Pacific Fishery Management Council Salmon Fishery Management Plan Impacts to Southern Resident Killer Whales

Draft Range of Alternatives and Recommendations

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1.0 INTRODUCTION

Over the last decade, the status of Endangered Species Act (ESA) -listed Southern Resident Killer Whales (SRKW, DPS listed under 70 FR 69903) has substantially declined (as of August 2019, the population was at 73), raising concern over their status and recovery. Since 2009, additional data has been gathered on SRKWs that resulted in an updated understanding of their distribution, diet, and birth and death rates, accompanied by new information on the spatial distribution of different stocks of Chinook salmon prey. As a result, in April 2019, NOAA's National Marine Fisheries Service (NMFS) re-initiated ESA consultation on Pacific Fishery Management Council (Council or PFMC) -directed ocean salmon fisheries and coordinated with PFMC to assess the effects of implementing the Pacific Coast Salmon Fishery Management Plan (FMP) in 2019 and beyond.

In April 2019, the Council established the SRKW Ad Hoc workgroup (Workgroup) with the primary task of reassessing the effects of PFMC ocean salmon fisheries on SRKW and if needed, developing a long-term approach that may include proposed conservation measure(s) or management tool(s) that limit PFMC fishery impacts to Chinook salmon (*i.e.*, the whales' primary prey). The Workgroup's Risk Assessment (RA) was completed in May 2020, and submitted to the Council for consideration (PFMC 2020).

Workgroup recommendations for management or conservation measures are described in this document and developed for Council consideration. The RA and the following recommendations are intended to help inform NMFS' ESA consultation.

The workgroup acknowledges that there are multiple factors that all play a role in the status of SRKW acting together to impact SRKWs including (1) the quantity and quality of prey, (2) bioaccumulation of toxic chemicals in apex predators, and (3) impacts from sound and vessels. Oil spills and disease are also risk factors. Multiple factors also affect prey abundance other than fishing, especially in the case of Chinook salmon. Thus, while the Workgroup was assembled with salmon fishery management and whale biology expertise, it still supports a holistic approach across a realm of activities, but its focus, as explained in the RA (PFMC 2020), was on Chinook salmon and so the alternatives in this document therefore also focus on Chinook salmon.

2.0 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

NMFS and Council staff held a scoping meeting with NMFS West Coast Region to determine the appropriate level of NEPA documentation.

2.1 Purpose and Need

The purpose of the recommendations and proposed alternatives are to act as conservation measure(s) or management tool(s) to further control harvest of Chinook salmon in directed ocean salmon fisheries under the Council's jurisdiction in the U.S. West coast Economic Exclusive Zone (EEZ) to limit impacts of these salmon fisheries on the Chinook salmon prey availability for SRKWs over the long term, if fishery management modifications are deemed necessary.

The need is to manage Council fisheries for sustainable salmon stocks and to ensure that the fisheries will not jeopardize the survival and recovery of SRKWs through their effects on the abundance of Chinook salmon prey availability. The Workgroup's RA and recommendations will help inform NMFS' ESA consultation and biological opinion.

2.2 Scope of Action

The scope of action is limited to Council-managed ocean salmon fisheries in the Exclusive Economic Zone (EEZ) implemented through the FMP. The Council can and does make recommendations to other entities regarding actions that are outside of its direct jurisdiction and authority that affect salmon managed by the Council. NMFS retains the authority for considering Council recommendations authorizing fisheries under the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.) and determining the risk for a variety of permitted actions as they relate to ESA (16 U.S.C. 1531 et seq.) and SRKW. The Council may make recommendations to NMFS or other entities regarding non-fishery actions as they relate to factors that affect salmon and SRKWs.

The Pacific Coast Salmon FMP guides management of salmon fisheries in Federal waters known as the EEZ 3 to 200 nautical miles off the coast of Washington, Oregon, and California. Salmon of U.S. and Canadian origin are included except in the case of species which are managed in those waters by another management entity with primary jurisdiction (*i.e.*, sockeye and pink salmon by the Fraser River Panel of the Pacific Salmon Commission in the Fraser River Panel Area (U.S.) between 49° N. latitude and 48° N. latitude). The FMP covers the coastwide aggregate of natural and hatchery salmon encountered in ocean salmon fisheries, but only has management objectives and allocation provisions for Chinook or king salmon (*Oncorhynchus tshawytscha*), coho or silver salmon (*O. kisutch*), and pink salmon (*O. gorbuscha*). Catches of other salmon species are inconsequential (low hundreds of fish or less each year) to very rare (PFMC 2016).

3.0 RECOMMENDATIONS FOR ACTION

3.1 Recommendation 1: Management strategy alternatives

Alternative 3.1.1: No Action – Status Quo Fishery Management Plan implementation.

- Continue to use existing harvest control rules and reference points as defined in the FMP on an annual basis.
- Continue to manage fisheries consistent with proposed actions described in biological opinions, reasonable and prudent alternatives, and terms and conditions addressing the effects of the fisheries on ESA-listed salmon.
- Continue to comply with accountability measures for stocks managed under regional agreements, and international agreements in which the U.S. participates such as the Pacific Salmon Treaty (PST).

Under Alternative 3.1.1, Council-area ocean salmon fisheries would continue to be planned and managed as they have been under the FMP, which first went into effect in 1977 and has since been amended 19 times, and by the suite of ESA limitations and annual NMFS guidance that also constrain fisheries. The focus of this management approach for ocean salmon fisheries is Chinook salmon abundance.

To implement the FMP each year, the Council and its Salmon Technical Team (STT) go through an extensive preseason salmon management process. Annual salmon abundance forecasts are inserted into salmon fishery management and harvest models to analyze the effects of fishery proposals (quotas, seasons, time, area, and gear restrictions) as they relate to management objectives.

In addition, fishery proposals must meet, in expectation, the conservation objectives of the FMP (usually spawning escapement goals or exploitation rate ceilings), and those specified under the ESA for fish, and under the PST which are all summarized in a guidance letter each year from NMFS to the Council.

Weak Stock Management

Although the west coast ocean salmon fisheries, by their very nature, harvest fish from a mix of stocks, they are managed to meet, in expectation, conservation objectives for individual stocks. For example, if one stock in the mix of stocks in the ocean is assessed to be compatible with relatively high fishing pressure, but another weaker stock requires a lower fishing pressure, then the ocean fishery is managed to target the limiting rate for the weaker stock and leave some of the harvestable fish from the stronger stock uncaught.

The implication of this approach for SRKW is that, although the ocean fishery has been primarily managed around Chinook salmon abundance – not around SRKW Chinook prey – it leaves many Chinook salmon unharvested and potentially available for SRKW to feed on. The arithmetic mean of Chinook salmon from North of Falcon (NOF) stocks (Puget Sound, Washington coast, and Columbia River) escaping to the terminal areas is 1.1 million mature fish per year. A much greater abundance of Chinook salmon is available to SRKW in the ocean than represented in the terminal run size because fish that are immature and will remain in the ocean are unaccounted for in terminal run size estimates. Additionally, the majority of Chinook salmon in the ocean and available to SRKW never return to the terminal area as they experience natural or fishery-related mortality. For example, of the 1,424,658 tagged releases for the Columbia Upriver Bright Chinook Technical Committee indicator stock in brood year 2013, 14,479 estimated tags were recovered in fisheries or escapement (CTC ERA, 2020), indicating the high rates of natural mortality Chinook experience. Therefore, terminal run sizes represent extreme minimum and unrealistically low estimates of the number of Chinook salmon available to SRKW. Still, the number reaching the terminal areas is approximately equal to three times the number calculated to meet the energetic needs of the SRKW population at the current ESA-listed level of approximately 73 whales if they fed only on Chinook salmon, at 13-16 Chinook salmon per whale per day (NMFS 2019), and only on Chinook salmon that spawn in the NOF region (*i.e.*, not including Chinook salmon from Canadian or South of Falcon stocks). However, as we describe in the RA report, Hilborn *et al.* (2012) found that forage ratios (the whales' bioenergetics needs compared to prey available) provide little insight into prey limitations and would require knowing the whale fitness/vital rates as a function of the supply and demand in order for the ratios to be useful.

Resulting NOF Quotas

The process of setting NOF ocean salmon seasons and quotas extends from the forecasting in January through the March and April Council meetings, and includes additional regional meetings among the NOF co-managers, and public meetings and hearings at which the Council receives public comment. Numerous ideas for fisheries are proposed each year, and then modeled to analyze their effects on each Chinook and coho salmon stock, and many of these proposals are then discarded if their modeled results do not meet salmon-specific conservation objectives.

Meeting stock-specific management objectives for salmon stocks in the Council's management models each year results in NOF ocean quotas that are sensitive to modeled Chinook salmon abundance. Figure 3.1.a shows the correlation between the annual NOF ocean quotas and the forecast abundance of the NOF Chinook salmon stocks originating in Puget Sound, the Washington coast and the Columbia River. Figure 3.1.b shows that a similar relationship applies not only to the forecasts, but also to the final post-season abundance estimates.

The relationships depicted in Figures 3.1.a and 3.1.b are descriptive, not prescriptive (*i.e.*, the regression relationship depicts the history of Council actions, not a management rule). Nevertheless, the graphs show that, in years of low NOF Chinook salmon abundance, the NOF quotas are set lower, whereas in years of high abundance, the quotas are set higher.

In the area south of Cape Falcon, Oregon (SOF), ocean salmon fisheries are developed based on conservation and management objectives and are also constrained by weak stocks, leaving Chinook salmon that would otherwise be available for harvest unharvested, and potentially available for SRKW to feed on. Time and area constraints are employed more often than quotas in SOF fisheries.

<u>Summary</u>

Overall, due to weak stock management in Council Area fisheries, a significant portion of the overall abundance goes unharvested and that portion has been increasing over the time period examined in the RA (1992-2016). As presented in the RA (PFMC 2020), "The fisheries effects on potential prey abundance have varied highly over this time period, but in general, reductions in abundance attributable to PFMC salmon fisheries have declined substantially between 1992 and 2016." The RA goes on to state, "These changes in the fisheries over time (i.e., fisheries have been taking less of the available abundance over time) are a combined result of effects of increased salmon restrictions through updates to harvest control rules, updated conservation objectives including those for ESA-listed species, and increasingly restrictive Pacific Salmon Treaty obligations."

Finally, there are few additional reasonable considerations from the workgroup's RA for this no action alternative. First, it is reasonable to conclude from the results of the RA that there may not be a strong and persistent relationship between aggregate salmon abundance and SRKW demographics in the spatial and temporal strata examined, and across the abundances and years utilized or observed. Three temporal strata were examined that span from the fall (October 1) of the preceding year, prior to most fishing activity along the coast, to the following fall (September 30) after much of the fishing activity has occurred. Seven spatial strata were examined that provided increasing granularity from Coastwide (U.S. EEZ south of Canada), NOF, SOF, Southwest Vancouver Island, Salish Sea, Oregon Coast, and California Coast. Given some of these larger spatial strata include the same areas examined with greater granularity (i.e. Coastwide vs. SOF vs. Oregon Coast) and the same timesteps used, there is some overlap in the fitted regressions. However, the workgroup utilized ever-increasing spatial granularity to evaluate the potential for more refined area-specific relationships between salmon abundance and SRKW demographics in the absence of a relationship at a larger spatial scale. In the end, that approach produced the few significant or marginally significant relationships in the RA. Not surprisingly, those relationships occurred in areas where Chinook salmon abundance overlaps with known high levels of SRKW use. As shown in Tables 5.a through 5.g of the RA, across all three timesteps and seven spatial strata, only 1 out of 126 of the fitted regressions met the typical criterion of $p \leq 0.05$ that is often associated with "statistical significance". Five additional fitted regressions fell between the typical criterion of $p \leq 0.05$ and a more relaxed criterion of $p \leq 0.10$ that is often used with limited data or analyses with high levels of 'noise'. In total, 120 of 126 fitted regressions failed to meet either criterion. While true, it is appropriate to note here that much attention was given in the RA to the unreliability and limited utility of the p value, specifically relaying concerns about model misspecification and biological versus statistical significance, caution is advised when interpreting the model results. However, despite the limitations or caveats applied to the p values themselves, in many cases even the sign of the fitted regressions was not suggestive of a predictable, strong, or persistent relationship, being opposite the expectation that SRKW demographics respond favorably to increasing salmon abundance. Many more were less than convincing when the coefficient was of the expected sign, but was not "strong". The RA also included a great deal of discussion about other key uncertainties in the analysis, aside from the utility of p values, and those uncertainties should also be considered when reviewing the fitted regressions, their sign, and steepness of the modeled responses. For example, not all vital rate – area – season – temporal lag combinations would have been considered equally plausible a priori based on information and assumptions about when whales are most likely to be where, so it could be of limited usefulness to simply count the total number of tests. Note that initial assumptions made by the workgroup that SRKW demographics are correlated with stock-specific or stock-aggregate Chinook abundance were based upon studies that were conducted several years ago, including Ford *et al*., 2009, Ward *et al*., 2013, and Vélez-Espino *et al*., 2014. Updating these studies to a more contemporary data set would cause relationships between SRKW demographics and Chinook salmon abundance to weaken due to recent years with relatively high Chinook salmon abundance and poor SRKW performance. This does not suggest that relationships between Chinook salmon abundance and SRKW are absent, as there are research sources that correlate poor body condition with mortality, but it may suggest that the importance of Chinook salmon abundance to SRKW demographics varies through time as other unanalyzed threats increase or decrease.

While this RA includes the first attempt to evaluate the effects of salmon abundance as modified by fishery removals on SRKW demographics at this scale of aggregate abundance across both time and space, and the analysis was developed using expert consensus within the Workgroup and the most appropriate data sources available, the SRKW population is small and inherently produces a small data set that is subject to semi-random events creating statistical noise (e.g., low number of births and deaths). Additionally, many confounding factors are difficult or impossible to isolate and remove that make it difficult to reduce much of the uncertainty in the analysis. Despite caveats and weaknesses that are further described in the RA, the model results represent an innovative approach to analyzing the effect of Chinook salmon abundance on SRKW demographics. They were explored using several different statistical methods, were in accordance with previous studies using different methodologies if updated to contemporary data (e.g., Ward et al., 2013), and represent the Workgroup's best attempt at quantitatively analyzing the data available given the time allocated to the Workgroup. Regarding the analysis, the Council's Science and Statistical Committee (SSC) concluded: "The SSC agrees that further analyses are unlikely to yield more informative results, as the regressions, generalized linear models, and cluster analyses had similar results to each other and to previous analyses. Given the large amount of data usually required to detect small differences in survival of long-lived species, further work is unlikely to resolve these relationships." (Supplemental SSC Report 1 November 2019, Agenda Item E.4.a).

The RA also certainly provides information regarding effects of the fishery on salmon abundance and adds additional context with which to consider impacts to SRKW, including SRKW status.

The RA's attempt to quantitatively assess effects of changing modeled Chinook abundances to match removals from Council salmon fisheries was unable to predictably show an appreciable effect to SRKW demographics. There are also uncertainties associated with this quantitative assessment, as well as with knowledge of both salmon and SRKW. One interpretation of the RA, the quantitative assessment and the associated uncertainty, is that the RA is insufficient to resolve whether the fishery has a negligible effect for SRKW. This interpretation would suggest that fishery constraints may still be needed, despite the inability to measure the effect. Doing so would give the benefit of any doubt to the imperiled species. This approach would suggest that fishery constraints may still be needed, despite the RA's inability to measure the effect. The very nature of uncertainty also allows for the possibility that the opposite is also true, and the results suggest the lack of a significant effect or increased risk to SRKW. In fact, it is commonplace for ESA consultations to rely on the best available science in the face of uncertainty to make a determination. That is in many respects an inherent characteristic to resource management and conservation. As such, it is reasonable to consider that interpretation and the no action alternative.

Last, the RA also reminds the reader that the SSC did not find the information it reviewed (chapter 5 and appendices of the RA) sufficient to quantitatively justify a threshold at which risk may be greater for SRKWs due to the effects of PFMC salmon fisheries (Supplemental SSC Report 1 November 2019, Agenda Item E.4.a). Thus, the threshold alternatives below are qualitatively justified (based on previously documented relationships between salmon abundance and SRKW demographics, observations of SRKW feeding on Chinook salmon, and the potential for temporally varying effects or effects at a finer scale than analyzed here). They are based on identifying periods of poor SRKW performance and the corresponding aggregate NOF abundances of Chinook salmon during those periods, even though periods of poor SRKW performance are not uniformly periods of low Chinook salmon abundance, or vice versa.

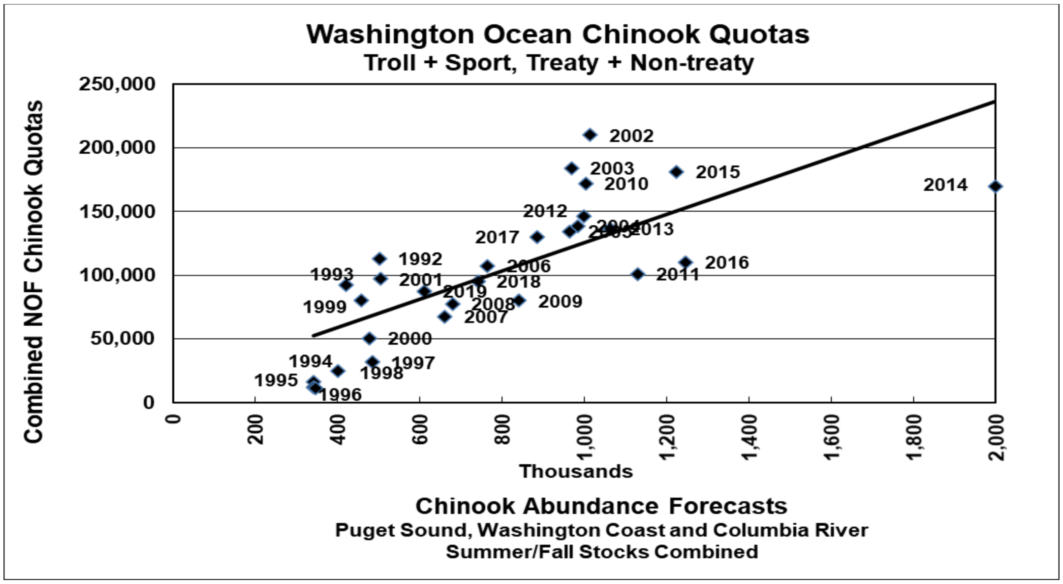

Figure 3.1.a. Relationship between North of Falcon ocean chinook quotas and the sum of the abundance forecasts for chinook stocks originating in the North of Falcon region.

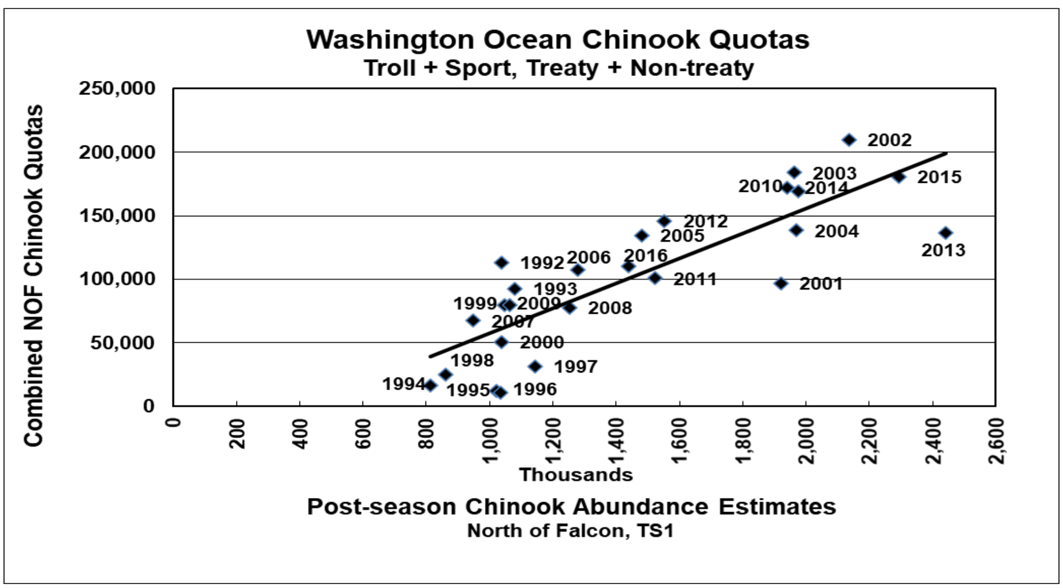

Figure 3.1.b. Relationship between North of Falcon ocean chinook quotas and the sum of the post-season abundance estimates for chinook stocks populating the North of Falcon region in the October-April time period.

Note: Although the relationships are similar, the horizontal axis differs from Figure 3.1.a, both because the "units of fish" used to measure abundances are different in the postseason estimates, and because the post-season estimates include stocks that might not originate in the North of Falcon region, but are found there during the October-April time period.

Alternative 3.1.2: Establish a threshold, or floor, for low pre-fishing Chinook salmon abundance in the area north of Cape Falcon, Oregon (NOF) below which some management action would be triggered. This alternative could also include a review schedule for possible updates to model parameters if new science becomes available.

- Under Alternative 3.1.2, Council-area ocean salmon fisheries would continue to manage fisheries consistent with reasonable and prudent alternatives, and terms and conditions in biological opinions addressing the effects of the fisheries on ESA-listed salmon (similar to Alternative 3.1.1) but would also be managed to be responsive to the endangered and declining status of the ESA-listed SRKW population. Similar to Alternative 3.1.1, the Council-area ocean salmon fisheries would also continue to comply with the FMP, and international agreements in which the U.S. participates such as the PST.
- Intuitively, at some low, but currently undetermined Chinook salmon abundance level (possibly at a finer spatial/temporal scale than we can currently model), the prey available to the whales will not be sufficient to allow for successful foraging leading to adverse effects such as reduced body condition and growth and/or poor reproductive success. This could affect SRKW survival and fecundity, whether or not a model can currently predict it.
- The threshold would be compared to single year preseason October 1 starting abundance (timestep 1, TS1) projections for the NOF area (hereafter referred to as "TS1 projected abundance"). The TS1 projections would be obtained by taking a weighted sum across modeled stocks of the stock-specific preseason projections of total ocean abundance on October 1, where the weights are the estimated proportions of each stock's ocean abundance in the NOF area according to the time-invariant distribution estimates for that time period obtained from the Shelton et al (2019) model, or the proxies identified in the final Workgroup report for stocks not included in Shelton et al (2019).
- If the TS1-projected NOF Chinook salmon abundance falls below the threshold, then a suite of responses would be considered when structuring salmon seasons (see section 3.1.2.e).

Under Alternative 3.1.2 the threshold would be based on the range of years analyzed in the RA (1992-2016) using criteria selected from options listed below. We round values calculated to the nearest thousand for ease of readability and given the qualitative basis for each subsequent alternative.

Options for criteria used to establish a threshold could include the following, although the list is not exhaustive:

3.1.2.a - Threshold based on the year with the lowest modeled abundance (1994); result: 813,000 adult Chinook salmon.

This option reflects the lowest abundance modeled within the range of years considered (1993-2016; the time series began with 1993 because the lagged survival metric was not available for 1992). This option considers that, despite being the lowest abundance, in 1994 the model-adjusted (standardizing for effects like age and sex) fecundity had a ranking of 2 out of 24 years and survival rates had a ranking of 6 out of 24 years (including 1-year lag) for SRKW. The SSC noted "It is likely that historical variability in salmon abundances outside of the range observed during the time period analyzed may have a more detectable effect on SRKW demographics."

- Consider adjusting threshold for forecast error as described below:

The threshold would be based on the minimum modeled abundance in the data series (1992-2016; lowest year = 1994) increased by the median estimated NOF forecast error (i.e., the 1994 abundance multiplied by 1.19).

The metric used to assess median forecast error in this scenario is a comparison of pre-season and post-season Fishery Regulation Assessment Model (FRAM) terminal run sizes, for all FRAM stocks with the exception of Mid Oregon Coast (this stock was not included in pre-season FRAM runs until 2017), weighted by their proportional contributions to NOF TS1 abundance. FRAM terminal run size forecasts were aggregated into Shelton et al. (2019) stock components and were apportioned among model areas according to Shelton et al. (2019) stock distributions. Management years used in the comparison were 2008 through 2016. While stock distribution would ideally be applied to the starting abundance stock aggregates, it was applied to the terminal run size in this exercise because pre-season FRAM runs (and thus starting abundances) were not available using the same base period. Also note that Klamath and Rogue are not part of the FRAM model and were not considered in this exercise. The median ratio between postseason terminal run size and preseason forecast was 0.84, meaning that over-forecasting occurred more than half of the time.

This accounts for the median amount of estimated NOF forecast error over the observed time period. For a NOF forecast equal to 1.19 (the inverse of 0.84) times the 1994 postseason abundance estimate, we would expect that half of the time the postseason abundance estimate would be lower than that from 1994 and half the time we would expect the postseason abundance estimate to be higher than that from 1994, assuming consistent forecast performance.

3.1.2.b — Threshold based on arithmetic mean of lowest three abundance years; result: approximately 874,000 adult Chinook salmon.

This option reflects examination of fecundity and lagged survival parameters ranked by year across the 24 years of available data. Chinook salmon abundance estimates ranged from 813,000 to 2,440,000 across those 24 years. Of those years, three fell below an abundance of 1,000,000, six fell between 1,000,000 and 1,100,000, and the remaining 15 were above 1,100,000. As a somewhat arbitrary breakpoint, the ranked fecundity and lagged survival values for years with abundances of less than 1,000,000 were evaluated.

For the three years with TS1 NOF Chinook salmon abundance of less than 1,000,000 (1994, 1998 and 2007, abundances ranging from 813,000 to 947,000), fecundity and lagged survival values ranked very high in 1994 and 2007 (fecundity ranked 2 and 4, lagged survival ranked 6 and 5), and very low in 1998 (fecundity ranked 18, lagged survival ranked 24). The modeled Chinook salmon abundance produced modeled positive and negative SRKW demographic responses at abundances in this range. As an approach more conservative than that presented above in 3.1.2a, the mean abundance from these three low abundance years (874,000) would be used as a threshold in this option.

- Consider adjusting for forecast error (as described in 3.1.2.a)

3.1.2.c. – Threshold based on 2020 NMFS guidance; result: approximately 966,000 adult Chinook salmon.

If the NOF abundance is equal to or less than the arithmetic mean of the seven lowest years of abundance (1994 – 1996, 1998 – 2000 and 2007) (FRAM TS1), the Council would implement precautionary conservation measures for Council salmon fisheries that affect the abundance in NOF waters (this includes salmon fisheries in Washington, Oregon, and California waters) to benefit the whales.

3.1.2.d — Threshold based on the maximum abundance during the mid to late 90s (1995, 1996, 1997, 1998, 1999, 2000); result: approximately 1,144,000 adult Chinook salmon.

This option considers NMFS guidance in 2020 (described further in the NMFS 2020 biological opinion) and updates it for a long-term approach. The maximum of the abundances is chosen here because these years of abundance characterize a range of concern. In general there is evidence SRKW and other killer whale populations (e.g. Northern Resident killer whales, NRKWs) that are known to consume Chinook salmon may have experienced adverse effects from low prey availability in the mid to late 1990s likely due to common factors affecting changes in the prey populations (NMFS 2008; Towers *et al*. 2015).

Nutritional stress as a chronic condition can lead to reduced body size and condition of individuals and lower birth and survival rates of a population (e.g., Trites and Donnelly 2003). During the mid to late 1990s, reduced body size was observed in both SRKWs and NRKWs (Groskreutz *et al*. 2019, Fearnbach *et al*. 2011). This apparent constrained physical growth in both resident killer whale populations was concurrent with overall population declines in the SRKW and NRKW populations (NMFS 2008). Multiple deaths occurring along with relatively poor survival in all three pods of the SRKW population in nearly all age classes and in both males and females drove this period of decline. Hilborn *et al*. (2012) stated that periods of decline across killer whale populations "suggest a likely common causal factor influencing their population demographics". During this same general period of time of declining body size in whales, and declining resident killer whale populations, all three SRKW pods experienced substantially low social cohesion (Parsons *et al*. 2009). This temporary shift in SRKW social cohesion may reflect a response to changes in prey. Although both intrinsic and extrinsic factors can affect social cohesion, it has been generally recognized the most important extrinsic factors for medium and larger terrestrial carnivores are the distribution and abundance of prey (refer to Parsons *et al*. 2009). Good fitness and body condition coupled with stable group cohesion and reproductive opportunities are important for reproductive success.

- Consider adjusting for forecast error (as described in 3.1.2.a)

Table 3.1.a – Summary of Alternatives for NOF Chinook salmon abundance TS1 thresholds*

Alternative	Brief Description	Result	If adjusted for error	Comment
3.1.2.a	lowest year	813,000	968,000	1994
3.1.2.b	arithmetic mean of three lowest years	874,000	1,040,000	1994, 1998, and 2007
3.1.2.c	2020 NMFS guidance	966,000	N/A	the arithmetic mean of the seven lowest years of abundance (1994-1996, 1998-2000, and 2007)
3.1.2.d	Maximum of mid-90s	1,144,000	1,362,000	the max abundance from 1995 through 2000 occurred in 1997

**Note: These values represent the current combined outputs from the FRAM and Shelton et al. models, and are subject to change whenever recalibrating these models, but the methodology determining each value would remain fixed as described in this report.*

3.1.2.e – List of potential responses if a year's preseason projection fall below a threshold:

The goal of management response(s) would be to benefit SRKWs while still providing some fishing opportunity in years when Chinook abundance is deemed low by surpassing a defined threshold (see 3.1.2). Responses could include but are not limited to:

1. Further limit NOF non-treaty Chinook quotas,
    a. Aggregate run size v. quota regressions – Non-treaty quota limits could be defined using a regression relationship between NOF TS1 abundance and non-treaty Chinook salmon quotas (see trend line in Figure 3.1.b). This would ensure that fisheries in years of low abundance could not have disproportionately high removals from the aggregate abundance relative to other years in the data series.
2. Attain NOF non-treaty quota incrementally over time (spring/summer split)
   NOF troll fisheries occur during spring/summer seasons with specified split of quota, which is typically two-thirds of the quota allocation going to the May-June time period. . Consider a limit on catch (quota) in spring (May through June) to potentially benefit whales. It is likely that fishery structure changes in May and June would provide a greater

benefit to SRKW than later months as the likelihood of usage in the NOF area is higher in the winter and spring than the summer months.

a. No more than 50 percent of Chinook salmon quotas assigned to spring (or a numerical value smaller than the recent 10-yr arithmetic mean)

b. Reduce sub-area Chinook salmon quotas for times and areas where temporal and spatial overlap with SRKW is likely to occur. As with other potential actions discussed, this would likely be of most benefit early in the season (May-June). Reduce sub-area quotas more in the northern part of the Washington coast, rather than all of NOF. Sub-area caps have been in place for areas north of the Queets River and south of Leadbetter for about the last decade.

3. NOF non-treaty Area closures (control zones),
   Ensure existing control zones are in place and consider expanding in time and/or space. Existing control zones with comments are as follows:

- Current: Columbia River Control (CRC) Zone - inside from B10 out to the end of each Jetty (B4 to B7). Closed to all ocean salmon fishing at all times. This location coincides with a known SRKW 'hotspot' so it likely provides some benefit to SRKW. The CRC Zone is defined as an area at the Columbia River mouth, bounded on the west by a line running northeast/southwest between the red lighted Buoy #4 (46°13'35" N. lat., 124°06'50" W. long.) and the green lighted Buoy #7 (46°15'09' N. lat., 124°06'16" W. long.); on the east, by the Buoy #10 line which bears north/south at 357° true from the south jetty at 46°14'00" N. lat.,124°03'07" W. long. to its intersection with the north jetty; on the north, by a line running northeast/southwest between the green lighted Buoy #7 to the tip of the north jetty (46°15'48" N. lat., 124°05'20" W. long.), and then along the north jetty to the point of intersection with the Buoy #10 line; and, on the south, by a line running northeast/southwest between the red lighted Buoy #4 and tip of the south jetty (46°14'03" N. lat., 124°04'05" W. long.), and then along the south jetty to the point of intersection with the Buoy #10 line.

a. Potential expansion for consideration: Adjust the Columbia River Control Zone during January 1 - June 15 to extend to a line running northeast/southwest between Buoy#1 and Buoy #2 in years when the threshold was triggered.

- Current: Grays Harbor Control Zone - In recent years, this control zone was closed beginning on the second Monday in August due to poor returns of Grays Harbor Fall Chinook. The closed area is offshore to a line extending north to south from Buoy 2 to Buoy 3.

b. Potential expansion for consideration: This area coincides with a known SRKW 'hotspot' (in winter months) so extending to January 1 - June 15 as an additional closure would provide support for SRKW if present in spring months.

- Cape Flattery Control Zone - always closed for non-treaty troll fisheries. Continue as current.

4. NOF non-treaty start/end time adjustments.
   NMFS' draft SRKW critical habitat designation identifies two areas in Washington and Oregon north of Cape Meares as being of importance with prey as an essential feature for both areas. SRKW usage of Area 1 (between the 6.1 and 50 meter isobaths) is recognized to occur at a higher frequency than usage of Area 2 (between the 50 and 200 meter

isobaths). The Workgroup discussed delaying the fishery start in Area 1 as the primary objective under this approach given the majority of data sample collection occurred there; however, in areas NOF the offshore boundary is relatively far from shore and there was concern that forcing the fishery offshore into Area 2 would effectively make the fishery inaccessible for some vessels and create safety concerns for all vessels, particularly early in the season. As a result, the Workgroup felt that for areas NOF, a delayed opening of the entire fishery might be preferable to closure of fishery inshore of the 50 meter isobath. Because SRKW use of ocean waters is believed to be more prevalent earlier in the season, delaying fishery openings until June 1 and June 15 were considered.

   a. Delay NOF fisheries until June 15
   b. Delay NOF fisheries until June 1

5. SOF in Oregon (OR) coastal waters,
   a. Delay OR SOF Troll until April 1.
      i. in year Chinook salmon abundance is below the threshold
   b. OR KMZ – while recognizing this area is not recognized as primary for prey in NMFS' draft SRKW Critical Habitat, consider a closure in the OR Klamath Management Zone (KMZ) beginning October 1 through March 31 of the following year, in years when the California (CA) KMZ is also closed (see SOF CA below).
   c. For the area between Cape Falcon and Cape Meares in SRKW Critical Habitat Area 1 (see Figure 3.1.2.a, SRKW Area 1). The closure period would be intended to match that for NOF areas; however, because the offshore boundary for Area 1 is closer to the shoreline between Cape Falcon and Cape Meares, there is less concern for safety issues for fishing in Area 2 that might occur during these timeframes.
      i. Delay fisheries until June 15
      ii. Delay fisheries until June 1

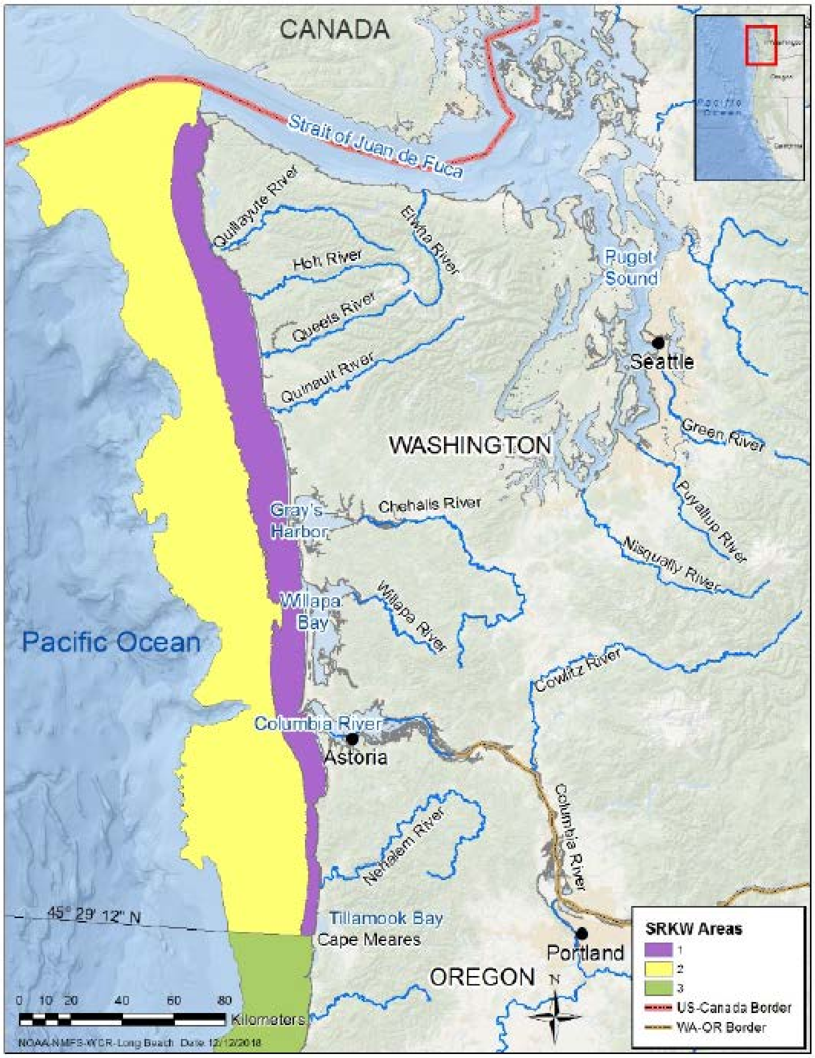

Figure 10. Map of Areas 1 and 2.

Figure 3.1.2.a. Derived from NMFS Critical habitat designation biological report Sept 2019.

6. SOF in CA coastal waters, in every year the NOF abundance threshold is triggered:

   a. beginning October 1 through March 31 of the following year:
      i. Closure in CA Monterey fishing area;
      ii. Closure in CA KMZ;

   b. The Klamath River Control Zone is always closed and is 3- miles N/S and seaward, and in August it is expanded to 6 miles N/S and 12 miles seaward. Consider extending the larger area beginning September 1 through March 31 the following year.

   c. Ensure other CA control zones are in effect year-round (Smith, Eel, Klamath rivers), as these coincide with light hotspot for foraging.

Alternative 3.1.3: Establish a threshold with possible responses in Alternative 3.1.2, but compare a multi-year metric to determine if the given TS1 projected abundance is above or below that threshold.

Options for range of years used to establish multi-year metric include:

3.1.3.a – running 2-year geometric-mean of TS1-projected abundance.

3.1.3.b – running 3-year geometric-mean of TS1-projected abundance.

Under these options, using the geometric mean rather than annual values would likely decrease how often the "responses" described under Alternative 3.1.2 were triggered, since the multi-year geometric mean abundance might remain above the threshold even if the current year's abundance was below it. However, a single year of low abundance would affect the geometric mean for multiple years, increasing the chance that "responses" would remain in place for multiple years once triggered, especially if abundance was far below the threshold in one year. Both of these effects would likely be stronger under option 3.1.3.b than 3.1.3.a.

The RA did not consider the cumulative effects of fishing for more than one year at a time. Improved fitness and body condition over multiple years potentially increases the likelihood of a whale's reproductive success. The gestational period for killer whales is approximately 17 – 18 months (Duffield *et al*. 1995; Robeck *et al*. 2016) and calves can nurse for several years before becoming fully weaned (although weaning can be variable among individuals, Mongillo *et al*. 2012). During these life stages, food consumption in the adult female killer whale may increase to compensate for the increased energetic costs (Noren 2011). Because whales integrate their prey over long periods of time and likely require more food consumption during certain life stages, it may be that multiple consecutive years of low abundance are important to consider. Using a 2-year or 3-year running geometric mean to compare to a low abundance threshold allows for the consideration of multiple years that are likely important for reproductive success.

Alternative 3.1.4: Establish a threshold from options described in 3.1.2.a through 3.1.2.d. For a single year below that threshold, a select subset of the responses described in 3.1.2.e would take effect. A second consecutive year below that threshold would include the subset of responses plus at least one additional response.

This option considers rationale similar to option 3.1.3.a and 3.1.3.b in that a single year below the threshold is a concern, but consecutive years below the threshold are an even greater concern.

3.2 Recommendation 2: Re-evaluate conservation objectives for Chinook stocks.

Alternative 3.2.1: Sacramento River Fall Chinook

The escapement goal range of 122,000-180,000 hatchery and natural-area adult spawners was adopted as a proxy for maximum sustainable yield in 1984, and much has changed in the Sacramento Basin since that time. Consideration should be given to estimating productivity of natural-area spawners and development of management objectives for this component of the SRFC stock, as has previously been recommended by California Hatchery Scientific Review Group (2012), Lindley *et al*. (2009), and the Pacific Fishery Management Council (2019). Consideration should also be given to development of sub-basin specific escapement goals. For example, natural-area juvenile production above Red Bluff Diversion Dam is maximized at escapement levels of approximately 80,000 females (PFMC 2019). Analyses such as this applied across other portions of the Sacramento Basin could be useful in the development of new conservation objectives. Munsch *et al*. (in press) found that aggregate fall, winter, and spring run natural-origin production was maximized at substantially higher multi-run natural-area spawner abundances than the current fall-run target for natural areas and hatcheries combined, but did not account for hatchery contributions to total production and did not restrict the analysis specifically to fall run. In addition, some consideration may need to be given to how water temperature and flow impact the potential productivity of freshwater habitat such that management goals set would be attainable under climate effects and water operations in the Sacramento Basin. Munsch *et al*. (in press) also found a strong relationship between flow and natural-origin production. Appropriate adjustments to this escapement objective stand to benefit the productivity of this stock and the organisms that depend on it for prey, including SRKW.

Alternative 3.2.2: Klamath River Fall Chinook

The goal of 40,700 natural-area adult spawners was set as the escapement goal for maximum sustainable yield in 2005, and the escapement goal is not expected to be revisited until the Klamath River dams are removed. However, once the dams are removed over 400 stream-miles of historic spawning habitat will be restored and available to this stock. Pending the results of recolonization and subsequent stock-recruitment analysis, this conservation objective should be revised. Ensuring that this stock remains at production levels consistent with maximum sustained yield stands to benefit the stock and the organisms that depend on it for prey, including SRKW.

While it is recognized that the dam removal process will likely necessitate such an adjustment to S_{MSY} for KRFC absent this workgroup recommendation, it is included here due to the significance and magnitude of the anticipated habitat restoration that will result as it compares to other such actions or needs for the stocks managed by the Council. It is also recognized that there may be other stocks managed by the Council that would stand to benefit SRKW to a greater extent should revisions to S_{MSY} be considered.

3.3 Recommendation 3: Improve stock assessment analytic methods

Develop an age-structured stock assessment for the SRFC stock using cohort reconstruction methods. The data needed to perform this assessment are largely available. Cohort reconstruction methods allow for estimation of exploitation rates, maturation rates, and other metrics of interest for SRFC. Such an assessment can also contribute to an assessment of productivity for natural-area spawners, as mentioned in Alternative 3.2.1.

Furthermore, this assessment will allow fishery managers to estimate the number of adult salmon that remain in the ocean post fishery closure and prior to the onset of fisheries in the following year (i.e., over the winter). Given that SRKW appear to utilize coastal waters south of Cape Falcon and in California most consistently during the winter and early spring, in between the implementation of ocean fisheries, this assessment will provide a tool for evaluating prey availability for SRKW and the effect that ocean salmon fisheries in this area may have.

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