patterns between effort, defined by total haul hours, and haul size proportions throughout the time series.

[1] The recent average for the CP sector is based on years 2018-2020 and 2022 (four total years). 2021 was not included due to data confidentiality. The recent average for the MS sector is based on years 2018-2022 (five total years).

Table 4. Among CP hauls only through June 4th, total CP haul hours as a proxy for annual effort, percent of CP hauls with Chinook salmon bycatch, and within those positive hauls, the proportion of CP hauls that caught 1-3 fish, 4-7 fish, or greater than 7 fish. 2021 was removed due to data confidentiality, and 2023 is broken out into May 1-14 and May 15-June 4.

Year	Total Haul Hours	% of Hauls with Chinook	% of Positive Hauls within Bins of Chinook Bycatch		
			1-3	4-7	>7
2011	1,400	10	80	4	16
2012	1,419	27	63	14	23
2013	1,109	7	76	24	
2014	1,595	13	63	8	29
2015	665	12	76	24	
2016	1,983	5	*		
2017	1,097	6	90	10	
2018	1,388	8	74	19	7
2019	1,634	7	92	8	-
2020	1,328	12	67	23	11
2022	1,869	7	76	21	3
Avg. 2018-2022 a/	**1,555**	**9**	**77**	**18**	**5**
2023	*2,044*	*40*	*52*	*23*	*24*
May 1-14	*334*	*45*	*51*	*49*	
May 15 - June 4	*1,710*	*39*	*53*	*21*	*26*

a/ 2021 was excluded due to confidentiality concerns, and therefore, is not included in the recent average.
* indicates confidential data

Table 5. Among MS hauls only through June 4th, total MS haul hours as a proxy for annual effort, percent of MS hauls with Chinook salmon bycatch, and within those positive hauls, the proportion of MS hauls that caught 1-3 fish or greater than 3 fish. 2023 is not broken out into the first two weeks due to data confidentiality.

Year	Total Haul Hours	% of Hauls with Chinook	% of Positive Hauls within Bins of Chinook Bycatch	
			1-3	>3
2011	380	14	78	22
2012	518	10	*	
2013	294	7	75	25
2014	344	6	*	
2015	611	13	85	15
2016	903	6	*	
2017	356	3	100	-
2018	541	5	*	
2019	1,257	7	82	18
2020	728	4	*	
2021	1,408	3	*	
2022	2,010	5	76	24
Avg. 2018-2022	**1,189**	**5**	**81**	**19**
2023	*1,113*	*25*	*59*	*41*

* indicates confidential data

Observed Size of Spring Chinook Salmon

Several industry accounts suggest that the Chinook salmon being caught in 2023 are atypically small, so the GMT investigated length distributions of Chinook bycatch. For the Spring 2023 season, the range of sizes observed in the bycatch was more variable compared to the majority of other years, and the median length of Chinook salmon for both the CP and MS sectors was marginally lower than the median across the full Spring 2002-2023 period of time (Figure 6). However, the median length of Chinook salmon caught in 2023 by the CP sector was similar to the observed median length in other recent years.

Projections for Fall 2023

A simulation-based bootstrap projection model was used to produce predicted distributions of Chinook salmon bycatch counts for the fall mode of the 2023 at-sea whiting fishery, which were combined with existing accumulated actual bycatch, to form total year projections. Appendix 1 provides the full description of the analysis. The analysis in Appendix 1 indicates that the bootstrap projections are sensitive to years of unusually high sea surface temperature, which may bias the results low if there are more periods of time with those conditions. Given the low attainment in the Spring 2023 season, the average and low attainment expected harvest scenarios may be the most

representative of the expected bycatch in 2023 (Table A 1 in Appendix 1). Average attainment was characterized by 88 percent of the initial Pacific whiting allocation for the CP sector and 57 percent for MS, and low attainment was defined by 68 percent of the initial Pacific whiting allocation for the CP sector and 39 percent for MS. For the CP sector, the 80th percentile values of the projected distribution for these scenarios (low and average attainment) were 4,396 and 5,583 Chinook salmon, respectively. For MS, the 80th percentile projected values were 2,267 and 3,690 Chinook salmon, respectively (see Table A 3 in Appendix 1).

The Chinook salmon guideline for the whiting sector is 11,000 fish, however, any sector (including non-whiting) that exceeds their guideline may access an additional reserve of 3,500 Chinook salmon bycatch numbers if action has been taken to minimize Chinook salmon bycatch. Action to minimize Chinook salmon bycatch is specifically defined as a Block Area Closure(s) (BAC) or Bycatch Reduction Area(s) (BRA) (50 CFR 660.60(i)(1)(ii)). If no action has been taken for a specific sector (or all sectors), vessels within that sector (or all sectors) may only access the reserve if they are parties to an approved Salmon Mitigation Plan (SMP). To address whether the whiting sector risks exceeding their Chinook salmon threshold, the GMT provides total Chinook salmon mortality projections, compared to the threshold, by combining the average and low at-sea Chinook salmon projections from the bootstrap analysis with potential year-end Chinook salmon mortality in the shoreside whiting sector based on two alternative scenarios (average, and maximum over the recent six-year period), as well as the tribal estimate which is the maximum value of the recent 5 years.

Under the average at-sea bootstrap projection, both of the shoreside whiting scenarios exceed the 11,000 fish bycatch threshold. However, under all scenarios, if the reserve amount is available to the whiting sectors and not needed by non-whiting sectors, total Chinook salmon bycatch in all whiting and tribal sectors would still be within the combined threshold and reserve amount of 14,500 fish. Currently, the non-whiting sectors are at 24 percent of their 5,500 fish bycatch threshold (PacFIN IFQ021), which includes the assumption of 500 Chinook salmon caught from the recreational sectors. This means that the non-whiting sectors are not likely to need access to the reserve based on recent trends. All vessels in the CP and MS sectors are party to approved SMPs, and while the majority of the shoreside sector is part of a cooperative with an approved SMP, any shoreside vessels not associated with an approved SMP would not have access to the reserve and therefore would be required to cease fishing, unless the Council implemented a BRA or BAC for the shoreside whiting sector as a whole. Vessels in the SMP may still be subject to the BRA or BAC pending Council recommendation (50 CFR 660.113(e)(1)).

Scenario 1 (Average) = average annual shoreside whiting catch, 2017-2022

Scenario 2 (Maximum) = maximum annual shoreside whiting catch, 2017-2022

Table 6. 2023 Chinook salmon catch projections in the at-sea and shoreside whiting sectors under alternative scenarios, along with the tribal estimate, compared to the 2023 fish bycatch threshold.

		Chinook Salmon Mortality (numbers of fish)	
At-Sea Scenario		**Low Attainment**	**Average Attainment**
Bootstrap Total 2023 Bycatch Projections for At-Sea Sectors[a/]		6,663	9,273
Tribal estimate (max. of recent 5 years)		264	
Mortality in Shoreside Whiting Sector	***Scenario 1***	*1,576*	
	Scenario 2	*2,333*	
Threshold		**11,000**	
		Percent Threshold	
Percent Threshold[b/]	**Scenario 1**	77%	101%
	Scenario 2	84%	108%

a/ The 2017 salmon biological opinion used the 80th percentile, as requested by the consultation team after review of the analytical results.
b/ The two scenario percentages include the tribal estimate and the two different shoreside whiting bycatch mortality scenarios.

At-sea Set-Asides

Spring 2023

During the June inseason report, the GMT provided an at-sea set-aside table of attainment (Agenda Item H.8.a, Supplemental GMT Report 1, June 2023, Table 7), and there have been no additional Spring catches since. Table 8 of the June 2023 report provides more information on the top five stocks with high set-aside attainment from the Spring 2023 season. Below, different total mortality scenarios were used to project the likelihood of exceeding the Annual Catch Limit (ACL) for each stock at the end of 2023. Figure 9-Figure 13 show the sector-specific and combined spatial patterns in bycatch rates for these stocks across Spring fisheries in 2018-2023.

Projections for Fall 2023

Table 7 and Table 8 show the results of the combined at-sea inseason bootstrap analysis to estimate the probability of the set-asides being exceeded using data through July 26, 2023. Predicted catch from both at-sea sectors were combined in Table 7 and Table 8, because the analysis is meant to assess the probability that the combined sector set-aside will be exceeded. 10,000 fishing seasons were simulated using individual whiting haul data from 2000-2022, with each individual simulated season first randomly selecting a year (e.g., 2003) and then resampling from all individual positive (i.e., Pacific whiting was caught) hauls within the selected year until a season closure occurred. A closure was only simulated once each sector's Pacific whiting allocation was reached. In the projections below, it can be understood that a certain percentage of the time, the sector is projected to land the corresponding value or less as these are a distribution of results. In other words, in

Table 7, the column labeled 90 percent means that 90 percent of the simulations would catch 130 mt or less of sablefish (i.e., conversely 10 percent of the simulations exceed 130 mt). These bootstrap estimates may be biased to an unknown degree since it is drawing from a long period of time where the overall abundance of each of the stocks could be lower or higher relative to current abundances. It is worth noting that starting in 2022 there have been multiple industry reports from many sectors of high sablefish bycatch of small fish due to recent strong year-classes for 2020 and 2021. For example, the estimated bycatch mortality in 2022 from the at-sea sector was 306 mt, nearly 3 times greater than the previous highest bycatch observed in 2016 of 117 mt. Therefore, the sablefish bootstrap projections may underestimate the probability of exceeding the set-aside. However, the simulation period for the bootstrap projections, 2000-2022, do include periods of higher and lower sablefish abundance with the abundance steadily increasing since 2016. Similar to the Chinook bycatch projections in the previous section, the GMT modeled set-aside bycatch projections under low (Table 8) and average (Table 7) Pacific whiting attainment scenarios, as these may be most representative.

Table 7 assumes an average attainment of 88 percent of the initial Pacific whiting allocation for the CP sector and 57 percent for the MS sector using the methods outlined above. For yellowtail rockfish, there is a 64 percent probability that the set-aside of 320 mt will be exceeded. For sablefish, the bootstrap analysis projects that there is a 22 percent probability that the set-aside will be exceeded, but as noted above, this could be an underestimate of the probability. To date in 2023, the darkblotched rockfish set-aside has already been exceeded, which is why the probability of exceeding the set aside is 100 percent. The probability that the set-asides for widow and canary rockfishes will be exceeded is less than 5 percent.

Table 7. The expected catch in metric tons (mt) corresponding to the 10th, 25th, 50th, 75th, 90th, and 95th quantiles by the at-sea sectors for species with set-asides based on the bootstrap analysis assuming average attainment of Pacific whiting (CP = 113,754 mt, MS = 52,011 mt), total at-sea set-aside (mt) for the year, catch through July 19th, and the probability of exceeding the set-aside. Percentiles with expected attainment that exceed the set-aside are shown in gray.

Species	Catch Values (mt) at or Below Percentage of Simulated Seasons						At-Sea Set Aside (mt)	At-Sea Catch through 7/19 (mt)	Probability of Set-Aside Exceeded
	10%	25%	50%	75%	90%	95%			
Darkblotched rockfish	81	84	87	94	117	123	76.4	78	100%
Widow rockfish	226	238	280	332	401	454	476	198	<5%
Yellowtail rockfish north of 40° 10′ N. lat.	286	304	340	410	492	585	320	266	64%
Sablefish	59	63	73	97	130	170	100	57	22%
Canary rockfish	20	20	21	23	24	25	36	20	<5%

Table 8 assumes a low attainment of 68 percent of the initial Pacific whiting allocation for the CP sector and 39 percent for the MS sector using the methods outlined above. The only differences under a low attainment scenario, compared to average, are the projections for yellowtail rockfish

and sablefish. Under a low-attainment scenario, there is a 43 percent probability that the yellowtail rockfish set-aside of 320 mt will be exceeded and an 11 percent probability that the sablefish set-aside of 100 mt will be exceeded.

Table 8. The expected catch in metric tons (mt) corresponding to the 10th, 25th, 50th, 75th, 90th, and 95th quantiles by the at-sea sectors for species with set-asides based on the bootstrap analysis assuming low attainment of Pacific whiting (CP = 87,901 mt, MS = 35,586 mt), the total at-sea set-aside (mt) for the year, catch through July 19th, and the probability of exceeding the set-aside. Percentiles with expected attainment that exceed the set-aside are shown in gray.

Species	Catch Values (mt) at or Below Percentage of Simulated Seasons						At-Sea Set Aside (mt)	At-Sea Catch through 7/19 (mt)	Probability of Set-Aside Exceeded
	10%	25%	50%	75%	90%	95%			
Darkblotched rockfish	80	81	84	89	103	107	76.4	78	100%
Widow rockfish	215	222	248	280	323	356	476	198	<5%
Yellowtail rockfish north of 40° 10′ N. lat.	277	289	312	352	403	461	320	266	43%
Sablefish	58	61	67	82	103	126	100	57	11%
Canary rockfish	20	20	21	22	23	23	36	20	<5%

To address whether there is risk of a harvest specification being exceeded, the GMT provides total mortality projections, compared to the ACL, by combining the low and average at-sea catch projections from the bootstrap analysis to three possible scenarios of mortality in all other fisheries. Data from 2020 was excluded from all scenarios due to COVID-19 related impacts. The same scenarios were used for darkblotched rockfish (Table 9), widow rockfish (Table 10), yellowtail rockfish north of 40° 10′ N. lat. (Table 11), and sablefish north of 36° N. lat. (Table 12):

> **Scenario 1 (Projection) =** Projections based on 2023-24 harvest specifications analysis for the non-at-sea sectors that do have projections (e.g., IFQ and commercial non-trawl sectors) + average mortality from 2017, 2018, 2019, and 2021 for sectors without a harvest specifications projection + full research, tribal, incidental, and EFP off-the-top deductions. For some stocks, projections were made for certain state recreational fisheries, and those are used instead of average mortality where applicable.
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> **Scenario 2 (Average) =** average annual mortality from 2017, 2018, 2019, and 2021 for all other (non-at-sea) sectors
>
> **Scenario 3 (High) =** maximum annual mortality from 2017, 2018, 2019, and 2021 for all other (non-at-sea) sectors. If the recent maximum mortality exceeds the 2023 allocation for the IFQ or non-trawl sectors, the full allocation is assumed to be taken for that sector.

The GMT chose to exclude canary rockfish, because the set-aside was not projected to be exceeded even in 95 percent of bootstrap simulations in all attainment scenarios. While that is also the case

for widow rockfish, widow rockfish tends to be a higher attainment stock across all fisheries and is of high economic importance to the midwater rockfish sector of the trawl fishery, so the GMT included a projection table for widow rockfish.

Based on possible mortality in other sectors, none of the ACLs for stocks in Table 9-Table 12 appear to be at risk of being exceeded under either low or average at-sea Pacific whiting attainment scenarios. The stock with the highest projected ACL attainments under all scenarios is widow rockfish, and the stock with the lowest is darkblotched rockfish, for which the at-sea set-aside has already been exceeded. With the exception of sablefish, the vast majority of catch of these stocks in other sectors occurs in the Individual Fishing Quota (IFQ) fishery. Stocks like widow and yellowtail rockfishes are economically important to non-whiting IFQ vessels.

For all stocks, the projection scenario (Scenario 1) assumes the full tribal allocation is taken. For sablefish, yellowtail rockfish, and widow rockfish, the full tribal allocation is 2, 4, and 14 times the recent maximum tribal catches, respectively, which is why the ACL attainment projected under Scenario 1 is slightly higher than under Scenario 2 for both yellowtail rockfish and sablefish. This is especially impactful for yellowtail rockfish for which the tribal allocation is 1,000 mt. Based on tribal catch in recent years, it is unlikely that the tribes would take the full allocation for these three stocks. Therefore, the average attainment scenarios may be more likely for those stocks.

Table 9. Projected darkblotched rockfish ACL attainment under low and average at-sea bycatch scenarios as well as 3 alternative scenarios of mortality in all other sectors.

		Darkblotched Rockfish Mortality (mt)	
	At-Sea Scenario	**Low Attainment**	**Average Attainment**
Bootstrap Total 2023 Bycatch Projections for At-Sea Sectors (90th percentile)		103	117
Mortality in All Other Sectors	***Scenario 1***	*263*	
	Scenario 2	*280*	
	Scenario 3	*372*	
	ACL	**785**	
		Darkblotched Rockfish ACL Attainment (%)	
ACL Attainment of At-Sea + All Other Sectors	**Scenario 1**	47%	48%
	Scenario 2	49%	51%
	Scenario 3	60%	62%

Table 10. Projected widow rockfish ACL attainment under low and average at-sea bycatch scenarios as well as 3 alternative scenarios of mortality in all other sectors.

		Widow Rockfish Mortality (mt)	
At-Sea Scenario		**Low Attainment**	**Average Attainment**
Bootstrap Total 2023 Bycatch Projections for At-Sea Sectors (90th percentile)		323	401
Mortality in All Other Sectors	***Scenario 1***	*9,482*	
	Scenario 2	*9,551*	
	Scenario 3	*11,593*	
ACL		**12,624**	
		Widow Rockfish ACL Attainment (%)	
ACL Attainment of At-Sea + All Other Sectors	**Scenario 1**	78%	78%
	Scenario 2	78%	79%
	Scenario 3	94%	95%

Table 11. Projected yellowtail rockfish ACL attainment under low and average at-sea bycatch scenarios as well as 3 alternative scenarios of mortality in all other sectors.

		Yellowtail Rockfish Mortality (mt)	
At-Sea Scenario		**Low Attainment**	**Average Attainment**
Bootstrap Total 2023 Bycatch Projections for At-Sea Sectors (90th percentile)		403	492
Mortality in All Other Sectors	***Scenario 1***	*3,695*	
	Scenario 2	*3,628*	
	Scenario 3	*4,126*	
ACL		**5,666**	
		Yellowtail Rockfish ACL Attainment (%)	
ACL Attainment of At-Sea + All Other Sectors	**Scenario 1**	72%	74%
	Scenario 2	71%	73%
	Scenario 3	80%	82%

Table 12. Projected sablefish north of 36° N. lat. ACL attainment under average and high at-sea bycatch scenarios as well as 3 alternative scenarios of mortality in all other sectors.

		Sablefish Mortality (mt)	
At-Sea Scenario		**Low Attainment**	**Average Attainment**
Bootstrap Total 2023 Bycatch Projections for At-Sea Sectors (90th percentile)		103	130
Mortality in All Other Sectors	***Scenario 1***	*5,687*	
	Scenario 2	*5,173*	
	Scenario 3	*6,133*	
ACL		**8,486**	
		Sablefish ACL Attainment (%)	
ACL Attainment of At-Sea + All Other Sectors	**Scenario 1**	68%	69%
	Scenario 2	62%	62%
	Scenario 3	73%	74%

Figures

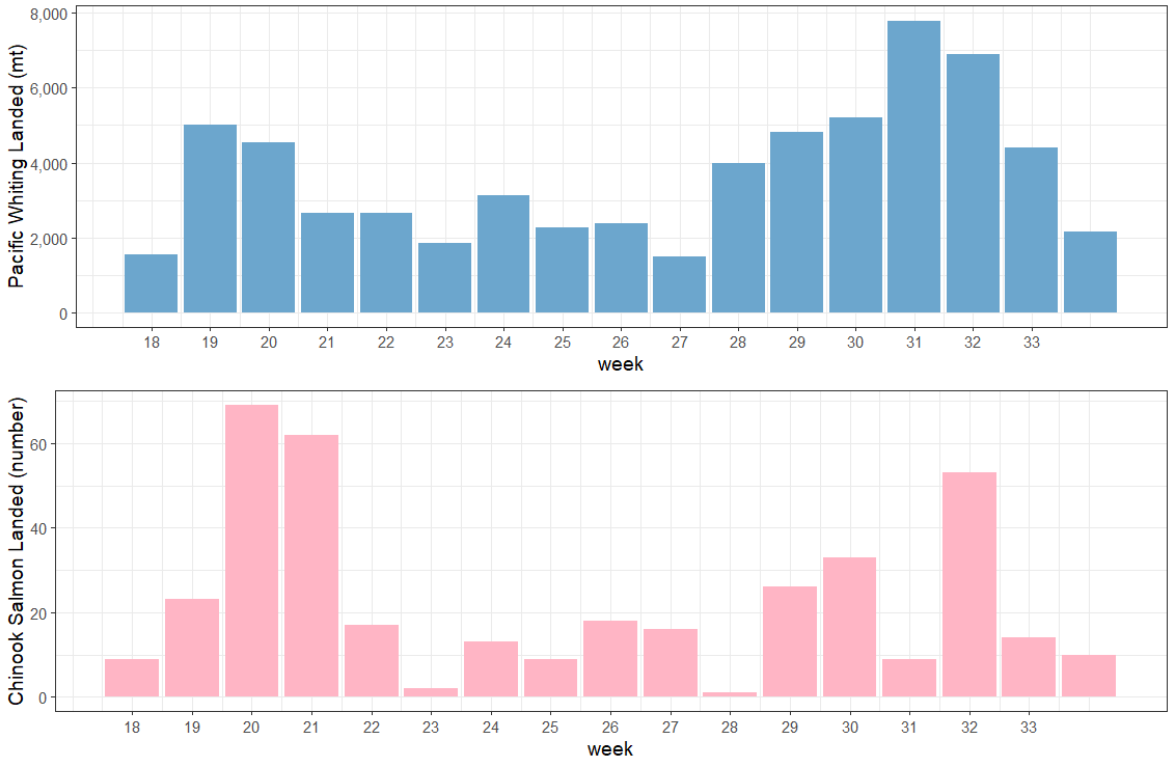

Figure 1. 2023 weekly total landings of Pacific whiting and Chinook salmon in the shoreside whiting sector. Weeks 18 and 19 correspond to May 1-14, the first two weeks of the 2023 fishing season.

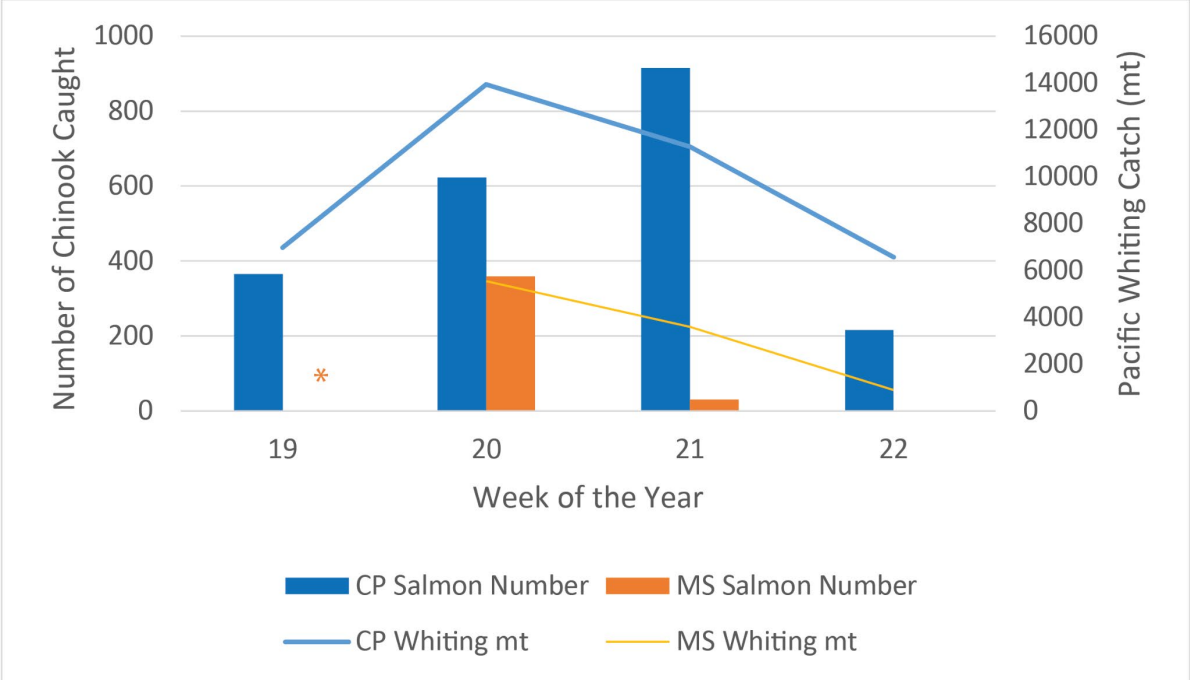

Figure 2. Characterization of the 2023 Spring season by number of Chinook salmon caught on the primary y axis and Pacific whiting caught on the secondary y axis. Orange hues are the MS fleet and blue hues are the CP fleet. The data from week 18 was confidential for both sectors.

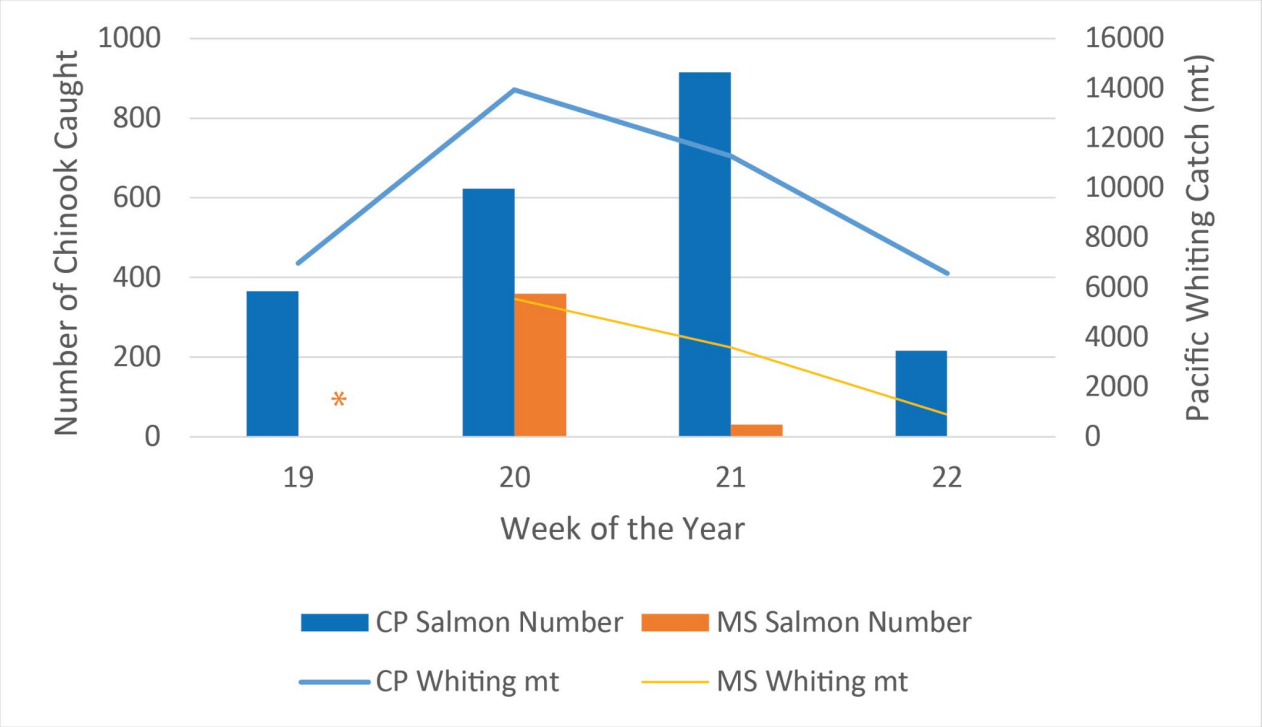

Figure 3. Characterization of the 2023 Spring season by number of Chinook salmon caught on the primary y axis and Pacific whiting caught on the secondary y axis. Orange hues are the MS fleet and blue hues are the CP fleet. The data from week 18 was confidential for both sectors and week 19 was confidential for the MS sector (weeks start on Monday). Source: NorPac 7/17/2023

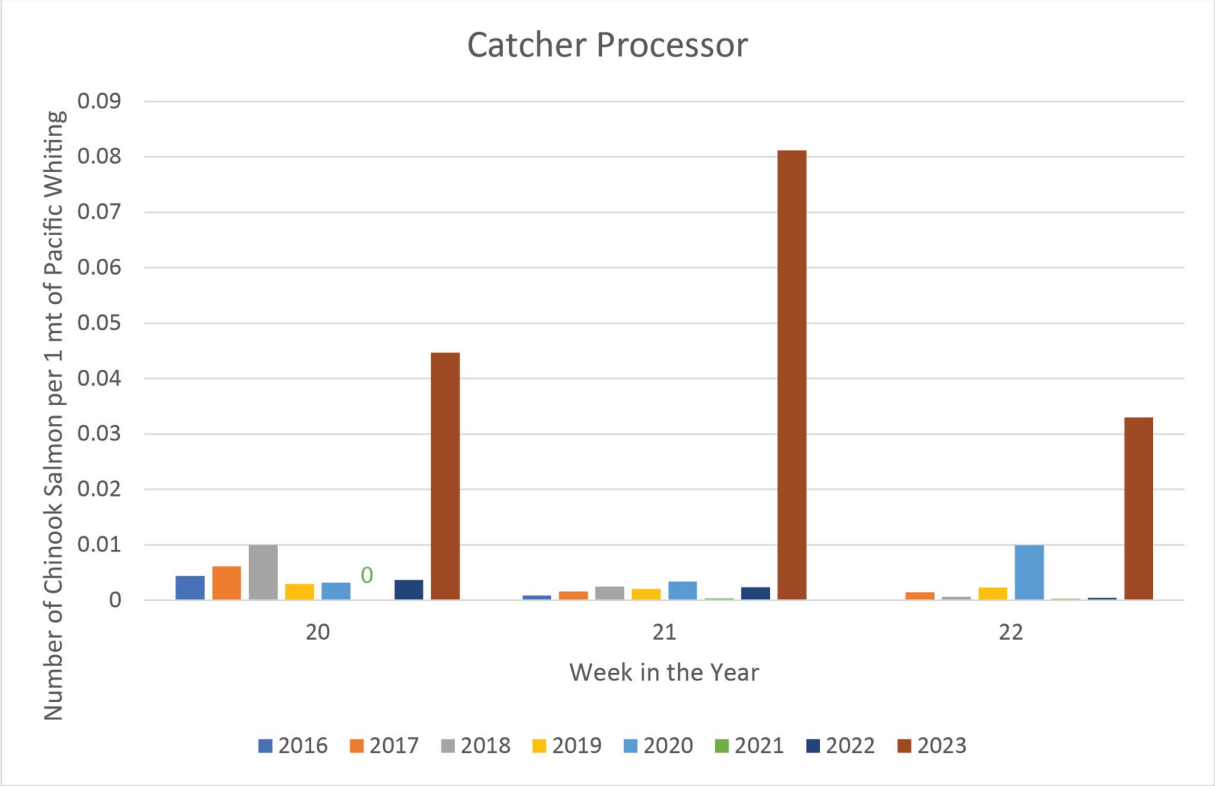

Figure 4. Chinook salmon bycatch : 1 mt Pacific Whiting catch rate in the CP sector since 2016 across weeks 20-22. 0's mean that there were no Chinook caught that week.

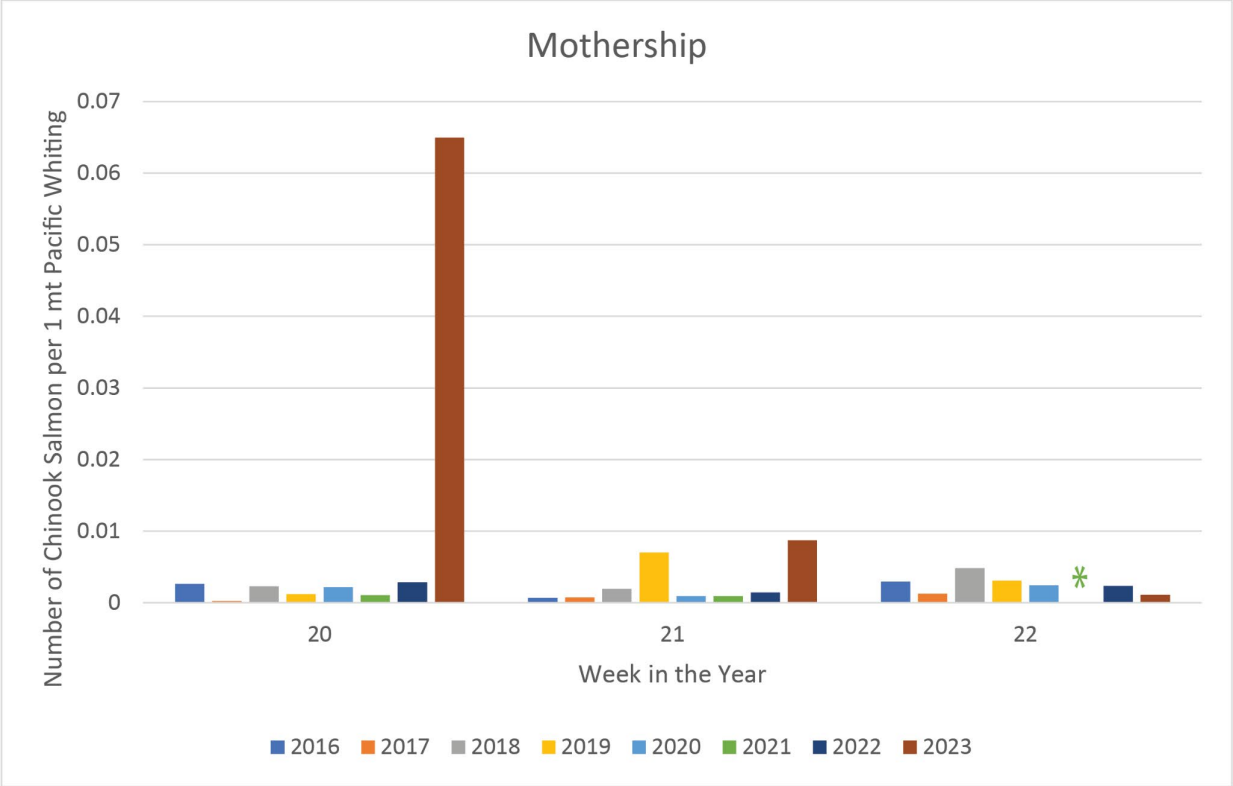

Figure 5. Chinook salmon bycatch : 1 mt Pacific Whiting catch rate in the MS sector since 2016 across weeks 20-22. * indicates a data point that is confidential in week 22 of 2021.

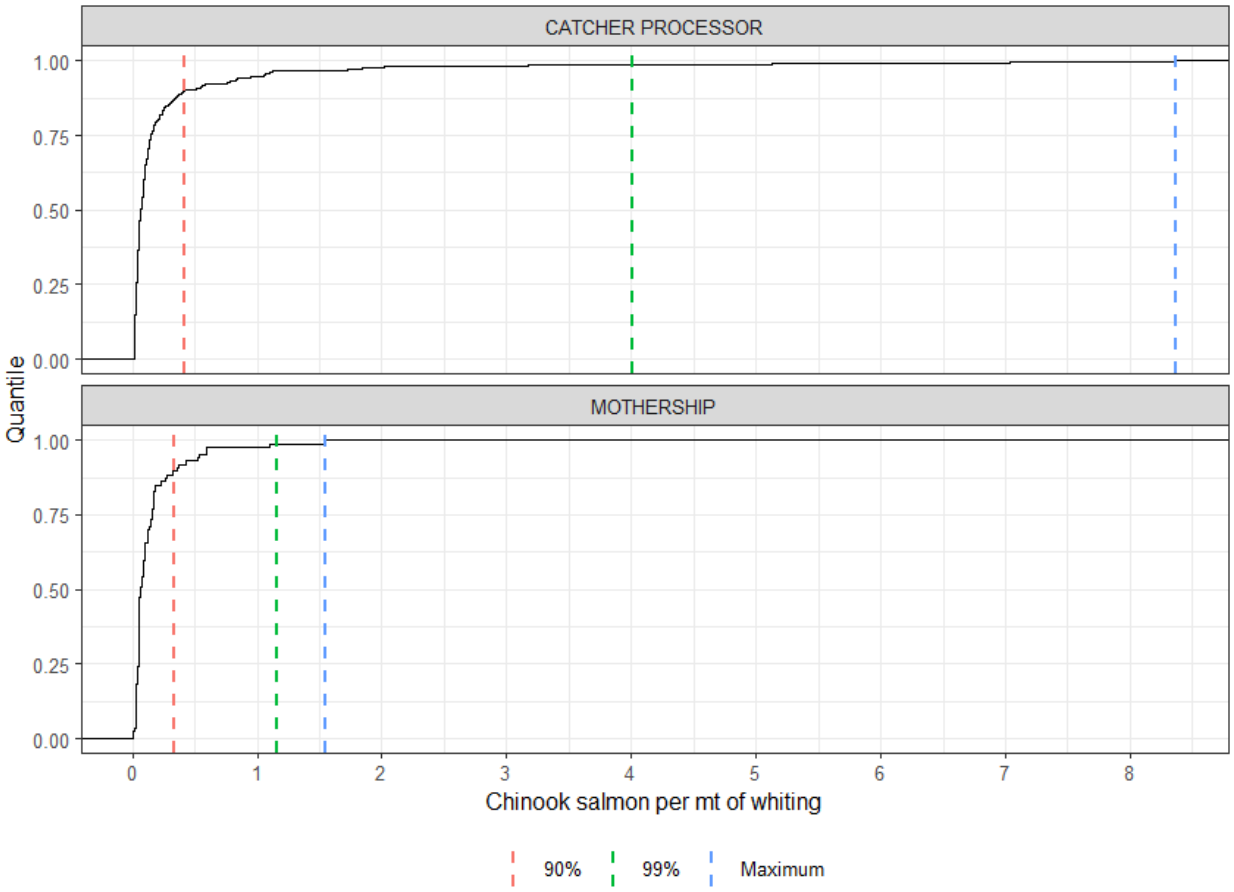

Figure 6. Empirical cumulative distribution of Spring 2023 haul rates of Chinook salmon per 1 mt of Pacific whiting, by at-sea sector. Red dashed lines represent the 90th percentile, green dashed lines represent the 99th percentile, and blue dashed lines represent the maximum.

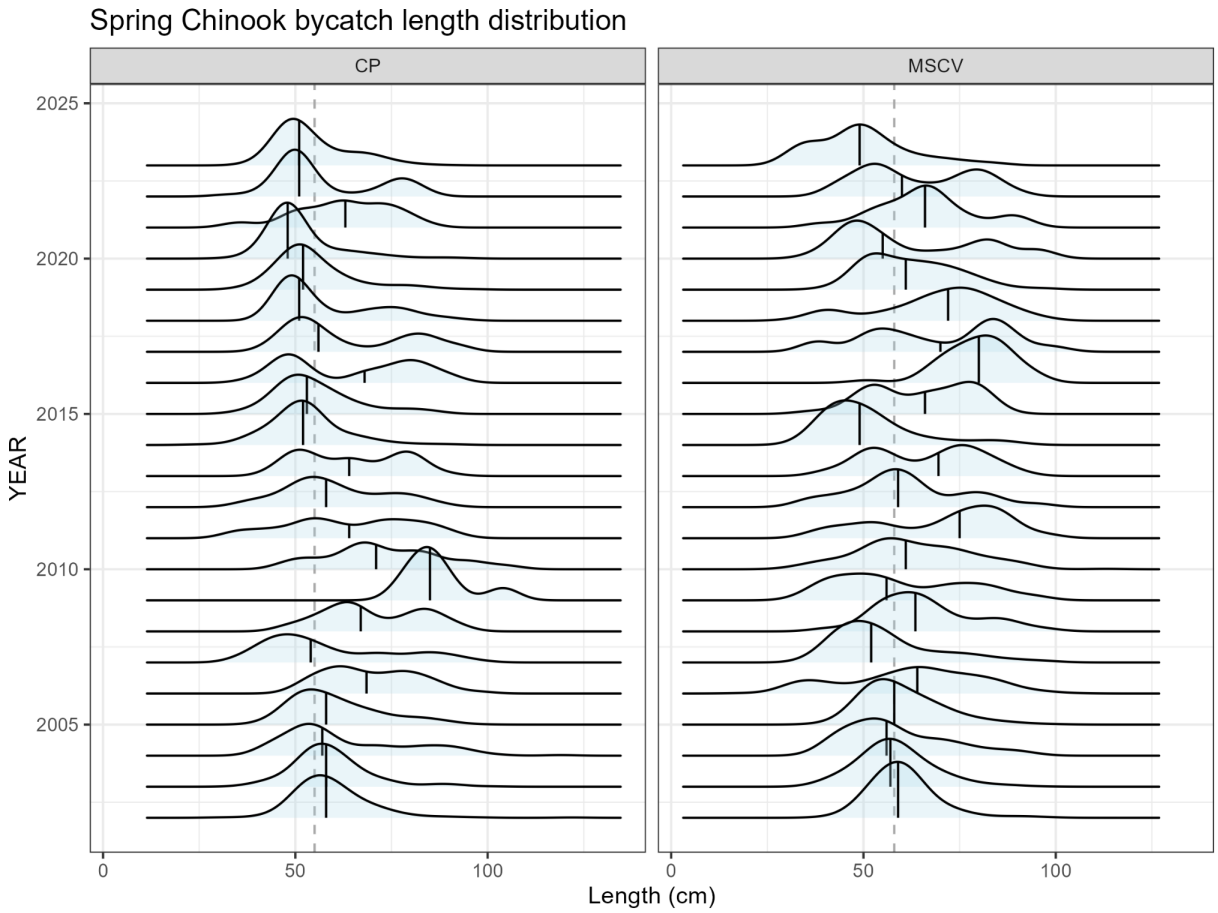

Figure 7. Density plot of Chinook salmon lengths by sector for spring 2002-2023. The vertical dashed line is the median across all years samples for the sector, and the vertical solid line for each year is the median for that year and /sector.

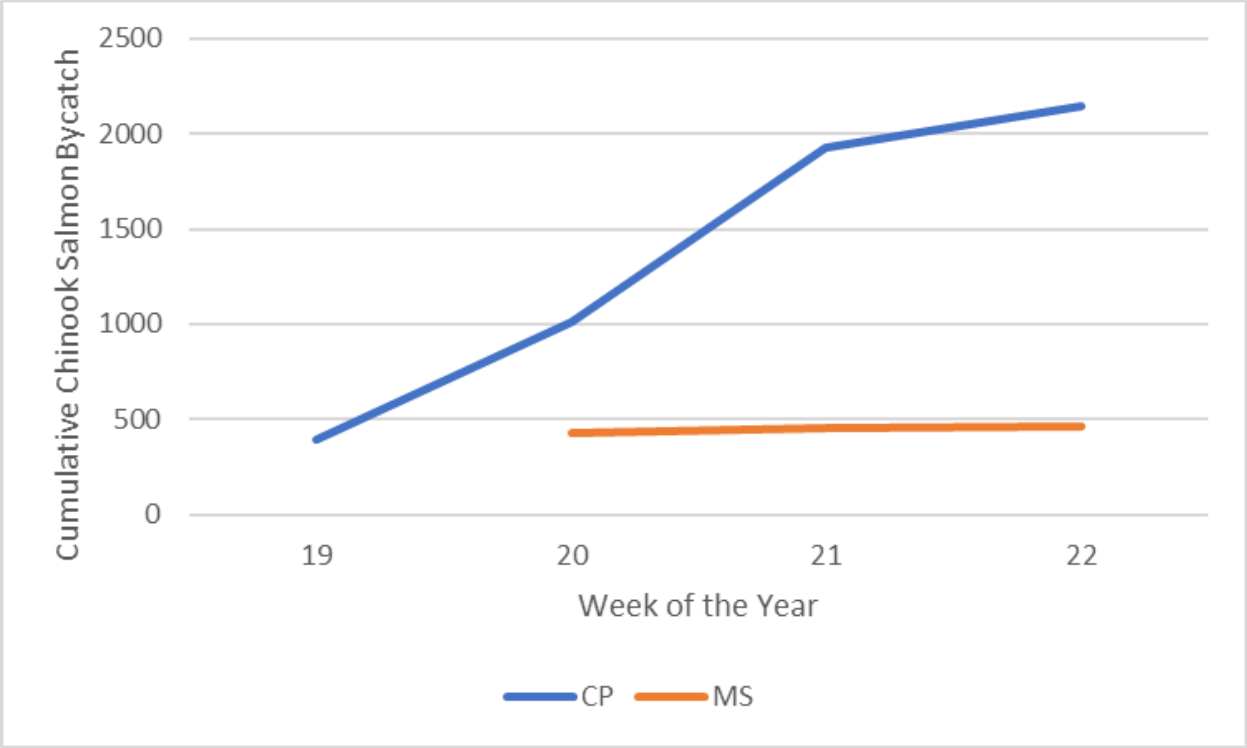

Figure 8. Cumulative Chinook salmon bycatch over the Spring season in 2023. Week 19 is the sum of week 18 and 19 data for the CP sector, since week 18 is confidential. Week 20 is the sum of week 18-20 for the MS sector due to confidentiality (week starts on Monday). Data Source: NorPac 7/17/2023

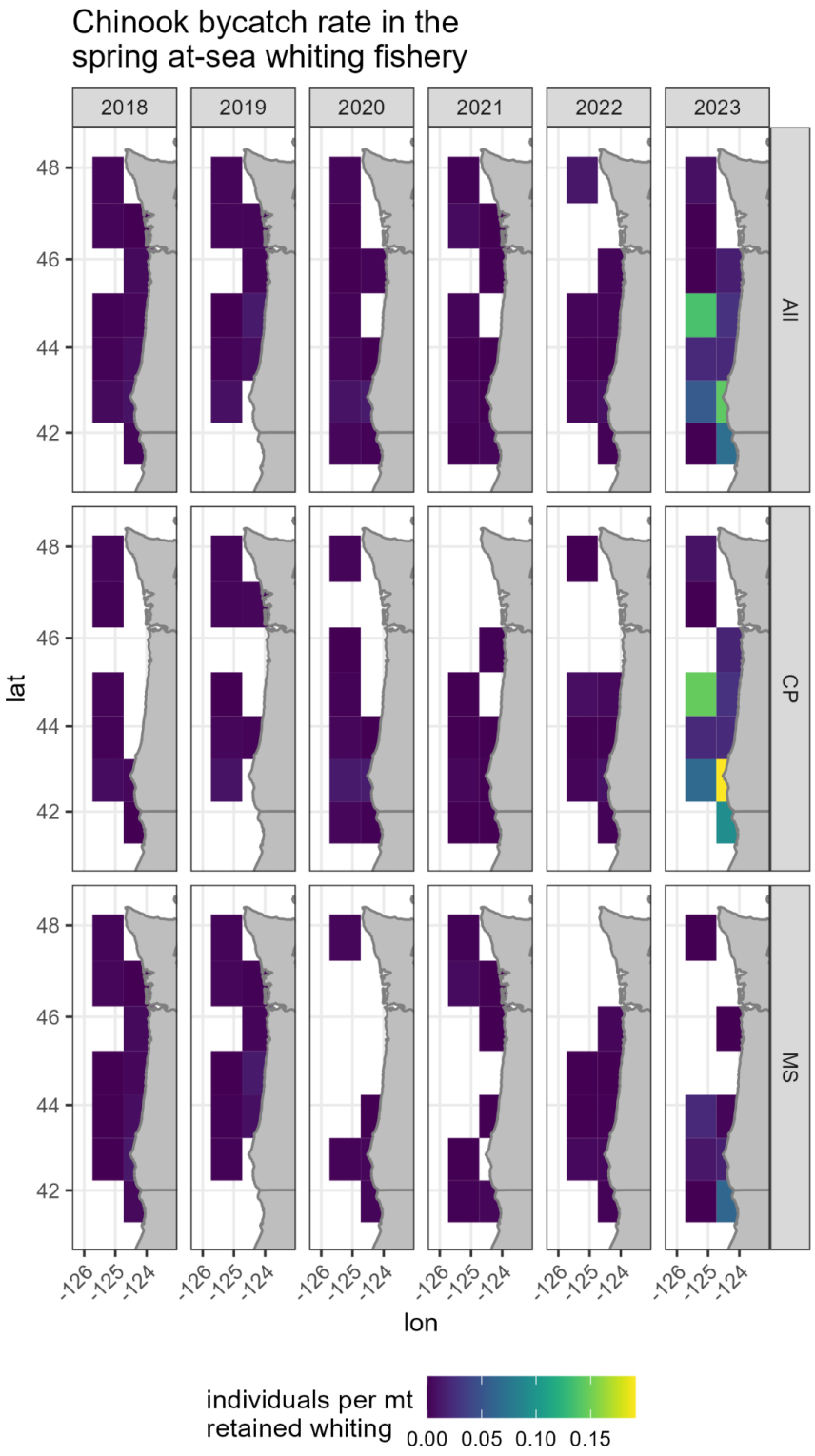

Figure 9. Chinook salmon bycatch rates (individuals per metric ton of retained whiting) in spring 2018-2023.

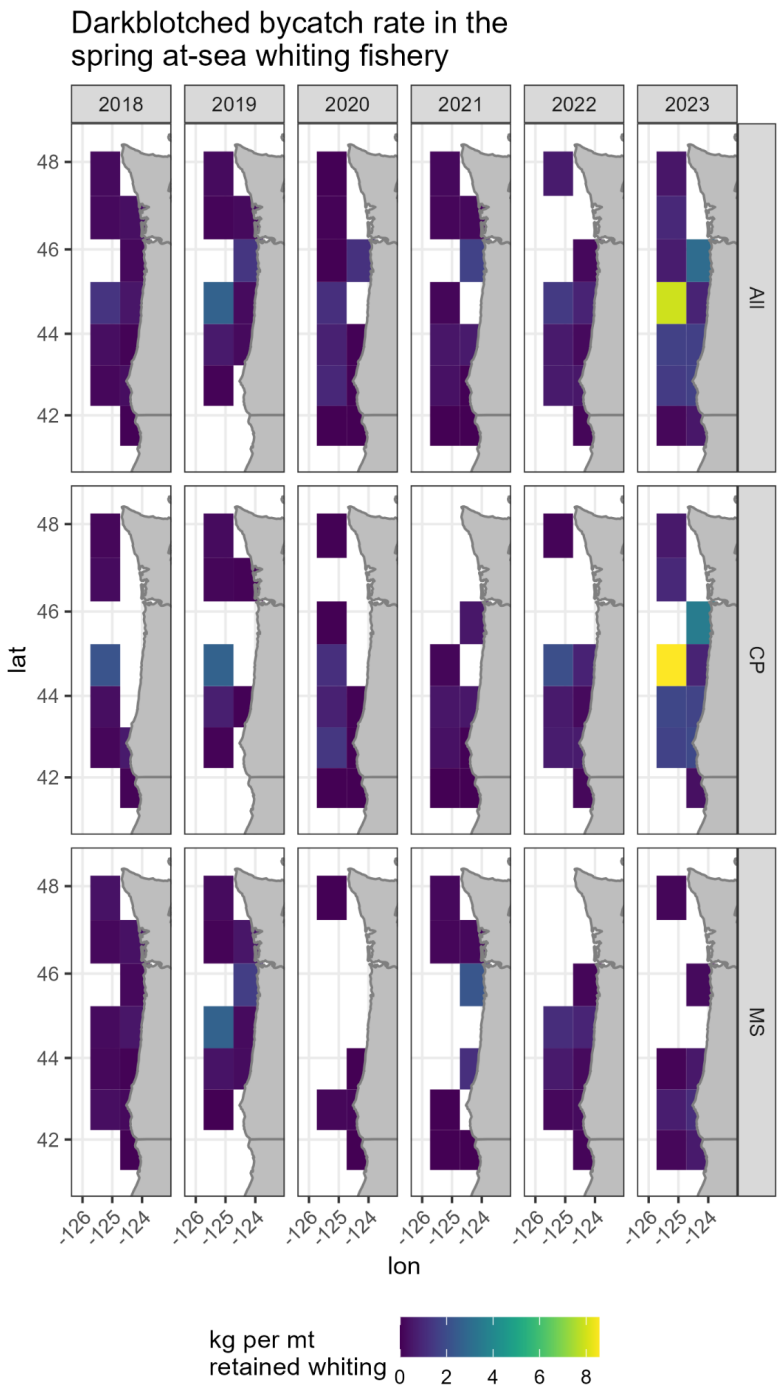

Figure 10. Darkblotched rockfish bycatch rates (kg per metric ton of retained whiting) in spring 2018-2023.

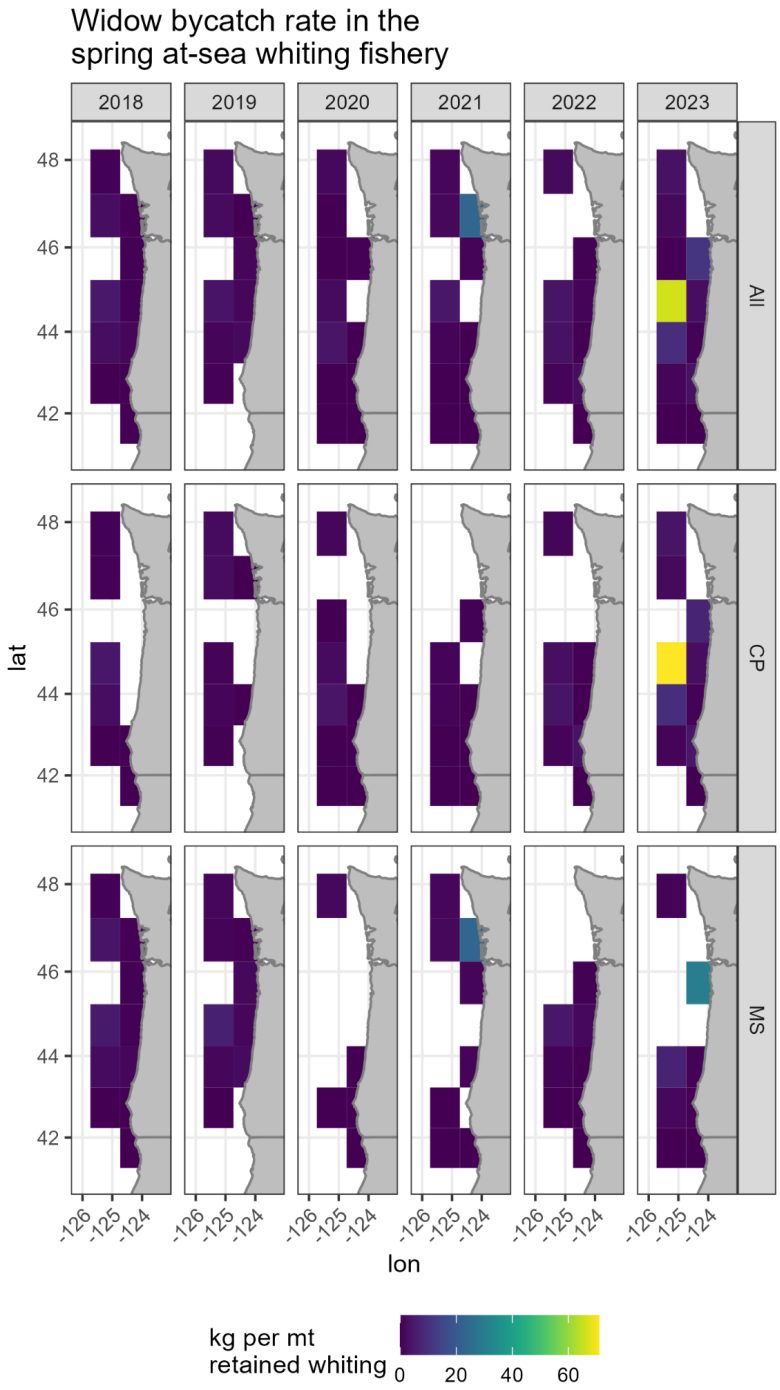

Figure 11. Widow rockfish bycatch rates (kg per metric ton of retained whiting) in spring 2018-2023.

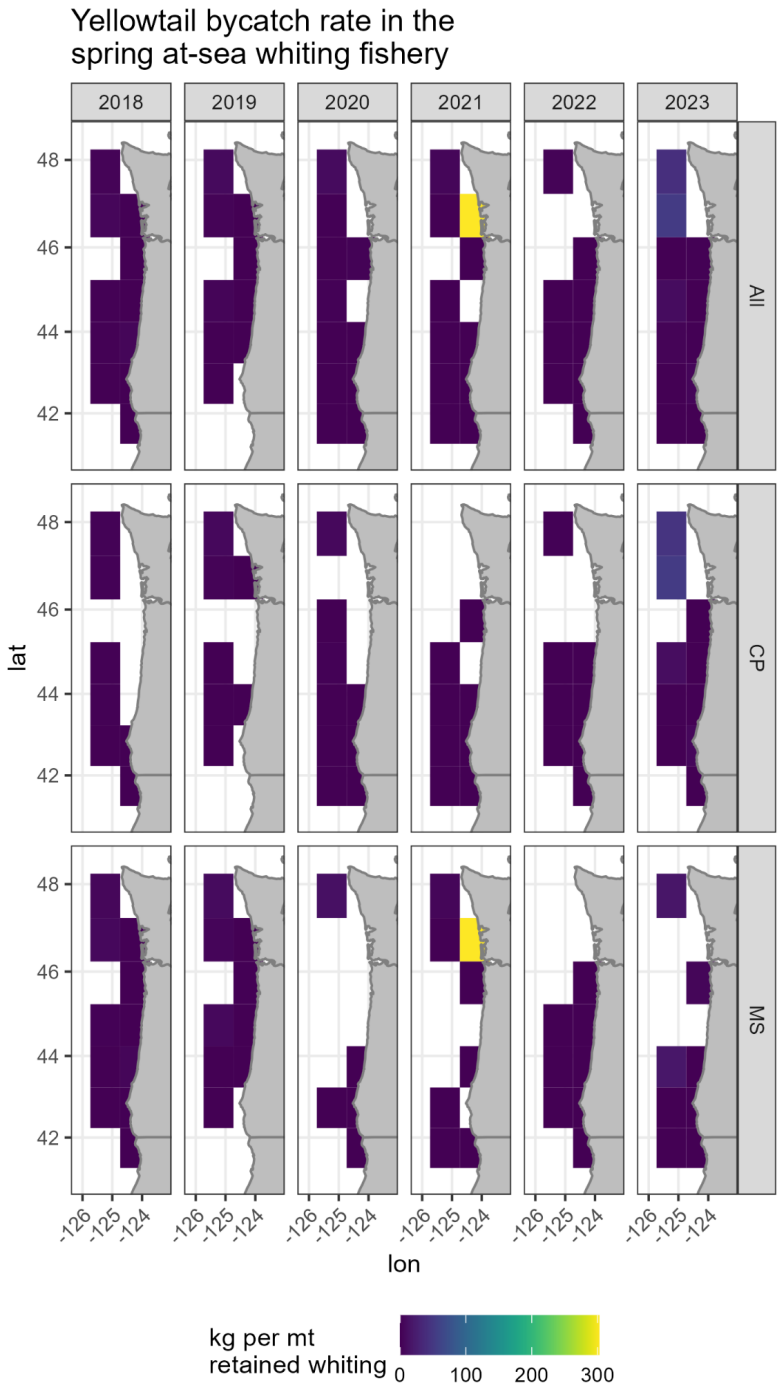

Figure 12. Yellowtail rockfish bycatch rates (kg per metric ton of retained whiting) in spring 2018-2023.

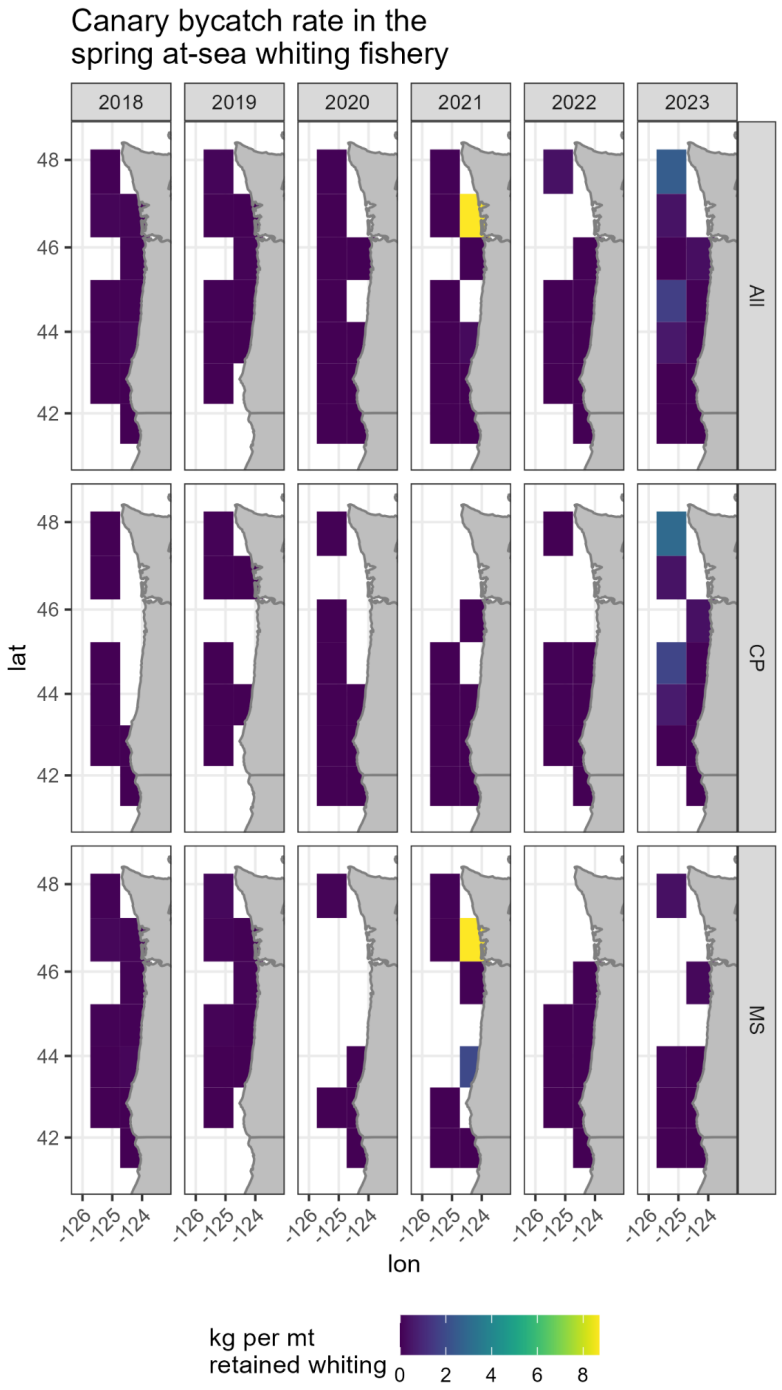

Figure 13. Canary rockfish bycatch rates (kg per metric ton of retained whiting) in spring 2018-2023.

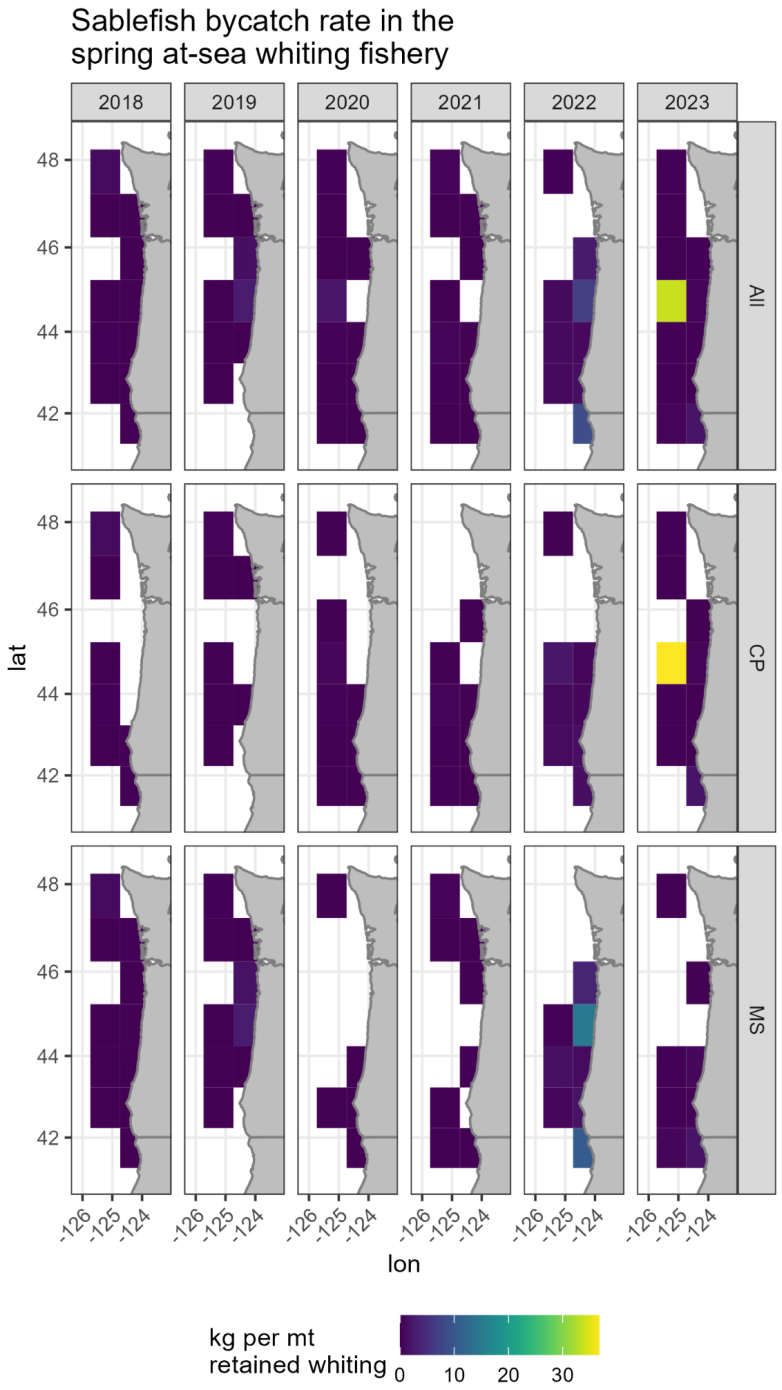

Figure 14. Sablefish bycatch rates (kg per metric ton of retained whiting) in spring 2018-2023.

Appendix 1

Inseason projections of Chinook bycatch in the at-sea whiting sectors for 2023

Sean E. Matson[1], Andrew Leising[2], Chris Harvey[3], Maggie Sommer[1], Vanessa Tuttle[4], Paul Moran[3]

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August 29, 2023

Contents

Executive Summary

We developed an analysis consisting of: a) model-based projections of Chinook bycatch in the at-sea whiting sectors for the 2023 year, b) a sensitivity analysis based on alternative scenarios considering recent climate information, and c) a retrospective analysis of early season projections and residuals; to help inform the Council on current status and expectations for this fishery over the remainder of the 2023 year, and contribute to an informational statement by the Groundfish Management Team (GMT).

We used a simulation-based, bootstrap projection model (Matson and Erickson 2018, Doerpinghaus 2016, Mirick et al. 2015, Stohs 2015) to produce predicted distributions of bycaught Chinook counts for the fall mode of the 2023 at-sea whiting fishery, and combined them with existing accumulated actual bycatch, to form total year projections.

The base model was developed using a reference year range of 2015-2022, which represented the years used for these sectors in the whiting utilization analysis carried out in 2021, updated to include the most recent available data. A mixed, coastwide effort distribution assumption represented the patterns observed over those years in the fall mode (Figure A 1, Figure A 2). Separate projections were made for each at-sea fishery sector, catcher-processor (CP) and mothership (MS). Three model scenarios were framed according to differing levels of expected whiting attainment in 2023 (minimum, mean, and 100 percent, over 2015-2022, Table A 1, Table A 2). Bycatch was projected only for the fall mode (August forward), and those projections were summed with Chinook bycatch which had already occurred during the spring mode, to comprise full year bycatch projection amounts.

The range of projected bycatch amounts is shown in Table A 3, Table A 4., and Figure A 3, including the 80th percentile amounts, the metric identified in the 2017 biological opinion as the preferred, risk-averse estimate for Chinook bycatch using this modeling approach.

The 80th percentile values of the projected distribution *assuming no reapportionment* for 2023 (Table A 3.), for the two most likely scenarios, low, and average attainment, were for the CP sector 4,396 and 5,583 fish, respectively. For the MS, the 80th percentile, projected values were 2,267 and 3,690 fish, respectively.

Assuming reapportionment does occur for 2023, results were somewhat higher overall (Table A 4.). The 80th percentile values of the projected distribution, for the two most likely scenarios, low, and average attainment, for the CP sector 4,857 and 6,176 fish, respectively. For the MS, the 80th percentile, projected values were 2,614 and 4,189 fish, respectively.

The 80th percentile projections are relatively high considering both historical annual bycatch amounts, and with the primary goal of staying beneath the combined whiting threshold of 11,000 Chinook among the combination of three commercial (CP, MS, and shorebased) whiting sectors, and should promote caution through the rest of the 2023 season, given the anomalous nature of the spring bycatch.

Given the marine heat wave (MHW) NEP23A, which originally formed off the West Coast in mid-May 2023, first moved ashore in July, has continued through August (Table A 4), and is expected to persist, potentially waxing and waning through the summer with increased risk of warming through to spring of 2024; and given that elevated sea surface temperature (SST) has recently been implicated as one predictor of high Chinook bycatch in these fishery sectors over multiyear time series (Sabal et al. 2023), we developed a configuration to explore model sensitivity to such events, by using MHW years to inform the model. Representative years were chosen using time series of MHW index data off Washington and Oregon, provided by staff from the Environmental Research Division, SWFSC; Conservation Biology Division, at the NWFSC, and collaborators in the California Current Integrated Ecosystem Assessment (CCIEA). Based on those indices (Figure A 6), four prominent MHW years between 2014 and 2022, which were active during the fall mode off Washington and Oregon, were selected to inform the exploratory model runs: 2014-2016, and 2019.

Results of these exploratory, model sensitivity runs appear in Table A 5, and show that compared with the base model, projected Chinook bycatch distributions were between 8 percent and 43 percent higher at the 80th percentile; between 6 and 10 percent higher at the 90th, and differed most at the median, between 13 percent and 107 percent higher than the base model results; that is, the middle of the distributions tended to differ most, and those differences lessened, and converged somewhat toward the higher value tails.

Results of this coarse exercise show that the model is sensitive to use of reference data from MHW-specific years, and produced notably higher predictions. They suggest that bycatch expectations under MHW conditions may be higher than more typical conditions represented by the base model. However, this exercise was too coarse and exploratory to make precise or specific inference from, and was not designed to investigate cause of a particular event. There are many potential reasons in addition to oceanographic and climate conditions that bycatch rates can vary within and among years, and between sectors, including effort distribution, behavior, bycatch abundance and demographics, and other causes. The degree of persistence and intensity of MHW NEP23A itself is uncertain for the remainder of 2023 as well. Annual Chinook bycatch rates over the fall mode in at-sea whiting sectors appear in Table A 6.

The last focus of this analysis was to examine bycatch projections made for the first 14 days of the whiting season, after the new start date of May 1 (moved from May 15), as part of the whiting utilization analysis performed in 2021; to compare those projections with actual catch during the first 14 days of the 2023 season. Doing so might offer some insights as to confidence in the current inseason projections for the remainder of 2023, and speak to the relevance of the additional 14 days of the fishing season for bycatch.

Actual Chinook bycatch during the first 14 days of the 2023 whiting season (Table A 7) in the MS sector was at the 86.5th percentile of the projected distribution, just over the 80th percentile (Appendix A. of the Whiting Utilization Analysis (Agenda Item E.2, Attachment 1, March 2022), which is the preferred, risk-averse estimate from the distribution of model-projected Chinook bycatch identified in the 2017 biological opinion, and used in subsequent fishery action analyses. However, actual bycatch in the CP sector, for the first 14 days of the 2023 season was beyond the limits of the projected distribution (105 fish over the 100th percentile) in the 2021 analysis.

Bycatch rates for both CP and MS sectors were lower from May 1 to 14, 2023 than the aggregate rate for the spring mode Figure A 7, Table A 7). For the CP sector, the bycatch rate during the first 14 days of the season of 0.048 Chinook per mt of retained hake, was 89% of the spring 2023 season rate of 0.054. For the MS sector, the bycatch rate during the first 14 days of the season of 0.017 Chinook per mt of hake, was just 51.5% of the spring 2023 season rate of 0.033 Chinook per mt of hake.

Spring bycatch rates in both of the at-sea sectors, particularly the CP, were substantially higher in 2023 than in previous years, as far back as 2011, apart from June of 2014 for the MS (Figure A 8). The data support the conclusion that beginning the season on May 1 was not a substantial cause of the higher than normal spring bycatch this year, rather the entire spring season of 2023 has been anomalous. Given this anomaly, it was not possible to foresee or project such a result from the typical, recent historical data that informed the projections of the early season start date in the whiting utilization analysis.

In conclusion, our investigation highlights a combination of evidence that warrants caution in the at-sea whiting sectors for the remainder of 2023, including anomalously high spring bycatch, and relatively high projected fall and total-year bycatch. Results of sensitivity analysis support that the model is sensitive to selection of MHW years in the reference data, and recent research (Sabal et al. 2023) has shown potential for higher bycatch in the at-sea whiting sectors during periods with high sea surface temperatures.

Introduction

The Pacific Fishery Management Council (Council) requested information from the Groundfish Management Team (GMT) regarding unusually rapid spring accumulation of Chinook salmon bycatch in 2023, during the June 2023 council meeting. To contribute to the GMT's effort, an analysis was developed consisting of a) model-based projections of Chinook bycatch in the at-sea whiting sectors for the 2023 year, b) a sensitivity analysis based on alternative scenarios considering recent climate information, and c) a retrospective analysis of recent early whiting season projections and residuals; to help inform the Council on current status and expectations for this fishery over the remainder of the 2023 year.

Methods

Modeling

Projected distributions of total Chinook counts, and latitude for the fall mode period of 2023 were produced using the same simulation-based (bootstrap) model used in the analysis for the 2017 biological opinion (Matson and Erickson 2018), and recommended by the Science and Statistical Committee (SSC). This same modeling approach has been used several times for fishery management within the Council to predict bycatch of species including ESA-listed salmon in fisheries for highly migratory species and groundfish. It was previously applied to analyze the 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), in addition to the analysis of Chinook bycatch for the 2017 biological opinion on the groundfish fishery's effects on ESA-listed salmon, subsequent similar analyses of Chinook bycatch for developing salmon bycatch minimization measures in the groundfish fishery, and for analysis of various bycatch

species in groundfish harvest specifications in multiple 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 biological opinion, at the conclusion of scoping of that item; it was used to analyze the suite of catch assumptions recommended by the Council, representing the future groundfish fishery for that purpose (Matson and Erickson 2018).

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 basic approach of the bootstrap model used 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 was modeled separately. 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. 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).

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

The bootstrap method employed 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 risk-averse approach used in the 2017 biological opinion on Chinook salmon bycatch in the groundfish fishery (NMFS, 2017) identified the 80th percentile of the projection distribution as the preferred estimate of Chinook salmon bycatch wherever the model was applied, given the protected or endangered status of particular ESUs, and this approach has subsequently been used

in fishery impact analyses concerning Chinook bycatch in groundfish sectors. Since 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 expected number of bycaught Chinook could be expected to lie at or beneath this level. This approach 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.). Use of risk-averse quantiles and probabilities for marine fisheries and conservation is established in the literature (Gerrodette et al. 2002; Wade 1998; Crowder and Murowski 1998; Stohs 2015), the choice of which quantile is informed by the data itself and amount of risk tolerance for the taxon at hand.

At-Sea Hake Observer Program (A-SHOP) data to inform the model were queried from the NORPAC Comprehensive table in the Pacific Fisheries Information Network (PacFIN) database.

Expected range of target catch

A range of whiting catch expected to occur within the fall mode of 2023 was identified by examining aggregate historical whiting catch data, allocations, and attainment (Table A 1) over the year range used to inform the model (2015-2022), and industry input about 2023 harvest expectations from the June 2023 Council meeting. Low, medium, and high catch scenarios were created by applying the minimum, the mean, and 100 percent attainment proportions to the 2023 allocations, and then subtracting the retained whiting already caught during the spring mode, to produce model stop points in the bycatch projection model for each of the two at-sea whiting sectors. The values appear in Table A 2.

Whether or not whiting reapportionment would occur for 2023 was not known at the time of this analysis, so both scenarios were evaluated for the base model. If reapportionment occurs, post-reapportionments have consistently been a mean of 1.114 times the initial allocations, with little variation (CV = 0.03%). And reapportionment of a portion of the tribal whiting allocation has occurred every year after 2011 through 2022.

Fishery spatial effort distribution

A mixed latitudinal distribution of fishery effort was observed within and among years, over the coast during the second fishing mode, through the years of the reference data, and thus a coastwide model was used for this analysis, given the annual patterns observed in Figure A 1. There were not enough clear, distinct northerly or southerly distributed years for the fall mode to justify spatially stratifying the model.

Year range and weighting

The year range from the Whiting Utilization Analysis (Agenda Item E.2, Attachment 1, March 2022) was extended forward to capture the most recent, available data, and comprised years 2015 through 2022. The years were weighted evenly in the base model configuration, with the goal of capturing a representative recent period with which to inform the model for fall, 2023 bycatch of Chinook salmon.

Sensitivity analysis

Given the marine heat wave (MHW) NEP23A, which originally formed off the West Coast in mid-May, moved ashore in July, has continued into August (Figure A 4), and is expected to persist through the summer with increased risk of warming through to spring of 2024; and given that elevated sea surface temperature (SST) has recently been implicated as one predictor of high Chinook bycatch in these fishery sectors over multiyear time series (Sabal et al. 2023), a configuration was also developed to explore model sensitivity to such events, by using MHW years to inform the model.

Representative years were chosen using time series of MHW index data off Washington and Oregon, provided by staff from the Environmental Research Division, SWFSC; Conservation Biology Division, at the NWFSC, and collaborators in the California Current Integrated Ecosystem Assessment (CCIEA). Based on those indices (Figure A 5, Figure A 6), four prominent four MHW years between 2014 and 2022, which were active during the fall mode off Washington and Oregon, were selected to inform the exploratory model runs, as 2014-2016, and 2019.

Indices used included 1) percent cover of the U.S. Exclusive Economic Zone (EEZ) of Oregon and Washington by heatwave conditions (area which exceeded 1.29 standard deviations in the sea surface temperature anomaly (SSTa)), 2) heat wave intensity, characterized by normalized standard deviation of the SSTa, averaged for all pixels that already exceeded the heatwave threshold 3) heat wave distance, which is the shortest distance between the edge of the feature, and a point along the coast midway in latitude within a chosen region, and 4) cumulative heat index values, daily accumulation within year for all spots in a region with a positive anomaly, in our instance we chose those with approximately 200 cumulative degrees Celsius or greater.

Results and discussion

Base model

Under the base model, the range of projected bycatch amounts is shown in Table A 3. and Table A 4., assuming no reapportionment of an unused portion of the tribal whiting allocation, and with reapportionment occurring (estimated only), respectively. Figure A3 illustrates the projected distributions summarized in Table A 3(without reapportionment). Results tables include including the 80th percentile amounts, the metric identified in the 2017 biological opinion as the preferred, risk-averse estimate for Chinook bycatch using this modeling approach.

The 80th percentile values of the projected distribution *assuming no reapportionment* for 2023 (Table A 3), for the two most likely scenarios, low, and average attainment, were for the CP sector 4,396 and 5,583 fish, respectively. For the MS, the 80th percentile, projected values were 2,267 and 3,690 fish, respectively.

Assuming reapportionment does occur for 2023, results were slightly higher overall (Table A 4) than without it, due to assuming the same attainment percentages of higher post-reapportionment allocations. The 80th percentile values of the projected distribution, for the two most likely scenarios, low, and average attainment, for the CP sector 4,857 and 6,176 fish, respectively. For the MS, the 80th percentile, projected values were 2,614 and 4,189 fish, respectively. Reapportionment values used for the projections were estimated only for this exercise, according

to the typical proportion of the pre-reapportionment allocations (mean, 1.114; CV, 0.03%, over 2015 to 2022). Table A 3. and Table A 4. show a full range of percentiles (assuming no reapportionment, and with reapportionment, respectively).

Results for 100 percent attainment are unlikely, and are only included for contrast, and a somewhat symmetrical range of projections, and thus are not considered as a viable scenario.

The 80th percentile projections are relatively high considering both historical annual bycatch amounts (see recent summary through 2020, from Matson et al. 2023, in Figure A 7), together with the primary goal of staying beneath the combined whiting threshold of 11,000 Chinook among the combination of three commercial (CP, MS, and shorebased) whiting sectors, and should promote caution through the rest of the 2023 season, given the anomalous nature of the spring bycatch.

Figure A 3(without reapportionment) portrays the projections as a combination of boxplots and histograms, which better communicate the full character of the projected distributions. In the outlier box plots, the horizontal line within the box shows the median. Ends of the box represent the 25th and 75th quantiles (1st and 3rd), respectively, the difference between them is the interquartile range (IQR). The confidence diamond contains the mean and the upper and lower 95% of the mean; top and bottom points of the diamond show the upper and lower 95% of the mean. Whiskers extend from the 1st quartile - 1.5*(interquartile range) and from the 3rd quartile + 1.5*(interquartile range). Dots outside the whiskers denote outliers. The bracket outside of the box identifies the shortest half, which is the densest 50% of the observations (Rousseeuw and Leroy 1987).

One feature of our analysis of projecting fall bycatch, and adding those projections to known spring bycatch, has both an obvious strength and a less intuitive potential weakness. The strength is by incorporating the known spring bycatch, we increase confidence in the total year projection. However, by projecting the fall bycatch separately, we decouple the seasonal bycatch within year. By doing so, we don't allow potential for compensatory bycatch avoidance, an effect that could potentially exist in the data. However we haven't yet seen this effect in the data. Spring bycatch is also normally much lower than fall, for the CP and MS (Figure A 6, Figure A 7, and Richerson et al. 2021).

MHW sensitivity runs

Results of the exploratory, model sensitivity runs assuming a resident MHW off the coast of WA and OR through the fall, appear in Table A 5, and show that compared with the base model, projected distributions were between 8 percent and 43 percent higher at the 80th percentile; between 6 and 10 percent higher at the 90th, and differed most at the median, between 13 percent and 107 percent higher than the base model results; that is, the middle of the distributions tended to differ most, and those differences lessened, and converged somewhat toward the higher value tails.

Results of this coarse exercise show that the model is sensitive to use of reference data from MHW-specific years, and produced notably higher predictions. They suggest that bycatch expectations under MHW conditions may indeed be higher than more typical conditions represented by the base model. However, this exercise was too coarse and exploratory to make precise or specific inference

from, and was not designed to investigate cause of a particular event. There are many potential reasons in addition to oceanographic and climate conditions that bycatch rates can vary within and among years, and between sectors, including effort distribution, behavior, bycatch abundance and demographics, and others. Annual Chinook bycatch rates for at-sea whiting sectors appear in Table A 7 which show broad variability.

Retrospective examination of May 1 start date projections

The last focus of this analysis is to examine bycatch projections made for the first 14 days of the whiting season, after the new start date of May 1 (moved from May 15), as part of the whiting utilization analysis performed in 2021; to compare those projections with actual catch during the first 14 days of the 2023 season. Doing so might offer some insights as to confidence in the current inseason projections for the remainder of 2023, and whether or not any bias correction could be justified for current projections.

Actual Chinook bycatch during the first 14 days of the 2023 whiting season in the MS sector was at the 86.5th percentile of the projected distribution, just over the 80th percentile, which is the preferred, risk-averse estimate from the distribution of model-projected Chinook bycatch identified in the 2017 biological opinion, and used in subsequent fishery action analyses. However, actual bycatch in the CP sector, for the first 14 days of the 2023 season was beyond the limits of the projected distribution (105 fish over the 100th percentile) in the 2021 analysis.

For the Catcher-Processor (CP) sector, actual bycatch of Chinook was 383 fish through May 14 (early season), and retained hake was 7,990.4 mt. The resulting bycatch rate was 0.048 Chinook per mt. This level of hake catch fits easily within the low catch assumption of up to 25,000 mt.

Given that the projections made for the early season start date were made with separate northern and southern assumptions, the actual bycatch of Chinook of 383 fish in this sector is 105 fish, or 38 percent greater than the 100th percentile of the predicted distribution.

For the Mothership (MS) sector, actual bycatch of Chinook was 68 fish through May 14 (early season), and retained hake was 4,024.8 mt. The resulting bycatch rate was 0.048 Chinook per mt. This level of hake catch fits easily within the low catch assumption of up to 10,000 mt.

For MS, the projections made for the early season start date were made with a coastwide assumption, based on the reference data of 2015-2019. However, the actual effort distribution for the first two weeks was more southern (Figure A 9). The actual bycatch of Chinook of 68 fish corresponds to the 86.5th percentile of the predicted distribution, slightly higher than the 80th percentile benchmark.

Bycatch rates for both CP and MS sectors were lower from May 1 to 14, 2023 than the whole of the spring mode (Figure A 7, Table A 7). For the CP sector, the bycatch rate during the first 14 days of the season of 0.048 Chinook per mt of hake, was lower than of the overall rate for spring of 2023; it was 89% of the spring 2023 season rate of 0.054. For the MS sector, the bycatch rate during the first 14 days of the season of 0.017 Chinook per mt of hake, was much lower than of the overall rate for spring of 2023; 51.5% of the spring 2023 season rate of 0.033 for the MS sector.

Spring bycatch rates in both of the at-sea sectors, particularly the CP, were substantially higher in 2023 than in previous years, as far back as 2011 (Figure A 8). The data support an assertion that beginning the season two weeks earlier than usual was not a substantial cause of the higher than normal spring bycatch this year, rather the entire spring season of 2023 has been anomalous. Given this anomaly, it was not possible to foresee or project such a result from the more typical historical data that informed the projection analysis of the early season start date. Rather than looking to the residuals of the season start date analysis as a guide for developing a bias correction for the present projection exercise, recognizing 2023 as a potentially anomalous year overall, and viewing the 2023 projections cautiously through that lens may be a more useful approach.

Conclusion

In conclusion, our investigation highlights a combination of evidence that warrants caution in the at-sea whiting sectors for the remainder of 2023, including anomalously high spring bycatch, and relatively high projected fall and total-year bycatch projections. Results of sensitivity analysis support that the model is sensitive to selection of MHW years in the reference data, and recent research (e.g. Sabal et al. 2023) has shown potential for higher bycatch in the at-sea whiting sectors during periods with high sea surface temperatures.

Tables and Figures

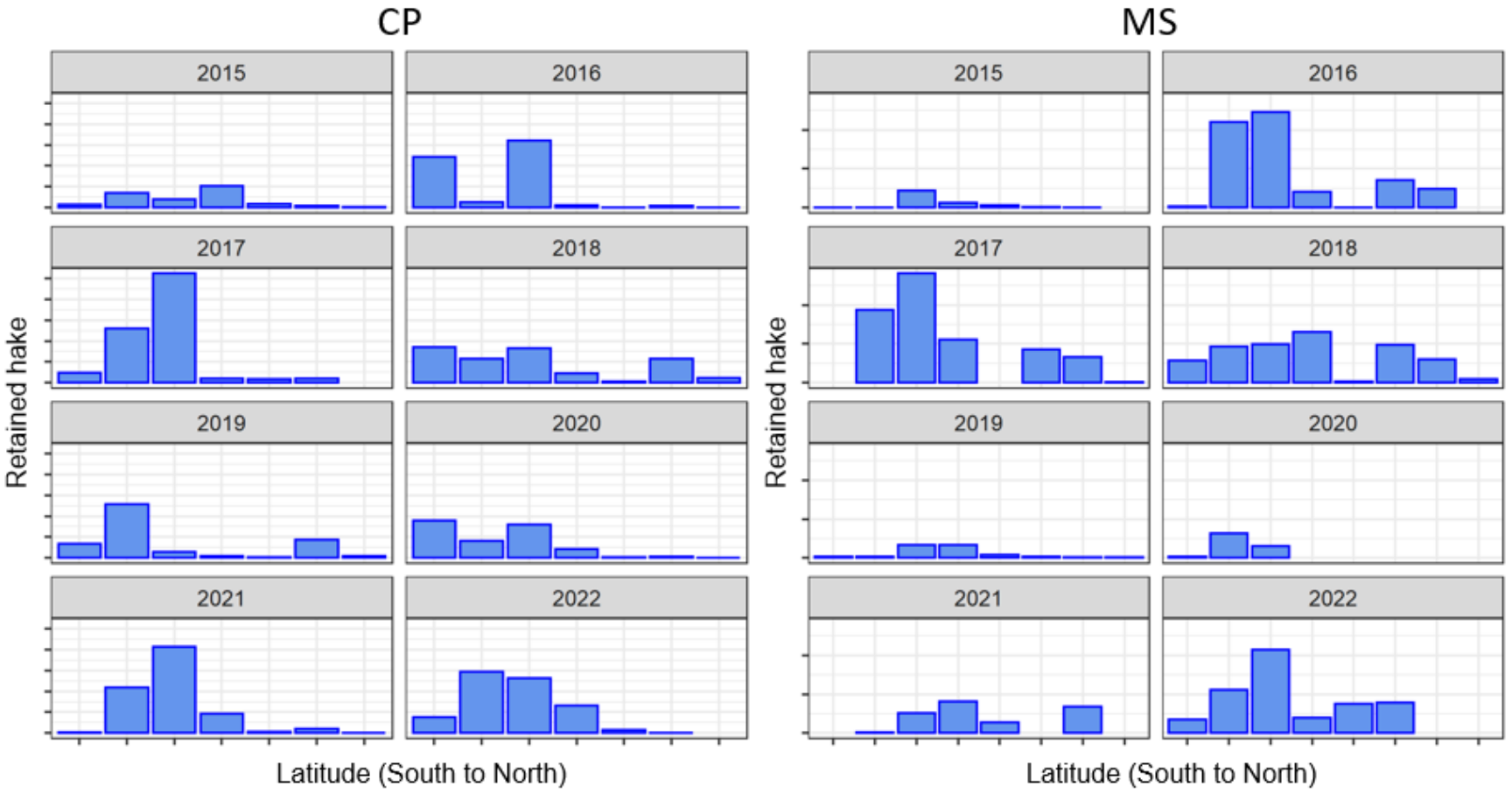
Table A 1. Annual retained catch, allocations, and attainment, for years 2015-2023 in the CP and MS at-sea whiting sectors. Note that 2023 data (italics) are only partial, complete through July 24, 2023. See Table A2 for values used in the model to make projections.

	Retained catch (mt)		Post-reapport. allocation		Post-reapport. attainment	
Year	MS	CP	MS	CP	MS	CP
2015	27,544	68,435	71,204	100,873	39%	68%
2016	64,597	108,781	80,575	114,149	80%	95%
2017	65,358	137,104	96,884	137,252	67%	100%
2018	65,997	116,005	96,644	136,912	68%	85%
2019	51,829	116,352	96,644	136,912	54%	85%
2020	37,978	111,144	93,352	132,249	41%	84%
2021	35,139	103,971	81,276	115,141	43%	90%
2022	59,157	126,247	89,144	126,287	66%	100%
*2023	*14,135*	*40,030*	*91,247*	*129,266*	*15%*	*31%*

Table A 2. Projection model initial conditions and assumptions under scenarios of reapportionment (RA) of tribal whiting (hake) occurring (Post-RA) and not occurring (Pre-RA).

Sector	Attainment level	Attainment proportion	Pre-RA 2023 hake allocation	Pre-RA Assumed 2023 total retained catch	Pre-RA hake model stop	Post-RA 2023 allocation	Post-RA assumed 2023 total retained catch	Post-RA hake model stop*	Actual 2023 retained catch as of July 24	Chinook count as of Jul 24
CP	High	1.00	129,266	129,266	89,236	144,002	144,002	103,972	40,030	2,148
CP	Average	0.88	129,266	113,754	73,724	144,002	126,722	86,692	40,030	2,148
CP	Low	0.68	129,266	87,901	47,871	144,002	97,922	57,892	40,030	2,148
MS	High	1.00	91,247	91,247	77,112	101,649	101,649	87,514	14,135	460
MS	Average	0.57	91,247	52,011	37,876	101,649	57,940	43,805	14,135	460
MS	Low	0.39	91,247	35,586	21,451	101,649	39,643	25,508	14,135	460

Figure A 1. Latitudinal effort distribution of hake fishing by at-sea sector and year, 2015-2022, for fall mode, for August forward. Based on the somewhat mixed results both within and among years, and a need to seek parsimony and limit the number of total model runs, the model was stratified coastwide for each sector. Axis labels omitted for confidentiality.



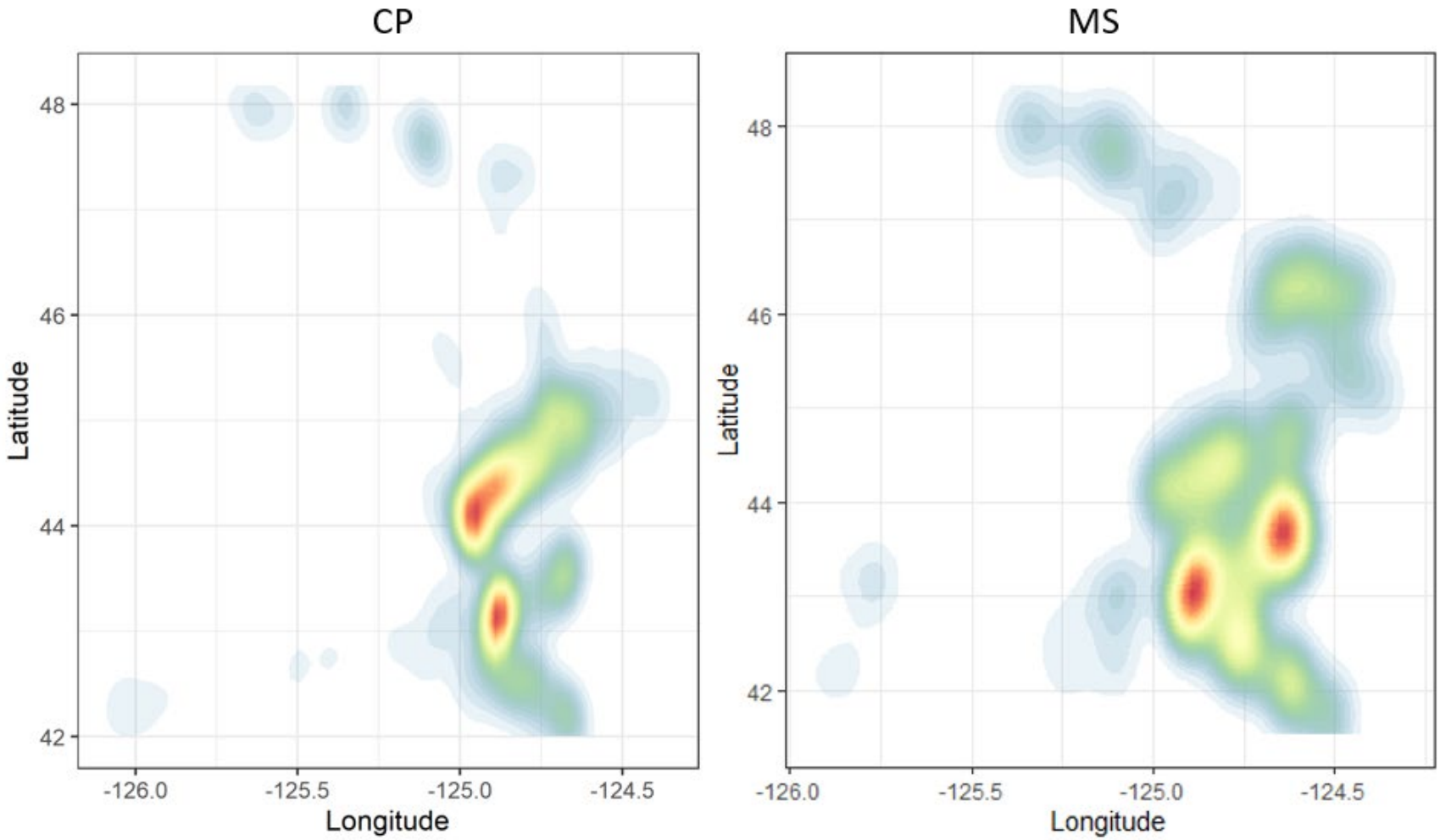


Figure A 2. Latitudinal effort distribution of hake fishing by at-sea sector as smoothed haul density (unweighted), over the pooled years 2015-2022, for fall mode, from August forward.

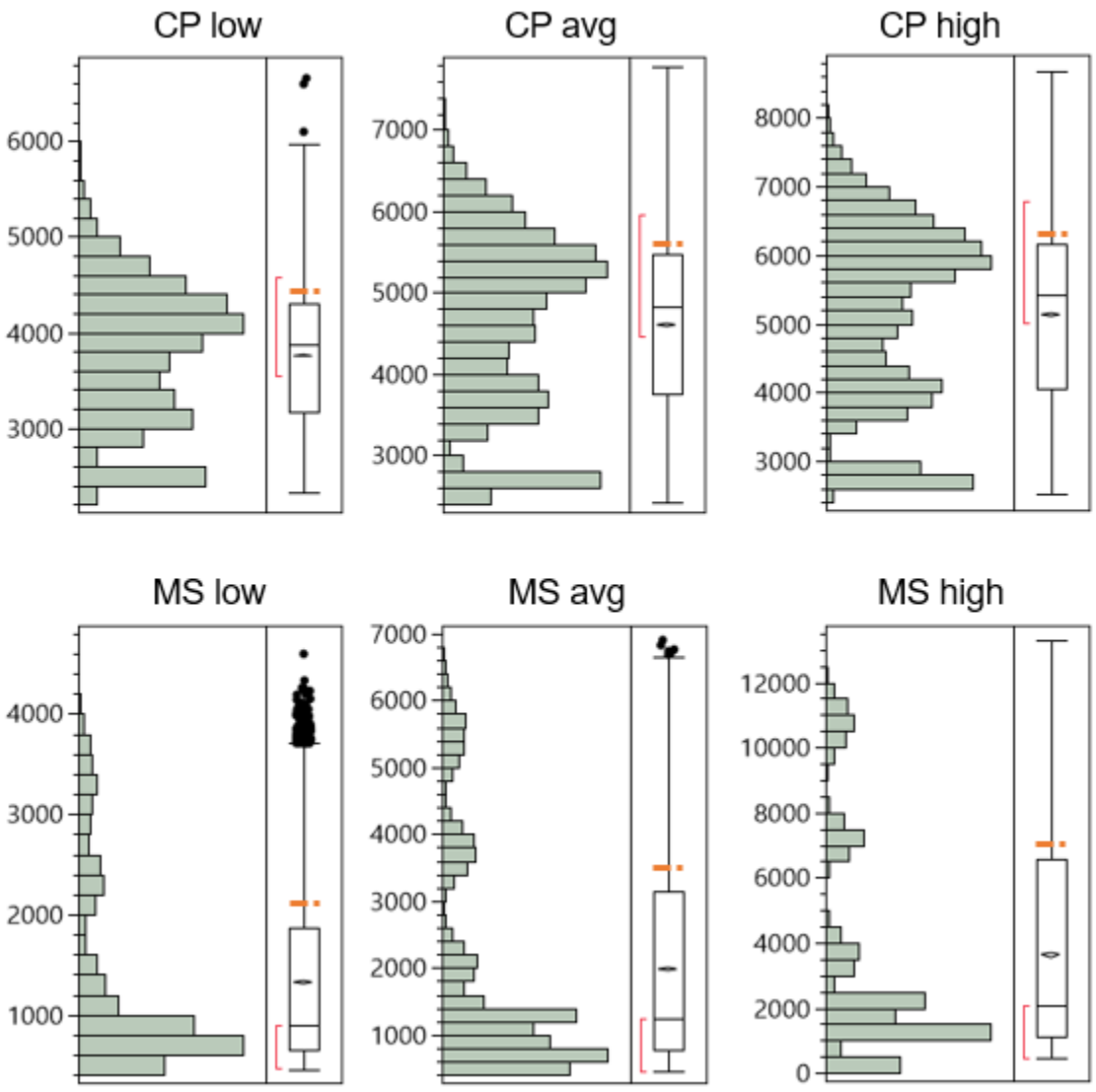


Figure A 3. Full-year, sum 2023 projected Chinook count distributions by at-sea sector and scenario without whiting reapportionment, using equally weighted years 2015-2022, for August through the rest of the year as input data, and adding projected fall bycatch to already caught through July 2023. Note different y axes. See text for box-plot features.

Table A 3. Total year sum 2023 projected chinook count distributions by at-sea sector and scenario, without whiting reapportionment, using equally weighted 2015-2022, August-Dec as input data, and summing projected fall bycatch with Chinook bycatch already accumulated through July 2023.

Sector	**CP**			MS		
Data years	2015-2022					
Effort dist.	Coastwide/mixed within season					
Exp. harvest	Low: 87.9k mt	Avg: 113.8k mt	High: 129.3k mt	Low: 35.6k mt	Avg: 52.0k mt	High: 91.2k mt
Exp. attain	68%	88%	100%	39%	57%	100%
Quantiles	Projected annual Chinook bycatch counts, 2023					
0%	2,324	2,430	2,520	460	462	470
1%	2,392	2,552	2,648	464	468	480
5%	2,467	2,646	2,750	468	474	490
25%	3,170	3,748	4,067	644	786	1,125
50%	**3,880**	**4,827**	5,419	**899**	**1,250**	2,088
75%	4,297	5,464	6,171	1,866	3,134	6,576
80%	**4,396**	**5,583**	6,313	**2,267**	**3,690**	7,174
90%	**4,649**	**5,932**	6,696	**3,039**	**5,126**	10,333
95%	4,856	6,182	6,967	3,408	5,611	10,964
99%	5,289	6,607	7,495	3,828	6,164	11,735
100%	6,660	7,773	8,674	4,597	6,904	13,284
Mean bycatch	3,758	4,614	5,134	1,321	1,988	3,627
Mean latitude	43.666	43.662	43.662	43.656	43.679	43.675
BC Range	4,336	5,343	6,154	4,137	6,442	12,814
BC Std Dev	737	1,101	1,325	955	1,666	3,436
BC CV	19.6%	23.9%	25.8%	72.3%	83.8%	94.7%

Table A 4. Total year sum 2023 projected chinook count distributions by at-sea sector and scenario, assuming whiting reapportionment, using equally weighted 2015-2022, August-Dec as input data, and summing projected fall bycatch with Chinook bycatch already accumulated through July 2023. ***Post-reapportionment allocations are estimated only for the purpose of the bycatch analysis, based on mean pre- versus post-apportionment allocation proportions, and have no bearing on whether or how much reapportionment may or may not occur for 2023.***

Sector	**CP**			**MS**		
Data years	2015-2022					
Effort dist.	Coastwide/mixed within season					
Exp. harvest	Low: 97.9k mt	Avg: 126.7k mt	High: 144.0k mt	Low: 35.6k mt	Avg: 57.9k mt	High: 101.6k mt
Exp. attain	68%	88%	100%	39%	57%	100%
Quantiles	Projected annual Chinook bycatch counts, 2023					
0%	2,362	2,486	2,555	460	462	470
1%	2,446	2,643	2,744	464	470	484
5%	2,528	2,737	2,847	468	476	494
25%	3,386	4,025	4,384	678	834	1,218
50%	**4,241**	**5,318**	5,967	**976**	**1,350**	2,295
75%	4,746	6,036	6,839	2,091	2,973	7,100
80%	**4,857**	**6,176**	7,004	**2,614**	**4,189**	7,991
90%	**5,135**	**6,527**	7,421	**3,549**	**5,890**	11,668
95%	5,360	6,799	7,731	3,931	6,408	12,342
99%	5,814	7,317	8,288	4,384	7,003	13,168
100%	6,747	8,738	9,537	5,280	7,898	14,249
Mean bycatch	4,084	5,037	5,625	1,474	2,205	4,001
Mean latitude	43.662	43.655	43.666	43.658	43.679	43.677
BC Range	4,385	6,252	6,982	4,820	7,436	13,779
BC Std Dev	880	1,276	1,545	1,132	1,929	3,862
BC CV	21.5%	25.3%	27.5%	76.8%	87.5%	96.5%

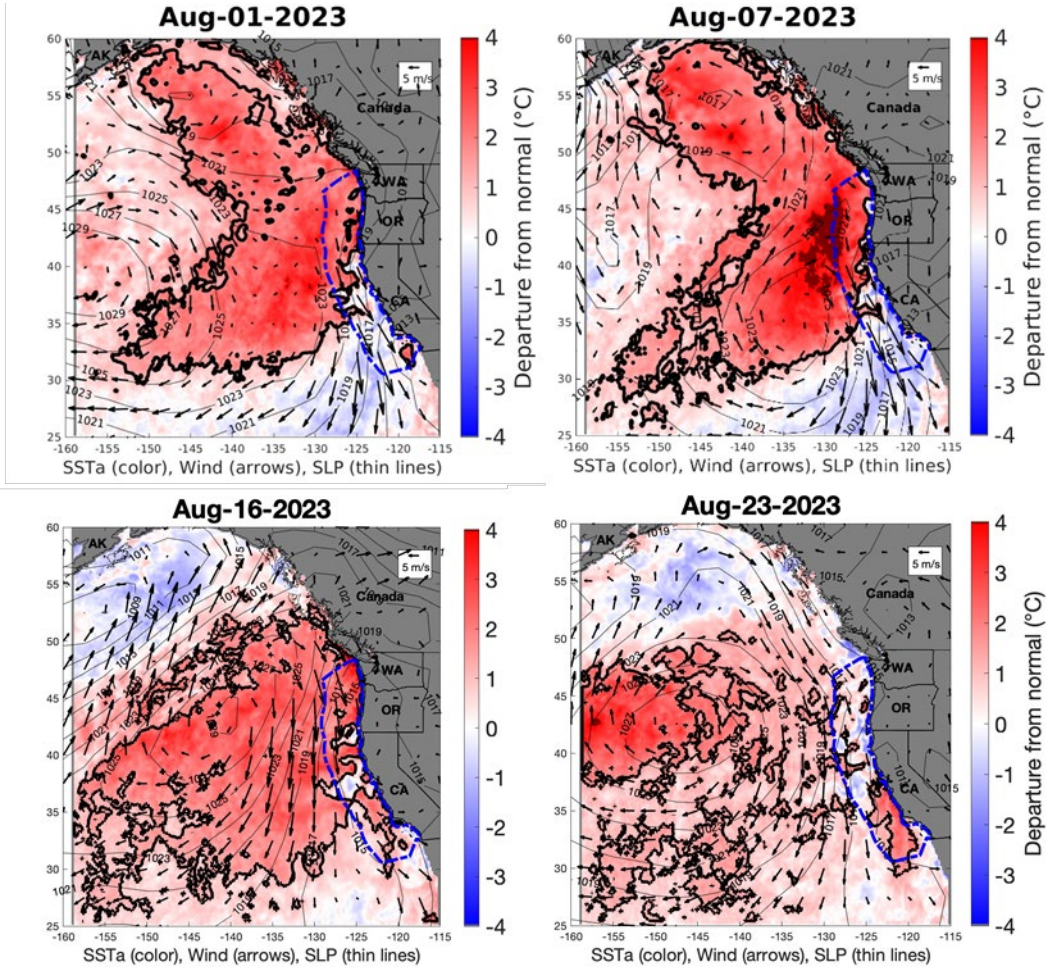


Figure A 4. Snapshots of daily sea surface temperature anomalies (SSTa) in the California Current ecosystem, as of August 1, 7, 16, and 23 showing a marine heatwave which appeared off the West Coast in July, 2023 (from the NOAA California Current Marine Heatwave Tracker (https://www.integratedecosystemassessment.noaa.gov/regions/california-current/california-current-marine-heatwave-tracker-blobtracker, and Andrew Leising, Environmental Research Division, Southwest Fisheries Science Center). Color represents SSTa, with the thick black line encircling regions which are in "heatwave status". Arrows represent wind speed and direction. Thin lines represent atmospheric pressure at sea level.

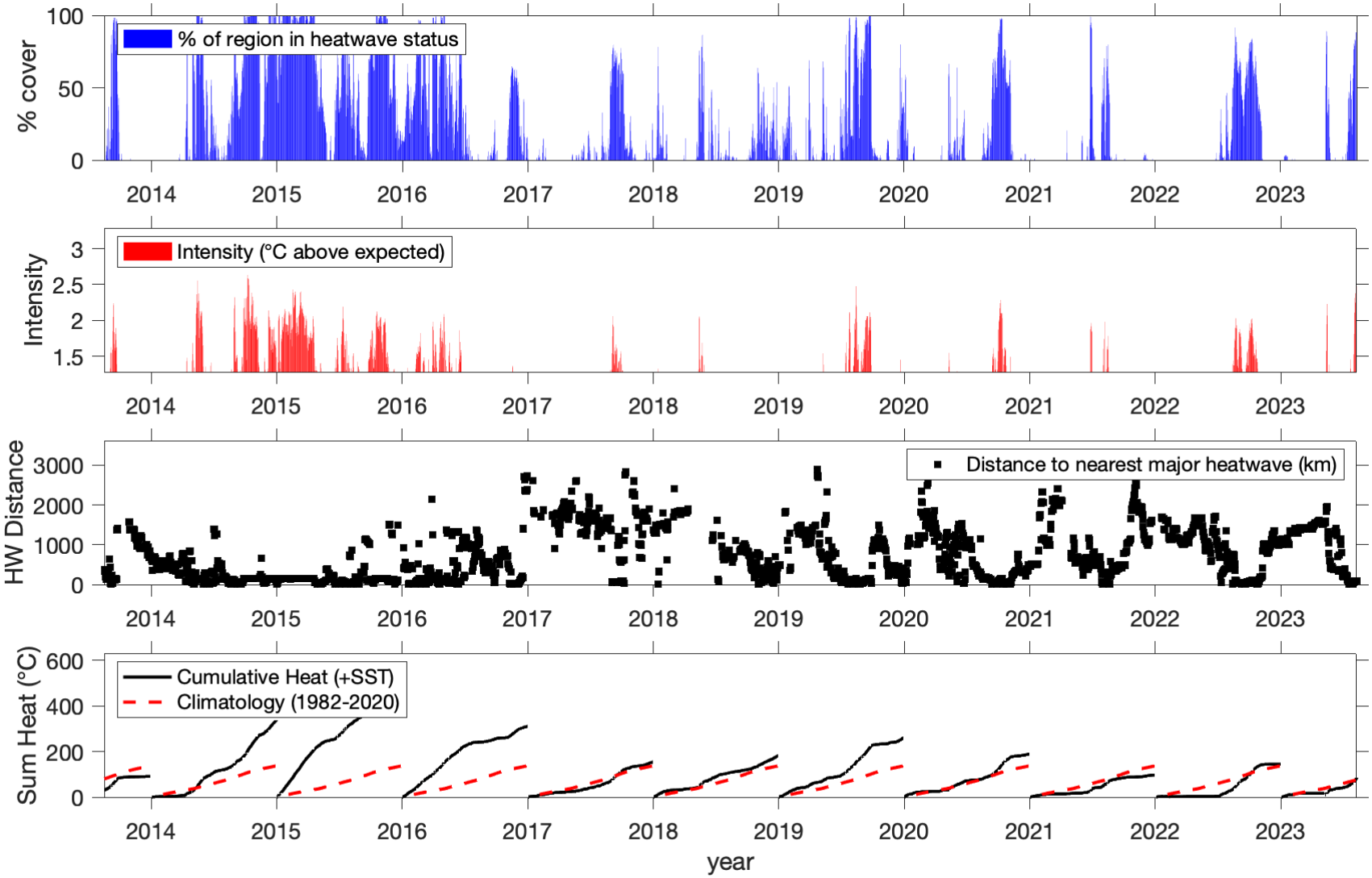


Figure A 5.. Washington coast: Time series across days of the year, for 2014 through July of 2023, of four MHW indices, used to select years to inform the MHW model sensitivity runs (Figure courtesy Andrew Leising, Environmental Research Division, Southwest Fisheries Science Center).

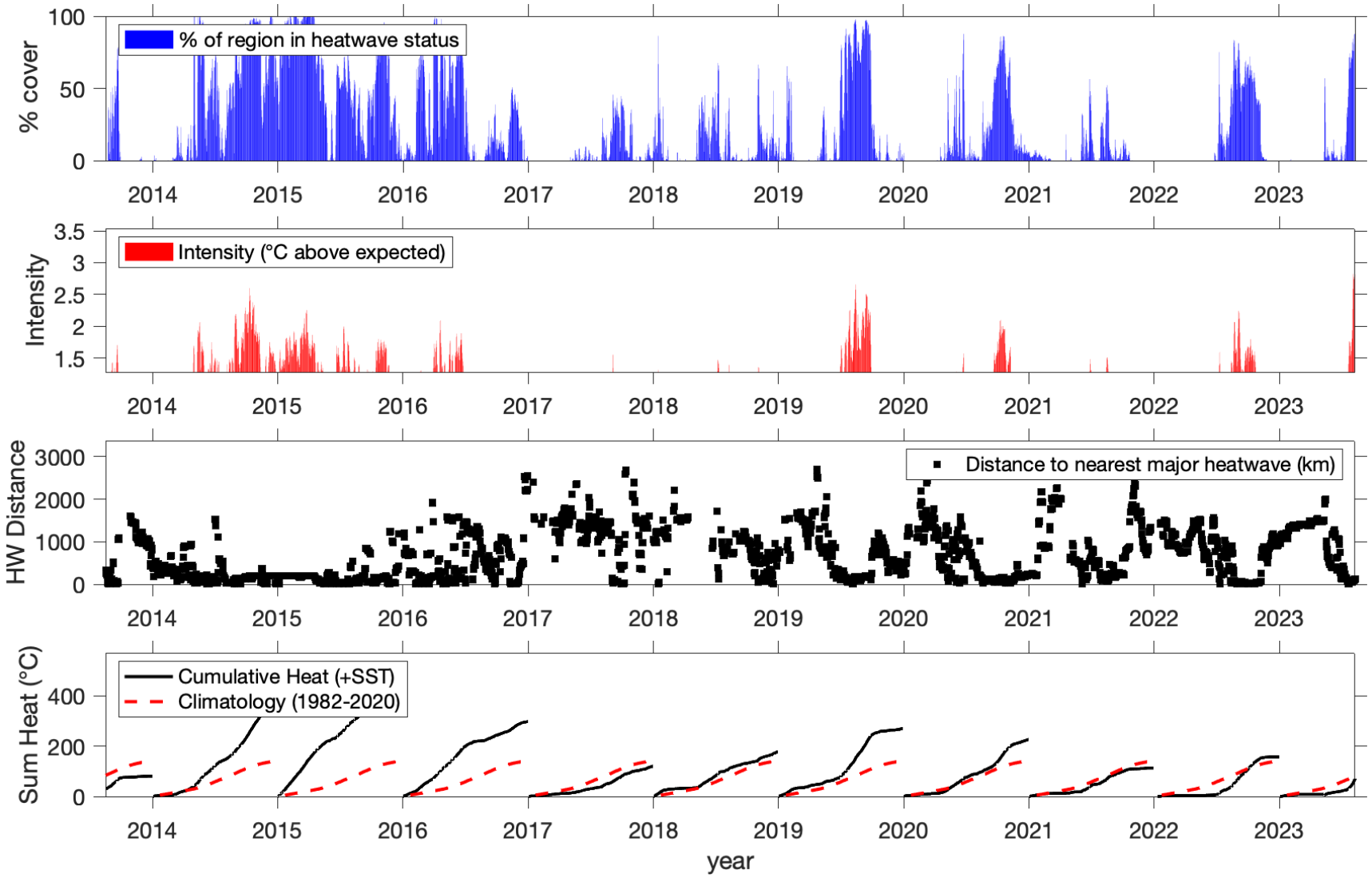


Figure A 6.Oregon coast: Time series across days of the year, for 2014 through July of 2023, of four MHW indices, used to select years to inform the MHW model sensitivity runs (Figure courtesy Andrew Leising, Environmental Research Division, Southwest Fisheries Science Center).

Table A 5.Results of sensitivity model runs under the assumption of a MHW through the fall fishing mode without whiting reapportionment: total-year sum 2023 projected chinook count distributions by at-sea sector and scenario, using equally weighted years 2014-2016, and 2019, August-December as input data, and summing with Chinook bycatch accumulated through July 2023.

Sector	**CP**			**MS**		
Data years	2014-2016, 2019 / MHW					
Effort dist.	Coastwide/mixed within season					
Exp. harvest	Low: 87.9k mt	Avg: 113.8k mt	High: 129.2k mt	Low: 35.6k mt	Avg: 52.0k mt	High: 91.2k mt
Exp. attain	68%	88%	100%	39%	57%	100%
Quantiles	Projected annual Chinook bycatch counts, 2023					
0%	3,298	3,965	4,570	578	685	995
1%	3,638	4,666	5,292	608	745	1,081
5%	3,852	4,905	5,557	632	779	1,129
25%	4,126	5,256	5,945	744	936	1,305
50%	**4,369**	**5,581**	6,325	**1,541**	**2,369**	4,314
75%	4,673	5,980	6,787	2,353	3,308	5,997
80%	**4,752**	**6,085**	6,900	**3,038**	**5,171**	10,261
90%	**4,976**	**6,360**	7,206	**3,394**	**5,627**	10,915
95%	5,143	6,590	7,444	3,608	5,905	11,284
99%	5,528	7,019	7,933	3,936	6,347	11,873
100%	6,532	8,038	8,970	4,926	7,205	13,529
Mean bycatch	4,420	5,646	6,392	1,762	2,751	5,103
Mean latitude	43.740	43.738	43.735	43.594	43.593	43.588
BC Range	3,233	4,074	4,400	4,348	6,520	12,534
BC Std Dev	406	522	593	1,007	1,761	3,560
BC CV	9.2%	9.2%	9.3%	57.1%	64.0%	69.8%

Table A 6. Annual aggregate Chinook bycatch rates for August-November of years 2011-2022 in at-sea hake fishery sectors.

Year	Sector	Chinook count	Retained hake (mt)	Bycatch rate
2011	CP	1231.9	32,709.1	0.038
2011	MS	876.0	29,893.8	0.029
2012	CP	1525.8	34,777.4	0.044
2012	MS	2249.8	30,824.5	0.073
2013	CP	1672.2	49,844.2	0.034
2013	MS	1857.4	37,074.4	0.050
2014	CP	3423.8	67,927.9	0.050
2014	MS	2290.8	38,866.9	0.059
2015	CP	1239.4	25,919.6	0.048
2015	MS	130.0	3,174.2	0.041
2016	CP	2575.6	61,349.8	0.042
2016	MS	295.2	31,401.2	0.009
2017	CP	2946.7	88,924.9	0.033
2017	MS	681.0	36,758.8	0.019
2018	CP	2799.9	64,297.7	0.044
2018	MS	2413.1	27,584.1	0.087
2019	CP	2309.0	46,301.6	0.050
2019	MS	590.7	4,402.9	0.134
2020	CP	332.0	46,914.5	0.007
2020	MS	2.0	4,920.3	0.000
2021	CP	1447.7	75,244.2	0.019
2021	MS	92.0	10,428.0	0.009
2022	CP	1897.8	77,749.9	0.024
2022	MS	635.9	27,715.2	0.023

Table A 7. Biweekly Chinook counts, retained hake amounts, and bycatch rates in the CP and MS at-sea fisheries, for spring of 2023. Bycatch rates during the first 14 days of the 2023 season (ISO Bi_week = 18-19 in the Table, and Figure) were moderate to low, while the largest amounts of Chinook bycatch, and the highest bycatch rates occurred during the second two-week period of the season, beginning on May 15, the previous season start date. Bycatch rates during the new first two weeks of the season (beginning May 1) were lower than the spring aggregate rate, in both sectors.

Year/season	Sector	ISO Bi_week	Chinook count	Retained hake mt	Bycatch rate
2023/spring	CP	18_19	383.3	7,990.4	0.048
		20_21	1,547.7	25,362.2	0.061
		22_23	216.7	6,676.3	0.032
		Sum	2,147.7	40,028.9	0.054
2023/spring	MS	18_19	68.0	4,024.8	0.017
		20_21	390.9	9,030.5	0.043
		22_23	1.0	902.3	0.001
		Sum	459.9	13,957.6	0.033

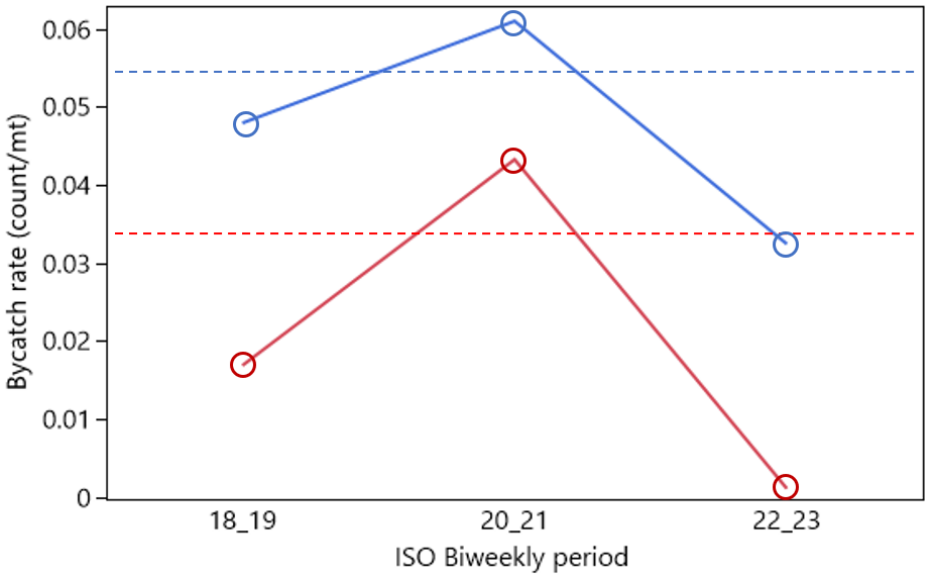


Figure A 7.Biweekly Chinook counts, retained hake amounts, and bycatch rates in the CP (blue line, circles) and MS (red line, circles) at-sea fisheries, for spring of 2023. The largest amounts of Chinook bycatch, and the highest bycatch rates occurred during the second two-week period of the season, beginning on May 15, the previous season start date. Bycatch rates during the new first two weeks of the season (May 1-14) were lower than the spring aggregate rate, in both sectors. The blue dashed line shows the aggregate bycatch rate for CP, and the red dashed line shows the aggregate bycatch rate for the MS sector.

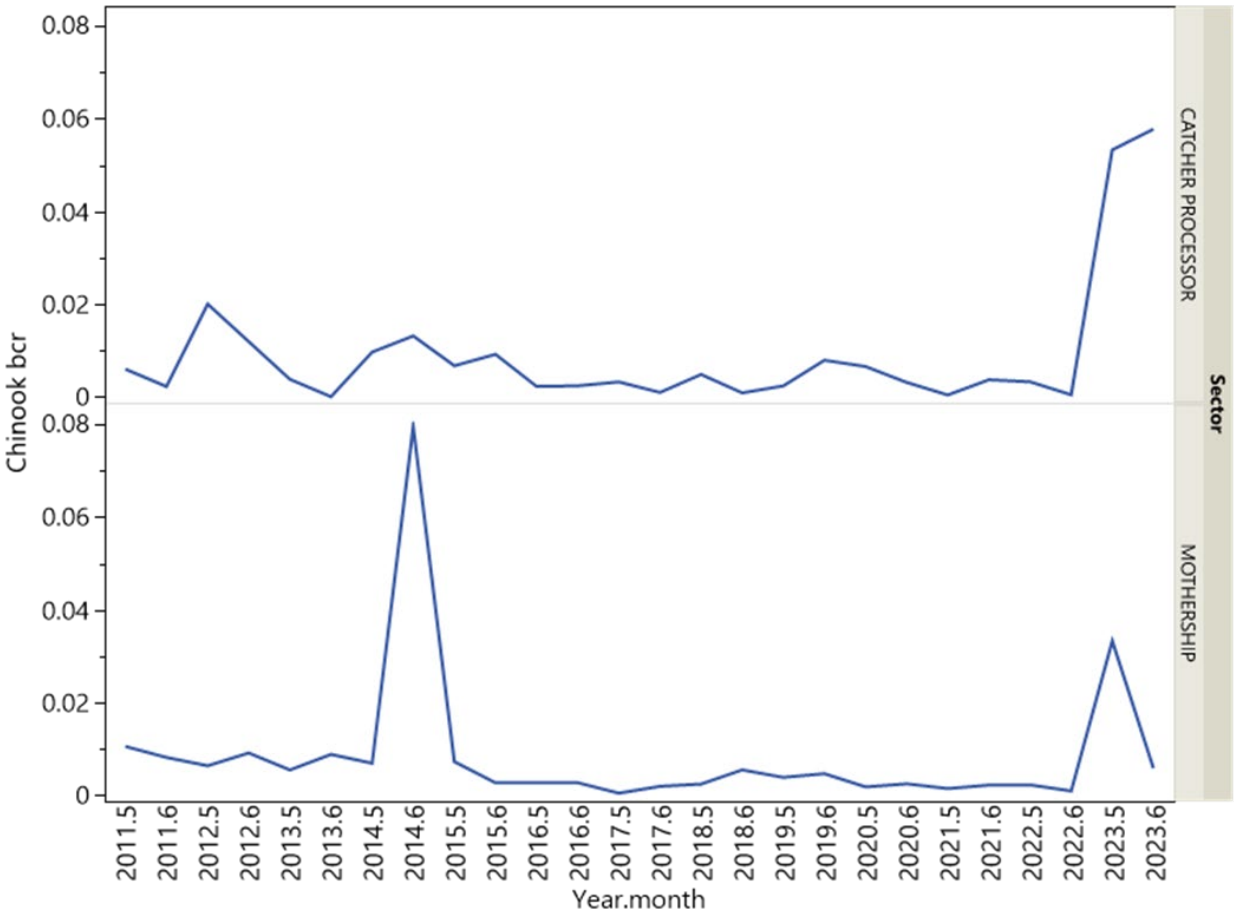


Figure A 8. Chinook bycatch rates in at-sea hake sectors, CP and MS, during the spring mode of each year from 2011 forward. The plot demonstrates the anomalously high bycatch rates during spring of 2023 for both sectors, as well as spring of 2014 for the MS sector.

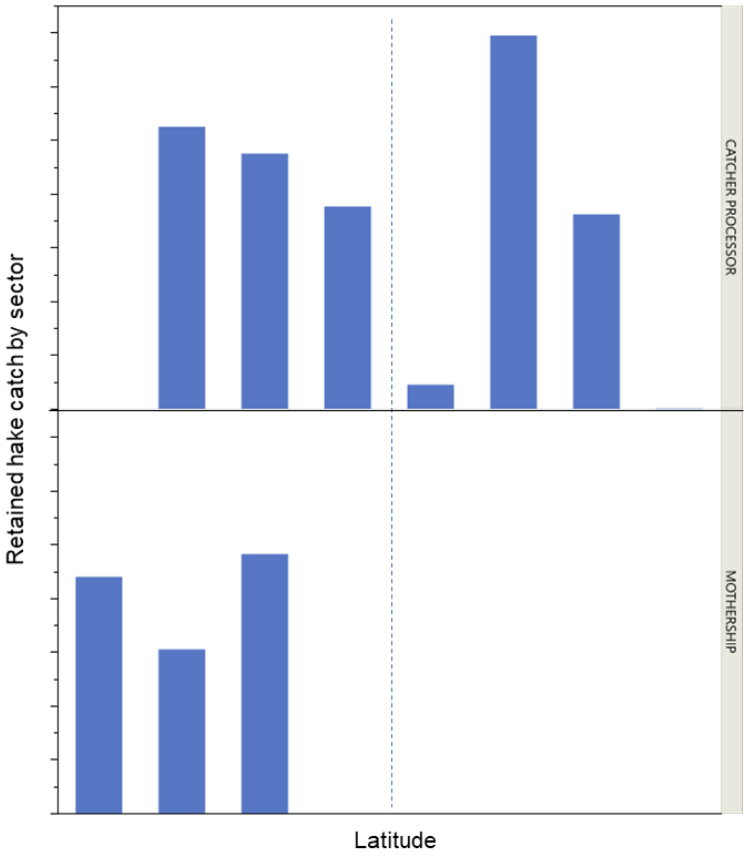


Figure A 9. At-sea hake spatial effort distribution over the first 14 days of 2023, during May 1-14, as retained hake catch. This distribution characterizes a mixed, or coastwide effort distribution for CP, and southern for MS. May 1 was the new, early season start date analyzed in the MS utilization item in 2021, which took effect in 2023. May 15 was the prior season start date. The X-axis midline (blue dashed line) is at 45 degrees N. lat. Axis labels are removed to preserve confidentiality.

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