Abundance-based Ocean Salmon Fisheries Management Framework for Sacramento River Winter-run Chinook

National Marine Fisheries Service Southwest Regional Office

Introduction - Consultation History, Impact Analysis, Jeopardy Determination,
In April, 2010, NOAA Fisheries (NMFS) completed a biological opinion (2010 BiOp) on the Authorization of Ocean Salmon Fisheries Pursuant to the Pacific Coast Salmon Fishery Management Plan (FMP) and Additional Protective Measures as it affects the Sacramento River Winter Chinook Salmon (winter-run) Evolutionary Significant Unit (ESU) (NMFS 2010). In the 2010 BiOp, NMFS found that given the current management structure of the fishery and the protective measures in place to protect winter-run, it is expected that spawning returns of winter-run will be reduced 10-25% per brood from impacts associated with incidental harvest in the ocean salmon fishery. These estimates are based under normal circumstances of the recreational fishery south of Point Arena being open from April to October/November, and more variable timing and levels of effort in the commercial fishery south of Point Arena, based on the status of target stocks managed under the FMP. These impacts are going to occur primarily as a result of the removal of age-3 winter-run, almost exclusively in the areas south of Point Arena, California, when fishing activity is permitted in those areas in conjunction with the seasonal and size restrictions associated with the proposed action as described in the 2010 BiOp. The results from the O'Farrell *et al*. (2011a) cohort reconstruction indicate that the majority of these impacts will be associated with the recreational fishery in this area.

It appears from the results of the cohort reconstruction analysis that ocean fishery impacts have remained fairly consistent (approximately a 20% reduction on average in a brood's eventual spawner returns) regardless of the spawning abundance of winter-run or the specific annual ocean fishery regulations over that last decade. There is little evidence to indicate that spatial structure is being affected by the reduction of spawning returns, because there is very little spatial diversity as this ESU has been restricted from most of its historical spawning areas and reduced to one remaining population.. From the point of view of recovery goals and criteria identified by NMFS, the ocean salmon fishery does not appear to be restricting winter-run from developing new populations.

Looking specifically at the last decade, it is clear that this winter-run population (and consequently the entire ESU) is capable of positive growth (cohort replacement rates greater than 1.0) while sustaining the 10-25% reduction in the cohort spawning returns due to ocean fishery impacts, up to spawning returns of at least 15,000 individuals, during times of favorable or improving conditions like those which appear to have occurred for the most part over the last 15 years until recently. Therefore, NMFS concluded that the expected impacts of the fishery, based on past performance of both the fishery and the winter-run population, were not expected to reduce the likelihood of survival and recovery of the species during periods when the winter-run population was stable or increasing as a result of the myriad factors, both natural and anthropogenic, that affect species viability. To a large degree, the consultation standards and management measures already in place to protect winter-run specifically, as well as other stocks of Chinook salmon, have served to reduce or avoid fishery impacts on the winter-run Chinook salmon population.

However, NMFS identified that during periods when the status of the population was declining to or stable at low abundance levels, measures that would avoid, reduce, or even constrain the fishery's impacts to winter-run during a time when the species' status is declining or is facing increased extinction risks were not in place. Without any explicit means to further constrain impacts after consideration of winter-run status in the fishery management process, the potential exists for total spawner reduction rates associated with the ocean salmon fishery to approach, and possibly exceed, 25% during periods of time when risks of extinction are significantly increased due to other factors. Therefore, NMFS concluded that the proposed operation of the fishery without any consideration for additional action based on the current status of winter-run has not ensured that the fishery is not likely to appreciably reduce the likelihood of survival and recovery of winter-run.

Reasonable and Prudent Alternative (RPA)

The Endangered Species Act requires that NMFS identify RPAs to a proposed Federal action that has not ensured against the likelihood of jeopardizing a listed species. By regulation, an RPA is defined as "alternative actions identified during formal consultation that can be implemented in a manner consistent with the intended purpose of the action, that can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, that is economically and technologically feasible, and that the [NMFS] Director believes would avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat" (50 CFR 402.02).

NMFS approach to developing an RPA to operation of the ocean salmon fishery under the Salmon FMP was to address the foundation of the jeopardy conclusion, which is the lack of explicit controls in the ocean salmon fishery management process to constrain and reduce impacts when the status of winter-run is declining or unfavorable, and the extinction risks are increased. In order to incorporate this consultation standard into the ocean salmon fishery management process, NMFS (in coordination with the Pacific Fisheries Management Council) is required to develop a management framework for winter-run that meets the overall objective of this RPA, and that also provides a methodology that is practical given the Salmon FMP, the ocean salmon fishery management process, and the extent of information that may be available for consideration on a timely basis. The 2010 BiOp required that the framework must be implemented as the consultation standard of the ocean salmon fishery for winter-run before NMFS issues ESA guidance to the PFMC for the 2012 fishing season, or no later than March 1, 2012.

The purpose of the RPA is to establish a long term management framework structure that allows NMFS to consider the status of winter-run on a regular basis under a defined set of criteria which will help guide the establishment of fishery management objectives that will ensure the ocean salmon fishery is not likely to jeopardize winter-run. At the time of the 2010 BiOp, the information and analysis required to establish specific management objectives or impact targets that are acceptable given various conditions, and the tools needed to incorporate these criteria into the fishery management process, were not available. It was clear that additional analytical effort would be required before this framework could be finalized and implemented. In the interim, NMFS determined that the winter-run population was in significant decline since 2006, and concluded conservative management measures should be taken and fishery impacts constrained in the interim of a new management framework. Options were given to the PFMC to either increase size limits or reduce fishing effort (seasonal closures) in the recreational fishery in 2010 and 2011 to produce a qualitative constraint and reduction in winter-run impacts (see NMFS 2010 and NMFS 2011 for explanation of interim RPA rationale).

Framework development

At the heart of the jeopardy determination was the lack of any quantitative analysis of what levels of fishery impact might be appropriate given any condition or status of winter-run, much less during times when increased extinction risks may be facing this population. Even if that information was available, no tool(s) to design annual salmon fishery management measures existed. In response to the RPA mandate, the NMFS Southwest Fisheries Science Center Salmon Assessment Team engaged in efforts to develop the analytical tools required to evaluate various fishery exploitation scenarios in a formal Management Strategy Evaluation process. The term "Management Strategy Evaluation" is being used to represent all aspects of the analytical work being used to support the decision–making process and implementation of a new fisheries management framework.

Management Strategy Evaluation (MSE)

The purpose of the MSE was to simulate the winter-run population dynamics under a variety of prospective fishery management "control rules" to assess the performance of these control rules relative to established population criteria or benchmarks. A control rule specifies the level of incidental take (age-3 impact rate) that fishery managers may target for in a given year. For example, a control rule which allows a fixed annual fishing impact rate could be simulated and compared to other rules, such as one that increases the allowable impact rate as the population increases. The goal of this simulation work was to evaluate the relative performance of various fisheries control rules for winter-run.

In order to perform the simulations, a life-cycle type model was developed for winter-run such that the prescribed fishing impact rate under a control rule could be directly input as a source of mortality (with its attendant uncertainty), which in turn affected the abundance of the spawning return, leading directly to the generation of the next cohort, and so on throughout the population simulation (Winship *et al*. 2012). The MSE evaluated several forms of fishery control rules including constant age-3 fishery impact target scenarios representing: no impact (0%), estimated historical fishery impacts (25%), current fishery impacts (20%); and several variations of control rules with decreasing age-3 fishery impacts at decreasing population abundance levels (Winship *et al*. 2012[1]). The performance of alternative control rules were compared in terms of

[1] The initial MSE analysis consisted of control rules as described in Winship *et al*. 2012. A control rule that closely approximates the winter-run fisheries management framework described in this document was subsequently evaluated within the same MSE structure for analysis and consistency in comparison. Those results are included in the Winship *et al*. 2012 report.

established population performance criteria. These criteria were based primarily on population abundance levels and trends related to extinction risk, but other aspects were examined as well. Important results and conclusions of the MSE are captured in the Key points of the Framework Overview and descriptions of the framework tiers below.

Winter-run Harvest Model (WRHM)

Implementation of the framework control rule by the PFMC required the development of a winter-run harvest model. The WRHM will be used to determine the expected age-3 impact rate as a function of fishery management measures. It will allow the PFMC to design ocean salmon fishery management measures on an annual basis such that the impact rate specified by the control rule is met. For example, if the control rule allows for a target impact rate of 20% given the current population status of winter-run, the WRHM will be used by the PFMC to design commercial and recreational fishing seasons to meet this standard. It is important to note that the WRHM will produce a pre-season prediction of the impact rate. It is possible, and in fact will be required, that a post-season estimate of the rate will be made following the fishery, once the data are available to do so (3 years after the fishing season has ended), in order to monitor the performance of the harvest model and management framework. The WRHM was developed using the most recent updated winter-run cohort reconstructions and estimates of winter-run fishery impacts (O'Farrell *et al.* 2011b), and shares many of the same characteristics and structure as other models developed for use in the PFMC process such as the Klamath and Sacramento harvest models. The WHRM has been subject to PFMC Salmon Methodology Review and is ready for use in the 2012 preseason management process.

Overview of the Framework

For the Pacific Salmon FMP, NMFS' goal was to identify a threshold or set of thresholds, based on the status of winter-run Chinook salmon, that would trigger additional measures to reduce the impacts of the ocean salmon fishery on the species. The intent was to ensure that fishery impacts do not further exacerbate the declining or depressed species' condition. For the purposes of this RPA, NMFS has established thresholds to protect the endangered winter-run Chinook salmon given their current conservation status. This ESU currently consists of a single population, confined to areas below currently impassable barriers. Recovery goals and strategies for the species include the establishment of additional populations of the species through barrier removal or modification, habitat restoration and management, and conservation hatchery inputs. Over time, as additional information and assessments of the species' status and its response to various natural and anthropogenic factors become available, the thresholds identified in this framework may change.

The new fisheries management framework for managing winter-run impacts in the ocean salmon fishery consists of two components. The first specifies that the previous consultation standards for winter-run regarding minimum size limits and seasonal windows south of Point Arena for both the commercial and recreational fisheries will continue to remain in effect at all times regardless of abundance estimates or impact rate cap (see 2010 BiOp). The second component is an abundance-based framework where, during periods of relatively low abundance, preseason fishery impact rate projections for winter-run based on the proposed structure of fishing management measures each year must be equal to or less than the maximum allowable impact rate (impact rate cap) specified annually, based on the population status of winter-run. These impact rate caps will be determined annually based on the geometric mean of the most recent 3 years of spawning return estimates for winter-run generated by carcass surveys conducted on the Sacramento River by the U.S. Fish and Wildlife Service and California Department of Fish and Game, including the fish collected at the Keswick trap. Preliminary return estimates from the prior season are typically made available to the PFMC Salmon Technical Team in January in time for use in the March/April salmon management process. For the purposes of this fisheries management framework, the estimates of spawning returns that will be considered reflect all spawning returns, both natural and hatchery origin, including jacks. The preseason forecast of the age-3 impact rate will depend on the salmon fishery management measures adopted each season, as determined by the WRHM. Postseason estimates of realized impact rates will be evaluated as the data become available, but deviations from the preseason projection in both the positive and negative direction are expected.

The framework is based primarily on: the conclusions of the 2010 BiOp; the status and trends of the winter-run population in recent decades (based on 1970 to 2011 time series data); the MSE (Winship *et al*. 2012); the framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin (Lindley *et al.* 2007); and additional information and analyses that support these documents as well as consultation with other NMFS biologists working on ESA-listed salmon conservation in the Central Valley.

Key points

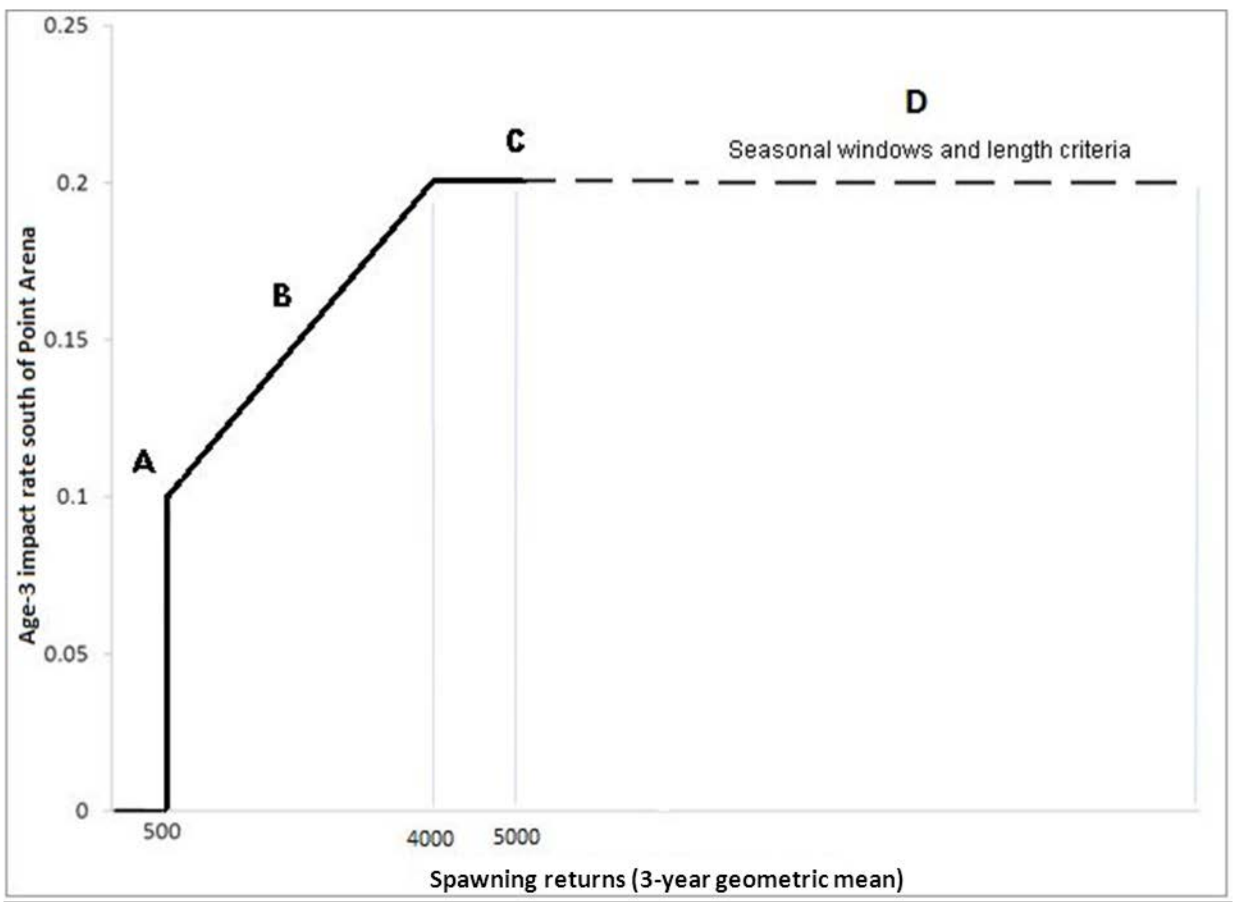
- NMFS identified that reducing fishery impacts when the status of winter-run is reduced or facing increased extinction risk is appropriate (2010 BiOp).
- MSE results illustrated the impact of perpetual harvest as a reduction in the equilibrium population value (spawning returns) over time.
- MSE results suggest that the most influential factors in winter-run population dynamics are related to variation in juvenile survival rates in the fresh water and marine environments (survival prior to age-2).
- The MSE results quantify the proportion of modeled population simulations that resulted in high, moderate, or low categories of extinction risk per the Lindley *et al*. (2007) criteria for each of the fishery control rules examined. Other performance measures such as long term equilibrium population size and relative fishing opportunity as measured by the distribution of the targetable impact rates over time were also quantified.
- MSE results indicate a higher proportion of modeled population simulations in the moderate or high risk of extinction categories under all control rules evaluated relative to the no-fishing scenario. In general, increased proportions of moderate and high risk were small, but noticeable, for all fishery control rules in the MSE using the Lindley *et al*. (2007) criteria.
- The use of decreasing target fishery impact rate caps as the population abundance is approaching low abundances is supported by the results of the MSE which showed that fishery control rule scenarios of reduced fishery impact rates based on declining population abundances would result in proportionally fewer simulations in the high or moderate risk of extinction categories than flat target impact rate control rules of 20 or 25%.

- The RPA and MSE were not designed or intended to identify the maximum amount of incidental impact that winter-run could sustain from fisheries without jeopardizing the species.
- The MSE was not designed to derive critical population abundance thresholds for winter-run, or evaluate changes in the extinction risk of the species at intervals less than the threshold shifts between the extinction risk categories identified in Lindley *et al.* (2007).
- NMFS is electing to employ some precaution in the development of a fisheries management framework where prudent as a matter of conservative policy in deference to the endangered status of this species.

Management Framework

As described above, the management framework consists of two components: the yearly season and size limit minimum restrictions, and during periods of low abundance, a control rule which caps the allowable age-3 impact rate at a value depending on the most recent 3-years of spawning abundance estimates. We describe now in detail the second component of the framework.

The impact rate control rule thresholds are based upon the abundance and trends of winter-run over the past 42 years (1970 to 2011). The control rule is displayed graphically below, followed by a discussion of its application and basis.



Condition A: Geometric mean of the most recent 3 years of spawning return estimates of less than 500 - 0% impact rate cap.
Condition B: Geometric mean of the most recent 3 years of spawning return estimates between 4000 and 500 – a straight line, proportional decline between 20% and 10% impact rate cap.
Condition C: Geometric mean of the most recent 3 years of spawning return estimates between 5000 and 4000 – 20% impact rate cap.
Condition D: Geometric mean of the most recent 3 years of spawning return estimates greater than 5000 - No preseason impact rate cap (Minimum size limit and seasonal window restrictions still in effect).

Description and basis of tiers:

1. **Condition A:** At some point, the winter-run population could get small enough that NMFS deems it appropriate to prohibit fishery impacts on winter-run. At this time, such a critical level has not been specifically identified for winter-run. However, the Lindley *et al*. (2007) population criteria did identify annual run sizes of 500 as a critical value relative to population decline and extinction. Whether a population has recently declined to below this value or has stabilized, it seems reasonable to conclude that the population is likely at an increased risk of extinction, possibly even at high risk. As a result, for the purposes of this framework NMFS deems this as a critically low abundance level below which it is appropriate to preclude any fishery impacts. It is important to note that 500 was identified in Lindley *et al*. (2007) as a critical value for any given single year of spawning returns of Central Valley salmonids. This framework is structured according to the principal that the 3-year geometric mean of spawning returns provides a reasonable reflection of the status of the total population of one complete generation of winter-run, and will not react exclusively on the performance of one weak cohort. Should some obvious trend in cohorts emerge that could be masked by use of a 3-year mean, NMFS will consider future modifications in how to approach this framework.

2. **Condition B:** Under this condition, a geometric mean of the most recent 3 years of spawning return estimates between 4000 and 500 individuals would be subject to a linearly declining allowable impact rates of between 20 and 10%. NMFS expects that winter-run will benefit from additional reduction in fishery impacts at reduced abundance levels, based on the results of the MSE and the 2010 BiOp. The trigger points for these additional reductions were derived using the record of winter-run spawning returns as the measure of population performance and identifying the general conditions when winter-run are doing relatively well or relatively poor. The 42-year record of the winter-run Chinook population indicates a geometric mean return size of approximately 3800 individuals. This 42-year record matches the timeframe reported annually in the PFMC Review of Ocean Salmon Fisheries report. This record includes periods of high returns and significant declines to very low abundances, including those that led to the species' listing under the ESA. These returns include estimates made using different approaches and quantitative methods over the years, and the confidence about the accuracy of some historical estimates is less than those made using current methods. Over the recent past (2001 – 2011), population abundances have again varied widely based on the species'

response to natural and anthropogenic influences in their freshwater and oceanic habitats. During this period, the geometric mean return size was approximately 4900 individuals. It is important to recognize that fishery impacts have been occurring all along during these historical time periods, at levels averaging about 20% in the recent decade, and likely at somewhat higher levels prior to the implementation of major restrictions on the ocean salmon fishery to protect winter-run beginning in the 1990s. Acknowledging that these mean estimates are uncertain and influenced by the time interval selected, NMFS observes that the 4000-5000 spawning escapement level appears to represent a breakpoint in the general condition and population performance of winter-run. As such, NMFS has selected 4000 as a threshold point at which to begin reducing the impact rate cap down from 20%. The variance between this abundance trigger point to begin reducing impacts and the approach taken in construction of trigger points in the fishery control rules analyzed in the initial MSE analysis represents a conservative approach in the implementation of the RPA and this framework (See discussion on Precautionary Approach below). The secondary trigger point of 500 is based on the Lindley *et al.* (2007) criteria as described above. The lowest impact rate cap level of 10% was based on the concept that reducing impact rates to less than 10% may effectively lead to a complete closure of the fisheries due to the basic economics and logistics involved with small scale salmon fisheries, and consideration of the MSE results which suggested that a 10% *de minimis* fishery impact rate at smaller population abundances did not substantially affect population size risks compared to the other impact rate control rules evaluated.

3. **Condition C:** A flat 20% impact rate cap is selected for population abundance levels between 4000 and 5000 individuals. As mentioned above, the end points of this range represent indictors of the general condition of the species over the longer term period of record used and the recent trends in population abundances. In particular, the past 10 years have included two record returns as well as the significant decline in abundance levels immediately following these record returns. The intent of this flat impact rate cap is to maintain control of fishery impacts during periods when the species may be declining towards or recovering from mean spawning escapement sizes of around 4000-5000 individuals. Relying solely on the framework’s season and size limit minimum restrictions (first component) may be expected to result in fishery impact rates that average about 20% over time, but in any given year could exceed 20%. The MSE results indicated a reduced proportion of simulations in the moderate to high risk extinction categories under a flat 20% vs. 25% impact rate cap scenario (which would be expected were the framework’s first component not in place).

4. **Condition D:** The 2010 BiOp concluded that the level of fishery impacts that had been experienced by winter-run in the recent past did not jeopardize the species during favorable conditions. In this framework, mean annual return estimates over 5000 are not subject to an explicit target impact rate cap, but the framework’s first component consisting of seasonal windows and minimum size limits still apply. These restrictions in and of themselves are likely sufficient to prevent extraordinarily high impacts and would generally be expected to result in an impact rate of about 20%, but could vary higher or lower as indicated by the recent performance of the fishery (prior to implementation of

the impact rate control rule). Condition D is designed to minimize limitations on the fishery if **both** target stocks (i.e. Sacramento and Klamath fall-run) **and** ESA-listed populations (i.e. winter-run) are doing well enough to support a large fishery, consistent with the conclusions of the 2010 BiOp.

For all specific impact rate caps, realized impact rates could be greater or lesser in some years, due to the nature of the harvest model used to forecast impact rates, variability in fishing effort, variations in the distribution of winter-run, etc. The MSE accounted for this uncertainty in the simulations used to evaluate the suite of fishery control rules examined, including the control rule that represents this management framework. In all those example scenarios, the results support the conclusion that this variation between the preseason impact rate forecasts and the postseason realized impact rates does not appear to influence extinction risks associated with the Lindley *et al*. (2007) population criteria over the long term.

Precautionary Approach

In the development of this framework, NMFS has relied upon the best scientific information available. The supporting analysis of the MSE in concert with the Lindley *et al.* (2007) population criteria for assessing extinction risk represent a reasonable and sophisticated approach given the current state of knowledge, the available data, and published information. However, NMFS is instituting a level of precaution into the fishery management framework that does deviate from some explicit elements of those documents. The reasons for this are based in the logic of conservation science and policy.

1. The winter-run ESU is composed of only one population with a relatively small remaining area where spawning could be expected to occur. NMFS has identified that the key to recovering this species rests on the ability to reintroduce additional viable populations. Until that time, it is essential that the lone population be treated with a commensurate level of precaution as the lone remnant of this endangered ESU.

2. NMFS notes that this framework is not typical of other salmon fishery control rules that are based on a forecast of the current year ocean abundance because there is no ability to make such a forecast for winter-run given their run-timing relative to the conduct of the fishery. As a result, this framework is not premised on a forecast of the winter-run spawner return that will result after the anticipated fishing impacts in any given year. The link between the framework and comparisons with abundance thresholds is not direct in real time.

3. The population criteria used in Lindley *et al*. (2007) represents thresholds between general extinction risk categories. It is the policy decision of NMFS to not manage the fishery impacts on winter-run down to the thresholds between risk extinction categories, particularly when the prohibition against jeopardizing a species speaks to appreciable reductions in the species' likelihood of survival and recovery, and not to significant changes or shifts between general extinction risk categories. The decision to start reducing impacts well before the population is approaching a population abundance risk

category threshold is a reflection of that conservative approach. The decision to preclude fishery impacts all together at very low abundance is reflective of this approach as well.

4. Similarly, the population criteria of Lindley *et al*. (2007) were not specifically developed based on the population demographics of winter-run. They reflect a general framework for assessing the viability of all salmonid populations in the Central Valley. While this work represents the best scientific advice available and remains the foundation of evaluating relative categories of extinction risk and the initial guide in establishing abundance thresholds for winter-run in the development of this management framework, it may not be prudent to literally incorporate those criteria/thresholds into fisheries management when they were not developed for this purpose. NMFS concludes that it is the general results and findings of the MSE that are most significant and informative, not the specific abundance thresholds adopted in the suite of control rules evaluated.

5. The MSE goes to great lengths to incorporate the uncertainties that are associated with implementing an abundance based control rule into the analysis of risk, and NMFS believes the results and conclusions drawn from the MSE are robust to those uncertainties over the long term. However, there are many factors that affect the population dynamics of winter-run that could not be incorporated into the models used in the MSE to more fully reflect the true complexity of the system. Given the mandate to be conservative relative to the management of ESA-listed species, a conservative approach in response to declining or low estimates of spawning returns is thus warranted.

Important factors influencing the population of dynamics of winter-run not fully incorporated into the MSE include climate change and genetic effects. Other important factors such as variability in early-life survival through age-2 are directly accounted for in the MSE, and the results reflect the response of the early life stages to varying habitat conditions in both the freshwater and marine environment, and the resulting consequences on population abundance and extinction risk. However, it would be desirable to link specific influences across the life history of winter-run into an ecosystem approach to managing impacts across that entire life history. If additional information or analytical tools become available in the future that would help inform these relationships or improve our knowledge of the system to allow for a more holistic approach to the management of winter-run, this framework should be re-examined.

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