Evaluation of and Recommended Determination on a Resource Management Plan (RMP), Pursuant to the Salmon and Steelhead 4(d) Rule

Comprehensive Management Plan for Puget Sound Chinook: Harvest Management Component

RMP Provided By:	Puget Sound Treaty Indian Tribes, Washington Department of Fish and Wildlife
Fisheries:	Strait of Juan de Fuca, Hood Canal, and Puget Sound salmon and steelhead fisheries potentially impacting listed Puget Sound Chinook salmon
Species Affected:	Puget Sound Chinook Salmon
NMFS Tracking Number:	F/NWR/2010/06051
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Acronyms and Abbreviations

AABM	aggregate abundance based management
BC	British Columbia
CERC	critical exploitation rate ceiling
CET	critical escapement thresholds
CPUE	catch per unit effort
C & S	ceremonial and subsistence
CTC	Chinook Technical Committee
CWT	coded wire tag
DPS	distinct population segment
EDT	ecosystem diagnosis and treatment
ER	exploitation rate
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FEIS	Final Environmental Impact Statement
FRAM	Fishery Regulation Assessment Model
ISAB	Independent Scientific Advisory Board
ISBM	individual stock based management
LAT	low abundance threshold
LCFRB	Lower Columbia Fish Recovery Board
MSH	maximum sustainable harvest
MSY	maximum sustainable yield
MU	management unit
NBC	Northern British Columbia
NCBC	North/Central British Columbia
NMFS	National Marine Fisheries Service
NWR	Northwest Region
NWFSC	Northwest Fisheries Science Center
NWIFC	Northwest Indian Fish Commission
PFMC	Pacific Fishery Management Council
PRA	population recovery approach
PSC	Pacific Salmon Commission
PSSMP	Puget Sound Salmon Management Plan
PST	Pacific Salmon Treaty
PSTIT	Puget Sound Treaty Indian Tribes
PSTRT	Puget Sound Technical Recovery Team
PT SUS	pre-terminal southern U.S.
QCI	Queen Charlotte Islands
QET	quasi-extinction threshold
RER	recovery exploitation rate
RET	recovery escapement threshold
RIST	regional implementation science team
RMP	resource management plan
SASSI	salmon and steelhead stock inventory
SEAK	Southeast Alaska
SUS	Southern United States
TAC	total allowable catch
TRT	Technical Recovery Team
UMT	upper management threshold
WCVI	West Coast Vancouver Island

WDFW Washington Department of Fish and Wildlife

VRAP viable risk assessment procedure

VSP viable salmonid population

1 - Introduction

On March 24, 1999, the National Marine Fisheries Service (NMFS) listed the Puget Sound Chinook Salmon (*Oncorhynchus tshawytscha*) Evolutionarily Significant Unit[1] (ESU) as a threatened species under the Endangered Species Act of 1973 (ESA) (64 Fed. Reg. 14308, March 24, 1999). The listing was affirmed in 2005 (70 Fed. Reg. 37160, June 28, 2005). The Puget Sound Chinook salmon ESU includes all naturally spawned populations of Chinook salmon from rivers and streams flowing into Puget Sound from the Elwha River, eastward. Major river systems within the ESU that support Chinook salmon populations include: the Nooksack, Skagit, Stillaguamish, Snohomish, Sammamish, Cedar, Duwamish-Green, White, Puyallup, Nisqually, Skokomish, Mid-Hood Canal, Dungeness, and Elwha rivers. Chinook salmon (and their progeny) from twenty-six artificial propagation programs are considered to be part of the ESU (70 Fed. Reg. 37160, June 28, 2005).

On July 10, 2000, NMFS issued a rule under section 4(d) of the ESA, establishing take prohibitions for 14 salmon and steelhead ESUs, including the Puget Sound Chinook salmon ESU (50 CFR 223.203(b)(6); July 10, 2000, 65 FR 42422). In 2005, as part of the final listing determinations for sixteen ESUs of West Coast salmon, NMFS amended and streamlined the previously promulgated 4(d) protective regulations for threatened salmon and steelhead (70 Fed. Reg. 37160, June 28, 2005)(thereafter referred to as the 4(d) Rule). Under these regulations, the same set of fourteen limits was applied to all threatened Pacific salmon and steelhead ESUs and Distinct Population Segments (DPS). The 4(d) Rule provides limits on the application of the take prohibitions (take prohibitions do not apply to the plans and activities set out in the rule if those plans and activities meet the rule's criteria). One of those limits (Limit 6) applies to jointly developed tribal and state resource management plans (RMP).

Since 2001, NMFS has received, evaluated, and approved a series of jointly developed RMPs from the Puget Sound Treaty Indian Tribes (PSIT) and the Washington Department of Fish and Wildlife (WDFW) under Limit 6 of the 4(d) Rule. These plans provide the framework within which the tribal and state jurisdictions jointly managed all salmon and steelhead fisheries impacting listed Chinook salmon within the greater Puget Sound region. The most recent RMP (May 1, 2004 through April 30, 2010) approved in 2005 expired as of April 30, 2010.[2] The 2004-2010 RMP was adopted as the harvest component of the Puget Sound Salmon Recovery Plan which includes the Puget Sound Chinook ESU.

For the past two years, the co-managers have been negotiating a successor to the 2004-2010 Puget Sound Chinook Harvest RMP. In April 2010, the Puget Sound Treaty Tribes and the WDFW submitted a jointly developed RMP to NMFS, Northwest Regional Office. The RMP

[1] An Evolutionarily Significant Unit or "ESU" is a distinctive group of Pacific salmon or steelhead, analogous to a Distinct Population Segment as described in the ESA.
[2] Short term biological opinions were issued for the gap between the time the current RMP expired at the end of April and the anticipated completion of NMFS' determination on the 2010 RMP (NMFS 2010a and 2010b).

entitled, the *Comprehensive Management Plan for Puget Sound Chinook: Harvest Management Component*, dated April 12, 2010 (hereafter referred to as 2010 Puget Sound Chinook RMP or RMP), provides the framework within which the tribal and state jurisdictions jointly manage all salmon and steelhead fisheries that may impact listed Chinook salmon within the greater Puget Sound area. The co-managers originally proposed that the RMP be in effect for five fishing seasons, from May 1, 2010, through April 30, 2015. However, on February 25, 2011, in response to concerns raised by NMFS related to prey available to listed Southern Resident killer whales and to coincide with a comprehensive review of U.S. and Canadian fisheries impacts on Southern Residents, the co-managers modified the RMP's duration to the period between May 1, 2011 and April 30, 2014[3] (Frank and Anderson 2011). If determined to be consistent with the requirements of the ESA salmon and steelhead 4(d) Rule, the 2010 (May 1, 2011 through April 30, 2014) Puget Sound Chinook RMP will replace the 2004 RMP as the harvest component of the Puget Sound Salmon Recovery Plan (NMFS 2006a).

1.1 Recommended Pending Determination

It is the proposed recommended determination of NMFS Northwest Region's Salmon Management Division, that the April 12, 2010 RMP entitled, *Comprehensive Management Plan for Puget Sound Chinook: Harvest Management Component*, provided by the PSIT and the WDFW and as subsequently amended (Frank and Anderson 2011), does not appreciably reduce the likelihood of survival and recovery of the Puget Sound Chinook salmon ESU. The Salmon Management Division recommends that the Regional Administrator determine that the RMP adequately addresses the criteria established for Limit 6 of the ESA 4(d) Rule for the listed Puget Sound Chinook salmon ESU. If the Regional Administrator so determines, the take prohibitions for listed Puget Sound Chinook would not apply to fisheries implemented in accordance with the RMP. The discussion of the biological analysis underlying this recommended determination follows.

1.2 Basis for Evaluation under the ESA (4)d Rule

The ESA 4(d) Rule for the Puget Sound Chinook salmon ESU states that the prohibitions of paragraph (a) of the rule (16 U.S.C. 1538(a)(1)) do not apply to actions taken in compliance with a RMP jointly developed by the States of Washington, Oregon and/or Idaho and the Tribes, provided that: (1) The Secretary has determined pursuant to 50 CFR 223.209[4] (Tribal 4(d) Rule) and the government-to-government processes therein that implementing and enforcing the joint tribal/state plan will not appreciably reduce the likelihood of survival and recovery of affected threatened ESUs; and (2) in making the determination for a RMP submitted under Limit 6, the Secretary of Commerce has taken comment on how any fishery management plan addresses the

[3] Since the provisions are the same as the RMP originally made available to the public for comment (only the duration has changed) we continue to refer to it as the 2010 Puget Sound Chinook RMP for consistency among the various regulatory documents related to the action and to minimize potential confusion for the public.
[4] Now found at 50 CFR 223.204.

criteria described under Limit 4 (Sec. 223.203(b)(4)) of the ESA 4(d) Rule (50 C.F.R. 223.203(b)(6)).

Regarding the first element, NMFS consulted with the Puget Sound Treaty Indian Tribes subsequent to the development of the RMP through government-to-government meetings. Consistent with legally enforceable tribal rights and with the Secretary of Commerce's tribal trust responsibilities, NMFS provided technical assistance, exchanged information, and discussed what is needed to provide for the conservation of listed species with the Tribes.
Regarding the second element, as required in section (b)(6)(iii) of the 4(d) Rule, NMFS takes comment on how the RMP addresses the eleven criteria under Limit 4 section (b)(4)(i). For the purposes of NMFS' analysis under Limit 6 and to facilitate public comment, we have addressed each criteria set forth in Limit 4. The criteria under Limit 4 section (b)(4)(i) are outlined in Table 1.

Table 1. A description of the eleven criteria for a RMP under Limit 4 section (b)(4)(i), and the chapter in on which the evaluation of the RMP of each criterion is discussed within this document.

Criterion	Section of 4(d) Rule	Description	Evaluation of the RMP on the criterion found in chapter:
1	Section (b)(4)(i)	Clearly defines its intended scope and area of impact.	3
2	Section (b)(4)(i)	Sets forth the management objectives and the performance indicators for the plan.	4
3	Section (b)(4)(i)(A)	Defines populations within affected Evolutionarily Significant Units, taking into account: spatial and temporal distribution, genetic and phenotypic diversity, and other appropriate identifiably unique biological and life history traits.	5
4	Section (b)(4)(i)(B)	Uses the concepts of ''viable'' and ''critical'' salmonid population thresholds, consistent with concepts in the Viable Salmonid Populations (VSP) paper (NMFS 2000b)	6
5	Section (b)(4)(i)(C)	Sets escapement objectives or maximum exploitation rates for each management unit or population based on its status, and assures that those rates or objectives are not exceeded.	7
6	Section (b)(4)(i)(D)	Displays a biologically based rationale demonstrating that the harvest management strategy will not appreciably reduce the likelihood of survival and recovery of the Evolutionarily Significant Unit in the wild, over the entire period of time the proposed harvest management strategy affects the population, including effects reasonably certain to occur after the proposed actions cease.	8
7	Section (b)(4)(i)(E)	Includes effective (a) monitoring and (b) evaluation programs to assess compliance, effectiveness, and parameter validation.	9
8	Section	Provides for (a) evaluating monitoring data; and (b) making	

	(b)(4)(i)(F)	any revisions of assumptions, management strategies, or objectives that data show are needed.	10
9	Section (b)(4)(i)(G)	Provides for (a) effective enforcement, (b) education, (c) coordination among involved jurisdictions.	11
10	Section (b)(4)(i)(H)	Includes restrictions on resident and anadromous species fisheries that minimize any take of listed species, including time, size, gear, and area restrictions.	12
11	Section (b)(4)(i)(I)	Is consistent with other plans and conditions established within any Federal court proceeding with continuing jurisdiction over tribal harvest allocations.	13

This proposed evaluation will address each of the criteria separately, in the order as provided in 4(d) Rule. Some criteria call for an evaluation of the RMP's impacts on individual populations. However, it is the ESU that is the listed entity under the ESA, not the individual populations that comprise the ESU. The proposed evaluation of the estimated aggregate impacts on the ESU, resulting from implementation of the RMP, will occur when addressing Criterion 6. The evaluation begins with an overview of the analytical approach and key assumptions NMFS adopted in its evaluation of the 2010 Puget Sound Chinook RMP.

2 ▪ Analytical Approach

The effects of the 2010 Puget Sound Chinook RMP on exploitation rates and natural escapement for ESA listed Puget Sound Chinook are compared using the Fishery Regulation Assessment Model (FRAM) in a retrospective approach. The results are then assessed relative to harvest standards developed by NMFS using the Viable Risk Assessment Procedure and other available information. A short summary of the methods is provided below, and the results from the analyses are included in the following discussion. More detailed descriptions of the methods and results are included in Appendices 1 and 2 of this evaluation.

The retrospective analysis examines a series of past years reflecting a range in abundance and fishing regimes likely to be encountered in the duration of the RMP. For each year, the analysis explores the potential impacts to listed Puget Sound Chinook under several management scenarios. It does so by applying the management objectives and other provisions of the 2010 Puget Sound Chinook RMP. The FRAM is used to do the analysis. Results are reported in natural spawning escapement and in total, southern U.S. and northern fishery (Canada and Alaska) exploitation rates. A similar approach was used to evaluate the 2008 Pacific Salmon Treaty Agreement (PST Agreement) (NMFS 2008a). NMFS then uses its own set of exploitation rate and escapement threshold standards, independent of the management objectives in the 2010 Puget Sound Chinook RMP and in combination with other available information, to assess the results of the retrospective analysis in terms of risk to the ESU. The *Viable Risk Assessment Procedure* (VRAP) is used to determine the exploitation rate that meets a set of probability criteria related to survival and recovery of a population as measured over a 25 year period. It has been used for the last decade to assess the effects of harvest on Puget Sound Chinook and in previous assessments of the effects on Lower Columbia River tule Chinook salmon.

Estimated impacts from the proposed action will vary by population and region, depending on the provisions of the 2010 Puget Sound Chinook RMP. Consistent with the first component of Limit 6 to assess ESU-wide effects, the evaluation of the effects of the RMP on the ESU will first examine the effects to individual populations and then the effects to each region. Finally, NMFS assesses the risk to survival and recovery of the ESU using the *Population Recovery Approach* (PRA). The PRA is a systematic framework that guides NMFS' assessment of the relative impact of proposed actions (harvest, hatchery, habitat, and hydropower) to individual populations and, subsequently, the survival and recovery of the ESU[5]. Criterion 6 will bring

[5] NMFS published the technical framework of the PRA for public review and comment during December 2010-February 2011 (75 FR82208, December 29, 2010; 76 FR6402, February 4, 2011). We are currently reviewing public comments received on the PRA and will continue to refine and update the PRA as new information becomes available. However, the PRA currently represents the best available information against which to assess the distribution of identified risks across populations to the survival and recovery of the ESU for the purposes of evaluating the RMP under the 4(d) criteria. We emphasize that the concepts underlying the PRA only apply when we exercise our authority under the ESA. In other contexts we will emphasize the importance of achieving broad sense recovery of all populations in Puget Sound, to satisfy tribal treaty rights and recreational and commercial fishing goals. NMFS acknowledges that consultations among tribal, state and local governments and other interested

together this information to assess effects of the 2010 Puget Sound Chinook RMP on the ESU as a whole.

in the PRA will be on-going. Going forward, NMFS will evaluate whether any future revisions to the PRA require NMFS to reconsider its analysis provided here. See 50 CFR 223.203(b)(6)(v), 402.16.

2.1 Retrospective Analysis

The retrospective analysis relies on a review of past circumstances to develop an understanding of the likely effect of the 2010 Puget Sound Chinook RMP on the fisheries, and on the exploitation rates and escapements of Puget Sound Chinook management units and populations. Actual outcomes over the next three years will depend on year-specific circumstances related to individual stock abundance, the combined abundances of stocks in particular fisheries, and how fisheries actually are managed in response to these circumstances.

The retrospective analysis uses years from the recent past (1994 through 2008) because they provide a known set of prior circumstances regarding stock abundance and actual fishery affects. Changes in stock status, management objectives and refinements in harvest management make it unlikely that fisheries seen in the early 1990s would occur during the implementation of the RMP. The retrospective analysis considers how outcomes would have changed under alternative management scenarios. The scenarios are explained in more detail below, but generally represent: 1) what actually occurred based on post season estimates of stock abundance and fishery catches; 2) what we can reasonably expect to occur under the 2010 Puget Sound Chinook RMP given an informed assessment of how fisheries are likely to be managed in the future; 3) what would occur under the 2010 Puget Sound Chinook RMP if Alaskan and Canadian fisheries were managed at the limits allowed under the 2008 Pacific Salmon Treaty Agreement; and 4) how the 2010 Puget Sound Chinook RMP would perform if there was an unexpected and broad scale reduction of 40% in the abundance of Chinook salmon. The 40% reduction scenario is not likely to occur during the term of the 2010 Puget Sound Chinook RMP. It is, however, included to illustrate the situation of a prolonged and broad scale down turn in productivity and abundance that may occur as a consequence of long term cycles in ocean conditions or global climate change. The scenarios build from those in the analysis of the 2008 PST Agreement thereby incorporating the work from the 2008 PST biological opinion and terms of the 2008 PST Agreement, and provide consistency with how fishery revisions were made outside the Puget Sound Action Area.

For this analysis, the following four scenarios are run in FRAM using a retrospective analysis of the 1994-2008 fishing years:

FRAM Validation

FRAM runs using actual post-season fishery catches and best available estimates of annual stock abundances. The FRAM Validation scenario approximates what actually occurred based on post season information. These runs also are used in other forums to evaluate the model and the management system and their relative success in meeting fishery and stock specific management objectives. All of the years in the time series reflect the higher catch provisions allowed under the previous Pacific Salmon Treaty agreements that were in place at the time.

AR015947

2010 RMP Likely

FRAM runs assuming that fish levels will be similar to those observed in recent years while applying the provisions of the 2010 Puget Sound Chinook RMP and the 2008 PST Chinook Annex Agreement. In recent years, impacts have been less than the ceilings allowed under the various fishery management agreements because of domestic concerns within Canada and the United States. This scenario is intended to approximate the exploitation rates and natural escapements under a "likely" range of fishing levels under the RMP during the next three years. Individual stock-based management (ISBM)[6] fisheries in the U.S. and Canada have been constrained well below ISBM limits in recent years because of domestic concerns. In the 2010 RMP Likely scenario we approximate our expectation of future constraints by assuming that fishing patterns and the associated fishing levels will be similar to those observed in recent years. The 1994-1998 ISBM fishing levels are based on the average fishing effort rates for 1999-2002. The ISBM fishing levels for 1999-2008 are based on the annual fishing effort rates as estimated in the FRAM Validation runs. Fisheries in Canada and Alaska under aggregate abundance-based management (AABM)[7] are modeled using the post-season Total Allowable Catch quotas adjusted for reductions in the 2008 PST Agreement. Puget Sound fisheries are adjusted if necessary to meet the 2010 RMP objectives.

High North

FRAM runs using year specific abundances with all fisheries modeled at the limits allowed under the 2008 PST Chinook Annex Agreement. Puget Sound fisheries are adjusted if necessary to meet the 2010 RMP objectives. This scenario evaluates the range in exploitation rates and natural escapements that would occur if Canadian domestic constraints were no longer limiting. The level of Canadian fisheries is an important consideration in anticipating potential impacts into the future. Depending on the management unit, Canadian fisheries on average, account for the majority of the total fishery-related mortality (Table A1-1 in Appendix 1). This scenario starts with the 2010 RMP Likely scenario and increases Canadian ISBM fisheries to the limits allowed under the 2008 PST Agreement. The AABM fisheries in Alaska and Canada are already maximized under the 2010 RMP Likely scenario. Southern U.S. ocean fisheries are modeled using the observed fishing effort scalars from the FRAM validation runs.

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[6] An ISBM fishery is a regime that constrains to a numerical limit the total catch or total adult equivalent mortality rate within the fisheries of a jurisdiction for a naturally spawning Chinook stock or stock group. Because all fisheries that are not AABM fisheries are ISBM fisheries, this provision essentially results in accounting for all Chinook impacts, whether they are the result of directed fisheries or are only incidental to fisheries directed at other stocks.

[7] An AABM fishery is an abundance-based regime that constrains catch or total adult equivalent mortality to a numerical limit computed from either a pre-season forecast or an in-season estimate of abundance, from which a harvest rate index can be calculated, expressed as a proportion of the 1979-1982 base period. Three fishery complexes are designated for management as AABM fisheries: 1) the SEAK sport, net and troll fisheries; 2) the Northern British Columbia (NBC) troll (Canada's Pacific Fishery Management Areas 1-2, 101-105 and 142) and the Queen Charlotte Islands (QCI) sport (Canada's Pacific Fishery Management Areas 1-2, 101, 102 and 142) and 3) the WCVI troll and outside sport (Canada's Pacific Fishery Management Areas 21, 23-27, 121, 123-127 but with additional time and area specifications which distinguish WCVI outside sport from inside sport).

40 Percent Reduction

Similar to the 2010 Likely scenario except all stock abundances are reduced 40%. This scenario addresses the question of how the RMP will perform if overall abundance was lower than observed in the past which could happen as a result of climate change, continued environmental degradation, or extended poor marine survival. Abundance of each FRAM stock would be reduced by 40% using the same basis for abundance reduction and approach as used in the biological opinion on the 2008 PST Agreement (Battin et al. 2007; Bishop 2008; LaVoy 2008). The scenario used the fishing effort scalars in the 2010 RMP Likely scenario and adjusted Puget Sound fisheries to meet the RMP objectives under the reduced abundances. This range of modeled abundance is considered conservative. Given the general trend of stable to increasing abundance, which will be discussed later in this document, it is likely that if the actual abundance in the next three years falls outside this range, the actual abundance would most likely be greater. The 40% reduction scenario is best compared to the 2010 RMP Likely scenario to provide a perspective on how the provisions in the proposed RMP would respond to reduced abundance in terms of affect on exploitation rates in those fisheries and resulting escapements.

For each of the ESA listed Puget Sound Chinook management units, exploitation rates and escapements are graphed for the four scenarios covering the 1994-2008 fishing years. Separate exploitation rates are graphed for all fisheries (Total ER), fisheries in Alaska and Canada only (northern fisheries), and U.S. fisheries south of Canada (southern fisheries). The total exploitation rate graphs show Rebuilding Exploitation Rates (RER) for those stocks that have population-specific RERs, or RER surrogates where population-specific RERs are not yet available. Estimates of natural spawning escapement are also shown compared to escapement goals or other escapement related metrics. For example, Rebuilding Escapement Thresholds (RET) and Critical Escapement Thresholds (CET), which are described in more detail in Appendix 1, are shown. Appendix 2 of this evaluation contains the individual retrospective model run results under each of the management scenarios by Puget Sound Chinook management unit. The results are presented and discussed in detail below, in the evaluation of Criteria 4 through 6.

2.2 Key Assumptions in Modeling and Application Results

In conducting this evaluation, NMFS assessed the proposed 2010 Puget Sound Chinook RMP against the range of abundance and fishing levels anticipated to occur in the retrospective analysis under the four management scenarios described above using the relevant management objectives. However, every possible outcome was not evaluated. For example, for populations that are not likely to fall under a Critical Exploitation Rate Ceiling (CERC) (defined and discussed in Criterion 2) based on the retrospective analysis, even under the 40% Reduction scenario, NMFS did not assess the adequacy of the CERC or its associated lower escapement threshold for those populations.

Conversely, Puget Sound fisheries were shaped such that at least one of the management units achieved its RMP exploitation rate ceiling or its CERC. Actual observed southern U.S. exploitation rates often have been less than the ceilings for many management units and this is likely to occur under implementation of the 2010 Puget Sound Chinook RMP as well. However, for populations at critically low levels of abundance in particular, because the preseason management intent has been to meet the CERC, NMFS believes it is appropriate to evaluate the risk associated with the ceiling rather than a lower rate observed in recent years. The Nooksack, Mid-Hood Canal, Dungeness, and Snohomish management units were often the primary constraining stocks. Under the weak stock management principles of the 2010 Puget Sound Chinook RMP, the management objectives for the weakest stock limit fishing opportunity on stronger stocks. Therefore, additional fisheries are not possible in order to 'fish up' to all RMP exploitation rate ceilings either because it is not possible without exceeding one or more RMP objectives on the weakest stocks or fisheries had not occurred in recent years in areas where it might be possible for other reasons other than Chinook conservation and so would not be expected to occur under the RMP.

Where the RMP did not provide a total southern U.S. (SUS) rate ceiling under the Critical Regime for an individual management unit (i.e., a pre-terminal SUS rate was provided for a subset of SUS fisheries), the co-managers specified fishery actions in the 2010 Puget Sound Chinook RMP that would be taken if that management unit should fall into the Critical Regime either within the management unit's profile in Appendix A in RMP or in Appendix B of the RMP. Where the RMP did not provide estimates of the total SUS exploitation rate resulting from these actions, NMFS estimated the total SUS exploitation rate for the management unit based on its assessment of those fishery actions (Lake Washington, Green, Skokomish). These represent NMFS' best estimate of what would occur as a result of implementing these individual fishery actions. They do not represent management objectives on the part of the co-managers that would constrain fisheries, so there is some additional uncertainty about the level of fishing-related mortality that would occur under the Critical Regime for these management units.

To assess abundance status relative to their critical and rebuilding escapement thresholds, management unit escapements were broken out to their individual Puget Sound populations by multiplying the management unit escapement by the percent of the observed escapement an individual population contributed in that year. For example, if the North Fork Nooksack population contributed 75% of the total Nooksack spring Chinook Management Unit escapement in 2003 based on observed data, then the Nooksack spring Chinook management unit escapement anticipated under each scenario in the retrospective analysis was multiplied by 0.75 to derive the escapement for the North Fork Nooksack population for each of the scenarios in 2003. We note that there is some additional uncertainty in taking this step. Since FRAM does not predict the outcome for individual populations, this step assumes that the distribution of escapement would be exactly the same, even across the different fishing regimes represented by the different scenarios. Less abundant populations will likely have more uncertainty in the absolute escapement values than larger populations because a small change in the absolute number of spawners results in a much larger difference in the actual distribution. Regardless, although some years may deviate substantially, the general distribution pattern across all years for populations within a management unit is relatively stable. Therefore, NMFS considers this the best approach to assess the general status of individual populations within the Puget Sound Chinook ESU and will focus on the pattern across years rather than comparisons of absolute numbers of escapement to thresholds in any individual year.

As a consequence of these key assumptions, NMFS' evaluation and possible approval of the plan does not denote consideration, approval, or acceptance of all objectives/provisions presented in the RMP. Although approval of the RMP would authorize take consistent with the management objectives in the RMP, that approval is based on the patterns of escapement and exploitation rates resulting from NMFS' analysis, anticipated levels of abundance over the duration of the RMP and the key assumptions described above. Based on post-season information, should actual circumstances deviate from those considered in the analysis such that the RMP is not effective in conserving listed Puget Sound Chinook, NMFS expects that the co-managers will take actions under the RMP to provide the necessary protections as per its adaptive management provisions, or NMFS may withdraw its approval as per the provisions of the 4(d) Rule (50 C.F.R. 223.203(b)(6)(v)).

2.3 Viability Risk Assessment Procedure

NMFS analyzes the effects of harvest actions on populations using quantitative analyses where possible (i.e., where a sufficiently reliable time series of data is available) and more qualitative considerations where necessary. In doing so, NMFS uses its own set of exploitation rate and escapement threshold standards independent of the management objectives in the 2010 Puget Sound Chinook RMP. The VRAP is an example of a quantitative risk assessment method developed by NMFS that so far has been applied primarily for analyzing harvest impacts on certain Puget Sound Chinook populations and Lower Columbia River tule Chinook. VRAP has not been used for other populations because of the lack of data, resources to do the necessary analysis, or because NMFS relied on other risk assessment techniques. VRAP provides estimates of the maximum population-specific exploitation rates (called Rebuilding Exploitation Rates or RERs) that are thought to be consistent with survival and recovery of a specific population.

In deriving the RERs, NMFS accounts for and makes conservative assumptions regarding management error, environmental uncertainty, and parameter variability. NMFS established RERs for 10 individual populations within the ESU and for the Nooksack Management Unit. The RERs are converted to FRAM-based equivalents (Table 2) for the purposes of assessing proposed harvest actions since FRAM is the analytical tool used to assess proposed fishery actions. Surrogate standards are identified for those populations where data are currently insufficient or NMFS has not completed population-specific analysis to establish RERs. Surrogates are chosen based on similarities in population size, life history, productivity, watershed size, and hatchery contribution with other populations in the ESU for which RERs have been derived (Appendix 1). Because they are not based on population-specific information, there is more uncertainty in quantifying the risk associated with exceeding RER surrogates than in doing so for population-specific RERs. The RERs that are ultimately derived for these populations may be higher or lower than the RER surrogates used in the analysis for the evaluation. The conversions to FRAM-based equivalents vary depending on the population, and the relationship between the data used to estimate its RER and the data used to estimate exploitation rates in FRAM. However, the RERs for populations that share similar characteristics of status and environment are generally similar where NMFS has derived population-specific RERs. Therefore, NMFS will use RER surrogates to assess potential risk in its analysis, but does not attempt to quantify the magnitude of the potential increase or decrease in that risk.

Rates that are expected to result from the proposed RMP are compared to the RER or RER surrogate for each population. Generally speaking, where estimated impacts of the proposed RMP are less than or equal to the RERs, NMFS considers the RMP to present a low risk to that population. This comparison, however, must take into account uncertainties associated with predicting the impacts of the harvest plan, and uncertainties regarding the estimated RER itself, which can change over time as additional and/or improved data become available or environmental conditions change. Deriving an RER is based on conservative assumptions regarding environmental conditions, and uncertainty in management performance and population dynamics based on observed patterns. The RER analyses are updated on a regular basis to incorporate the most recent information and assumptions are made conservatively (e.g., assuming low marine survival) to protect against overly optimistic future projections of population performance.

Table 2. Rebuilding Exploitation Rates by Puget Sound Chinook population. Surrogate RERs are italicized.

Region	Management Unit	Population	Rebuilding Exploitation Rate	FRAM-based Rebuilding Exploitation Rate
Strait of Georgia	Nooksack Early	N.F. Nooksack S.F. Nooksack	21%	23%
Whidbey/Main Basin	Skagit Spring	Upper Skagit River Lower Skagit River Lower Sauk River	54% 36% 33%	60% 51% 49%
	Skagit Summer/Fall	Upper Sauk River Suiattle River Upper Cascade	46% 50%	38% 41% *38-41%*
	Stillaguamish	N.F. Stillaguamish River S.F. Stillaguamish River	45% 28%	30% 18%
	Snohomish	Skykomish River Snoqualmie	24%	18% *18%*
South Sound	Lake Washington Duwamish-Green White Puyallup Nisqually	Sammamish[a] Cedar[a] Duwamish-Green White[b] Puyallup[c] Nisqually[c]	62%	*30%* *30%* 46% *23%* *33-46%* *33-46%*
Hood Canal	Mid-Hood Canal Skokomish	Mid-Hood Canal[d] Skokomish	36%	*18-23%* 33%
Strait of Juan de Fuca	Dungeness Elwha	Dungeness[b] Elwha[b]		*23%* *23%*

[a]Uses North Fork Stillaguamish RER (30%) as a surrogate for the Cedar and the Sammamish given similarity of current abundance and escapement trends.
[b] Uses Nooksack early RER as surrogate
[c] Uses range encompassing Skokomish (33%) and Green River (46%) RERs as surrogates
[d] Uses range encompassing Nooksack early (23%) and South Fork Stillaguamish (18%) RERs as surrogates

The results of the comparison of RERs/RER surrogates, escapement thresholds and RMP outcomes from the retrospective analysis, together with more qualitative considerations for individual populations, are then used in making the jeopardy determination for the ESU as a whole. Although component populations contribute fundamentally to the structure and diversity of the ESU, it is the ESU, not individual populations, that is the listed species under the ESA. That is, RERs for individual populations are not used in isolation as jeopardy standards for the ESU. The risk to the ESU associated with an individual population not meeting its RER also must be considered within the broader context of other information such as recovery plan guidance on the number, distribution, and life-history representation within regions and across the ESU; the role of associated hatchery programs; observed population status, and trend; and the practical effect of further constraints on the proposed action. Therefore, it is important to consider the anticipated exploitation rates and escapements relative to the RERs and thresholds, together with the observed information on population status, environmental conditions, and exploitation rate patterns. The distribution of risk across populations based on the weight of information available is then used in making the jeopardy determination for the ESU.[8] A brief summary of VRAP and how it is used to derive escapement thresholds and RERs is provided in Appendix 1. For a more detailed explanation see NMFS (2000a), NMFS (2004c) and NMFS (2005a).

2.4 Population Recovery Approach

Application of the delisting criteria in the Puget Sound Salmon Recovery Plan allows for a range of risks across populations within the Puget Sound Chinook ESU. In its final supplement to the Puget Sound Salmon Recovery Plan (NMFS 2006a), NMFS identified the need for Northwest Region coordination in terms of how to consistently apply its viability criteria when reviewing proposed projects for ESA compliance and their effects on ESU recovery. Therefore, in responding to this identified need, the NMFS Northwest Region developed a systematic framework that further distinguishes among all the Chinook salmon stocks and watersheds in the Puget Sound region. This framework, termed the *Population Recovery Approach*, carries forward the biological viability and delisting criteria described in the Supplement (NMFS 2006a; Ruckelshaus et al. 2002). The approach complements approaches in other salmonid recovery plans recently accepted by NMFS (e.g., LCFRB 2010) and is a refinement of the category designation used by the Puget Sound co-managers described in Criterion 3.

The PRA evaluates each of the 22 identified populations in the Puget Sound Chinook ESU through the same comprehensive, systematic, and transparent process. The PRA overlays watershed and stock information from Volumes I and II of the Puget Sound Salmon Recovery Plan[9] on the population structure of the ESU (Shared Strategy for Puget Sound 2007;

[8] NMFS has used RERs as part of its assessment of proposed harvest actions on the Puget Sound Chinook ESU in biological opinions and application of take limits under the ESA 4(d) Rule since 1999 (NMFS 1999; NMFS 2000b; NMFS 2001; NMFS 2003a; NMFS 2003b; NMFS 2004a; NMFS 2004b; NMFS 2005a; NMFS 2008a; NMFS 2010a; NMFS 2010b).

[9] Key considerations are the uniqueness, status, and physical location of the stock, the present condition and use of

Ruckelshaus et al. 2006), to develop a tool that can be used by NMFS staff to prioritize resources and, through ESA consultation processes, provide common guidance in the agency's assessment of the relative impact to the recovery of the ESU of proposed actions (harvest, hatchery, habitat and hydropower) affecting individual populations or watersheds across the ESU. Based on the combined information, populations are assigned to one of three tiers (Table 3). The assigned tier indicates the relative role of each of the 22 populations comprising the ESU to the viability of the ESU and its recovery. Not all populations have an equal role in the survival and recovery of the ESU. Tier 1 populations are most important for preservation, restoration, and ESU recovery. Tier 2 populations play a less important role in recovery of the ESU and Tier 3 populations play the least important role. When we analyze proposed actions, we evaluate impacts at the individual population scale for their effects on the viability of the ESU. We expect that impacts to Tier 1 populations would be more likely to affect the viability of the ESU as a whole than similar impacts to Tier 2 or 3 populations, because of the relatively greater importance of Tier 1 populations to overall ESU viability. NMFS will adjust this tiered prioritization approach in response to changes in the status of populations and the condition of the habitat they use and in response to new information.

The population rankings in Table 1 reflect each population's relative role in recovery of the listed ESU and will inform NMFS' assessment of the effects of the 2010 Puget Sound Chinook RMP on overall viability and conservation value under the ESA. In general, we expect negative effects on populations in more important roles would be more likely to reduce the chances of survival and recovery of the ESU than negative effects on populations with less important roles.

the populations freshwater, estuarine, and adjacent nearshore habitats, and the likelihood for preserving and restoring those habitats given present and likely future condition.

Table 3. Assignments of Puget Sound Chinook salmon populations to tiers by biogeographical region based on NMFS' Population Recovery Approach.

Biogeographical Region	Population	Tier Assignment
Strait of Georgia	North Fork Nooksack	1
	South Fork Nooksack	1
Whidbey Basin	Upper Skagit	1
	Lower Skagit	1
	Upper Sauk (early run)	1
	Lower Sauk	1
	Suiattle (early run)	1
	Cascade (early run)	1
	North Fork Stillaguamish	2
	South Fork Stillaguamish	2
	Skykomish	2
	Snoqualmie	3
Central/South Sound	Sammamish	3
	Cedar	3
	Duwamish-Green	2
	Puyallup	3
	White	1
	Nisqually	1
Hood Canal Strait of Juan de Fuca	Skokomish	1
	Mid-Hood Canal	1
	Elwha	1
	Dungeness	1

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3 ▪ Criterion 1: Intended Scope & Area of Impact

Section (b)(4)(i) clearly identifies its intended scope and area of impact.

The 2010 Puget Sound Chinook RMP clearly defines the intended scope of the fisheries management regime and its area of impact. The RMP guides the implementation of salmon and steelhead fisheries under the co-managers' jurisdiction that may affect Puget Sound Chinook salmon in Washington waters from the mouth of the Strait of Juan de Fuca at Cape Flattery, eastward. This geographic scope (hereafter referred to as the Puget Sound Action Area) encompasses all marine and freshwater fishing areas included in the Puget Sound Chinook Salmon ESU, as well as the western portion of the Strait of Juan de Fuca within the United States (Figure 1). The RMP governs implementation during the next three fishing seasons from May 1 of one year through April of the following year, encompassing annual fishing seasons from May 1, 2011, through April 30, 2014.

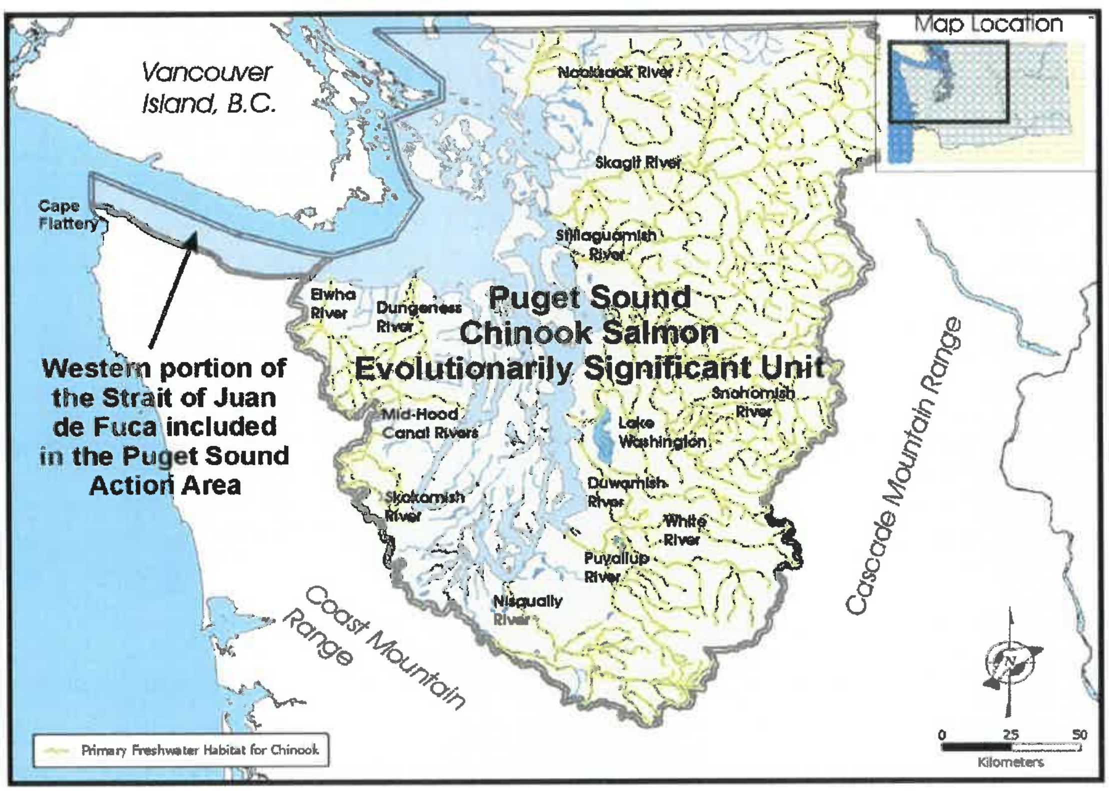

Figure 1. Puget Sound Action Area, which includes the Puget Sound Chinook Salmon Evolutionarily Significant Unit and the western portion of the Strait of Juan de Fuca in the United States.

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4 - Criterion 2: Management Objectives & Performance Indicators

Section (b)(4)(i) sets forth the management objectives and the performance indicators for the plan.

4.1 Management Objectives

The following describes the management, resource use and allocation objectives, management principles, performance indicators and their basis that the co-managers propose to use to manage Puget Sound salmon and steelhead fisheries under the 2010 Puget Sound Chinook RMP. These form the foundation of the retrospective analysis described previously. In Criteria 3 through 6, NMFS uses the results of the retrospective analysis to assess the effects on the individual populations and the ESU as a whole using an independent set of exploitation rate and escapement threshold standards in combination with other available information.

The 2010 Puget Sound Chinook RMP's stated objective is to ensure that:

> *[f]ishery-related mortality will not impede rebuilding of natural Puget Sound Chinook salmon populations, consistent with the capacity of properly functioning habitat, to levels that will sustain fisheries, enable ecological functions, and are consistent with treaty-reserved fishing rights (see page 4 of the RMP).*

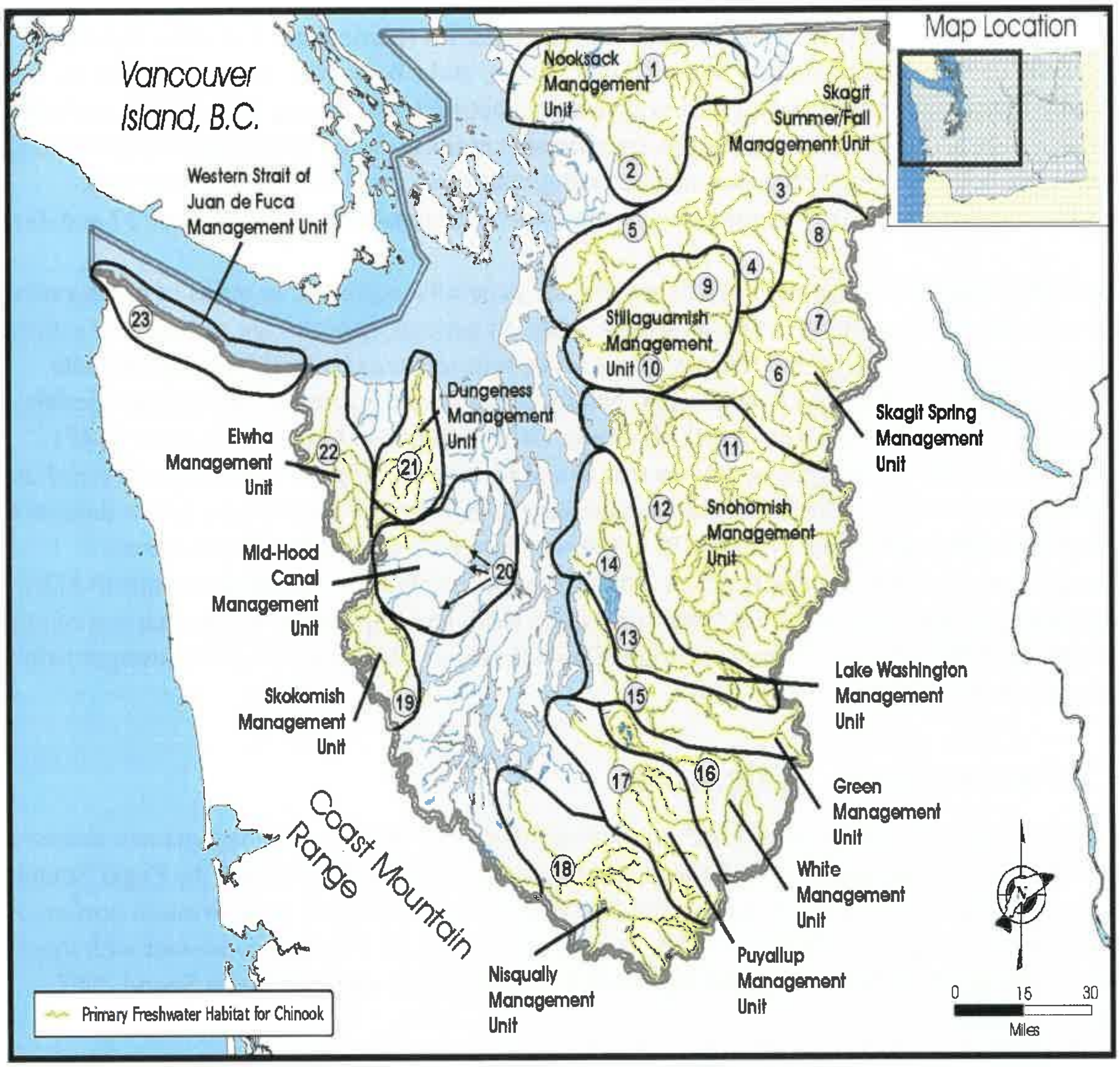
The guiding principles of the RMP are listed on pages 5 and 6 of the RMP and include: (1) conserve the productivity, abundance, and diversity of all populations within the Puget Sound Chinook salmon ESU; (2) meet the ESA jeopardy standards; (3) manage for risk and uncertainty in the estimates of Chinook productivity and survival; (4) provide opportunity to harvest surplus production from other species and populations; (5) account for all sources of fishery-related mortality (including non-landed mortality); (6) follow the principles of the Puget Sound Salmon Management Plan (PSSMP 1985) and other legal mandates pursuant to *U.S. v. Washington* (384 F. Supp. 312 (W.D. Wash. 1974)) and *U.S. v. Oregon*; (7) achieve the guidelines on allocations of harvest and conservation objectives that are defined in the 2008 Annex IV, Chapter 3, Chinook Salmon of the Pacific Salmon Treaty (PST 2008); and, (8) ensure exercise of protected Indian treaty rights.

The fishery limits in the 2010 Puget Sound Chinook RMP are the result of complex negotiations among the co-managers wherein the Parties sought to find an acceptable and effective distribution of harvest opportunities and fishery constraints that, when combined with fishery impacts outside Puget Sound, would be consistent with the fundamental conservation and sharing objectives of the Puget Sound Salmon Management Plan, the Pacific Salmon Treaty, and other legal guidance and resource use objectives. The RMP is reflective of many considerations, including the historical relationship among fisheries, the variable and evolving nature of the resource base, the effects of Alaskan and Canadian fisheries (particularly Canadian fisheries which are outside the jurisdiction of the United States), and a balancing among fisheries to allocate fishing opportunities and fishery constraints between and among mixed stock and more-terminal fisheries. The fishery and stock-specific annual limits in the 2010 Puget Sound Chinook RMP were negotiated with the clear understanding that more restrictive fishery and stock-specific measures might be required and applied where circumstances warrant (pgs. 37 and 39).

The RMP contains management objectives that are generally expressed in terms of management unit-specific exploitation rates or escapement goals. In general, fisheries are managed to achieve these biological objectives, but there is a base level, referred to as Critical Exploitation Rate Ceilings, which the fisheries would not go below. CERCs are triggered by population-specific low abundance thresholds. The Tribal Minimum Fishery Regime (Appendix B in the RMP) provides example of the types of actions that would be taken in tribal fisheries to not exceed the CERCs. However, the CERCs are the management constraints for populations below their low abundance thresholds (page 37 of RMP) not the minimum fishing regime. From the co-managers' perspective, the RMP strikes a balance between biological and policy objectives by addressing conservation concerns "while providing sufficient opportunity for the harvest of other species, abundant returns of hatchery-origin Chinook and available surplus from stronger natural Chinook stocks" (page 34 of the RMP).

4.2 Performance Indicators

The 2010 Puget Sound Chinook RMP provides a framework for fisheries management measures affecting 23 Chinook salmon populations. Twenty-two populations are within the Puget Sound Chinook Salmon ESU, and one population (the Hoko River) is located in the western portion of the Strait of Juan de Fuca (Figure 2). The populations within the ESU are consistent with those defined for the Puget Sound Salmon Recovery Plan (Shared Strategy for Puget Sound 2007; NMFS 2006a).



Key: Chinook salmon populations.

1 - North Fork Nooksack River
2 - South Fork Nooksack River
3 - Upper Skagit River
4 - Lower Sauk River
5 - Lower Skagit River
6 - Upper Sauk River
7 - Siuattle River
8 - Upper Cascade River
9 - North Fork Stillaguamish River
10 - South Fork Stillaguamish River
11 - Skykomish River
12 - Snoqualmie River
13 - Cedar River
14 - Sammamish River
15 - Duwamish-Green River
16 - White River
17 - Puyallup River
18 - Nisqually River
19 - Skokomish River
20 - Mid-Hood Canal Rivers
21 - Dungeness River
22 - Elwha River
23 - Hoko River

Figure 2. Location of the RMP's salmon populations and management units within the Puget Sound Action Area. One salmon population identified in the RMP, the Hoko River (23), is not within the Puget Sound Chinook Salmon ESU.

For harvest management purposes, the RMP distributes the 22 populations within the Puget Sound Chinook ESU among 15 management units (Table 4). The RMP describes a management unit as a group of populations that exhibit similar run timing and return to a single river system flowing into salt water which are aggregated for the purposes of managing harvest (pages 25 and 26 of the RMP). Six of the 15 management units contain more than one population. These populations are monitored annually by the co-managers, and their status will be used as the performance indicators for the RMP (see more discussion in Criterion 3).

Sources of mortality for listed Chinook salmon include fish killed incidentally in fisheries directed at unlisted Chinook salmon or other salmon species, and fish taken in fisheries directed at listed Chinook salmon. However, the RMP prohibits directed harvest unless there are strong indicators of harvestable surplus and states that any directed fisheries will be implemented cautiously (pages 34-36 of the RMP). The RMP proposes management objectives that control the cumulative directed and incidental fishery-related mortality to each Puget Sound Chinook salmon population or management unit. The RMP's management objectives are expressed as: (1) upper management thresholds; (2) low abundance thresholds; (3) exploitation rate ceilings; and (4) critical exploitation rate ceilings (Section 4 in RMP). The proposed management objectives from the 2010 Puget Sound Chinook RMP are summarized by management unit in Table 4. The RMP does not explicitly include management objectives for the Sammamish population. The co-managers used several methods to derive the RMP's management objectives. The methodologies for each management unit are described in Appendix A of the RMP (Management Unit Status Profiles). The co-managers' management objectives and management tools have been evolving since the early 1990s in response to the declining status of Puget Sound salmon populations and improved information. The following is a brief description of these management objectives:

4.2.1 Upper Management Threshold

The co-managers define the upper management (escapement) threshold (UMT) as the "escapement level associated with achieving optimum productivity (i.e. maximum sustainable harvest (MSH)), unless agreement has been reached by the co-managers on an alternative definition" (page 29 of the RMP). Where data or technical tools were available, the co-managers calculated the RMP's UMT under current habitat conditions (page 29 of the RMP). As habitat conditions change, the UMTs will be adjusted to account for different productivity or capacity. In the RMP, the co-managers use them to both assess population status and as a trigger for circumstances that would allow directed harvest (Sections 4.1 and 5.1 of RMP).

The RMP's annual management strategy depends on whether a harvestable surplus is forecast for a given management unit. A management unit is considered to have a harvestable surplus only if the spawning escapement is expected to exceed its UMT (see Section 5.2 of the RMP). Moreover, if a management unit does not have a harvestable surplus, then harvest-related mortality is constrained to incidental impacts in fisheries targeted at stronger Chinook stocks and other salmon species.

The technical basis for the 2010 Puget Sound Chinook RMP's UMTs varies among management units. For populations with sufficient population-specific information (Skagit summer/fall, Skagit spring, Stillaguamish, and Snohomish), the co-managers derived UMTs using such methods as standard spawner-recruit calculations (Rawson 2003a; Rawson 2003b; Ricker 1975), other methods of population dynamic simulations, or Monte Carlo simulations that buffer for error and variability (Hayman 2003 and Skagit Management Unit Profile in RMP). The co-managers established UMTs for these management units above the estimated or assumed Maximum Sustained Harvest level both to compensate for the uncertainty in quantifying recruitment and recent productivity, and to reduce the risk of under-escapement under potentially higher harvest. The co-managers state that "Setting the UMT at the current MSH escapement level or higher is a conservative strategy that assures that harvest will not impede recovery"(page 29 of the RMP).

Where data were not available to quantify recent productivity by conventional cohort reconstruction, the co-managers derived upper management thresholds based on reference to habitat-based productivity modeling, using the Ecosystem Diagnosis and Treatment (EDT)[10] method or other habitat based assessments to emulate current habitat condition. Upper management thresholds for the White River, Dungeness and Puyallup Management Units were derived from this method. The RMP establishes a UMT for the Puyallup Management Unit using South Prairie Creek as an index for the management unit as a whole. The glacial nature of the watershed often makes escapement estimation for the basin difficult. Based on past patterns in escapements, the co-managers expect that escapements of at least 500 Chinook to South Prairie Creek will result in escapements of 1,000 or more to the full Puyallup system. However, if information indicates total Puyallup River escapement is lower than 1,000 even when South Prairie Creek escapement is 500 or above, we expect that the co-managers will revise the RMP to take measures intended to increase escapement to the full system as per its adaptive management provisions (see discussion under Section 2.2).

For the remaining management units or populations (Cedar, Green, Mid-Hood Canal, Skokomish and Elwha) co-managers set UMTs at historical escapement goals, which in some cases were derived from historical spawner density and spawning habitat area, and in other cases based on historically high escapements (page 29 of RMP). For most management units, these UMTs are probably higher than the levels associated with Maximum Sustained Harvest under current habitat condition given the degradation in habitat that has occurred over the intervening 30-40 years in most areas (Shared Strategy for Puget Sound 2007). Upper management thresholds have not been established for the Nisqually Management Unit or the Sammamish component of the Lake Washington Management Unit. However, the exploitation rate for the Nisqually

[10] Caution is necessary with this approach. Peer reviews of the EDT model and its use in related models concluded that although the EDT model was valuable in comparing the relative merits of different habitat restoration scenarios, the quantitative results are highly uncertain and the reviewers caution against using it to make predictions and quantitative assessments of watershed potential capacity or productivity without validation of the results using population specific empirical data (Beechie et al. 2003; Booth et al. 2005; ISAB 2001; LCFRB 2004; McElhaney et al. 2010; PSTRT 2005; Rawding 2004; RIST 2009).

Management Unit was derived by taking into account a maximum sustainable yield (MSY) escapement of 1,200 based on an assessment of current habitat conditions. That escapement is consistent with the rebuilding threshold for the Nisqually population used by NMFS to assess risk to this population in this evaluation.

4.2.2 Low Abundance Threshold

The co-managers define the low abundance threshold (LAT) as a "spawning escapement level, set above the point of biological instability, which triggers extraordinary fisheries conservation measures to minimize fishery related impacts and increase spawning escapement" (page 70 of the RMP). In the RMP, the co-managers use them to both assess population status and as a trigger for response to critical status (sections 4.2 and 5.3 of the RMP). For management units with more than one population, if preseason projections indicate escapement is below the LAT for any of the populations within the management unit, fisheries will be shaped to increase escapement above the LAT or so that the exploitation rate does not exceed the Critical Exploitation Rate Ceiling for the management unit (page 48 of the RMP). This would not apply to the Sammamish population within the Lake Washington Management Unit for which the RMP does not provide management objectives. For the Skagit summer/fall, Skagit spring, and Snohomish Management Units, each with more than one population, the management unit LAT is greater than the sum of the component population LATs. The MU LATs are set at these levels to minimize the risk of going below any of the component population LATs when managing for the pooled populations as a unit.

The method chosen by the co-managers to define a particular LAT depended on the quality and quantity of population-specific data available (see Appendix A in the RMP (Management Unit Status Profiles)). The methods included: (1) the lowest escapement with a greater than one return per spawner ratio (Stillaguamish, Snohomish, Green); (2) the forecasted escapement for which there is "acceptably low" probability that the observed escapement will be below the point of instability (Skagit summer/fall, Skagit spring); (3) in cases where specific data were lacking, the RMP proposes generic low abundance threshold above levels designed to avoid demographic instability or loss of genetic integrity based on the scientific literature (Cedar, White); or, (4) 50% of the escapement corresponding with the estimated MSY level for the management unit (Skokomish, Mid-Hood Canal Rivers, Dungeness, Elwha)(see page 31 in the RMP)(Beattie 2010a). The basis for the LATs for the Puyallup and Nooksack early Management Units are not provided in the RMP, but both are well above escapement levels that fit the definition based on other assessments of productivity and capacity and the general scientific literature. NMFS' assessment of MSY for the Nooksack early Management Unit is 500 compared with proposed LATs of 1,000 spawners for each population within the management unit. Habitat-based assessment indicates MSY for the Puyallup (including South Prairie Creek) is about 522 (page 190 in the RMP) compared with a LAT of 500 for the management unit. NMFS' derived generic critical thresholds at 200 spawners based on review of the scientific literature (McElhaney et al. 2000) and the mean generation time for Chinook. Lower management thresholds have not been established for the Nisqually management unit or the Sammamish component of the Lake

Washington management unit. The co-managers expect escapements to remain well above the LAT for the Puyallup population or approaching levels that could raise concerns about low abundance for the Nisqually population for the duration of the RMP (see specific Management Unit Profiles in the RMP).

4.2.3 Exploitation Rate

The co-managers define exploitation rate as the total mortality in a fishery or aggregate of fisheries divided by the sum of total mortality plus escapement[11] (Beattie 2010b). Exploitation rate ceilings for management units "comprised of more than one population are defined with the intent of rebuilding each component population" within the constraints of the available habitat (page 7 of the RMP). Exploitation rate ceilings are allowable maximums, not annual targets for each management unit. The annual fishing regime will be devised to meet the conservation objectives of the weakest, least productive management unit or component population. Because these units commingle to some extent with more productive units, even in terminal fishing areas, meeting the needs of these units may require reduction of the exploitation on stronger units to a significantly lower level than the level that would only meet the conservation needs of the stronger units. During the implementation of the 2010 Puget Sound Chinook RMP, co-managers will design fisheries to not exceed the management unit's exploitation rate however that is defined (see pages 1 and 36 of the RMP).

The RMP's exploitation rates are in terms of total southern U.S., or pre-terminal southern U.S. (PT SUS), rates and may not be directly comparable to NMFS' RERs discussed previously. The co-managers' exploitation rates are management unit based, which may contain more than one Chinook salmon population. Total exploitation rates include impacts to listed Puget Sound Chinook in all salmon fisheries from southeast Alaska, British Columbia, and the west coast of the southern U.S. The SUS exploitation rates include impacts to all U.S. fisheries south of the Canadian border that may harvest listed Puget Sound Chinook salmon. This would include listed Puget Sound Chinook salmon that are taken in fisheries off the coast of Washington, Oregon, and northern California. The SUS fishery includes both pre-terminal SUS and terminal SUS fisheries. Impacts on Puget Sound Chinook associated with Alaska or Canadian fisheries are not included in SUS exploitation rates. The co-managers define a pre-terminal fishery as a "fishery that harvests significant numbers of fish from more than one region of origin" (page 71 of the RMP). So PT SUS exploitation rate ceilings include impacts to listed Puget Sound Chinook in those fisheries and do not include impacts in SUS terminal fisheries. The co-managers define a terminal fishery as a "fishery, usually operating in an area adjacent to or in the mouth of a river, which harvests primarily fish from the local region of origin, but may include more than one management unit. Non-local stocks may be present, particularly in marine terminal areas" (page 71 of the RMP). The terminal SUS fisheries will vary by management unit and may occur in freshwater and marine areas, i.e., rivers and adjacent estuary areas.

[11] This definition is a correction of the definition of exploitation rate found on page 70 of the RMP.

Some of the RMP's exploitation rates are based on risk assessment that reflects the productivity and capacity of an individual population. Calculating a total exploitation rate that reflects the productivity and capacity of an individual population ideally requires knowledge of a spawner-recruit relationship based on escapement, age composition, coded-wire tag distribution, environmental parameters, and management error (page 33 of the RMP; NMFS 2000a). These types of data are available for several management units. The co-managers calculated exploitation rates using this method for the Skagit Summer/Fall,[12] Skagit Spring, Stillaguamish, and Snohomish Management Units. For these management units, the co-managers' expectations are that application of these exploitation rates will: (1) result in escapement levels that are less than the critical threshold (point of instability)[13] no more than five percent more often than if no harvest had occurred over 25 or 40 years[14]; *and* (2) lead to a high (at least 80 percent) probability that spawning escapements will increase in 25 or 40 years to a specified (upper) threshold, *or* that the percentage of escapements less than the RMP's low abundance threshold at the end of 25 or 40 years will differ from a no-harvest regime by less than 10 percent (pages 32 and 33 of the RMP; Skagit, Stillaguamish and Snohomish Management Unit Profiles in Appendix A of the RMP).

The data required to calculate a spawner-recruit relationship are limited for most Puget Sound Chinook salmon populations. Therefore, for the remaining Puget Sound management units, the co-managers generally established proposed exploitation rates based on "reviewing fisheries regimes implemented in 1998 through 2003, and their spawning escapement outcomes relative [to] the best available values for optimum escapement or spawning habitat capacity for each population" (page 33 of the RMP). The potential benefits of higher escapements from reduced exploitation rates were balanced against harvest opportunity on stronger Chinook stocks and other salmon species in establishing exploitation rates for those management units. The Nisqually Management Unit exploitation rate ceiling is designed to step down over the three years of the RMP. Under the RMP, the co-managers propose a SUS exploitation rate for the Dungeness, Elwha and Western Strait of Juan de Fuca management units of 10 percent. For the Green and Mid-Hood Canal Management Units, exploitation rate ceilings are established for pre-terminal SUS fisheries. The PTSUS exploitation rate for the Green River Management Unit is coupled with achieving its UMT of 5,800. For the Mid-Hood Canal Management Unit, the co-managers propose that the terminal fisheries in Hood Canal would have an exploitation rate of less than 1 percent.

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[12] The co-managers updated the exploitation rate ceiling for the 2010 RMP for the Skagit summer/fall management unit incorporating recent abundance, an updated spawner-recruit function, and the risk assessment procedure (Beattie 2010b).

[13] The co-managers define the point of instability as "that level of abundance (i.e., spawning escapement) that incurs substantial risk to demographic or genetic integrity" (page 71 of the RMP).

[14] Explained in more detail in Appendix A of the RMP (Management Unit Status Profiles). The RMP uses a 25-year projection for the Stillaguamish and Snohomish Management Units in development of the proposed exploitation rate. The RMP uses a 40-year projection for the Skagit Summer/Fall and Skagit Spring Management Units.

With two exceptions, the RMP states that the fisheries will not exceed the exploitation rate ceilings for individual management units (see page 36 of the RMP). One exception is the Lake Washington Management Unit. When the in-season update indicates that the Cedar River population will exceed its UMT, directed fisheries may be implemented that would result in an exploitation rate that exceeds the 20% ceiling for the management unit. However, in this circumstance, the fisheries will be designed to result in escapements greater than the Cedar River UMT and to increase as abundance increases (page 170 of the RMP). The other exception is associated with the Chinook salmon harvest in Canadian fisheries, which were approved under the Pacific Salmon Treaty. For those management units substantially affected by Canadian fisheries (Table A1-1 in Appendix 1), in some years the RMP's critical exploitation rate ceiling may be the restraining limit on Puget Sound fisheries, with the total exploitation rate in that year exceeding the RMP's exploitation rate for a given management unit or set of management units.

4.2.4 Critical Exploitation Rate Ceiling

The co-managers established a Critical Exploitation Rate Ceiling for all management units with a LAT (Table 4). For most management units, the CERCs impose upper limits on SUS exploitation rates when spawning escapement for a management unit is projected to fall below its LAT *or* if Canadian fisheries make it difficult or impossible to remain below the RMP's exploitation rate ceiling (Section 5.3 of the RMP) when combined with SUS fisheries designed to provide some opportunity on healthier salmon species and Chinook stocks. The 2010 Puget Sound Chinook RMP's exploitation rate ceilings, the UMTs, and LATs discussed above are intended to be primarily biologically-driven objectives. The 2010 Puget Sound Chinook RMP's CERCs are primarily driven by policy considerations informed by pre-season SUS or pre-terminal SUS exploitation rate estimates from fishing years 2000-2003. According to the 2010 Puget Sound Chinook RMP, "These years offered recent perspective on harvest regimes constrained by critical status for some Puget Sound populations, and very significant reductions in harvest of Puget Sound Chinook relative to SUS fisheries in the late 1980s." (page 32 of the RMP). The co-managers assert that the CERCs, when imposed on SUS fisheries, would result "in minimal additional demographic and genetic risk to critical stocks while allowing some opportunity" to harvest non-listed salmon species, including non-listed hatchery Chinook salmon, for which harvestable surpluses have been identified (page 32 of the RMP). In particular, the CERC emphasizes continued exercise of tribal treaty fishing rights under limited circumstances.

Implementation of CERCs when abundances are below LATs is relatively straightforward. However, the provision for northern fisheries requires more explanation. Harvest in some coastal fisheries in British Columbia, Canada has increased recently, approaching the limits agreed to by the United States under Annex IV, Chapter 3 of the Pacific Salmon Treaty. Increases in Canadian fisheries result in increased impacts on Puget Sound Chinook salmon, most significantly for those populations for which a majority of the catch occurs in Canadian fisheries (see Table A1-1 in Appendix 1). During preseason planning, if the exploitation rate associated with northern fisheries (southeast Alaska and Canada) on a management unit is projected to exceed the difference between the management unit's exploitation rate ceiling and its CERC, the constraint for that management unit in SUS fisheries in that year will be its CERC. The RMP, in this circumstance, constrains SUS fisheries to the same degree as if the management unit were in critical status, i.e., below its LAT (see page 38 of the RMP). The retrospective analysis demonstrates the potential for the total exploitation rate to exceed the 2010 Puget Sound Chinook RMP's exploitation rate ceiling for several management units during the duration of the proposed RMP; particularly under the High North management scenario (see discussion under Criterion 5).

For the majority of the management units, the 2010 Puget Sound Chinook RMP's CERCs are defined as an exploitation rate ceiling for the all SUS fisheries. For the Lake Washington, Green, Puyallup, Mid-Hood Canal and Skokomish management units, the RMP's critical exploitation rate ceiling applies only to the PT SUS fisheries. The co-managers outline additional terminal fishery management conservation measures that may be considered in response to critical status for these units (Appendix A of the RMP (Management Unit Status Profiles) and Appendix B of the RMP (Tribal Minimum Fisheries Regime)). The RMP states that, "Reducing tribal fisheries to those specified in the minimum fishery regime, while requiring significant sacrifice of the fishing opportunity guaranteed by treaty rights, represent the minimum level of fishing that allows some exercise of those rights. The tribal minimum fishing regime, however, is presented only as a standard, and not as a guarantee – under critical status, it is the CERC that is the overriding management constraint, whether it accommodates the tribal minimum fishing regime fisheries or not." (page 37 of the RMP). Where analysis can demonstrate that additional conservation measures in fisheries would contribute substantially to recovery of a management unit, the co-managers may, at their discretion, in combination with other specific habitat and enhancement actions, implement them (see pages 37 and 39 of the RMP).

The co-managers will provide annual fishing-related mortality information as well as information on escapement for all populations identified in the RMP (see discussion under Criterion 7). The co-managers and NMFS will continue to evaluate the status and trends of populations, which may lead to modifications of the co-managers' proposed management of the fisheries. The RMP includes provisions (see preceding paragraph and Chapter 8 of RMP) such that the RMP can be amended based on new information. If the Plan is amended, changes will be provided to NMFS for review, well in advance of their implementation. Because these provisions are a component of the RMP itself, by themselves, amendments to the RMP would not require a new evaluation by NMFS under the 4(d) Rule.

Table 4. The RMP's proposed management objectives by management unit and population.

Management Unit	Population	Exploitation Rate [1]	Upper Management Threshold	Low Abundance Threshold	Critical Exploitation Rate Ceiling
Nooksack		-	4,000	-	7%/9% SUS[3]
	North Fork Nooksack River	-	2,000	1,000[4]	-
	South Fork Nooksack River	-	2,000	1,000[4]	-
Skagit Summer/Fall		50%	14,500	4,800	15% SUS
	Upper Skagit River	-	-	2,200	Even-Years
	Lower Sauk River	-	-	400	17% SUS
	Lower Skagit River	-	-	900	Odd-Years
Skagit Spring		38%[2]	2,000	576	18% SUS
	Upper Sauk River	-	-	130	-
	Suiattle River	-	-	170	-
	Upper Cascade River	-	-	170	-
Stillaguamish		25%[2]	900[4]	700[4]	15% SUS
	North Fork Stillaguamish River	-	600[4]	500[4]	-
	South Fork Stillaguamish River	-	300[4]	200[4]	-
Snohomish		21%[2]	4,600[4]	2,800[4]	15% SUS
	Skykomish River	-	3,600[4]	1,745[4]	-
	Snoqualmie River	-	1,000[4]	521[4]	-
Lake Washington		20% SUS[2]	-	-	10% PT SUS
	Cedar River	-	1,680	200	-
	Sammamish River	-	-	-	-
Green	Duwamish-Green River	15% PT SUS[2]	5,800	1,800	12% PT SUS
White River	White River	20%[2]	1,000	200	15% SUS
Puyallup	Puyallup River	50%[2]	-	500	12% PT SUS
	(South Prairie Creek Index Area)	-	500	-	
Nisqually	Nisqually River	65-56-47%[2,5]	-	-	-
Skokomish	Skokomish River	50%[2]	3,650[6]	1,300[7]	12% PT SUS
Mid-Hood Canal	Mid-Hood Canal Rivers	15% PT SUS[2]	750	400	12% PT SUS
Dungeness	Dungeness River	10% SUS	925	500	6% SUS

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Elwha	Elwha River	10% SUS	2,900	1,000	6% SUS
Western Strait of Juan de Fuca	Hoko River	10% SUS	850	500	6% SUS

[1] Exploitation rates are expressed as either total, southern United States (SUS), or pre-terminal southern United States (PT SUS). The SUS fishery includes all fisheries south of the border with Canada that may harvest listed Puget Sound Chinook salmon. The SUS fishery includes both pre-terminal SUS and terminal SUS fisheries. The co-managers define a pre-terminal fishery as a "fishery that harvests significant numbers of fish from more than one region of origin". The co-managers define a terminal fishery as a "fishery, usually operating in an area adjacent to or in the mouth of a river, which harvests primarily fish from the local region of origin, but may include more than one management unit." Terminal SUS fisheries will vary by management unit and may occur in freshwater and marine areas.

[2] Exploitation rates based on the unmarked (e.g., non-adipose clipped) component of the population (see Appendix A of RMP and Chin110final2010.xls).

[3] The southern U.S. exploitation rate will not exceed 7% in 4 out of 5 years.

[4] These thresholds are designated as representing natural-origin spawners by the co-managers. A natural-origin spawner is any naturally spawning salmon that has spent essentially all of its life-cycle in the wild and whose parents spawned in the wild. "Natural-origin spawner" is synonymous with "wild fish" in the RMP. "Natural spawner" is any naturally spawning salmon (hatchery or natural-origin).

[5] The Nisqually Management Unit will be managed for a total exploitation rate that incrementally decreases through the life of the plan (65% in 2010-2011, 56% in 2012-2013 and 47% in 2014). Although the provision for a 47% exploitation rate during the 2014 fishing year is outside the duration of the RMP, NMFS envisions that the co-managers will constrain fisheries to 47% during 2014 based on co-manager statements that they intend to implement the full suite of actions described in the RMP (P. Pattillo and G. Graves 2011). A UMT and LAT and a CERC are not provided in the RMP (see Nisqually watershed profile in Appendix A for further background information).

[6] Skokomish Management Unit's UMT of 3,650 spawners is composed of 1,650 natural spawners and 2,000 hatchery-return spawners.

[7] Skokomish Management Unit's LAT of 1,300 spawners is composed of 800 natural spawners and 500 hatchery-return spawners.

5 ▪ Criterion 3: Puget Sound Population Structure

Section (b)(4)(i)(A) defines populations within affected Evolutionarily Significant Units, taking into account: spatial and temporal distribution, genetic and phenotypic diversity, and other appropriate identifiably unique biological and life history traits. Populations may be aggregated for management purposes when dictated by information scarcity, if consistent with the survival and recovery of the listed ESU.

The Puget Sound Technical Recovery Team (TRT) identified 22 demographically independent populations within five geographic regions across the Puget Sound Chinook ESU, representing the primary historical spawning areas of Chinook salmon (Ruckelshaus et al. 2006). These populations form the core of the Puget Sound Salmon Recovery Plan (Shared Strategy for Puget Sound 2007; NMFS 2006a). The TRT reviewed several sources of information in delineating its populations including geography, migration rates, genetic attributes, patterns of life history and phenotypic characteristics, population dynamics, and environmental and habitat characteristics of potential populations (Ruckelshaus et al. 2006). As discussed in Criterion 2 above, the 2010 Puget Sound Chinook RMP provides a framework for fisheries management measures affecting 23 Chinook salmon populations, including 22 populations within the Puget Sound Chinook ESU and one population (the Hoko River) located in the western portion of Strait of Juan de Fuca (Figure 2). The 22 populations within the Puget Sound Chinook ESU defined in the 2010 Puget Sound Chinook RMP are consistent with those identified by the TRT.

The RMP distributes the 22 populations within the Puget Sound Chinook ESU among 15 management units (Table 5). The RMP describes a management unit as a group of populations that exhibit similar run timing and return to a single river system flowing into salt water which are aggregated for the purposes of managing harvest (page 25 of the RMP). Six of the 15 management units (Nooksack, Skagit Summer/Fall, Skagit Spring, Stillaguamish, Snohomish, and Lake Washington) include multiple populations which share similar temporal and spatial harvest distributions. The co-managers aggregated populations within these management units for several reasons: (1) information is currently insufficient to derive population-specific objectives; (2) there is no information suggesting the populations are exploited unequally in mixed-population fisheries, and none of the populations have discrete extreme terminal areas where they could be harvested independently; (3) the populations have similar migration timing, catch distribution and productivity such that harvest objectives should also be similar; or (4) objectives have been derived for each population, and the management unit as a whole is managed to achieve the most constraining population objective (Skagit spring (Skagit Technical Workgroup 2003), Stillaguamish (page 139 of the RMP)). Populations within the Snohomish Management Unit will be monitored for indications of differential harvest impacts (page 145 of the RMP). Annual escapements by Puget Sound Chinook population and management unit since 1999 are provided in Tables 5 and 6.

For management units with multiple populations, each component population "…is managed to avoid or reduce its risk of extinction."(page 27 of the RMP). As described in Criterion 2 above, UMT and LATs are defined for individual populations which trigger different fishery management responses. A more detailed discussion of the response of the RMP to individual populations can be found in Section 6.3 of the RMP. NMFS' evaluation takes into consideration the adequacy of the RMP's population structure of the management units in determining whether the RMP would not appreciably reduce the likelihood of survival and recovery of the ESU.

Table 5. Natural escapement for Puget Sound Chinook salmon populations, 1999 to 2009.[1] Includes hatchery adults spawning naturally.

Management Unit	Population	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Nooksack		1,111	1,242	2,605	4,366	3,427	1,889	2,277	1,699	1,761	1,709	2,360
	North Fork Nooksack	823	373	2,185	3,741	2,857	1,719	2,047	1,184	1,428	1,266	1,903
	South Fork Nooksack	288	1,615	420	625	570	170	230	515	323	443	457
Skagit Summer/Fall		4,924	16,930	13,793	19,591	9,777	23,553	20,803	20,818	11,291	11,664	6,955
	Upper Skagit River	3,586	13,092	10,084	13,815	7,123	20,040	16,608	16,215	9,855	8,441	5,290
	Lower Sauk River	295	576	1,103	910	1,493	443	875	1,095	383	538	226
	Lower Skagit River	1,043	3,262	2,606	4,866	1,161	3,070	3,320	3,508	1,053	2,685	1,439
Skagit Spring		471	1,021	1,856	1,065	844	1,575	1,246	1,896	613	1,470	978
	Upper Sauk River	180	388	543	460	193	700	308	1,043	282	983	367
	Suiattle River	208	360	688	265	353	495	518	375	108	203	273
	Upper Cascade River	83	273	625	340	298	380	420	478	223	284	338
Stillaguamish		1,098	1,646	1,349	1,588	990	1,509	1,036	1,254	609	1,671	474
	N.F. Stillaguamish River	845	1,403	1,066	1,253	884	1,340	947	1,035	569	1,393	431
	S.F. Stillaguamish River	253	243	283	335	106	169	89	219	40	278	43
Snohomish		4,790	6,095	8,164	7,223	5,447	10,602	4,484	8,309	3,982	8,373	2,309
	Skykomish River	3,446	4,668	4,575	4,327	3,472	7,614	3,203	5,694	2,648	5,813	1,414
	Snoqualmie River	1,344	1,427	3,589	3,589	1,975	2,988	1,281	2,615	1,334	2,560	895
Lake Washington		-	762	2,499	1,847	1,209	1,599	1,377	3,304	3,029	2,089	1,874
	Cedar River	241	120	810	369	559	587	511	2,214	1,729	788	713
	Sammamish River	-	642	1,689	1,478	650	1,012	866	1.090	1,300	1,301	1,161
Green River	Duwamish-Green River	11,025	6,170	7,975	13,950	10,406	13,991	4,089	10,157	7,186	5,901	688
White River	White River[2]	556	1,490	2,023	739	1,444	1,456	1,782	2,059	4,604	1,811	787
Puyallup	Puyallup River	1,988	1,193	1,915	1,807	1,547	1,843	1,063	2,232	2,932	2,725	1,526
	S. Prairie Creek Index Area	1,430	695	1,154	840	740	573	389	978	1,194	925	-
Nisqually	Nisqually River	1,399	1,253	1,079	1,542	627	2,788	2,159	2,179	1,743	3.398	872
Skokomish	Skokomish River	1,692	962	1,913	1,479	1,125	2,398	2,032	1,209	531	1,134	1,066
Mid-Hood Canal	Mid-Hood Canal Rivers:	762	438	322	95	194	129	45	30	73	273	129
	Hamma Hamma River	557	381	248	32	95	49	33	16	60	255	98
	Duckabush River	151	28	29	20	12	-	2	1	4	-	9
	Dosewallips River	54	29	45	43	87	80	10	13	9	18	23
Dungeness	Dungeness River	75	218	453	633	640	953	955	1,405	305	140	128
Elwha	Elwha River[3]	2,956	3,361	1,222	1,562	1,216	1,150	1,608	2,517	2,358	1,602	1,851
ESU Total		33,164	42,339	49,308	59,141	40,644	68,262	45,856	59,442	40,999	44,436	23,049

Table 6. Natural-origin escapement for Puget Sound Chinook salmon populations, 1999 to 2009.[1] Excludes hatchery adults spawning naturally. Information is limited or does not currently exist for many areas.

Management Unit	Population	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Nooksack		117	271	423	359	279	343	229	316	360	387	314
	North Fork Nooksack	85	160	264	224	210	314	210	275	334	307	269
	South Fork Nooksack	32	111	159	135	69	29	19	61	26	80	45
Skagit Summer/Fall		4,817	16,628	13,277	18,372	9,256	22,563	19,753	19,396	11,281	10,450	4,929
	Upper Skagit River	3,479	12,815	9,637	12,833	6,616	19,291	15,703	15,015	9,845	7,791	5,290
	Lower Sauk River	295	576	1,098	910	1,493	413	875	1,042	383	444	226
	Lower Skagit River	1,043	3,238	2,542	4,629	1,147	2,859	3,205	3,339	1,053	2,215	1,354
Skagit Spring		471	1,021	1,849	1,061	783	1,571	1,241	1,891	613	1,470	978
	Upper Sauk River	180	388	543	460	178	700	308	1,043	282	983	367
	Suiattle River	208	360	688	265	353	495	518	375	108	203	273
	Upper Cascade River	83	273	618	336	252	376	415	473	223	284	338
Stillaguamish	N.F. Stillaguamish River	514	884	653	748	401	701	444	457	311	839	431
	S.F. Stillaguamish River				-	-	-	-	-	-	-	-
Snohomish		2,440	3,023	6,336	-	-	7,909	-	6,896	2,684	-	-
	Skykomish River	1,400	1,775	3,052	-	-	5,417	-	4,735	1,510	-	-
	Snoqualmie River	1,040	1,248	3,284	-	-	2,492	-	2,161	1,174	-	-
Lake Washington		-	-	-	-	646	618	474	1,180	1,493	995	-
	Cedar River	-	-	-	-	424	378	350	869	1,473	709	583
	Sammamish River	-	-	-	-	221	240	124	311	200	286	-
Green River	Duwamish-Green River	6,022	5,190	6,086	11,054	4,408	8,083	1,927	4,063	3,347	3,851	182
White River	White River	453	1,470	2,022	642	1,185	1,247	1,321	1,443	2,883	1,369	593
Puyallup	Puyallup River	-	-	-	1,489	758	1,047	669	922	1,200	1,779	501
	(South Prairie Creek Index)				570	349	433	320	552	658	633	NA
Nisqually	Nisqually River	-	-	-	-	-	-	1,015	458	436	1,211	129
Skokomish	Skokomish River	383	220	105	1,369	859	749	434	492	297	510	405
Mid-Hood Canal	Mid-Hood Canal Rivers:	-	-	-	-	-	-	-	-	-	-	-
Dungeness	Dungeness River	75	218	17	115	123	193	304	293	146	86	71
Elwha	Elwha River	-	-	-	-	-	-	-	-	-	-	-

Notes for Tables 5 and 6:

[1] Source data are from the management unit profiles in the proposed 2010-2014 Puget Sound Chinook Harvest Management Plan (PSIT and WDFW 2010) and estimates of the fraction of hatchery fish in natural spawning escapements provided in the co-managers postseason reports on the performance of the 2004 Puget Sound Chinook RMP (WDFW and PSTIT 2004, 2005, 2006, 2007, 2008, 2009, and 2010) or Puget Sound TRT unpublished data.

[2] Data source WDFW (Adicks 2010a).

[3] Escapement is considered in-river gross escapement plus hatchery voluntary escapement minus pre-spawning mortality.

To assist the co-managers in analyzing the impacts of their management actions, the RMP categorizes each Chinook salmon population according to the population's life history, genetic and production characteristics and role of artificial production in the watersheds (Section 3.3 of the RMP). The co-managers used this method to assign populations to one of three possible watershed based categories, as shown in Table 7[15]:

Category 1 - natural production is predominantly of natural origin, by native/indigenous stock(s), or enhanced to a greater or lesser extent by hatchery programs that utilize indigenous broodstock. Conservation of Category 1 populations is the first priority of the RMP, because they comprise what are currently considered genetically and ecologically unique components of the ESU. The co-managers designated 17 of the 22 populations within the ESU as Category 1 (Table 7).

The status of Category 1 populations within the ESU varies. Some populations have fallen to such low levels that the ability to maintain their genetic diversity may be at risk. In some cases, lacking hatchery operations, populations would likely decline further or go extinct. Hatchery recovery programs are essential to protecting the genetic and demographic integrity of critically depressed populations in the Nooksack, Stillaguamish, White, Dungeness, and Elwha rivers and are considered part of the listed ESU. Other populations are more robust and the abundance levels are above what is needed to sustain genetic diversity, but often not at levels that will sustain maximum yield. NMFS subsequently listed hatchery production in Green and the Wallace River (Skykomish), because these hatchery stocks were not significantly divergent from naturally-spawning fish in those systems (NMFS 2005b; NMFS 2005c). These two hatchery programs were initiated with the primary objective of enhancing fisheries, thereby mitigating the decline in natural production resulting from loss of habitat function.

Category 2 - natural production is predominantly by a non-native stock, introduced for use in local hatchery production, and influenced by ongoing hatchery contribution. Although Chinook existed in these watersheds historically, the indigenous population is now functionally extinct (i.e., no genetic difference between the hatchery and wild spawners). Habitat condition may not currently support self-sustaining natural production. However, the co-managers believe that self-sustaining natural production is possible given restored habitat. The co-managers designated five of the 22 populations within the ESU as Category 2 (Table 7).

Category 2 populations are primarily found in southern Puget Sound and Hood Canal where hatchery production has been used extensively to mitigate for natural production lost to habitat degradation. Historically, these areas were managed for hatchery production. Consequently, in many of these systems, hatchery and natural fish are currently indistinguishable on the spawning grounds. On-going mass marking programs implemented at regional hatcheries are providing a means to distinguish between hatchery-origin and natural-origin adult Chinook salmon on the spawning grounds but data are currently limited. NMFS subsequently listed hatchery production

[15] The method has been used in previous RMPs that NMFS has evaluated under the 4d Rule (PSIT and WDFW 2001; PSIT and WDFW 2003; PSIT and WDFW 2004).

in Issaquah Creek (Sammamish), and in the Puyallup, Nisqually, Skokomish, and mid-Hood Canal rivers, because these hatchery stocks were not significantly divergent from naturally-spawning fish in those systems (NMFS 2005b; NMFS 2005c). These hatchery programs were initiated with the primary objective of enhancing fisheries, thereby mitigating the decline in natural production resulting from loss of habitat function. Hatchery production was seen as a solution to the increasing demand for fishing opportunity, particularly following the resolution of *U.S. v. Washington*, and the rapid human population increase in the Puget Sound region. Some programs operate under legally-binding mitigation agreements associated with hydropower projects. Formerly, the harvest management strategy for these programs was to fully utilize the increased hatchery production and constrain harvest only to the extent necessary to ensure that escapement was adequate to perpetuate the hatchery program. However, high exploitation rates were not sustainable for commingled natural Chinook populations. Management objectives were refined over the past decade to respond to the status of naturally spawning Chinook in these watersheds. For both the Nisqually and Skokomish populations, the 2010 Puget Sound Chinook RMP proposes to reduce allowable harvest rates to "…assure their viability and to preserve future options to manage for higher natural-origin production as recovery potential improves in response to habitat restoration." (page 28 of the RMP). For the Puyallup and Mid-Hood Canal Rivers populations, the co-managers' goal of harvest management is to provide sufficient escapement to the spawning grounds to maintain stable escapements, and restore natural-origin sub-populations, respectively.

Table 7. The RMP's assigned categories and run timing of the Chinook salmon populations within the ESU.

RMP's Management unit	RMP's Populations	RMP's Assigned Population Category	Run Timing[1]
Nooksack	North Fork Nooksack River South Fork Nooksack River	1 1	Early Early
Skagit Summer/Fall	Upper Skagit River Lower Sauk River Lower Skagit River	1 1 1	Moderately early Moderately early Late
Skagit Spring	Upper Sauk River Suiattle River Upper Cascade River	1 1 1	Early Very early Moderately early
Stillaguamish	North Fork Stillaguamish River South Fork Stillaguamish River	1 1	Early Moderately Early
Snohomish	Skykomish River Snoqualmie River	1 1	Late Late
Lake Washington	Cedar River Sammamish River	1 2	Late Late
Green	Duwamish-Green River	1	Late
White	White River	1	Early
Puyallup	Puyallup River	2	Late
Nisqually	Nisqually River	2	Late
Skokomish	Skokomish River	2	Late
Mid-Hood Canal	Mid-Hood Canal Rivers	2	Late
Dungeness	Dungeness River	1	Early
Elwha	Elwha River	1	Late

[1] Based on NMFS' final supplement to the Puget Sound Salmon Recovery Plan (NMFS 2006a)

Category 3 – an independent natural population was not historically present; natural production may occur, involving adults returning to a local hatchery program, or straying from adjacent natural populations or hatchery programs.

Category 1 and 2 populations comprise the remaining 22 extant populations delineated by the Puget Sound TRT (Ruckelshaus et al. 2006) and they are the focus of the RMP and NMFS' evaluation. The co-managers have assigned populations to Category 2 based on current information. Ongoing monitoring and studies may identify remnant indigenous populations, which if found, may cause the population to be reassigned to Category 1.

The Puget Sound TRT determined that all 22 populations are currently at high risk (NMFS 2006a). Delisting criteria described in the final supplement to the Puget Sound Salmon Recovery Plan (NMFS 2006a; Ruckelshaus 2002) require that two to four populations in each of the five biogeographical regions in the ESU recover to viability, depending on the historical biological characteristics and acceptable risk levels for populations within each region. Within each region, one or more populations representing each major genetic and life history group historically present within that geographic region must achieve viability. Three of the five regions (Strait of Juan de Fuca, Georgia Basin, and Hood Canal) contain only two populations, both of which must be recovered to viability to recover the ESU (NMFS 2006a). The Suiattle and one each of the early, moderately early, and late run-timing populations in the Whidbey Basin Region, as well as the White and Nisqually[16] (or other late-timed) populations in the Central/South Sound Region must also achieve viability (NMFS 2006a). Consistent with these delisting criteria and assessment in NMFS' PRA, the Nisqually, Skokomish and Mid-Hood Canal populations, currently classified as Category 2 watersheds in the 2010 Puget Sound Chinook RMP, will therefore need to transition over time to management consistent with its Tier 1 status under the PRA as the populations adapt to the watersheds and habitat conditions improve to support natural production. The timing and magnitude of changes in harvest that occur in these watersheds must be coordinated with corresponding habitat and hatchery actions. The relevance of distinctions for specific populations in assessing risk of survival and recovery to the Puget Sound Chinook ESU as reflected is discussed in more detail in Criteria 5 and 6.

[16] The TRT noted that the Nisqually watershed is in comparatively good condition, and thus the certainty that the population could be recovered is among the highest in the Central/South Region. NMFS concluded in its supplement to the Puget Sound Salmon Recovery Plan that protecting the existing habitat and working toward a viable population in the Nisqually watershed would help to buffer the entire region against further risk (NMFS 2006a).

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6 ▪ Criterion 4: Application of VSP Concepts, Population Status, and Assessment

Section (b)(4)(i)(B) uses the concepts of ''viable'' and ''critical'' salmonid population thresholds, consistent with concepts in the Viable Salmonid Populations (VSP) paper (McElhaney et al. 2000).

Criterion 4 of the 4(d) Rule provides that harvest plans utilize the concepts of "viable" and "critical" thresholds as defined in the *Viable Salmonid Populations* (VSP) document (McElhaney et al. 2000) in such a manner that fishery management actions: (1) recognize significant differences in risk associated with viable and critical population threshold states; and (2) respond accordingly to minimize long-term risks to population persistence. Given considerations of actions in the other "Hs" (Habitat, Hatchery, and Hydropower), harvest actions that impact populations that are currently at or above their viable thresholds must maintain the population or management unit at or above that level. Fishing-related mortality on populations above critical levels but not at viable levels (as demonstrated with a high degree of confidence) must not appreciably slow rebuilding to viable function. Fishing-related mortality to populations functioning at or below their critical thresholds must not appreciably increase genetic and demographic risks facing the population and must be designed to permit achievement of viable functions, unless the harvest plan demonstrates the likelihood of survival and recovery of the entire ESU in the wild would not be appreciably reduced by greater risks to an individual population.

After taking into account uncertainty, the critical threshold is defined as a point under current conditions below which: (1) depensatory processes are likely to reduce the population below replacement; (2) the population is at risk from inbreeding depression or fixation of deleterious mutations; or (3) productivity variation due to demographic stochasticity becomes a substantial source of risk (McElhaney et al. 2000). A viable population is defined as: (1) a population large enough to have a high probability of surviving environmental variation of the patterns and magnitudes observed in the past and expected in the future; (2) a population with sufficient abundance for compensatory processes to provide resilience to environmental and anthropogenic perturbation; (3) a population sufficiently large to maintain its genetic diversity over the long term; and (4) a population sufficiently abundant to provide important ecological functions throughout its life-cycle (McElhaney et al. 2000). Population status evaluations should take uncertainty regarding abundance into account.

Consistent with this criterion of the ESA 4(d) Rule, the harvest regime specified by the co-managers in the 2010 Puget Sound Chinook RMP takes into account the different risks facing a population by using escapement thresholds to trigger different harvest regimes based on population status relative to those thresholds (see discussion under Criterion 2 above). The RMP defines its own upper management and low abundance thresholds, but these are readily comparable to the viable and critical thresholds. In most cases, the co-managers have set the

LAT intentionally above what would be defined by McElhaney et al. 2000 as the critical threshold. However, viable thresholds in the context of this evaluation are a level of spawning escapement associated with rebuilding to recovery, consistent with current environmental and habitat conditions. For most populations, the UMTs are well below the escapement levels associated with recovery (Table 8), but achieving these goals under current environmental and habitat conditions is a necessary step to eventual recovery when habitat and other conditions are more favorable. NMFS completed an independent comprehensive analysis to derive rebuilding (i.e., viable) and critical escapement thresholds for a subset of Puget Sound Chinook salmon populations under current habitat and environmental conditions (Table 8). In some cases, they are similar to the escapement thresholds proposed by the co-managers; however, the co-manager thresholds are based on a variety of methods incorporating use as well as biological information depending on the population. The NMFS-derived thresholds are based on population-specific information focused on natural-origin spawners or generic guidance from the scientific literature using methods which are applied consistently across populations in the ESU. They provide a set of biologically-based standards which NMFS will use together with other available information to independently assess the performance of the proposed 2010 Puget Sound Chinook RMP. The NMFS-derived escapement thresholds are key standards used in the following assessment of how the 2010 Puget Sound RMP addresses this criterion of the 4(d) Rule. A more detailed description of the process NMFS used in deriving these population-specific rebuilding and critical thresholds is presented in Appendix 1 of this evaluation and Appendix C: Technical Methods - Derivation of Chinook Management Objectives and Fishery Impact Modeling Methods, Final Environmental Impact Statement, Puget Sound Chinook Harvest Resource Management Plan (NMFS 2004a). The NMFS-derived rebuilding and critical thresholds were used to develop the RERs for these same populations (see discussion in Chapter 2). Where population specific information is not currently sufficient, NMFS relied on generic guidance from the VSP document (McElhaney et al. 2000) based on its review of the scientific literature (NMFS 2004a). Tables 8-10 summarize the current status of the Puget Sound Chinook populations. Table 8 compares average abundance and productivity of Puget Sound Chinook populations over the last decade with the RMP's LAT and UMT thresholds, the NMFS-derived critical and rebuilding thresholds and the high productivity recovery goals from the Puget Sound Salmon Recovery Plan. Table 9 summarizes the available information on trends in escapement and growth rate. Both the status of the populations relative to their critical and rebuilding thresholds and the trends in escapement and growth rates were considered in evaluating the population's status. Table 10 summarizes the information in Tables 8 and 9 to describe the current status of the populations relative to their thresholds to assess this criterion of the 4(d) Rule.

Table 8. Estimates of escapement and productivity for Puget Sound Chinook populations. Natural origin escapement information is provided where available. For several populations, data on hatchery contribution to natural spawning are limited or unavailable.

Region	Population	1999 to 2009 Geometric mean Escapement (Spawners)		RMP Escapement Thresholds		NMFS Escapement Thresholds		Recovery Planning Abundance Target in Spawners (productivity) [2]	Average % hatchery fish in escapement 1999-2008 (min-max) [5]
		Natural [1]	Natural-Origin (Productivity[2])	Lower	Upper	Critical [3]	Rebuilding [4]		
Georgia Basin		2,107	283		4,000[16]	400	500		
	NF Nooksack	1,701	227[9] (0.7)	1,000[16]	2,000[16]	*200*[6]	-	3,800 (3.4)	85 (76-94)
	SF Nooksack	376	56[9] (1.0)	1,000[16]	2,000[16]	*200*[6]	-	2,000 (3.6)	83 (62-92)
Whidbey/ Main Basin	Skagit Summer/Fall MU			4,800	14,500				
	Upper Skagit River	10,092	9,585 (2.4)	2,200		967	7,454	5,380 (3.8)	5 (0-7)
	Lower Sauk River	618	599[8] (1.7)	400		*200*[6]	681	1,400 (3.0)	2 (0-7)
	Lower Skagit River	2,245	2,144[8] (1.9)	900		251	2,182	3,900 (3.0)	3 (0-7)
	Skagit Spring MU				2,000				
	Upper Sauk River	423	418 (1.8)	130		130	330	750 (3.0)	1 (0-8)
	Suiattle River	312	312 (1.9)	170		170	400	160 (3.2)	0
	Upper Cascade River	308	302 (1.6)	170		170	*1,250*[6]	290 (3.0)	2 (0-15)
	Stillaguamish MU			700[16]	900[16]				
	NF Stillaguamish R.	959	551[9] (1.2)	500[16]	600[16]	300	552	4,000 (3.4)	46 (37-56)
	SF Stillaguamish R.	152	152 (0.9)	200[16]	300[16]	*200*[6]	300	3,600 (3.3)	NA
	Snohomish MU			2,800	4,600				
	Skykomish River	3,918	2,578[8] (1.4)	1,745[16]	3,600[16]	1,650	3,500	8,700 (3.4)	32 (17-47)
	Snoqualmie River	1,906	1,731[8] (1.9)	521[16]	1,000[16]	400	*1,250*[6]	5,500 (3.6)	14 (7-23)
Central/ South Sound	Cedar River	555	605[8] (1.7)	200	1,680	*200*[6]	*1,250*[6]	2,000 (3.1)	22 (10-36)
	Sammamish River	1,148	221[8] (0.3)	-	-	*200*[6]	*1,250*[6]	1,000 (3.0)	79 (66-88)
	Duwamish-Green R.	6,754	3,615[9] (1.9)	1,800	5,800	835	5,523	-	46 (16-74)
	White River[10]	1,457	1,349[8] (1.8)	200	1,000	*200*[6]	1,100[7]	-	35 (27-49)
	Puyallup River	1,809	969[8] (0.6)	500	500[11]	*200*[6]	522[7]	5,300 (2.3)	44 (18-59)
	Nisqually River	1,550		-	-	*200*[6]	1,200[7]	3,400 (3.0)	71 (53-85)
Hood Canal	Skokomish River	1,311	434[9] (1.1)	1,300[12]	3,650[13]	452	1,160	-	56 (7-77)
	Mid-Hood Canal Rivers[14]	150		400	750	*200*[6]	*1,250*[6]	1,300 (3.0)	NA

Strait of Juan de Fuca	Dungeness River Elwha River[15]	376 1,748	114[8] (0.6)	500 1,000	925 2,900	*200[6]* *200[6]*	925[7] *1,250[6]*	1,200 (3.0) 6,900 (4.6)	69 (39-96) NA

[1] Includes naturally spawning hatchery fish.
[2] Source for 1999-2009 productivity is Abundance and Productivity Tables from Puget Sound TRT database; measured as the mean of observed recruits/observed spawners over the 1999-2009 period. Sammamish productivity estimate has not been revised to include Issaquah Creek. Source for Recovery Planning productivity target is the final supplement to the Puget Sound Salmon Recovery Plan (NMFS 2006a); measured as recruits/spawner associated with the number of spawners at Maximum Sustained Yield under recovered conditions.
[3] Critical natural-origin escapement thresholds under current habitat and environmental conditions (McElhaney et al. 2000; NMFS 2000a).
[4] Rebuilding natural-origin escapement thresholds under current habitat and environmental conditions (McElhaney et al. 2000; NMFS 2000a).
[5] Estimates of the fraction of hatchery fish in natural spawning escapements are from the Puget Sound TRT database and co-manager postseason reports on the Puget Sound Chinook Harvest Management Plan (WDFW and PSTIT 2005, 2006, 2007, 2008, 2009, 2010) and the proposed 2010-2014 Puget Sound Chinook Harvest Management Plan (PSIT and WDFW 2010).
[6] Based on generic VSP guidance (McElhaney et al. 2000; NMFS 2000a).
[7] Based on alternative habitat assessment.
[8] Estimates of natural-origin escapement for Snohomish available only for 1999-2001, 2004, and 2006-2007; for Lake Washington for 2003-2009; for White River 2004-2009 ; for Puyallup 2002-2009; and for Dungeness 2001-2009.
[9] Estimates of natural-origin escapement available only for 1999-2008.
[10] Captive broodstock program for early run Chinook salmon ended in 2000; estimates of natural spawning escapement include an unknown fraction of naturally spawning hatchery-origin fish from late- and early run hatchery programs in the White and Puyallup River basins.
[11] South Prairie index area provides a more accurate trend in the escapement for the Puyallup River because it is the only area in the Puyallup River for which spawners or redds can be consistently counted (PSIT and WDFW 2010).
[12] Skokomish Management Unit's critical threshold of 1,300 spawners is composed of 800 natural spawners and 500 hatchery-return spawners. If pre-season projections of natural escapement are 800 or less, *or* the hatchery component is expected to result in less than 500 spawners, pre-terminal fisheries will be constrained to 12% exploitation rate and terminal fisheries directed at Chinook salmon will be adjusted with the intention of increasing the number of natural spawners above 800 naturally spawning adults (see page 202 of the RMP).
[13] Skokomish Management Unit's upper threshold of 3,650 spawners is composed of 1,650 spawners and 2,000 hatchery-return spawners.
[14] The Puget Sound TRT considers Chinook salmon spawning in the Dosewallips, Duckabush, and Hamma Hamma rivers to be subpopulations of the same historically independent population; annual counts in those three streams are variable due to inconsistent visibility during spawning ground surveys.
[15] Estimates of natural escapement do not include volitional returns to the hatchery or those fish gaffed or seined from spawning grounds for broodstock collection.
[16] Represents natural-origin escapement.

Table 9. Trends in abundance and productivity for Puget Sound Chinook populations. Long-term, reliable data series for natural-origin contribution to escapement are limited in many areas.

Region	Population	Escapement Trend[1] (1990-2009)			Median Growth Rate[2] (1990-2008)	
		NMFS		Co-manager	Return (Recruits)	Escapement (Spawners)
Georgia Basin	NF Nooksack (early)	1.21	Increasing	NA	1.04	1.03
	SF Nooksack (early)	1.06	Increasing	NA	1.01	1.00
Whidbey/Main Basin	Upper Skagit River (moderately early)	1.04	Increasing	increasing	0.96	1.01
	Lower Sauk River (moderately early)	1.02	stable	increasing	0.93	1.00
	Lower Skagit River (late)	1.03	stable	increasing	0.94	0.99
	Upper Sauk River (early)	1.02	stable	increasing	0.95	0.99
	Suiattle River (very early)	0.98	stable	stable	0.92	0.95
	Upper Cascade River (moderately early)	1.04	increasing	increasing	0.98	1.02
	NF Stillaguamish R. (early)	1.02	stable	stable	0.92	0.99
	SF Stillaguamish R[3] (moderately early)	0.93	**declining**	stable	0.91	0.97
	Skykomish River (late)	1.03	stable	increasing	0.98	1.01
	Snoqualmie River (late)	1.05	increasing	increasing	1.01	1.04
Central/South Sound	Cedar River (late)	1.05	Increasing	increasing	1.00	1.00
	Sammamish River[4] (late)	1.07	stable	NA	0.88	0.93
	Duwamish-Green R. (late)	0.99	stable	stable	1.01	1.03
	White River[5] (early)	1.09	increasing	increasing	1.15	1.16
	Puyallup River (late)	0.99	stable	stable	0.97	0.99
	Nisqually River[3] (late)	1.07	increasing	increasing	0.97	0.98
Hood Canal	Skokomish River (late)	1.01	Stable	increasing	0.91	0.95
	Mid-Hood Canal Rivers (late)	1.00	Stable	stable	0.93	0.98
Strait of Juan de Fuca	Dungeness River (early)	1.09	Increasing	increasing	1.08	1.08
	Elwha River[3] (late)	0.99	Stable	stable	0.95	0.95

[1] Escapement Trend is calculated based on all spawners (i.e., including both natural origin spawners and hatchery-origin fish spawning naturally) to assess the total number of spawners passed through the fishery to the spawning ground. Directions of trends defined by statistical tests.
[2] Median growth rate (λ) is calculated based on natural-origin production. It is calculated assuming the reproductive success of naturally spawning hatchery fish is equivalent to that of natural-origin fish (for those populations where information on the fraction of hatchery fish in natural spawning abundance is available). Source: Abundance and Productivity Tables from Puget Sound TRT database.
[3] Estimate of the fraction of hatchery fish in time series is not available for use in λ calculation, so trend represents that in hatchery-origin + natural-origin spawners.
[4] Median growth rate estimates for Sammamish has not been revised to include escapement in Issaquah Creek.
[5] Natural spawning escapement includes an unknown fraction of naturally spawning hatchery-origin fish from late- and early run hatchery programs in the White and Puyallup River basins.

Table 10. Threshold classification based on NMFS' natural-origin escapement thresholds and growth rates, and escapement trends for Puget Sound Chinook salmon populations using the information provided in Tables 8 and 9.

Classification[1]	Management Unit	Population	Escapement Trend	Median Growth Rate (1990-2008)	
				Return	Escapement
average escapement is above the rebuilding threshold:	Skagit Summer/Fall:	Upper Skagit R.	Increasing	0.96	1.01
			Stable	0.95	0.99
				1.01	1.04
	Skagit Spring	Upper Sauk R.	Increasing	0.97	0.99
			Stable	0.95	0.95
	Snohomish	Snoqualmie R.	Increasing	1.15	1.16
	Puyallup	Puyallup River	Stable		
	White River	White River			
	Elwha	Elwha River			
average escapement is above the critical threshold but below the rebuilding threshold:	Skagit Summer/Fall	Lower Sauk R.	Stable	0.93	1.00
		Lower Skagit R.	Stable	0.94	0.99
	Skagit Spring:	Suiattle River	Stable	0.92	0.95
		Upper Cascade	Increasing	0.98	1.02
	Stillaguamish	N.F. Stillaguamish	Stable	0.92	0.99
	Snohomish	Skykomish R.	Stable	0.98	1.01
	Lake Washington	Cedar River	Increasing	1.00	1.00
		Sammamish R.	Stable	0.88	0.93
	Green River	Duwamish-Green	Stable	1.01	1.03
	Nisqually[2]	Nisqually River	Increasing	0.97	0.98
	Nooksack	N. F. Nooksack	Increasing	1.04	1.03
average escapement is below the critical threshold:	Nooksack	S. F. Nooksack	Increasing	1.01	1.00
	Stillaguamish	S.F. Stillaguamish	Declining	0.91	0.97
	Mid-Hood Canal	Mid-Hood Canal	Stable	0.93	0.98
	Skokomish	Skokomish River	Stable	0.91	0.95
	Dungeness	Dungeness River	Increasing	1.08	1.08

[1] The thresholds used in the classification were the NMFS-derived critical and rebuilding population thresholds from Table 8.

[2] Data are limited on hatchery contribution but the best estimates are the 76% on average of the natural spawners are returning hatchery adults (page 196 of RMP). Applied to the average natural escapement in Table 8, the resulting natural-origin escapement would be approximately 400 spawners.

Survival and recovery of the Puget Sound Chinook Salmon ESU will depend, over the long term, on necessary actions in all H sectors; particularly those resulting in improved habitat conditions. The Puget Sound Salmon Recovery Plan describes the types of actions in all sectors that must occur to achieve a positive trajectory toward recovery for the ESU (Shared Strategy for Puget Sound 2007). If implemented, these actions will have a positive effect on Puget Sound Chinook. However, unlike harvest actions that are implemented, effective and assessed in a matter of days to several years, habitat and hatchery actions take much longer to implement and decades to assess. This timeframe is well outside the duration of the 2010 Puget Sound Chinook RMP. Their pace of implementation and the resulting level of benefit are highly uncertain. Incorporating assumed benefits given such uncertainty could result in overly optimistic projections of future production. Therefore, in this evaluation NMFS takes a precautionary approach: assessing the performance of populations in the ESU under recent productivity conditions, i.e., assuming that the impacts of hatchery and habitat management actions remain consistent with current practices.

Estimates of the fraction of natural spawners that are of hatchery origin are currently limited. Some data are available for 19 of the 22 populations in the ESU, but the information is available for only the most recent 5-10 years and varies greatly in quality (Table 8). Based on the available information, the six Skagit populations have very little hatchery contribution to natural spawning. The Cedar, Duwamish-Green, White, Puyallup, Stillaguamish and Snohomish populations have moderate proportions of naturally spawning hatchery fish. The remainder of the populations has substantial numbers of naturally spawning hatchery fish. Better, more broad-scale information will become available over the next several years because management agencies have increased marking of hatchery fish and improved monitoring programs to better assess the contribution of hatchery fish to natural spawning areas.

Average natural-origin escapements for six of the 22 populations are above their NMFS-derived rebuilding thresholds (Tables 8 and 10), although hatchery fish contribute substantially to natural escapement for the Elwha population. Average natural-origin escapements for 11 of the 22 populations are between their critical and rebuilding thresholds, although the North Fork Stillaguamish escapement is very close to its rebuilding threshold (551 average vs. 552 threshold). Average natural-origin escapements are below their critical thresholds for five populations: the South Fork Nooksack, South Fork Stillaguamish, Skokomish, Mid-Hood Canal Rivers, Skokomish, and Dungeness populations (Table 8 and 10). Average natural-origin escapements for the North Fork Nooksack and Sammamish populations are near their critical thresholds. Of the populations below their critical thresholds, adult production originating from associated conservation programs contribute extensively to the annual abundance and natural escapements of the North Fork Nooksack River, and Dungeness Chinook population (Table 8). Conservation hatchery adults contributing to naturally spawning escapement buffer genetic and demographic risks for these populations. Hatchery-origin adults from the associated fishery augmentation programs contribute extensively to the Sammamish and Skokomish spawning ground escapement. Hatchery and wild spawners in these areas are genetically indistinguishable (Ruckelshaus et al. 2006); also buffering genetic and demographic risks (Jones 2006, NMFS 2004d).

NMFS assessed patterns in productivity based on several different measures: trends in natural escapement, growth rate of natural-origin return and growth rate of natural-origin escapement. Trend in natural escapement assesses the trend in the number of total spawners on the spawning ground (wild and hatchery) over time. It is an indicator of the trend in total adults passed through the fishery to the spawning grounds. Growth rate of natural-origin return assesses the trend in natural-origin recruits (i.e., pre-fishing abundance) over time while growth rate of natural-origin escapement assesses the trend in natural-origin spawners over time. Growth rate of natural-origin return is an indicator of the trend in the natural-origin population before fisheries occur. Growth rate of natural-origin escapement is an indicator of the trend in the natural-origin population after fisheries occur, i.e., as adults on the spawning grounds. Looking at all three indicators helps us to assess population trends at different life stages (i.e., recruit vs. spawner), and to better assess the effects of harvest on the population by comparing growth rates on natural-origin return (before harvest) with growth rates on natural-origin escapement (after harvest). Of the three indicators, trends in natural escapement and growth rates of natural-origin escapement are most reflective of the effects of harvest.

Based on NMFS' analysis, 21 of the 22 Puget Sound Chinook populations exhibit stable or increasing trends in natural escapement (Tables 9 and 10). The North Fork Nooksack, White and Dungeness River populations have the most positive trends; but associated supplementation programs contribute substantially to natural escapement for all three populations. The co-managers also conducted an assessment of natural escapement trends using a different methodology (Table 9 and page 50 of the RMP) that provided similar overall results. Of 19 populations for which data were sufficient for the analysis, all populations exhibited positive or stable escapement trends over the past 15 years (1994-2008). Differences in the results are likely due to differences in methodology and years included in the analysis.

Nine populations exhibit a stable or increasing growth rate in natural-origin return and 17 populations exhibit a stable or increasing growth rate in natural-origin escapement (i.e., $\geq$ 0.98)(Table 9). The White River population shows a strongly positive trend in growth rates for both natural-origin return and natural-origin escapement (Table 9). Growth rates for both natural-origin return and natural-origin escapement are declining for the Suiattle, South Fork Stillaguamish, Sammamish, Skokomish and Elwha populations. No clear patterns in trends in escapement or growth rates are evident among the five major regions of Puget Sound. Trends in growth rate of natural-origin escapement are generally higher than growth rate of natural-origin return. This indicates some stabilizing influence on escapement from past reductions in fishing-related mortality. Trends in growth rates are generally similar to or lower than those for trends in escapement (Table 9). Since the growth rate reflects the performance of the naturally produced fish, the differences between growth rate and escapement trend likely reflect the influence of degraded habitat and potential negative effects of the intermingled hatchery fish.

The proposed 2010 Puget Sound Chinook RMP does not provide lower or upper management thresholds for the Nisqually or Sammamish populations. NMFS relied on its independent escapement threshold standards, past fishery patterns and additional assumptions about future conduct of the fisheries to assess the effect of the proposed 2010 Puget Sound

RMP on these populations. Natural-origin escapement for the Sammamish has been generally close to but above its NMFS-derived critical threshold of 200 spawners and for the Nisqually population generally well above its critical threshold over the past five to seven years (Table 6). Total natural escapement for each population has averaged above 1,000 over the last 11 years (Table 8). We anticipate these trends to continue over the duration of the 2010 Puget Sound Chinook RMP (see analysis in next section). In addition, the stepped exploitation rate approach for the Nisqually Management Unit was derived by taking into account an MSY escapement of 1,200 natural-origin spawners based on an assessment of current habitat conditions. That escapement is consistent with the rebuilding threshold for the Nisqually population used by NMFS to assess risk to this population in this evaluation. Current natural-origin escapement is between the critical and rebuilding escapement thresholds; the escapement trend is increasing; and the growth rate of natural-origin escapement is stable.

The co-managers state that the Cedar River management objectives "provide protection for the Sammamish River population as well as the Cedar River population" (pg 171 of the RMP) in lieu of providing Sammamish specific management objectives. NMFS' analysis will assume that impacts on the Sammamish population will be the same as that for the Cedar River in SUS fisheries, i.e., the co-managers will not target the Sammamish population in Lake Washington in isolation of management for the Cedar River Chinook population. The RMP provides that directed Chinook fisheries in Lake Washington cannot occur unless the in-season update indicates with a high degree of confidence that the abundance of the Cedar River population is above its UMT. Data and technical tools are currently insufficient to manage and assess impacts to the two populations differentially in-season. Therefore, directed Chinook fisheries within Lake Washington during the duration of the RMP will be driven by the status of the Cedar population.

After establishing the status of the populations, the 4(d) Rule provides for a risk analysis of the populations under the implementation of a harvest plan. The VSP document (McElhaney et al. 2000) describes four key parameters for evaluating the status of salmonid populations. These parameters are: (1) population size (abundance); (2) population growth rate (productivity); (3) spatial structure; and (4) diversity. Below is an evaluation of how the RMP is expected to perform relative to these four VSP parameters for the Puget Sound Chinook Salmon ESU.

6.1 Abundance

As discussed previously in the introduction to the evaluation (see Chapter 2, Analytical Approach), NMFS used a retrospective analysis to analyze potential risks posed by the RMP on Puget Sound Chinook salmon population abundance. The retrospective analysis considers how outcomes would have changed under alternative management scenarios based on a series of past years reflecting a range in abundance and fishing regimes likely to be encountered over the duration of the RMP. The scenarios generally represent: 1) what actually occurred based on post season estimates of stock abundance and fishery catches; 2) what would occur under the 2010 Puget Sound Chinook RMP if Alaskan and Canadian fisheries were managed at the limits allowed under the 2008 Pacific Salmon Treaty Agreement; 3) what we can reasonably expect to occur under the 2010 Puget Sound Chinook RMP given an informed assessment of how fisheries are likely to be managed in the future; and 4) how the 2010 Puget Sound Chinook RMP would perform if there was an unexpected and broad scale reduction of 40% in the abundance of Chinook salmon. Anticipated escapements resulting from implementation of the various management scenarios are compared with NMFS' standards of critical and rebuilding escapement thresholds. The FRAM Validation scenario which represents current status is the basis of comparison to determine how the proposed 2010 RMP might affect population status as per this 4(d) criterion. More detailed descriptions of the methods and results are included in Appendices 1 and 2 to this evaluation.

NMFS' critical and rebuilding escapement thresholds represent natural-origin spawners. However, long-term time series of data on the contribution of natural-origin fish to escapement are limited for all Puget Sound populations; particularly those historically dominated by hatchery production. Consequently, the retrospective analysis of escapements compared to NMFS' escapement thresholds represents a variety of different levels of hatchery contribution depending on the available information. In general, FRAM-estimated escapement for the Nooksack, Skagit spring, and Skagit summer/fall represent primarily natural-origin escapement while hatchery-origin spawners may contribute significantly to FRAM's estimates of the remaining population escapements (Table 8)(Hagen-Breaux 2010; LaVoy et al. 2010). Therefore, escapements and exploitation rates estimated by FRAM for the retrospective analysis are not directly comparable to the NMFS thresholds in terms of natural-origin production. However, FRAM is the only available technical tool with the capabilities to model the complexities of fishery structure, stock distribution and life history required for the analysis. Using the FRAM Validation scenario as the basis for comparison in the retrospective analysis indicates how overall abundance might change from current levels under the implementation of the 2010 Puget Sound Chinook RMP and therefore how the population is anticipated to perform relative to this criterion of the 4(d) Rule.

The co-managers are refining abundance forecasts and modeling tools like the FRAM as better information becomes available. Several historically hatchery-dominated populations are transitioning to natural-origin management and, for others hatchery production will continue to contribute significantly to escapement depending on their role in ESU recovery. NMFS expects the treatment of escapements to become more refined over time as information and modeling tools improve (Hagen-Breaux 2010; LaVoy et al. 2010), as decisions are made regarding the treatment of hatchery- and natural-origin fish in an individual watershed, and as the role of individual populations in ESU recovery becomes better defined.

6.1.1 Strait of Georgia Basin Region

There are two populations within the Georgia Basin Region: the North Fork Nooksack River and the South Fork Nooksack River populations. Both populations currently are classified as Category 1 populations by the co-managers and Tier 1 populations by NMFS, exhibit early timed life histories, and are required to be viable to recover the Puget Sound Chinook ESU. The broodstock used for the Kendall Creek Hatchery program, located on the North Fork Nooksack River, retains the genetic characteristics of the wild population and is considered essential for the survival and recovery of the population given the low productivity of the habitat and low resulting abundance (Table 8). Genetic analysis of natural origin and Kendall Creek Hatchery-origin spring Chinook salmon indicate that there are no significant differences between the natural and hatchery populations, and that they are one distinct stock (Young and Shaklee 2002). Additionally, the co-managers are applying operational techniques that decrease the likelihood for divergence of the hatchery population from the extant natural population. Adult fish produced by the Kendall Creek Hatchery program buffer genetic and demographic risks to the natural-origin North Fork Nooksack River population (NMFS 2004d). A captive brood program was started in 2007 in an effort to protect and rebuild the remaining native population in the South Fork Nooksack given the critically low numbers of returning adults and the time it will take until benefits from habitat improvements are realized (Tynan 2010). The captive-brood program is now funded through the Critical Stocks Program developed as part of the 2008 PST Agreement negotiations. Canada and the U.S. recognized during the course of completing the 2008 PST Agreement that certain Chinook stocks in Puget Sound were more depressed and that immediate actions beyond the proposed harvest reductions could and should be taken to address their particular circumstances. The objective of this project and others in the Critical Stocks Program is to implement hatchery and habitat actions in watersheds with critical stocks to address threats to these stocks to improve the likelihood of their persistence (WDFW and NWIFC 2010a).

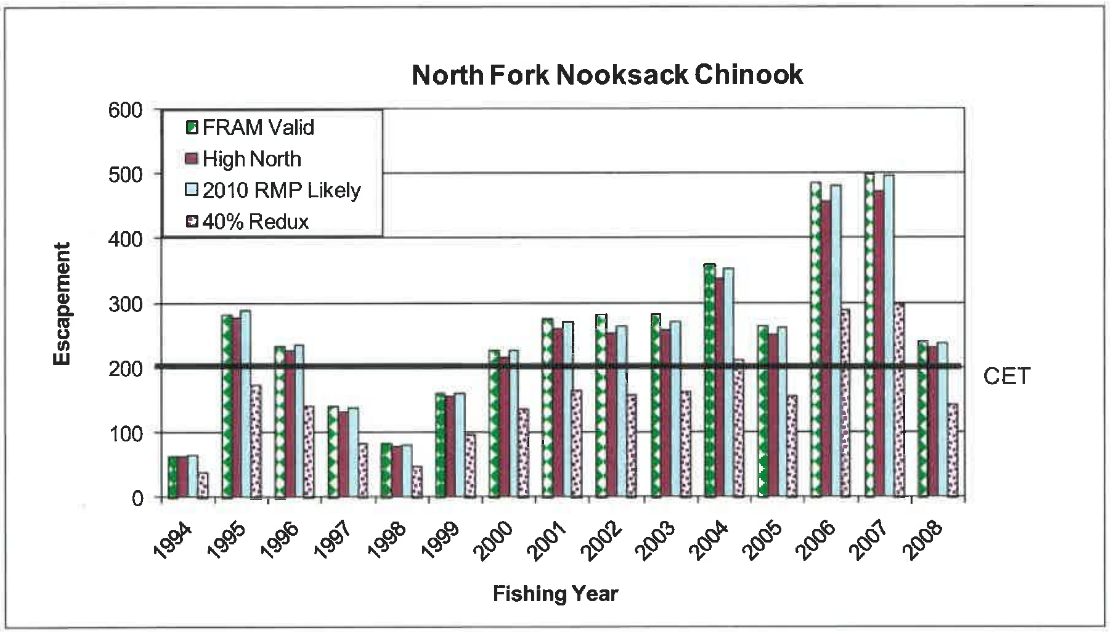
The 1999 to 2009 average escapement of 227 natural-origin spawners for the North Fork Nooksack River population is just above the NMFS-derived critical threshold of 200 fish. However, when including Kendall Creek hatchery-origin fish, an average aggregate escapement of 1,701 natural spawners for the North Fork Nooksack River has been observed since listing. The 1999 to 2009 average escapement of 56 natural-origin spawners for the South Fork Nooksack River population is significantly below the NMFS-derived critical threshold of 200 fish. Fish from the Kendall Hatchery and North Fork Nooksack River have contributed in significant numbers to the South Fork Nooksack escapement resulting in a 1999-2009 average total escapement of 376 adults. Both Nooksack River populations have exhibited increasing trends in natural escapement and growth rate (Table 9).

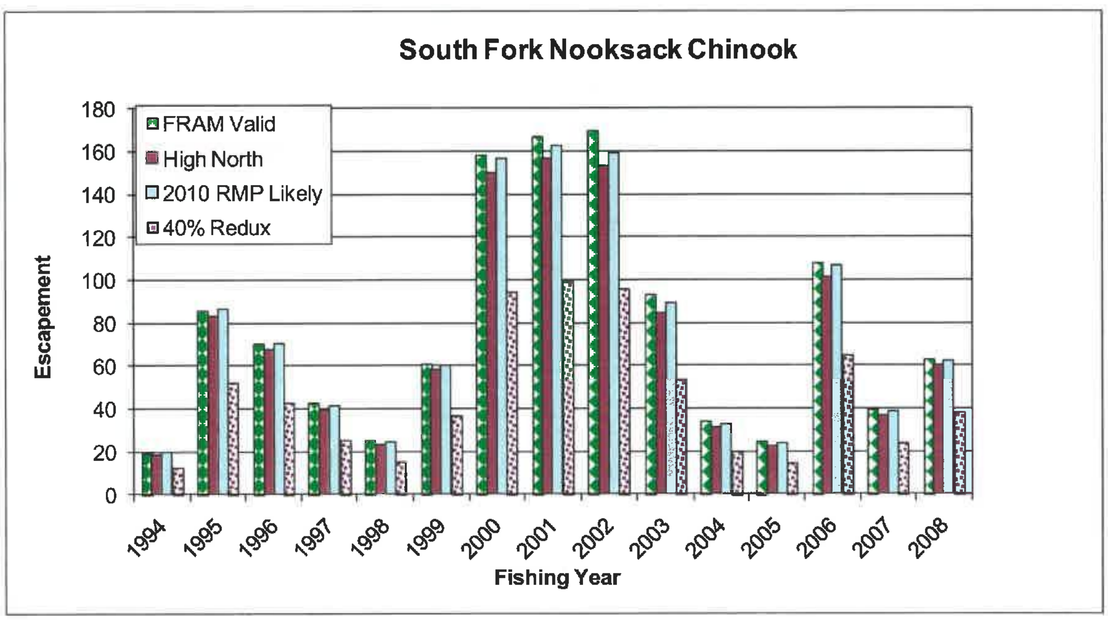
The retrospective analysis indicates that natural-origin escapement for both populations is expected to remain at depressed to critical levels (results from the retrospective analysis are also shown in tabular form in Appendix 2). The South Fork Nooksack population is expected to remain well below its critical threshold under all scenarios. The North Fork Nooksack population is expected to remain at very depressed levels, particularly in years similar to those prior to listing (1999), but escapements exceed the critical threshold under all scenarios except the 40% Reduction scenario in the most recent years (2000-2008)(Figure 3). The 2010 RMP Likely scenario shows a slight decrease in escapement (5 natural-origin spawners for both populations combined) when compared with the current status of the populations as described under the FRAM Validation scenario. This is due to the slightly higher exploitation rates possible under the proposed 2010 Puget Sound Chinook RMP (7%).[17] Under the High North scenario, escapement would decrease by 19 natural-origin spawners for both populations (15 for the North Fork Nooksack and 4 for the South Fork Nooksack) because of the higher impacts possible in northern fisheries. As expected, given the current low natural-origin abundance, the 40% Reduction scenario results in natural-origin escapements below critical thresholds for all but a few years for both populations.

The North Fork Nooksack population is currently near but above its critical threshold and below its rebuilding threshold. The South Fork Nooksack population is below its critical threshold. Due to the low natural productivity of the habitat (Table 8) and the small range in differences in escapement among the High North, 2010 RMP Likely and FRAM Validation scenarios, further fishery constraints in southern U.S. fisheries that are the subject of the 2010 Puget Sound RMP would not substantively reduce the genetic or demographic risks to the populations from their current status, or change the critical status of the population should very low abundance conditions occur. The additional returns of hatchery spawners from the conservation hatchery programs should continue to mitigate to some degree risks to the low escapement of natural-origin fish to the North Fork Nooksack, and to the South Fork Nooksack when adults from that program begin to return in 2014. Additional risk assessment for both populations will be discussed in Criteria 5 and 6.

[17] However, it should be noted that the 2004 Puget Sound Chinook RMP included the same SUS exploitation rate ceilings. The actual rates were less than the ceiling (1994-2008 average = 5%). This is likely to occur under implementation of the 2010 Puget Sound Chinook RMP as well, but because preseason fisheries are often shaped to meet the 7% objective, it is appropriate to evaluate the risk associated with the ceiling rather than a lower rate.

Figure 3. Estimates of natural origin escapement for the North Fork and South Fork Nooksack spring Chinook populations from the retrospective analysis.





6.1.2 Whidbey/Main Basin Region

The largest river systems in Puget Sound are found within the Whidbey/Main Basin Region. There are ten populations within the Whidbey/Main Basin Region: the Upper Sauk, Suiattle, Upper Cascade, Upper Skagit, Lower Sauk, and Lower Skagit populations in the Skagit River basin; the Skykomish and Snoqualmie River populations in the Snohomish River basin and the North Fork Stillaguamish and South Fork Stillaguamish populations in the Stillaguamish River basin. All populations are currently classified as Category 1 populations by the co-managers. NMFS classifies the Skagit spring and summer/fall populations in Tier 1 and the Stillaguamish and Snohomish populations in Tier 2. The populations vary in run timing and life history type (Table 3, Ruckelshaus et al. 2006). The Suiattle and one each of the remaining life history types are required to be viable in order to delist the ESU (Table 7)(NMFS 2006a).

Eleven Chinook hatchery programs operate in this region: three conservation programs, three combination research/harvest augmentation programs, one temporarily suspended Tulalip tribal program producing spring Chinook for tribal ceremonial and subsistence (C & S) use, and four harvest augmentation programs. The three conservation hatchery programs are specifically designed to reduce the risk of extinction for the North Fork Stillaguamish (2 programs) and South Fork Stillaguamish River Chinook. Except for the C&S fishery program, all of the hatchery populations propagated in the region are designated as part of the Puget Sound Chinook ESU and listed with the natural populations (NMFS 2004d). A new conservation hatchery program is under development for fall Chinook in the South Fork Stillaguamish River (Tynan 2010). This program is funded through the Critical Stocks Program developed as part of the 2008 PST Agreement negotiations. The objective of this project and others in the Critical Stocks Program is to implement hatchery and habitat actions in watersheds with critical stocks to address threats to these stocks to improve the likelihood of their persistence (WDFW and NWIFC 2010a).

The 1999 to 2009 average natural-origin escapements for three of the 10 populations exceed their rebuilding escapement thresholds, and all exceed their critical thresholds by 56 to 900% except for the South Fork Stillaguamish population (Table 8). Overall trends in natural escapement are stable or positive for all populations within the region except for the South Fork Stillaguamish, although the trend in underlying growth rate of natural-origin return for nine of the 10 populations has been less than 1.0 (Table 9). Growth rate of natural-origin escapement has been greater than the growth rate of natural-origin return for all populations within the region; trending at 1.0 or greater for five of the 10 populations (Table 9). This indicates some stabilizing influence on escapement from past reductions in fishing-related mortality (see discussion under Criterion 5, (b)(4)(i)(C)).

Table 12 summarizes the results of the analyses across the scenarios and compares them with the appropriate NMFS-derived critical and rebuilding escapement thresholds. Anticipated escapements are expected to show low to moderate increases under implementation of the

2010 Puget Sound Chinook RMP when compared with current conditions (FRAM Validation)(range = 5% for North Fork Stillaguamish and Snoqualmie to 11% for Suiattle).

Table 12. Average estimated escapements (1994-2008) from the retrospective analysis compared with escapement thresholds for the population groups within the Whidbey/Main Basin Region. Shaded areas exceed thresholds.

Population	Threshold	FRAM Validation		High North		2010 RMP Likely		40% Reduction	
		[redacted]sc.	# years above	Avg. Esc.	# years above	Avg. Esc.	# years above	Avg. Esc	# years above
Critical Threshold									
Upper Skagit	967	10,223	15/15	10,432	15/15	11,023	15/15	6,590	15/15
Lower Skagit	251	2,151	15/15	2,169	15/15	2,291	15/15	1,370	15/15
Lower Sauk	200	667	14/15	665	14/15	705	14/15	421	12/15
Suiattle	130	414	15/15	434	15/15	458	15/15	272	12/15
Upper Sauk	170	462	14/15	466	14/15	494	14/15	294	13/15
Upper Cascade	170	357	14/15	367	14/15	388	14/15	231	11/15
N.F. Stillaguamish	300	961	15/15	999	15/15	1,013	15/15	608	15/15
S.F. Stillaguamish	200	206	10/15	218	10/15	221	10/15	133	1/15
Skykomish	1,650	4,028	15/15	4,084	15/15	4,292	15/15	2,572	14/15
Snoqualmie	400	1,842	14/15	1,853	15/15	1,943	15/15	1,165	14/15
Rebuilding Threshold									
Upper Skagit	7,454	10,223	10/15	10,432	10/15	11,023	10/15	6,590	5/15
Lower Skagit	2,182	2,151	7/15	2,169	7/15	2,291	9/15	1,370	2/15
Lower Sauk	681	667	6/15	665	6/15	705	6/15	421	2/15
Suiattle	400	414	8/15	434	9/15	458	9/15	272	2/15
Upper Sauk	330	462	9/15	466	12/15	494	12/15	294	4/15
Upper Cascade	1,250	357	0/15	367	0/15	388	0/15	231	0/15
N.F. Stillaguamish	552	961	15/15	999	15/15	1,013	15/15	608	8/15
S.F. Stillaguamish	300	206	1/15	218	2/15	221	2/15	133	0/15
Skykomish	3,500	4,028	8/15	4,084	8/15	4,292	8/15	2,572	1/15
Snoqualmie	1,250	1,842	11/15	1,853	10/15	1,943	12/15	1,165	6/15

Under the 2010 RMP Likely scenario, the retrospective analysis indicates that escapements for all of the populations within the region are expected to exceed their critical escapement thresholds in almost all years. However, the South Fork Stillaguamish remains close to its critical threshold (Table 12). Under the 2010 RMP Likely scenario, eight of the 10 populations in the region (Upper Skagit, Lower Skagit, Lower Sauk, Suiattle, Upper Sauk, North Fork Stillaguamish, Skykomish and Snoqualmie) are expected to exceed their rebuilding thresholds on average. Under this scenario, escapements are expected to increase and the frequency of attaining escapement thresholds is the same or improved for all populations in the region when compared with current conditions.

The High North scenario results in small increases in average natural escapements (range = 0% for Lower Sauk to 6% for South Fork Stillaguamish). The pattern of escapement relative to critical thresholds is similar to the FRAM Validation scenario (Table 12). Six of 10 populations are above their critical thresholds in all 15 years under the High North scenario compared with five of 10 populations under the FRAM Validation scenario. The South Fork Stillaguamish remains close to its critical threshold. The number of populations with average escapements exceeding their rebuilding thresholds is the same under the High North and FRAM Validation scenarios (6 of 10) although the frequencies of exceeding the rebuilding threshold are similar or greater depending on the population (Table 12). The effect of the 40% Reduction scenario is primarily on the ability to meet rebuilding thresholds. The frequency of escapements above the rebuilding threshold drops substantially when compared with the FRAM Validation scenario although all but the Upper Cascade and South Fork Stillaguamish populations are expected to exceed their rebuilding threshold at least once during the 15 years of the analysis. All populations are anticipated to remain above their critical thresholds on average under the 40% Reduction scenario except for the South Fork Stillaguamish population. The frequency of times above the critical threshold decreases for six of the10 populations under the 40% Reduction scenario as compared with the other three scenarios, but the decrease is not as large as might be expected with such a significant reduction in abundance. The exception is the South Fork Stillaguamish which would only exceed its critical threshold in one of the 15 years in the analysis period compared with 10 of 15 years in the other three scenarios. However, the South Fork Stillaguamish is close to its critical threshold under all scenarios. It is a Tier 2 population whose life history is represented by three other populations in the region that are in much healthier condition. Therefore, any increased risk to this population would not impede viability for the region based on NMFS' delisting criteria.

Three of the 10 populations in the region are above their rebuilding thresholds; six are between their critical and rebuilding threshold and one (South Fork Stillaguamish) is below its critical threshold with declining escapement trend and growth rates. Based on the results of the retrospective analysis, implementation of the 2010 Puget Sound Chinook RMP should not impede maintenance or attainment of viable function for the populations in this region or the ESU consistent this criterion of the 4(d) Rule.

6.1.3 Central/South Sound Region

There are six populations delineated within the Central/South Puget Sound Region: the Sammamish and Cedar River populations in the Lake Washington basin; the Duwamish-Green; the Puyallup and White River populations in the Puyallup basin, and the Nisqually River population. The White River population is the only remaining early-timed (spring) run in the region. The other five populations are late-timed (fall) runs. The co-managers classify the White, Cedar and Green River populations as Category 1 populations. They classify the Sammamish, Puyallup and Nisqually populations as Category 2 populations. NMFS classifies the White and Nisqually populations in Tier 1; the Green population in Tier 2, and the Cedar, Sammamish and Puyallup populations in Tier 3. Genetically, the present fall spawning aggregations in the region are similar, likely reflecting the extensive influence of transplanted stock hatchery releases, primarily from the Green River population (Ruckleshaus et al. 2006). Most Chinook salmon in the region have similar life history traits, e.g., ocean type rearing and age. Consequently, life history and genetic variations were not useful in delineating most populations within the Central/South Sound Region (Ruckelshaus et al. 2006). NMFS has determined that the White River and Nisqually[18] populations must eventually be viable to recover the ESU (NMFS 2006a).

The basins in this region are the most urbanized and some of the most degraded in the ESU. The lower reaches of all these systems flow through lowland areas that have been developed for agricultural, residential, urban or industrial use. Much of the watersheds or migration corridors for five of the six populations in the region are within the cities of Tacoma or Seattle or their environs (Sammamish, Cedar, Duwamish-Green, Puyallup, and White). Natural production is limited by stream flows, physical barriers, poor water quality and limited spawning and rearing habitat related to timber harvest and residential, industrial and commercial development (Shared Strategy for Puget Sound 2007).

Numerous hatcheries in this area account for the majority of Chinook salmon produced in Puget Sound. With the exception of the White River program, the purpose of hatchery production in the region is primarily for fishery augmentation. Because of chronically low abundance, a conservation hatchery program was initiated in the mid-1970s to help rebuild White River spring Chinook salmon. Until the mid-1990s, inter-basin transfers of Chinook between hatcheries were common and extensive, with the Green River stock propagated at the WDFW Soos Creek Hatchery serving as the primary source for broodstock. Hatchery spawner contribution to natural escapement is moderate to heavy in this region (Table 8).

Natural-origin escapements for two populations (Puyallup and White) are above their rebuilding threshold. The remaining four populations are above their critical thresholds but below their

[18] The Puget Sound TRT noted that the Nisqually watershed is in comparatively good condition, and thus the certainty that the population could be recovered is among the highest in the Central/South Region. NMFS concluded in its supplement to the Puget Sound Salmon Recovery Plan that protecting the existing habitat and working toward a viable population in the Nisqually watershed would help to buffer the entire region against further risk (NMFS 2006a).

rebuilding thresholds (Table 10). When hatchery contribution to natural escapement is taken into account, average natural escapements for four of the six populations exceed rebuilding thresholds (Table 8). Average-natural-origin escapement for the Sammamish (210 fish) is close to its critical threshold, although natural escapement has exceeded 1,000 spawners in five of the last six years (range = 866-2,214)(Table 5). Hatchery and wild spawners in the Sammamish River are genetically indistinguishable (Ruckelshaus et al. 2006), buffering demographic risks (Jones 2006, NMFS 2004d)[19]. Trends in natural escapement are stable or increasing for all populations within the region, although the trend in underlying growth rates of natural-origin return for the Sammamish, Puyallup and Nisqually populations are less than 1.0 (Table 9). Growth rates of natural-origin escapement are the same or greater than the growth rate of natural-origin return for all populations within the region; trending at 1.0 or greater for three of the six populations (Table 9). This indicates some stabilizing influence on escapement from past reductions in fishing-related mortality (see discussion under Criterion 5, (b)(4)(i)(C)).

Table 13 summarizes the results of the analyses across the scenarios and compares them with the appropriate NMFS-derived critical and rebuilding escapement thresholds from Table 8. The retrospective analysis indicates that escapements for all of the populations within the region are expected to exceed their critical escapement thresholds in all or almost all (Lake Washington) 15 years in the analysis period under all scenarios (Table 13). Average escapements are expected to increase under implementation of the 2010 RMP Likely scenario when compared with the FRAM Validation scenario and are the highest of the four scenarios. The increases are relatively small for the Lake Washington, Duwamish-Green and White populations (4-6%), moderate for the Puyallup population (28%) and substantial for the Nisqually population (96%). Under the 2010 RMP Likely scenario, average escapement for four of the six populations in the region (Duwamish-Green, White, Puyallup, and Nisqually) are expected to exceed their rebuilding thresholds (i.e., 67% of the region), the same number of populations as under the FRAM Validation scenario. The frequency of meeting the rebuilding threshold under the 2010 RMP Likely scenario is greater than under the FRAM Validation scenario. However, hatchery contribution is expected to be substantial to natural escapements for all four populations. The results of the High North scenario are similar to the 2010 RMP Likely scenario (Table 13).

The effect of the 40% Reduction scenario is primarily on the frequency of the populations in meeting rebuilding thresholds. The number of populations with average escapements exceeding their rebuilding threshold is the same under the 40% Reduction as under the FRAM Validation scenario (4 of 6) but the frequency of meeting the threshold is reduced for the Lake Washington and White River populations (Table 13). All populations are anticipated to remain above their critical thresholds during all 15 years in the analysis under the 40% Reduction scenario except

[19] In 2006 NMFS updated its 2004 SHIEER document (NMFS 2004d) which determined the relationship of each Puget Sound hatchery program to the ESU. In the 2006 update, the Issaquah hatchery population was included in the Puget Sound ESU. Although NMFS did not update its assessment of VSP effects at the time, the updated status and character of the program is similar to that determined for hatchery programs for the Nisqually River and other transplanted Green River populations and so it is reasonable to expect that the VSP effects would also be similar.

for the Cedar population (Table 13). The Cedar River escapement falls below the critical threshold four times during the 15 year period under the 40% Reduction scenario as compared to one time under the FRAM Validation or other scenarios; less often than would be expected with such a significant reduction in abundance.

Table 13. Average escapements (1994-2008) from the retrospective analysis compared with escapement thresholds for the population groups within the Central/South Sound Region. Shaded areas indicate escapements that exceed thresholds.

Population	Threshold	FRAM Validation		High North		2010 RMP Likely		40% Reduction	
		Avg. Esc.	# years above	Avg. Esc.	# years above	Avg. Esc.	# years above	Avg. Esc	# years above
Critical Threshold									
Sammamish Cedar	200 200	941 544	15/15 14/15	966 557	15/15 14/15	981 566	15/15 14/15	593 343	15/15 11/15
Duwamish/ Green	835	9,794	15/15	10,219	15/15	10,367	15/15	6,686	15/15
White	200	1,657	15/15	1,725	15/15	1,716	15/15	1.028	15/15
Puyallup	200	1,922	15/15	2,460	15/15	2,456	15/15	1,455	15/15
Nisqually	200	1,045	15/15	2,135	15/15	2,047	15/15	1,232	15/15
Rebuilding Threshold									
Sammamish Cedar	1,250 1,250	941 544	4/15 1/15	966 557	5/15 1/15	981 566	6/15 1/15	593 343	1/15 0/15
Duwamish/ Green	5,523	9,794	12/15	10,219	14/15	10,367	14/15	6,686	12/15
White	1,000	1,657	9/15	1,725	12/15	1,716	12/15	1,028	7/15
Puyallup	522	1,922	15/15	2,460	15/15	2,456	15/15	1,455	15/15
Nisqually	1,200	1,045	7/15	2,135	10/15	2,047	10/15	1,232	7/15

Two populations are currently above their rebuilding threshold (White and Puyallup). The remaining four populations are above their critical thresholds but below their rebuilding thresholds. The Sammamish population is close to its critical threshold and growth rates in natural-origin escapement and natural-origin return are both declining; both causes for concern. Although total natural escapement has averaged over 1,000 across the last 11 years, productivity of the habitat is very low (Table 8) likely limiting gains in natural-origin production. It is a Tier 3 population, i.e., managed at a slower trajectory toward recovery compared to the Tier 1 and 2 populations in the region. Its life history is represented by other populations in the region that are in much healthier condition. Therefore, any increased risk to this population would not impede viability for the region based on NMFS' delisting criteria. The White and Nisqually populations are essential to recovery of the ESU. Based on the results of the retrospective analysis, implementation of the 2010 Puget Sound Chinook RMP would result in increased escapements and the same or improved conditions for all populations in the region when compared to current conditions as represented by the FRAM Validation scenario. Therefore implementation of the 2010 Puget Sound Chinook RMP should not impede maintenance or attainment of viable function for the populations in this region or the ESU consistent this criterion of the 4(d) Rule.

6.1.4 Hood Canal Region

The Hood Canal Region has two fall Chinook salmon populations, one in the Skokomish River, and a second in mid-Hood Canal that encompasses three Hood Canal rivers (Dosewallips, Duckabush, and Hamma Hamma rivers)(Ruckelshaus et al. 2006). The co-managers classify both the Skokomish and Mid-Hood Canal Rivers populations as Category 2 populations. NMFS determined that both populations will eventually need to be viable to recover the ESU (NMFS 2006a) and has categorized them as Tier 1. Historically, the Skokomish River supported the largest natural Chinook run in Hood Canal. Natural production in the North Fork Skokomish has been limited as a result of impacts associated with dams that block anadromous passage at river miles 17 and 19 and greatly limited in-stream flow due to an out of basin diversion. Natural production in the South Fork is further limited by the effects of intensive logging activity (WDF et al. 1993). A great deal of uncertainty remains about the relationship among Chinook in the three rivers of the Mid-Hood Canal population. Little information is available about the populations prior to significant habitat alteration and hatchery supplementation in these rivers. The largest uncertainty within the Hood Canal populations is the degree to which Chinook salmon spawning aggregations are demographically linked in the Hamma Hamma, Duckabush, and the Dosewallips Rivers. The Puget Sound TRT identified two possible alternative scenarios to the current delineation. One that the Chinook salmon in the Hamma Hamma, Duckabush, and Dosewallips were each independent populations; the other that Chinook in the three rivers were subpopulations of a single, large Hood Canal Chinook salmon population whose primary spawning aggregation resided in the Skokomish River (Ruckelshaus et al. 2006). The Puget Sound TRT indicated that additional monitoring of abundance and straying as well as any additional historical information may be useful in further evaluating the plausibility of each of the possible delineations.

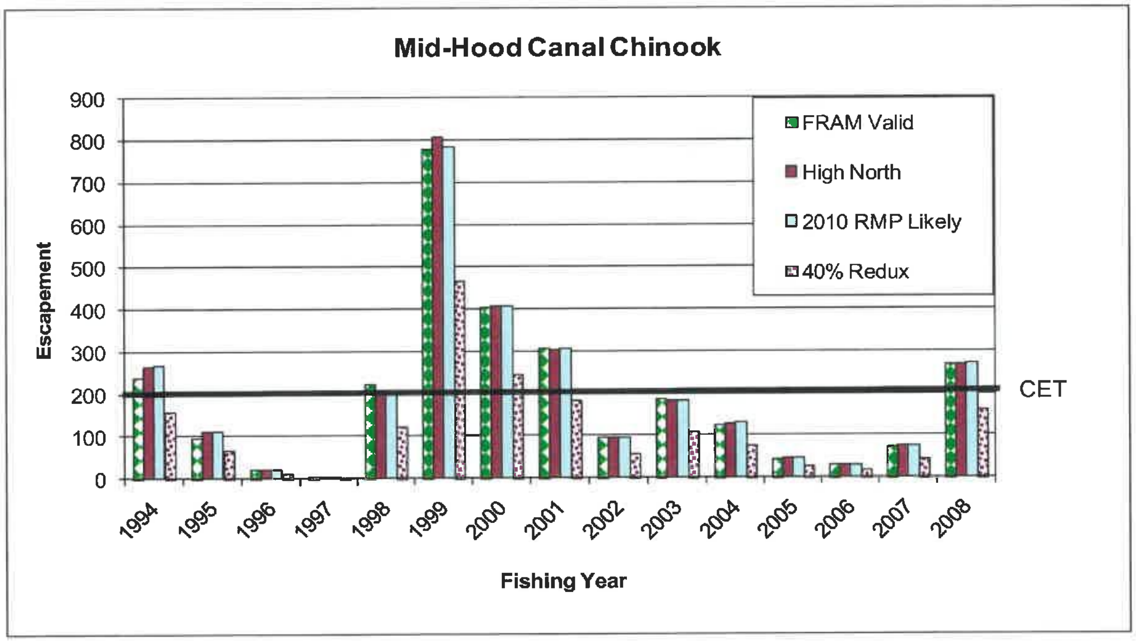
Natural-origin escapements for both populations are below their critical threshold (Table 10). When hatchery-origin spawners are taken into account for the Skokomish, the average total natural escapement of 1,311 (range = 531-2,398) exceeds the rebuilding escapement threshold of 1,160 (Table 8).The 1999 to 2009 average escapement for the Mid-Hood Canal Rivers population is 150 (range = 30-762), below its critical threshold of 200, and escapements since 2002 have been less than 200 in all but one year (range=30-273). Escapement into the individual systems has varied, with the spawning aggregation in the Hamma Hamma River representing the majority of the total Mid-Hood Canal Rivers population abundance in recent years. Escapements to the Dosewallips and Duckabush Rivers have averaged 15 and 4 fish respectively from 2005-2009 (PSIT and WDFW 2010; WDFW and PSTIT 2010). Adult returns resulting from the Hamma Hamma River supplementation program, which relies partially on broodstock returning to the river and possible strays from nearby net pen programs that have since been terminated, may have contributed substantially to escapements in earlier years. The on-going supplementation program has not been successful in recent years in substantially increasing abundance for even the Hamma Hamma component of the population, primarily because of very low survivals of fish released from the program. Trends in natural escapement since 1990 are stable for both populations although the trend in growth rates of natural-origin return and natural-origin escapement are less than 1.0 (Table 9). Growth rate of natural-origin escapement is greater than the growth rate of natural-origin return for both populations within the region (Table 9). This indicates some stabilizing influence on escapement from past reductions in fishing-related mortality (see discussion under Criterion 5, (b)(4)(i)(C)). Hatchery and wild spawners in these areas are genetically indistinguishable (Ruckelshaus et al. 2006), buffering demographic risks (Jones 2006, NMFS 2004d)[20]. Improvements in the operating protocols of the Hamma Hamma supplementation program in recent years may increase the contribution of the program to recovery of the population.

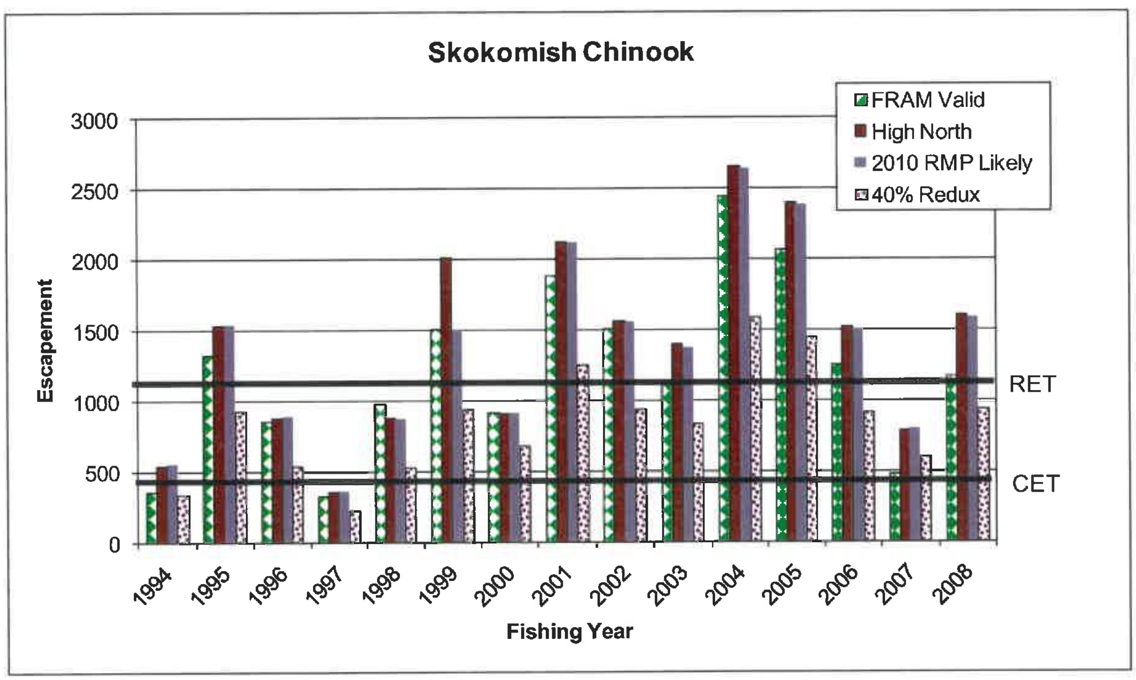
Figure 4 summarizes the results of the analyses across the scenarios and compares them with the appropriate critical and rebuilding escapement thresholds (results from the retrospective analysis are also shown in tabular form in Appendix 2). The 2010 RMP Likely and High North scenarios result in negligible (Mid-Hood Canal = 2-3 fish) to low (Skokomish = 14%) increases in average escapements for the Hood Canal populations when compared with the FRAM Validation scenario (Figure 4). The frequency of attaining thresholds for the 2010 RMP Likely and High North scenarios is similar to that for the FRAM Validation scenario. The retrospective analysis indicates that escapements for the Mid-Hood Canal population are expected to be below its critical escapement threshold in most years under all scenarios (Figure 4). Skokomish escapements are expected to be above its critical threshold in 13 to 14 of the 15 years in the analysis for all scenarios; and above its rebuilding threshold in 8-9 years (Figure 4) under the

[20] In 2006 NMFS updated its 2004 SHIEER document (NMFS 2004d) which determined the relationship of each Puget Sound hatchery program to the ESU. In the 2006 update, the Hood Canal fall Chinook hatchery populations were included in the Puget Sound ESU. Although NMFS did not update its assessment of VSP effects at the time, the updated status and character of the programs are similar to that determined for hatchery programs for the Nisqually River and other transplanted Green River populations and so it is reasonable to expect that the VSP effects would also be similar.

High North and 2010 RMP Likely scenarios. The frequency of the Skokomish exceeding its rebuilding threshold drops to three of the 15 years in the analysis under the 40% Reduction scenario. Hatchery contribution is expected to be substantial to natural escapements for the Skokomish population.

Figure 4. Estimates of natural escapement for the Mid-Hood Canal Rivers (top) and Skokomish (bottom) Chinook populations from the retrospective analysis.





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Natural-origin escapements for both populations in the Hood Canal Region are currently below their critical thresholds. Based on the results of the retrospective analysis, implementation of the 2010 Puget Sound Chinook RMP would result in increased escapements and similar conditions for both populations in the region when compared to current conditions as represented by the FRAM Validation scenario. However, the low escapements combined with declining growth rates is a concern. The two extant populations in the Hood Canal Region are both essential to recovery of the Puget Sound Chinook ESU but the indigenous populations have been extirpated in both watersheds. The general characteristics of the Mid-Hood Canal Rivers population, including genetic lineage, life history, and run timing, are also found in the Skokomish River population. The focus of recovery, therefore, is on re-introduction of localized natural populations and transition of both populations to natural-origin management over time as the populations adapt to the watershed and habitat conditions improve to support natural production. The timing and magnitude of changes in harvest that occur in these watersheds must be coordinated with corresponding habitat and hatchery actions and take into account the Category 2 status of the population. Hatchery and wild spawners are indistinguishable genetically and so hatchery fish should provide some buffer to genetic and demographic risks at low abundances and during the transitional period (Jones 2006, NMFS 2004d). Due to the small range in differences in escapement among the High North, 2010 RMP Likely, and FRAM Validation scenarios, further fishery constraints in southern U.S. fisheries that are the subject of the 2010 Puget Sound Chinook RMP would not substantively reduce the genetic or demographic risks from current status, or change the critical status of the Mid-Hood Canal population. Therefore implementation of the 2010 Puget Sound Chinook RMP should not impede attainment of viable function for the populations in this region or the ESU consistent with this criterion of the 4(d) Rule.

6.1.5 Strait of Juan de Fuca Region

The Strait of Juan de Fuca Region has two populations including an early-timed population on the Dungeness, and a fall-timed population on the Elwha (Ruckelshaus et al. 2006). The co-managers classify them both as Category 1 populations. NMFS determined that both populations must eventually be viable to recover the ESU and has classified them as Tier 1. The Dungeness River is located in the rain shadow of the Olympic Mountains and, as a result, receives relatively little rainfall (less than 20 inches per year). Flows in the Dungeness River are therefore particularly dependent on annual precipitation and snow pack, and the river is susceptible to habitat degradations that exacerbate low flow conditions. Agricultural water withdrawals remove as much as 60% of the natural flow during the critical late summer low flow period which coincides with Chinook salmon spawning (Bishop and Morgan 1996). Other land use practices have also substantially degraded the system. Recently, a water conservation project funded through the Critical Stocks Program developed as part of the 2008 PST Agreement negotiations was implemented to address part of the concerns regarding water withdrawals. The project involves piping the entire distribution system of the Dungeness Irrigation District and is expected to result in anticipated in-river water savings of 3-4 cubic feet per second (WDFW and NWIFC

2010b).[21] Much of the Elwha River drainage is still pristine and protected in the Olympic National Park. However, two dams at river miles 4.9 and 13.4 block passage to over 70 miles of potential habitat. The remaining habitat below the first dam is degraded by the loss of natural gravel, large woody debris, and the adverse effects of high water temperatures. In some years, high temperatures exacerbate problems with the parasite *Dermocystidium* resulting in pre-spawning mortality sometimes as high as 70% (WDF et al. 1993; Shared Strategy for Puget Sound 2007). Recovery of the Elwha population depends on the removal of the two dams, and restoration of access to high quality habitat in the upper Elwha River basin. Preparation for removal of the Elwha Dams is underway, although their removal will take several years to complete. Restoration of upstream access after the dams are removed will greatly enhance the prospects for eventual recovery of a viable Chinook salmon population. During dam removal, natural production will be severely disrupted and may be eliminated entirely for some years because of lethal turbidity and sedimentation levels (Ward et al. 2008). During this time, production will rely on listed fish production from the hatchery program to maintain the population (Ward et al. 2008).

The co-managers, in cooperation with federal agencies and private-sector conservation groups, have implemented a supplementation program to rehabilitate the Dungeness River Chinook population.[22] The primary goal of the supplementation program is to increase the number of fish spawning naturally in the river, while maintaining the genetic characteristics of the existing stock. The fish propagated at WDFW's Dungeness Hatchery for this conservation program are considered part of the listed Puget Sound Chinook ESU. Chinook salmon produced by the hatchery mitigation program in the Elwha River system are also considered part of the listed Elwha Chinook salmon population. Fish produced by both programs are essential to the recovery of the ESU and Chinook production from the Elwha Hatchery will be a key component of watershed rehabilitation and population maintenance as the dams are removed.

The Elwha population is above its rebuilding threshold. The Dungeness is below its critical threshold. Hatchery contribution to natural spawning escapement is high for both populations. The 1999 to 2009 average natural escapement for the Elwha population is 1,748 fish (range = 823-3,741 fish). Natural escapements have been above the critical threshold in every year during the period and above the rebuilding threshold in four of 11 years. The 1999 to 2009 average natural-origin escapement for the Dungeness population is 124 fish (range = 17-304 fish). Average total natural escapement is 395 for the Dungeness, which is well above the critical threshold when the supplementation program contribution is taken into account. Natural escapements have been above the critical threshold in every year during the period except 1999, 2008, and 2009. The primary goal of the supplementation program is to increase the number of spawners while maintaining the genetic character of the existing natural population (page 211 of the RMP). Trends in natural escapement are stable for the Elwha and increasing for the

[21] The objective of this project and others in the Critical Stocks Program is to implement hatchery and habitat actions to address immediate threats to these stocks to improve the likelihood of their persistence.
[22] This is also funded in part by the Critical Stocks Program.

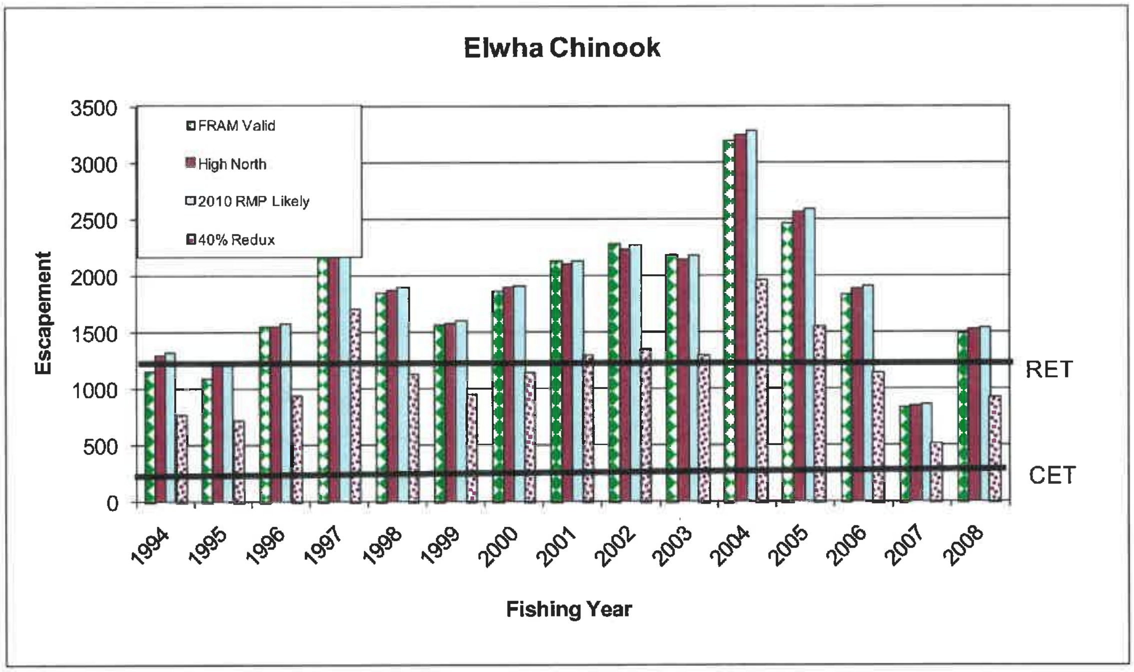
Dungeness although the underlying growth rate is less than 1.0 for the Elwha population (Table 9). Growth rate of natural-origin escapement is the same as the growth rate of natural-origin return for both populations within the region; trending at 0.95 and 1.08 for the Elwha and Dungeness populations, respectively (Table 9). Adult fish production resulting from hatchery programs in both areas will buffer genetic and demographic risks to the Dungeness River population (NMFS 2004d).

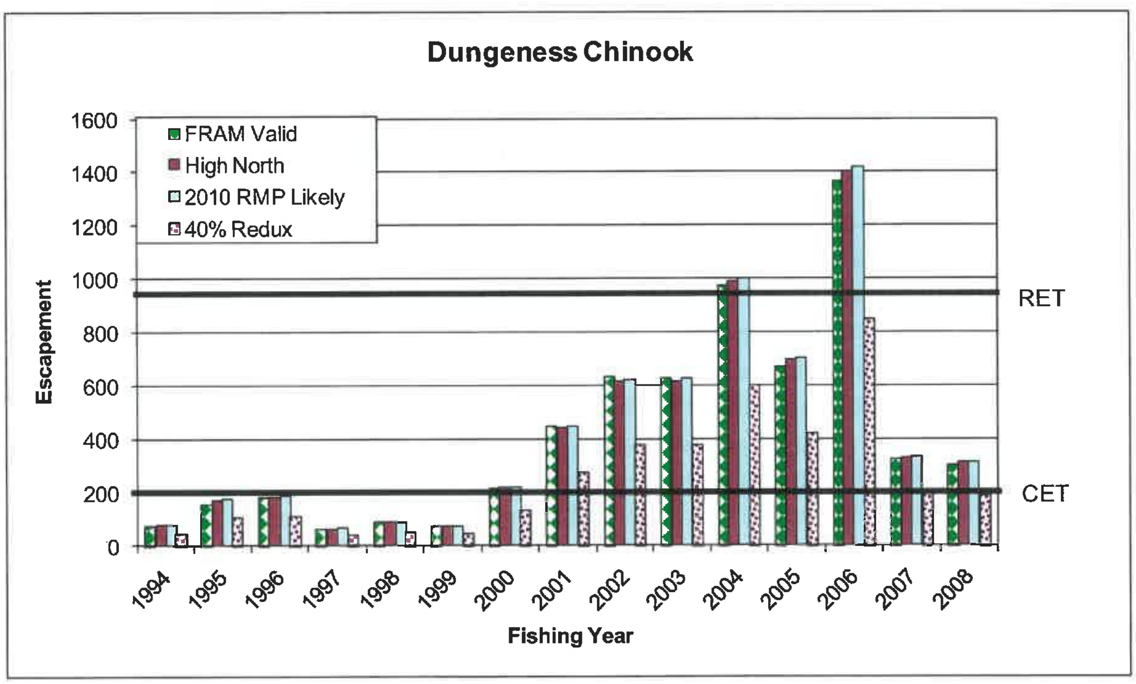
Figure 5 summarizes the results of the analyses across the scenarios and compares them with the appropriate critical and rebuilding escapement thresholds (results from the retrospective analysis are also shown in tabular form in Appendix 2). Results for the 2010 RMP Likely and High North scenarios are similar to the FRAM Validation scenario in terms of the status and frequency of escapements relative to their thresholds. The increase in the average natural escapements under the 2010 RMP Likely and High North scenarios compared with the FRAM Validation scenario is small (37-61 fish for Elwha and 6-11 for Dungeness) (Figure 5). The retrospective analysis indicates that escapements for the Elwha population would be above its critical escapement threshold across all scenarios (Figure 5). The retrospective analysis indicates that escapements for the Dungeness population would be above its critical escapement threshold in nine or more of 15 years in the analysis across the 2010 RMP Likely, High North, and FRAM Validation scenarios and above the threshold for all years since 2001 (Figure 5).

The effect of the 40% Reduction scenario is on the frequency of achieving the rebuilding threshold for the Elwha and the critical threshold for the Dungeness. The Elwha population would meet its rebuilding threshold six of 15 years compared to 12 of 15 years under the FRAM Validation scenario. The Dungeness population is expected to meet its critical threshold in six of 15 years compared to nine of 15 years under the FRAM Validation scenario. Regardless of scenario, the Dungeness would rarely meet its rebuilding threshold if at all.

The Elwha population is above its rebuilding threshold although hatchery contribution to escapement is likely substantial. The Dungeness is below its critical threshold. Both populations are essential to the recovery of the ESU. Due to the low natural productivity of the habitat (Table 8) and the small range in escapement differences among the High North, 2010 RMP Likely, and FRAM Validation scenarios, further fishery constraints in southern U.S. fisheries that are the subject of the 2010 Puget Sound Chinook RMP would not substantively reduce the genetic or demographic risks to the populations from their current status, or change the critical status of the population. Escapement trends and growth rates have been positive for the Dungeness although this was likely primarily due to the influence of the supplementation program. The contribution of additional spawners from the conservation hatchery programs should continue to mitigate risks to the low escapement of natural-origin fish to the Dungeness and through dam removal on the Elwha River (NMFS 2004d). Based on the results of the retrospective analysis, implementation of the 2010 Puget Sound Chinook RMP should not impede maintenance or attainment of viable function for the populations in this region consistent with this criterion of the 4(d) Rule.

Figure 5. Estimates of natural escapement for the Elwha (top) and Dungeness (bottom) Chinook populations from the retrospective analysis.





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In summary, the co-managers have provided upper and lower escapement management thresholds for all but two populations or management units in the Puget Sound Chinook ESU that recognize differences in risk based on stock status relative to those thresholds consistent with the 4(d) Rule. The 2010 Puget Sound Chinook RMP proposes different management regimes that respond to those different states of risk intended to minimize risk to the long-term persistence of the populations (see discussion under Criterion 1 above). These thresholds represent a mix of natural-origin and total natural spawner escapements depending on the population or management unit (Table 8 and Table FRAM-2 in Appendix 1). For three populations, including those for which the RMP did not provide management thresholds, the anticipated abundance levels over the next three years, from May 1, 2011 through April 2014, make the actual implementation of the RMP's upper thresholds (Mid-Hood Canal Rivers) or lower thresholds (Sammamish, Nisqually) to trigger changes in fishing regimes very unlikely. The Nisqually exploitation rate objective was derived based on attainment of a level of escapement consistent with NMFS' rebuilding threshold, and the RMP asserts that management for the Cedar River management objectives will be protective of the Sammamish population. The analysis discussed above supports that assertion. However, given that the RMP includes no specific management objectives for the Sammamish population, actual management outcomes are more uncertain.

Overall, along with other on-going habitat and hatchery programs, the proposed 2010 Puget Sound Chinook RMP is consistent with this criterion of the 4(d) Rule. Based on the above analysis, those populations currently at or above their rebuilding thresholds (Table 10) should remain at or above those thresholds on average except under very low abundances, particularly under the 2010 RMP Likely scenario. However, even under reductions of 40% in abundance, all the populations should retain their ability to rebuild above their rebuilding threshold particularly if environmental and other limiting factors improve.

For populations between their critical and rebuilding thresholds (Table 10), implementation of the 2010 Puget Sound Chinook RMP should not slow attainment of the rebuilding threshold. Based on the results of the retrospective analysis, implementation of the 2010 Puget Sound Chinook RMP would result in increased escapements and the same or improved conditions for all populations except the North Fork Nooksack when compared to current conditions, except under very low abundance. Under low abundances, populations remain above their critical thresholds on average and attain their rebuilding threshold at least once during the analysis where that occurred under higher abundance conditions. Some additional concerns were noted for the North Fork Nooksack and Sammamish populations due to potential low natural-origin abundance and/or declining growth rates. However, the analysis concluded that further fishery constraints in southern U.S. fisheries would not substantially reduce the genetic or demographic risks to the North Fork Nooksack from its current status or impede the ability of the Central/South Sound Region to achieve viability.

For populations below their critical threshold (Table 10), harvest must not appreciably increase genetic or demographic risks unless it would not appreciably reduce recovery of the ESU. All populations except the South Fork Nooksack are expected to see minor improvements in average escapement. The analyses concluded that further fishery constraints in southern U.S. fisheries would not substantially reduce the genetic or demographic risks to the populations from their current status or, in the case of the South Fork Stillaguamish, impede the ability of the Whidbey/Main Basin Region to achieve viability. Therefore the levels of risk associated under the implementation of the RMP's management thresholds are consistent with NMFS' standards based on our expectation of abundances and trends over the duration of the RMP. Further discussion of these populations' status, in regards to the likelihood of survival and recovery of the ESU, is under Criterion 6, (b)(4)(i)(D).

6.2 Productivity

Productivity is generally understood to be the ratio of the abundance of juveniles or adults produced in one generation to the abundance of their parent spawners. Productivity is driven primarily by habitat quantity, quality, and reproductive fitness. All watersheds in Puget Sound have degraded habitat from a variety of causes, including logging, road building, agriculture, urbanization, flood control, and hydropower. The degree to which each of these causes contributes to the decline in habitat quality or quantity varies from watershed to watershed. Changes in the abundance of salmonid populations also are affected substantially by changes in marine environments, e.g., El NiZo. Climate change is expected also to result in more variable freshwater and marine environments resulting in more variable survival rates. The survival and recovery of these species will depend on their ability to persist through periods of low survival. This rationale was the basis for the 40% Reduction scenario.

Harvest management objectives must be appropriate for the habitat capacity and productivity requirements of individual populations. The RMP provides no explicit management objectives for productivity. The exploitation rates, upper management thresholds, and the low abundance thresholds are based, when feasible, on current survival and productivity rates, with adjustments to account for data uncertainty and management imprecision.

Another aspect of habitat quality is the level of marine-derived nutrients introduced into an ecosystem by eggs deposited by spawning salmon and by decaying salmon carcasses. This can be influenced in part, by fisheries, since they will have a negative effect on escapement. More in-depth discussion of the role of adult salmon in nutrient re-cycling can be found in Appendix D: "Role of Salmon in Nutrient Enrichment of Fluvial Systems in the 2004 Puget Sound Chinook RMP" (PSIT and WDFW 2004). Marine-derived nutrients are a source of food for juvenile salmonids, invertebrates, and provide basic nutrients to the ecosystems (Larkin and Slaney 1996; Gresh et al. 2000; Murota 2003; Wipfli et al. 1998). However, nutrient dynamics in aquatic systems is very complex (Polis et al. 1997; Bisson and Bilby 1998; Murphy 1998; Naiman et al. 2000). The importance of salmon nutrient re-cycling within a given aquatic ecosystem remains poorly understood and is dependent on numerous site-specific factors. These factors include: the species of salmon; spawning density; spawning location; stream discharge regimes in the area; stream habitat complexity; basin geology; light; temperature; and ecosystem community structure.

The role of returning adult Chinook salmon as a means of re-cycling nutrients into a freshwater ecosystem must be examined in the context of the limitations of current research on the subject, Chinook salmon life history, and Chinook salmon abundance relative to the generally more abundant escapement of coho salmon (*Oncorhynchus kisutch*), pink salmon (*O. gorbuscha*), and chum salmon (*O. keta*) in the larger river systems that typically support the Puget Sound Chinook salmon populations. Additionally, while the limited available research suggests that salmon-derived nutrients can benefit coho salmon, sockeye salmon (*O. nerka*), and cutthroat trout (*O. clarki*) populations, data and technical tools establishing or quantifying the relationship between marine-derived nutrients and Chinook salmon are not available.

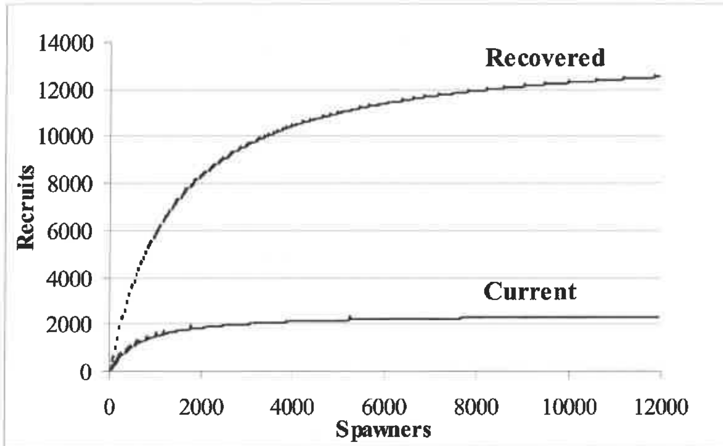
Chinook salmon populations in Puget Sound typically exhibit a relatively short freshwater residence, at least when compared with coho salmon, sockeye salmon, and steelhead. It is not known if newly emerged Chinook salmon fry actively feed on Chinook salmon carcasses, or if Chinook salmon carcasses are retained for a sufficient period in the freshwater ecosystem to allow direct consumption by emerging fry, especially in the larger river systems which support Chinook salmon. The larger river systems in the action area generally exhibit peak winter flow events which may flush the Chinook salmon carcasses from the freshwater ecosystem prior to the emergence of juvenile Chinook salmon.

The benefits of marine derived nutrients for juvenile Chinook salmon may be more fully realized in estuaries (Simenstad 1997), where most Chinook salmon rear for a critical period prior to migrating seaward. However, even less is known about the role of marine-derived nutrients in estuaries. Consequently, it has not been demonstrated that carcass nutrient limitation, as it may affect secondary production of prey species or direct enhancement of food supply, currently exerts a key limit on the productivity of Chinook salmon in the Puget Sound Action Area.

The co-managers propose to continue monitoring and the evaluation of the fisheries as required in the RMP. Based on information they obtain and that may be provided by other resource managers, the co-managers may revise the management objective in future plans, reflecting changes in environmental conditions and scientific understanding of carcass nutrient limitation. The intent of the co-managers is to increase spawning escapement in concert with the recovery of the system's productivity and capacity resulting from habitat restoration efforts. Under this approach, the co-managers will annually provide sufficient escapement to enable each management unit to generate maximum surplus under progressively improving habitat conditions. The RMP's harvest strategy will complement concurrent efforts to restore and protect habitat, improve hatchery management practices, and mitigate the impacts of hydroelectric operations. In addition, spawner recruit functions used to derive many of the RMP's objectives express the impacts of all the factors that influence productivity, including nutrient input. However, changes in productivity will be difficult to attribute to changes in nutrient input relative to other environmental responses.

For reasons discussed previously, NMFS evaluated the RMP by evaluating the future performance of the Puget Sound populations and ESU under current productivity conditions, assuming that the impacts of the hatchery and habitat actions remain as they are presently. The recovery goals in the Puget Sound Salmon Recovery Plan (NMFS 2006a; Shared Strategy for Puget Sound 2007) can provide a useful contrast between current productivity and the level of potential productivity associated with recovery. For Puget Sound Chinook salmon populations, recovery is dependent on an increase in productivity (recruitment) relative to current status, not simply achieving the optimum escapement levels associated with current habitat conditions. That is why the Puget Sound Salmon Recovery Plan includes both abundance and productivity recovery goals. All populations are well below their recovery goals for productivity (Table 8). The current status and trends in productivity for each of the Puget Sound Chinook populations are summarized in Tables 8 and 9 and discussed in the ESU overview and abundance section above. Past harvest constraints (see discussion under next criterion – Criterion 5 (b)(4)(i)(D)) have contributed to the stable or increasing trends in escapements discussed previously in this criterion. For several populations these escapements include hatchery-origin adults. However, the trend in natural-origin returns, when compared with hatchery returns, into several systems suggests that marine, freshwater, and estuary habitat quality and quantity is the primary constraint on productivity. Spawner-recruit functions derived from Ecosystems Diagnostics and Treatment or EDT [23] modeling of habitat capacity under current and recovered conditions demonstrates that natural production is constrained below that associated with a recovered habitat condition (Figure 6).

[23] The Ecosystems Diagnostics and Treatment or EDT model provides a conceptual framework for organizing information to describe a watershed ecosystem in order to apply scientific principles to the understanding of that ecosystem. The model describes how the fish population would respond to conditions in a stream based on our scientific understanding of their needs. It is an analytical tool used to analyze environmental information and draw conclusions about the ecosystem, and designed to provide a practical, science-based approach for developing and implementing watershed plans. EDT models have been used to develop fish and wildlife plans for many watersheds throughout the Pacific Northwest. As noted previously, caution is necessary with this approach. The EDT model was valuable in comparing the relative merits of different habitat restoration scenarios as it is used in this instance, but the quantitative results are highly uncertain.



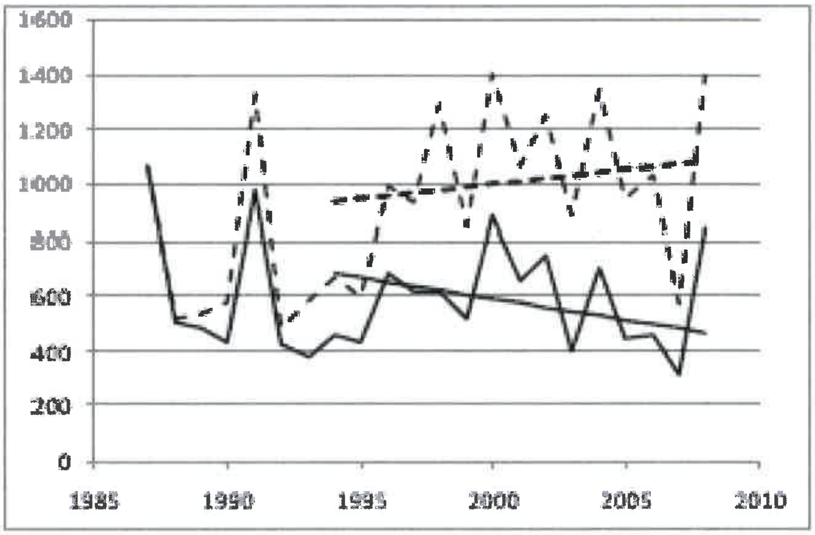
Source: 2010 Puget Sound Chinook RMP, Figure 9 on page 57

Figure 6. Productivity (adult recruits) of North Fork Stillaguamish summer Chinook salmon under current and recovered habitat conditions. Beverton-Holt functions derived from habitat analysis using the EDT method.

Further harvest constraint will not, by itself, effect an increase above the asymptote associated with current productivity, until habitat conditions improve. Very similar conclusions can be drawn from examination of current natural-origin escapement trends in the Nooksack, Puyallup, Sammamish, Skokomish, and Dungeness rivers. In these systems, natural-origin returns have remained at very low levels, while total natural escapement has increased due to hatchery programs (Table 8).

In making an evaluation of future escapement performance under current productivity conditions, it is useful to examine recent escapement trends in relation to past reductions in harvest rates. Mass marking of hatchery production has enabled managers to begin accurate accounting of the contribution of natural-origin and hatchery-origin spawners to the natural escapement for most Puget Sound Chinook salmon populations (see Chapter 6 of the RMP and Appendix A: "Management Unit Status Profiles" of the RMP). Sufficient data has accumulated to conclude that reductions in harvest rates, along with more favorable conditions for marine survival, have contributed to an increasing trend in hatchery-origin returns. In some systems harvest rates have been reduced over 40 percent since the early 1980s (see discussion under next Criterion 5, (b)(4(i)(C)). However, the returns of natural-origin fish in those same systems have not responded similarly. This evidence suggests that, in some systems, natural production is constrained primarily by the condition of the marine, freshwater, and estuary habitat (see also discussion under Section 6.4.2 – Genetic Diversity and Fitness).

The population trend for the North Fork Stillaguamish River is cited here as an example. Fingerlings released by the summer Chinook salmon supplementation program are coded wire tagged, enabling accurate estimation of their contribution to escapement. The 2004 to 2008 average total, adult-equivalent exploitation rate for the Stillaguamish Management Unit of 20 percent has declined 62 percent when compared with the 1983 to 1987 average total, adult-equivalent exploitation rate of 53 percent (see Figure 1, page 137 of the RMP). Although the return of hatchery-origin Chinook salmon appear to have responded to this decrease in exploitation rate, averaging 959 since 1999, the natural-origin returns have declined , averaging 565 fish (Figure 7). Hatchery production since 1989 has been relatively constant in the system (Tynan 2010).



Source: 2010 Puget Sound Chinook RMP, Figure 9 on page 57.

Figure 7. The return of natural-origin (solid line) Chinook salmon to the North Fork Stillaguamish River has remained relatively stable, while the number of hatchery-origin adults (dashed line) has increased substantially.

In most systems, harvest constraint, along with other ongoing conservation efforts, has contributed to stable or increasing trends in escapement (Table 9). On-going hatchery conservation programs further guard against catastrophic decline and are key to recovery for several essential populations and thus to recovery of the ESU. However, the trend in natural-origin escapement suggests that, although escapement may be stable or even trend upward toward or above the MSY level associated with current habitat condition, natural-origin recruitment only will increase marginally beyond current levels unless constraints limiting survival prior to entry to fisheries are alleviated. As described previously in Criterion 2 and in the management profiles of Appendix A of the RMP, management objectives for several management units are based on population-specific productivity and capacity estimates of MSY and conservative assumptions of environmental conditions. For these management units, implementing the RMP should experimentally test production at escapement levels greater than the estimated MSY level if they should occur, and capitalize on favorable survival conditions that may occur. Overall, based on the information presented here, NMFS concludes that implementation of the RMP would not limit the productivity of Puget Sound Chinook and

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includes provisions where information is available to promote improved productivity should environmental conditions improve.

6.3 Spatial Structure

The spatial structure of a population results from a complex interaction of the genetic and life history characteristics of a population, the geographic and temporal distribution and quality of habitat, and the disturbance level of the habitat. Although the understanding of these interactions is limited, the ability of individuals to successfully colonize and move through habitat at each subsequent life stage is essential for population viability.

As described earlier, the Puget Sound TRT identified five biogeographical regions within the Puget Sound Chinook ESU and associated each of the 22 populations with one of the regions. This structure is illustrated in Figure 1. NMFS' final supplement to the Puget Sound Salmon Recovery Plan adopted six delisting criteria that describe a viable ESU (NMFS 2006a) based on the TRT's recommendations: 1) The viability status of all populations is improved from current condition; 2) Two to four populations in each of the regions achieve viability, depending on the historical biological characteristics and acceptable risk levels for populations within each region; 3) At least one population from each major genetic and life history group historically present within each of the five biogeographical regions is viable; 4) Tributaries not identified as primary habitat are functioning sufficient to support an ESU-wide recovery scenario; 5) Production from tributaries not identified as primary freshwater habitat occurs in a manner consistent with ESU recovery; and, 6) Populations that do not meet the viability criteria for all VSP parameters are sustained to provide ecological functions and preserve options for ESU recovery.

Three of the five biogeographical regions (Strait of Juan de Fuca, Georgia Basin, and Hood Canal) contain only two populations, both of which, according to the delisting criteria in NMFS' final supplement to the Puget Sound Recovery Plan, must be recovered to viability. The Suiattle and one each of the early, moderately early, and late run-timing populations in the Whidbey Basin Region, as well as the White and Nisqually[24] (or other late-timed) populations in the Central/South Sound Region must also achieve viability (NMFS 2006a).

The previous section described the trends and status of populations within the various regions. In general, the Strait of Juan de Fuca, Georgia Basin, and Hood Canal regions are at greater risk than the other regions due to critically low abundance and/or declining growth rates of at least one of the two populations in the region. In addition, spatial structure, or geographic distribution, of the White, Skagit, Elwha and Skokomish populations has been substantially reduced or impeded by the loss of access to the upper portions of those tributary basins due to flood control

[24] The TRT noted that the Nisqually watershed is in comparatively good condition, and thus the certainty that the population could be recovered is among the highest in the Central/South Region. NMFS concluded in its supplement to the Puget Sound Salmon Recovery Plan that protecting the existing habitat and working toward a viable population in the Nisqually watershed would help to buffer the entire region against further risk (NMFS 2006a).

activities and hydropower development. It is likely that genetic diversity has also been reduced by this habitat loss. The habitat conditions conducive to salmon survival in most other watersheds have been reduced significantly by the effects of land use, including urbanization, forestry, agriculture, and development (NMFS 2005d; NMFS 2006b; NMFS 2008b; Shared Strategy for Puget Sound 2007). Rearing habitat in the ESU has been significantly reduced particularly at lower elevations due to loss of wetland, nearshore and estuary habitat, removal or degradation of riparian vegetation, channelization and bank hardening.

The diversity of some populations has been eroded further by hatchery and harvest influences in addition to degraded habitat conditions, all of which have contributed to low population sizes and loss of life history types in some areas (NMFS 2008b; NMFS 2005d; WDF et al. 1993). In particular, the distribution of early-type Chinook salmon life histories (also called spring-type) was historically much wider in the ESU (WDF et al. 1993; Nehlsen et al. 1991). Early Chinook no longer exist in the Hood Canal Region or in most rivers in the Central/South Sound Region where they occurred historically. Of the seven extant early populations, only those in the Whidbey Basin Region are not supported by conservation hatchery programs.[25] Fall Chinook populations in the Central/South Sound, Hood Canal, and Strait of Juan de Fuca regions are sustained predominately by hatchery production. Indigenous fall Chinook in the Sammamish, Puyallup, Nisqually, Skokomish, and Mid-Hood Canal watersheds have been extirpated due to habitat degradation, hatchery introgression, and historical over-fishing. Genetically, most of the present spawning aggregations in the Central/South Sound and Hood Canal Regions are similar, likely reflecting the extensive influence of transplanted hatchery releases, primarily from the Green River population (Ruckelshaus et al. 2006).

Spatial structure should be accounted for in the population level analyses with the implementation of the RMP for three reasons: 1) the spatial and temporal distribution, quantity, and quality of habitat (landscape structure) dictates how effectively juvenile and adult salmon can bridge freshwater, estuarine, nearshore and marine habitat patches during their life cycle; 2) there is a time lag between changes in spatial structure and population response, and extinction risk at the 100-year time scale may be affected in ways not readily apparent from short-term observations of abundance and productivity; and 3) population spatial structure affects evolutionary processes and may therefore alter a population's ability to respond to environmental change (McElhaney et al. 2000; Ruckelshaus et al. 2006).

A fishery could target a certain portion of the run, which may result in a decrease in the number of spawners destined to a particular spawning location or population through time. For example, the early portion of a run of salmon may be the fish that will spawn the farthest upstream. If a fishery harvests just the early portion of the total adult return, the percentage of the population spawning in the upper portion of the system may be changed. In Puget Sound, the co-managers generally shape salmon fisheries to harvest throughout the run timing of the returning adults. In river systems with multiple populations (e.g., Nooksack, Skagit), the co-managers often

[25] A captive brood program began in 2007 for the South Fork Nooksack population.

sequence fishery openings as the fish move up the rivers. However, when harvest must be reduced, fishing-related mortality on listed Chinook salmon is reserved as incidental harvest in salmon fisheries directed at other species. In these situations, the salmon fishery may concentrate incidental fishing-related mortality on the extreme ends of the run timing of listed fish in order to protect the majority of the run while providing access to other salmon species. The extent that a fishery may concentrate incidental fishing-related mortality on the extreme ends of the run could vary from year to year. In mixed-population salmon fisheries, harvest generally occurs throughout the migration of the returning Chinook salmon. In terminal areas where Chinook salmon are caught incidentally in fisheries targeting other species, harvest probably affects 10 percent or less of the run on either end of the run timing. There is currently no information to indicate that these incidental impact salmon fisheries are having deleterious effects on certain segments of the populations or to the ESU. For example, neither NMFS' status reviews (Good et al. 2005; Myers et al. 1998) nor the Puget Sound Salmon Recovery Plan (NMFS 2006a; Shared Strategy for Puget Sound 2007) noted any trends in size, weight, fecundity or other life history traits for Puget Sound Chinook salmon that might be a result of fishing activities.

The RMP includes management objectives for all but the Sammamish population in the ESU encompassing all five bio-geographical regions and the range of life histories across the Puget Sound Chinook ESU. Most populations in the Puget Sound Chinook ESU return to river systems that share a common entrance to the marine environment where the approach described in the above paragraph, coupled with management objectives appropriate to the productivity and capacity of the populations, should adequately protect the spatial structure of the populations. The spatial structure of the Mid-Hood Canal Management Unit is unique among the management units in the RMP. The Mid-Hood Canal Management Unit contains only one population, the Mid-Hood Canal rivers population (Category 2/Tier 1), which is composed of an aggregation of spawners from three adjacent rivers that are tributaries to Hood Canal. Unlike other populations within the ESU, these spawning aggregations are separated by salt water.

The historical structure of the Hood Canal Chinook salmon population is unknown (Ruckelshaus et al. 2006). Historical returns and distributions of Chinook salmon in Hood Canal have been affected by the construction of dams, fisheries, and the introduction of non-native fish. The largest uncertainty within the Hood Canal populations, as identified by the TRT, is the degree to which Chinook salmon spawning aggregations are demographically linked in the Hamma Hamma, Duckabush, and the Dosewallips rivers. The TRT identified two possible alternative scenarios to the one adopted for the Mid Hood Canal Rivers population. One is that the Chinook salmon in the Hamma Hamma, Duckabush, and Dosewallips were each independent populations (Ruckelshaus et al. 2006). Habitat differences do exist among these Mid-Hood Canal rivers. For example, the Dosewallips River is the only system in the snowmelt-transition hydroregion. The other scenario is that Chinook salmon spawning in the Hamma Hamma, Duckabush, and Dosewallips rivers were subpopulations of a single, large Hood Canal Chinook salmon population with a primary spawning aggregation in the Skokomish River. Only a few historical reports document Chinook salmon spawning in the mid-Hood Canal streams, which is consistent with one theory that they were not abundant in any one stream before hatchery supplementation began in the early 1900s. In addition the overall size of each watershed and the area accessible to anadromous fish are small relative to other independent populations (Ruckelshaus et al. 2006). Although the TRT ultimately identified two independent populations within Hood Canal Region (the Skokomish and Mid-Hood Canal rivers populations), the TRT noted that important components of the historical diversity may have been lost, potentially due, in part, to the use of transplanted Green River origin fish for hatchery production in the region (Ruckelshaus et al. 2006). Life history information for the extant populations within Hood Canal Region was not useful in discriminating different populations (Ruckelshaus et al. 2006). The TRT also found genetic data not informative in reconstructing population structure under historical conditions. Allele frequencies between the Skokomish River population and the spawning aggregate in the Hamma Hamma River (Mid-Hood Canal Rivers population) were not different (P = 0.136 as reported in Ruckelshaus et al. 2006). Extant Hood Canal Chinook salmon belonged to the same genetic cluster as late-returning Chinook salmon southern populations within the South Puget Sound Region (see Figure 5 in Ruckelshaus et al. 2006). However, each of the alternatives indicates the Mid-Hood Canal rivers are important to the spatial structure of Chinook within the Hood Canal Region.

The 1999 to 2009 average natural escapement of 150 fish for the Mid-Hood Canal Rivers population is below NMFS' critical threshold of 200 (Table 8). The Mid-Hood Canal Management Unit has exhibited a stable escapement trend since listing (Table 9). However, escapement trends in the individual rivers comprising the Mid-Hood Canal rivers population have not varied uniformly.

Since 1998, the spawning aggregation in the Hamma Hamma River has generally comprised the majority of the Mid-Hood Canal rivers population (Table 14). In comparison, the other two rivers in the population have seen decreases in escapements during this same time period. Spawning levels below 10 and 20 fish have been observed in recent years in the Duckabush and Dosewallips rivers, respectively (Table 5).

Table 14. The trend of the Mid-Hood Canal rivers population's individual spawning aggregates.

Mid-Hood Canal Rivers Population	1990 to 1996, 1998		1999 to 2009		Percent Difference[1]
	Average	Percent of Total	Average	Percent of Total	
All Spawning Components:	102	100.0%	150	100.0%	+48%
Hamma Hamma River	39	38.5%	96	66.9%	+144%
Duckabush River	10	9.8%	11	7.5%	+9%
Dosewallips River	40	38.8%	29	25.6%	-28%

[1] The Percent Difference is the difference in percent of the 1999 to 2009 average escapement when compared to the 1990 to 1996, 1998 average escapement

Genetic analysis indicates the Hamma Hamma population is not distinct from spawners returning to the Skokomish Rivers or George Adams or Hoodsport hatcheries (Marshall 1999; Marshall 2000). The degree to which this is influenced by straying of Skokomish River Chinook in addition to the use of George Adams broodstock in the supplementation program is uncertain. Exchange among the Duckabush and Dosewallips stocks, and other Hood Canal natural and hatchery populations is probable although information is limited due to the very low escapements (PSIT and WDFW 2010). The co-managers have increased mark rates of hatchery fish to distinguish them from natural-origin spawners in catch and escapement. The resulting information may provide better estimates of stray rates between the Mid-Hood Canal rivers and the Skokomish River system. Uncertainty about the historical presence of a natural population notwithstanding, current habitat conditions may not be suitable to sustain natural Chinook production. There is evidence to suggest that the changes in abundance were in part related to concurrent changes in marine net pen yearling Chinook hatchery production in the area, and therefore not indicative of changes in the status or productivity of the population per se. (Adicks 2010b).

The TRT suggests that most of the historical Chinook salmon spawning in the Mid-Hood Canal rivers was "likely to [have] occurred in the Dosewallips River because of its larger size and greater area accessible to anadromous fish" (Ruckelshaus et al. 2006). However, production from the Hamma Hamma Fall Chinook Restoration Program, a hatchery-based supplementation program, has contributed substantially to the Mid-Hood Canal rivers population. The goal of the restoration program is to restore a healthy, natural-origin, self-sustaining population of Chinook salmon to the Hamma Hamma River. This hatchery production is at least partially responsible for the recent increase in escapement observed in the Hamma Hamma River. During 2008 and 2009, it is estimated that approximately 53-85% of the Chinook salmon spawning in the Hamma Hamma River were of hatchery origin (WDFW and PSTIT 2009; WDFW and PSTIT 2010). The program may also buffer demographic risks to the Mid-Hood Canal Rivers population, particularly to the natural-origin spawning aggregate returning to the Hamma Hamma River (Jones 2006, NMFS 2004d).

NMFS then examined the practical effect of the fisheries in the RMP on the structure of the Mid-Hood Canal Rivers population. Using the 2010 RMP Likely scenario, it is conservatively assumed that escapements will remain more closely aligned to the 2004-2008 estimated average escapement in the retrospective analysis (111 fish) than the 1994-2008 average (195 fish), which includes years of substantially higher abundance. Benefits to this population from further reductions in fisheries-related impacts are limited. Given the ratio of recent year escapements into the individual river systems in the Mid-Hood Canal population, a total closure of southern U.S. fisheries (including Puget Sound) would result in an estimated increase of at most 14 adults, to the Mid-Hood Canal population including 9 to the Hamma Hamma, 4 to the Dosewallips, and 1 to the Duckabush. These estimates do not account for natural mortality of the fish that go uncaught. As a result, these estimates are higher than the number that would actually return.

Since most harvest impacts on this population occur outside Hood Canal and the abundance in each of the rivers is so small, it is not feasible for the co-managers to impose differential harvest effects on the individual spawning aggregate components in order to adjust spawning distribution among the rivers. Given the diffuse timing of fisheries outside Hood Canal, however, it is unlikely the fisheries would differentially affect the spatial structure of the population. Exploitation rates on the Mid-Hood Canal population within Hood Canal averaged 0.3% from 2004 through 2008. The rivers and adjacent areas are currently closed to fishing during the primary Chinook migration and spawning times (WDFW and NWIFC 2010b) and it is expected that these regulations will remain in place throughout the duration of the RMP. In the future should the size and distribution of abundance among rivers increase to the extent fisheries might affect spatial structure of the Mid-Hood Canal Rivers population, or the distribution of fishing mortality changes, further fishery actions may be required. Additional discussion regarding the Mid-Hood Canal Rivers population, in regards to the likelihood of survival and recovery of the ESU, will be provided in the section that addresses Criterion 6, (b)(4)(i)(D).

6.4 Diversity

6.4.1 Biological Diversity

The transfer from parents to offspring (heritability) of certain biological traits such as age at maturity, growth rate, and the effect of these traits on each other has been researched and described (Carlson and Seamons 2008; Clark and Blackbird 1994; Donaldson and Menasveta 1961; Hankin et al. 1993; Heath et al. 1994a and 1994b; Silverstein et al. 1998). Under certain circumstances, fishing may influence the biological traits of salmon that return to spawn, and potentially the traits that are passed to their offspring.

Diversity in biological traits is important so that populations can successfully respond to changing environmental conditions. For example, numerous studies have emphasized the possible importance of large size in naturally-spawning populations of Chinook salmon for mate choice and reproductive success (Baxter 1991; Berejikian et al. 2000; Bromaghin et al. in press; Healey 2001; Healey and Heard 1984; Roni and Quinn 1995; Silverstein and Hershberger 1992). A fishery is characterized as selective whenever fish with particular characteristics are caught more frequently than they occur in the population at large. Selective fishing may affect the diversity of size, age and sex ratio in the salmon population escaping to spawn.

Salmon fisheries may be size-selective, stock-selective, or species-selective. Size-selective fisheries catch fish within a certain size range at a greater rate than smaller or larger fish. Stock-selective fisheries harvest some populations at different rates than other populations. Fisheries are usually deliberately structured to be stock-selective or species-selective by shaping the time, location, or physical attributes of fish that may be caught. Harvest managers have implemented both stock- and species-selective fisheries in Puget Sound.

Several recent studies have used age-structured quantitative genetic models to assess the possible long-term evolutionary effects of size-selective fishing on Chinook salmon (Hard 2004a; Hard et al. 2009; Bromaghin et al. in press; Eldridge et al. in press). Based on genetic data from one Puget Sound population, Hard (2004a) concluded that under most conditions of high populations productivity and moderate gear selectivity, directional selection imposed by size-selective fishing is likely to produce modest short-term reductions in size, but the effects depend critically on population productivity, harvest rate and selectivity, the strength of stabilizing natural and sexual selection on spawner size, and the age structure and heritability of each trait, as well. Hard also found that the capacity of size-selective fishing to reduce size depends on correlations among size, age and growth rate. Other scientists have found similar results (Andersen and Brander 2009).

When fisheries are stock-selective, open and closed periods for fisheries may result in differential exploitation rates being applied to different stocks where timing patterns differ among stocks. Because run timing is thought to be an inherited trait, such fishery harvest policy may, in the long term, unintentionally select for run-timing that corresponds those stocks with the lower exploitation rates (see Nicholas and Hankin 1988 for examples of this phenomenon in a hatchery setting). Other examples of stock-selective fisheries for salmon are those that call for the release of all fish caught without an identifying mark (e.g., intact adipose fins), while a certain number (specified by bag or possession limits) of fish with marks may be retained. These policies are deliberately designed to produce, at least in theory, greater exploitation rates for hatchery fish (marked) than for wild fish (unmarked).

Long-term Selective Effects of Fishing in Puget Sound

Although the potential consequences of size-selective fishing have been recognized, the ability of fisheries managers to address the potential long-term consequences is limited. The magnitude of selective effects will vary depending on the intensity of selective-fishing on a particular salmon population, the period of time over which those effects are encountered, and the biological characteristics of the population itself (Heath et al. 1994a; Hard 2004a; Eldridge et al. in press). Hard (2004a) and Hard et al. (2009) predicted that, in general, reducing the exploitation rate tends to reduce the selection intensity, and that changes in life history traits under most of the harvest scenarios they examined were expected to be modest, over a few generations for productive populations experiencing sustainable harvest rates.

Information on the effects of fishery selectivity on Puget Sound Chinook salmon is very limited. Ricker (1980, 1981, 1995) documented a decline in the average weight of Puget Sound Chinook salmon caught between the 1950s and 1970s, which stabilized at a lower level in the 1980s. However, his analysis was not population specific and was conducted on mixed-stock fishery data which included populations returning both to Canada and Puget Sound. NMFS found a decline in the size of Puget Sound coho salmon spawners since the 1970s, and noted it as a risk factor (Weitkamp et al. 1995). However, in its review of West Coast Chinook salmon populations (Myers et al. 1998), NMFS did not note any trends in recent decades for size, weight, or age for Puget Sound Chinook salmon that might be the result of fishing activities; nor was it considered a limiting factor in recovery (NMFS 2006a). The lack of an observed selective-fishing effect may be the result of the way Puget Sound fisheries are structured. Puget Sound salmon fisheries, including those harvesting Chinook salmon, are managed for stock-specific exploitation rates that depend on the underlying productivity of each population where information is available. In most areas, Puget Sound Chinook salmon harvest generally occurs throughout their run timing. In a few areas, harvest may be focused on the early or late part of the Chinook salmon run in order to protect the majority of the population while allowing some harvest on other salmon species that occur earlier or later in timing. However, this generally will affect 10 percent or less of the population on either end of its run timing, depending on the specifics of the annual fishing regime.

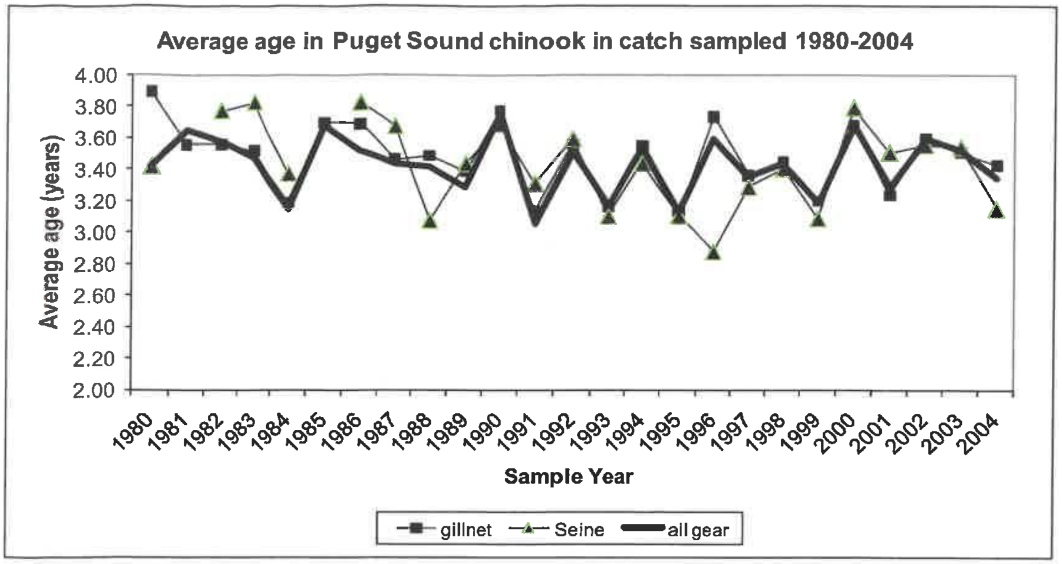
With regard to the potential age-selectivity of fishing gear types, Puget Sound gillnet fisheries do not appear to be substantially more age-selective for Chinook salmon than gear types like purse seines that use small mesh and are thus considered to be relatively non-selective in these local fisheries (Table 15 and Figure 8). Based on the Puget Sound population-specific data that are available, there are no trends in age structure observed in Puget Sound Chinook salmon escapement over the last 24 to 30 years that one might expect if there were age-selective fishing effects (Figure 9).

Table 15. Average age composition of the Puget Sound Chinook salmon catch by gear type.

Gear Type	Age composition of Puget Sound Chinook salmon catch (1980–2004)			
	Age-2	Age-3	Age-4	Age-5
Gillnet	2%	34%	59%	5%
Purse seine	6%	37%	55%	4%
All gear types	3%	35%	56%	6%

Source: Bishop 2010

Figure 8. Age composition of Puget Sound Chinook salmon catch. Average age has changed little since 1980.



Source: WDFW 2007.

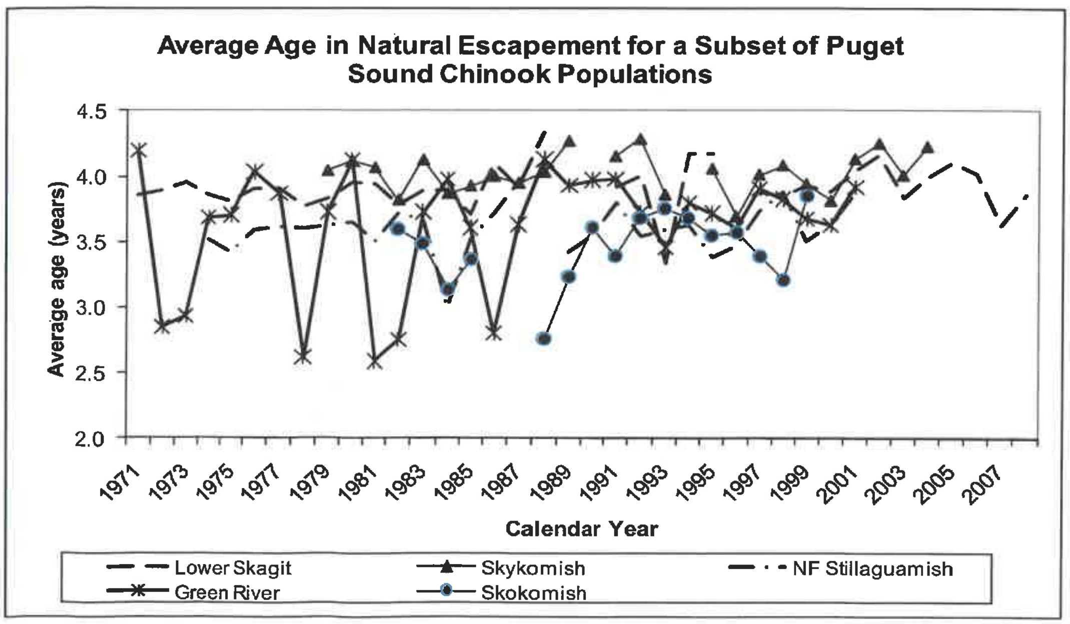


Figure 9. Age composition of escapement in several Puget Sound Chinook salmon populations. Average age has changed little since the 1970s.

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NMFS also conducted analyses to determine whether there were detectable changes in size at a specific age and sex of Puget Sound Chinook salmon and, if so, whether they might be attributable to fishing effects. That is, although there might not be a change in the age composition, fish of the same age could be getting smaller or larger over time. NMFS focused its analyses on a subset of Puget Sound Chinook salmon populations for which sufficient information was available and that represented some diversity in life history (spring and fall run types), geographic distribution, and fishing intensity. NMFS also limited its analysis to terminal in-river net fisheries[26] for which data were available so that the analyses were not confounded by the catch of immature fish that commonly occurs in marine fisheries. While NMFS is aware that marine fisheries may also be selective through the use of size limits or selective gear, the analyses were intended to narrow the number of environmental factors that might account for a change in size at age detected in the analysis. To do this, the analyses should evaluate adults experiencing as similar an environment as possible. Otherwise, it is not be possible to determine whether a change in size at age from analyses that included immature fish was due to a change in the size of returning adults of a particular age, or due to differences in growth rates from fish that matured at a given age versus those that would have grown and matured at an older age. While fisheries may act to affect either size directly or growth rate (see earlier discussion), these analyses are intended to examine the direct effect of fisheries on size. Although we can theoretically explore the effects of fisheries on growth rate and maturation (Eldridge et al. in press), it is not technically feasible, with the tools and data available at this time, to directly assess the effects of Puget Sound fisheries on growth rate.

The analyses were broken into three steps: (1) compare the average size at age and sex of coded-wire tagged fish recovered in the terminal net fishery with those recovered in the hatchery escapement; (2) size at age and sex information collected from naturally spawning adults was compared with results for returning hatchery adults; and, (3) analysis was conducted to see whether the magnitude of change in size could be linked to effects of the terminal fishery. A similar analysis was conducted for the evaluation of the 2004 Puget Sound Chinook Harvest RMP. The analytical methods are the same, but the 2010 analysis incorporates the additional years of available data. Differences in the results of the two analyses are also noted in the following discussion. A more detailed discussion of the data and methods can be found in Ryding and Reidinger (2010) and Ryding (2010).

As seen in Table 16, the average total exploitation rates for these populations have decreased over time. Terminal fishery rates have remained relatively stable or increased over the same time period, indicating that terminal harvest accounts for a greater proportion of the harvest related mortality in recent years. The Green River, Skokomish, Nisqually and Samish populations have moderate to high terminal and total exploitation rates while terminal exploitation rates on the Nooksack and Skagit spring populations are low. Total exploitation rates for the Skagit spring Chinook are moderate.

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[26] These fisheries intercept fish returning to a single river system; the one in which the fishery occurs.

Table 16. Characteristics of populations chosen for size at age analyses.

			Average Exploitation Rate		
Population	Location	Life History Type	Time Period	Total	Terminal
Green River	Central Puget Sound	Fall	1983-2008 1983-1994 1995-2008	56% 72% 42%	19% 20% 18%
Skokomish	Hood Canal	Fall	1983-2008 1983-1994 1995-2008	65% 85% 49%	22% 24% 20%
Nisqually	South Puget Sound	Fall	1983-2008 1983-1994 1995-2008	86% 95% 77%	39% 30% 46%
Nooksack	North Puget Sound	Spring	1983-2008 1983-1994 1995-2008	27% 34% 21%	2% 2% 2%
Samish	North Puget Sound	Fall	1983-2008 1983-1994 1995-2008	87% 90% 84%	45% 33% 56%
Skagit	North Puget Sound	Spring	1983-2008 1983-1994 1995-2008	44% 62% 29%	6% 11% 2%

Source: LaVoy 2010d

Gillnets are the primary fishing gear used in terminal net fisheries. Three and four year old fish comprise the majority of the fish caught in the terminal fisheries (Figure 8, Table 15). Therefore, if fisheries are exerting a significant effect on size at age, it would most likely be observed for these ages. Some caution is warranted in the use of the results since the analyses are based on the best available data and not that which was collected under an experimental design with the intent of examining changes of mean length over time.

The first step involved two parts: (1) coded-wire tagged fish recovered in the terminal net fishery and escapement were examined for overall trends in average size at age/sex during the period 1975-2007; then, (2) average size at age/sex of the same coded-wire tagged fish recovered in the terminal net fishery was compared with those recovered in the hatchery escapement (Ryding 2010; Ryding and Reidinger 2010). These populations are subject to the strongest fishing pressure and therefore are most likely to show size-selective responses if they occur. These coded-wire tag fish are part of the Pacific Salmon Commission indicator stock program which was implemented specifically to assess survival, distribution, and fishing-related mortality for

Puget Sound Chinook salmon. The use of coded-wire tagged fish ensured that the analysis included only fish from the same population based on the unique coded-wire tag code implanted into the fish prior to their release from the hatchery. Several new indicator stock programs have been added since the 2004 analysis, but the number of years of data and the number of recoveries are not yet sufficient to provide meaningful results for these programs.

The effect of mark-selective fisheries on the relative contribution of hatchery and wild fish to escapement is not a concern at this point given the stocks and years used in the analysis. Mark-selective fisheries are designed to harvest hatchery fish at a higher rate than wild fish. The proportion of hatchery fish relative to wild fish on the spawning grounds could change as a result of the fishery thereby calling into question whether the hatchery fish were experiencing the same selective pressures as the wild fish and could be used to represent them. However, of the stocks in the analysis, only Skagit spring and Nisqually fall Chinook have had terminal mark-selective fisheries and only since 2005. The fishery has occurred for too few years to show any effects of that fishery on spawning ground contribution in the dataset we currently have available. In addition, initial modeling results indicate more intense fishing pressure is required from selective fisheries to effect hatchery contribution to escapement than occurs in the Skagit fishery (Kope 2009). Available comparisons of marked and unmarked coded-wire tagged fish subject to selective fishing detected limited differences in contribution in some years and for some stocks but those differences were not consistent in direction or magnitude across the stocks and years evaluated (Alexandersdottir 2008). Results of the length analysis are presented in Tables 17 and 18. Estimates are presented as the increase or decrease in the length of a fish per year. Significant results should be treated with caution because thus far no adjustments were made in the α-level to account for the number of tests in the analysis. The effect of this might be that currently statistically significant results would not be significant. Therefore, this analysis will overestimate the number of significant results.[27]

[27] The series of tests required to assess length trends across all stocks requires a downward adjustment to the significance level under the original null hypothesis of no change in length over time. One method would be to divide the α-level (0.05) by the number of tests (48), the "new" significance level (0.001) would indicate that only the trends for age-3 male Skagit, age-4 male Skokomish (escapement only), age-4 Nisqually and age-4 female Green and Skokomish, fish would be significant. However, this simple Bonferroni correction is a highly conservative adjustment.

Table 17. Trends in size at age and sex for selected Puget Sound Chinook populations using fishery and escapement data combined (significance level (P-value) = 0.10). Significant results are shaded. The analysis of fishery and escapement data combined found no significant difference between female and male length trends. Two-year old females are rare and they were either not present in the available data or sample sizes were insufficient for analysis.

Hatchery	Life History Type	Terminal Exploitation Rate	Age 2 M+F Combined Estimate	Age 2 M+F Combined P-value	Age 3 M+F Combined Estimate	Age 3 M+F Combined P-value	Age 4 M+F Combined Estimate	Age 4 M+F Combined P-value	Age 5 M+F Combined Estimate	Age 5 M+F Combined P-value
Nooksack Fingerling	Spring	Low	0.573	0.032	0.2	0.134	0.08	0.419	0.144	0.321
Nooksack Yearling	Spring	Low	0.236	0.029	0.351	0.337	-0.076	0.651	-0.644	0.005
Samish	Fall	High	0.3	0.034	0.108	0.014	0.033	0.316	0.076	0.69
Skagit	Spring	Low	0.166	0.256	0.369	<0.001	0.178	0.042	0.228	0.001
Green River	Fall	Moderate	0.213	0.002	0.027	0.541	-0.07	0.018	-0.013	0.838
Nisqually	Fall	High	0.332	0.083	0.226	0.038	0.047	0.463	-0.039	0.801
Skokomish	Fall	Moderate	0.241	0.008	0.066	0.316	-0.036	0.429	0.157	0.111

Source: Ryding and Reidinger, 2010.

Table 18. Difference in size at age and sex for selected Puget Sound Chinook populations comparing fishery samples with those recovered in escapement (significance level (P-value) = 0.10). Significant results are shaded. The analysis found no significant differences between size in the terminal fishery and in escapement for females. Two-year old females are rare and they were either not present in the available data or sample sizes were insufficient for analysis.

Hatchery	Life History Type	Terminal Exploitation Rate	Age 2 Males Estimate	Age 2 Males P-value	Age 3 M+F Combined Estimate	Age 3 M+F Combined P-value	Age 3 Males Estimate	Age 3 Males P-value	Age 4 M+F Combined Estimate	Age 4 M+F Combined P-value	Age 4 Males Estimate	Age 4 Males P-value	Age 5 M+F Combined Estimate	Age 5 M+F Combined P-value	Age 5 Males Estimate	Age 5 Males P-value
Samish	Fall	High			3.060	0.916	-1.180	0.288	1.913	0.783	1.642	0.604	-1.352	0.362	1.973	0.910
Skagit	Spring	Low							1.286	0.610	1.121	0.854	0.790	0.722	-0.870	0.369
Green River	Fall	Mod.	-0.427	0.375	0.310	0.681	0.438	0.731	1.895	1.00	2.77	0.99	-0.713	0.269	-0.77	0.365
Nisqually	Fall	High	-1.800	0.193	-0.822	0.044	-1.357	0.016	1.562	0.884	2.978	0.882	2.907	0.937	3.754	0.827
Skokomish	Fall	Mod.	-1.049	0.074	-1.471	0.104	-0.646	0.317	0.872	0.808	-0.223	0.458	-0.061	0.495		

Source: Ryding 2010.

Step 1 of the analysis indicates that there were significant trends in size at age for some Puget Sound Chinook salmon hatchery populations. In the analysis of fish returning to the terminal area (terminal fishery and escapement combined), no differences in trends or mean lengths across years were detected between the sexes so the data were combined (Table 17). Twelve of the 28 trends were significant; particularly for 2 year old fish. Of those, all but two were positive across all age/stock combinations indicating increasing size at age. Only 5 year old Nooksack yearling-type and 4 year old Green River fish showed declining trends. Significant trends were found across all ages, but varied across populations, and most were of ages that are thought to be least affected by fishing. Trends ranged from a decrease of 0.64 centimeters per year for 5 year old Nooksack yearling-type adults (about 3 centimeters per generation) to an increase of 0.57 centimeters per year for 2 year old Nooksack fingerling-type adults (about 2-3 centimeters per generation).

There were only three cases where significant differences in length between fish caught in the terminal fishery and those in escapement were detected. That is, the trends observed for terminal abundance were also reflective of escapement in most cases. Harvested age 2 fall Chinook males from George Adams were larger than escaped fish. Harvested Nisqually River age 3 fall Chinook were, on average, 0.82 cm. larger in length than their escaped counterparts over the range of years examined in the analysis (1988 – 2007); males were approximately 1.36 cm larger than fish returning to the hatchery and spawning grounds. There were not enough years of recovery information to analyze length differences for Nooksack spring Chinook. No significant differences in females for any of the stocks. For the ages most likely to be affected by fisheries (three and four year old fish), significant trends in size at age in those stocks with moderate to high exploitation rates were increasing except for four year old Green River fish. Of these stocks, only the Nisqually exhibited significant differences in size at age between the terminal abundance and escapement, and that only for three year old fish.

These results are in contrast to the 2004 analysis (Ryding and Reidinger 2004) where, except for four year old fish, there was no consistent pattern in the trends of size at age, with trends being significantly different between males and females and trends in female size at age more often statistically significant than those of the males. Where terminal abundance (catch plus escapement) was compared with escapement, the results were generally similar. For the ages most likely to be affected by fisheries (three and four year old fish), all statistically significant trends in size at age in those populations with moderate to high exploitation rates were decreasing. All trends in size at age for these populations for age four males and females were statistically significant and declining. Trends were also significant and declining for age three females for Skokomish River hatchery escapement and Nisqually River terminal abundance. For three and four year old fish in those populations with low terminal exploitation rates, only Skagit spring three year old females was statistically significant and the trend was increasing.

Therefore, this step of the analysis indicates that there were significant trends in size at age for some Puget Sound Chinook salmon hatchery populations which are generally inconsistent with the expectation that populations with high exploitation rates would show declining trends in size for ages most likely to be affected by fishery selectivity. When populations with moderate to high terminal area exploitation rates are compared with populations with low exploitation rates, significant trends showed almost exclusively increasing size at age for the two ages most likely to experience any selective effects. Nisqually age 3 fish were statistically smaller in escapement compared with terminal abundance but the overall trend in size at age for the populations is increasing. Whether these changes are biologically significant is unknown. The RMP proposes substantial reductions in exploitation rates for both the Nisqually and Skokomish populations which would be expected to reduce fishing pressure on size at age if it has been a contributing factor. These results are very different than the earlier 2004 analysis which suggested a possible fishery effect on size of populations with moderate to high terminal exploitation rate.

The results should also be viewed in light of other factors that might influence size at age: (1) environmental influence may be overwhelming any effect of fisheries on size at age; (2) the difference in size at age between terminal abundance and escapement for Nisqually age four Chinook which are also vulnerable to selective fishing effects were insignificant even though four year old fish contribute at similar levels; (3) the trends would also have reflected the result of cumulative selective pressures of fisheries other than Puget Sound terminal net fisheries. The increased amount of data since the previous analysis in 2004 should enhance our ability to detect trends if they exist.

In the second step of the analysis, size at age, and sex information collected from naturally spawning adults was compared with results from the first step. This aspect of the analyses is intended to compare adult spawners that spawn naturally with the hatchery-based comparison of recovered coded-wire-tagged adults from the same population.[28]

The results of the analysis on the natural spawners by each population and age group are summarized in Table 19. Data for two of the six Puget Sound Chinook salmon populations evaluated in Step 1 were available to conduct the analysis, including only one of the four populations in the moderate-high exploitation rate category. The trends in size at age were significant for all four analyses conducted. Trends were not significantly different among males and females although the intercepts were slightly different. Size-at-age trends are increasing for both populations across ages.

[28] The length and age data used in these analyses were collected from fish on spawning grounds and are thought to represent primarily "wild" spawning fish. Only unmarked salmon (fish with adipose fins intact) were used in the analysis.

Table 19. Changes in size at age for selected Puget Sound Chinook populations (significance level (P) = 0.05). Significant results are shaded.

Population	Life History Type	Terminal Exploitation Rate	Age 3		Age 4		Age 5	
			Estimate	P-value	Estimate	P-value	Estimate	P-value
Skagit	Spring	Low			0.374	0.006	0.438	<0.001
Green	Fall	Moderate	0.190	0.063	0.210	<0.001		

Source: Conrad 2010

A comparison of results from Step 1 and Step 2 is summarized in Table 20. The results in Steps 1 and 2 are consistent in direction and significance of trends for only one of the four population/ages that were compared. However, three of the four share positive trends although only one of those was statistically significant in the Step 1 analysis. Both analyses indicated trends between male and female Chinook salmon spawners were similar. The results of the analyses in Step 2 seem to indicate that trends of size at age between the hatchery and naturally spawning components may be different for four year old Green River fish. Neither of the analyses indicates that fisheries are affecting the naturally spawning component of the population in the ways that might be expected, i.e., declining size at age with increasing exploitation. The differences in the two analyses could reflect actual differences between trends in size-at-age in hatchery and naturally-spawning adult Chinook, or differences in the sampling and data collection in the two environments.

Table 20. Comparison of size at age analyses for hatchery and natural spawning escapement analysis for those population and age strata in common to both analyses. Significant results are shaded.

Population	Life History Type	Terminal Exploitation Rate	Age	Step 1		Step 2	
				Estimate	P-value	Estimate	P-value
Skagit	Spring	Low	4	0.178	0.042	0.374	0.006
			5	0.228	0.001	0.438	<0.001
Green	Fall	Moderate	3	0.027	0.541	0.190	0.063
			4	-0.07	0.018	0.210	<0.001

Sources: Conrad 2010; Ryding and Reidinger 2010.

From the discussion above, it appears that most trends in size at age are increasing or are not significant and that fisheries are not currently exerting a deleterious effect. However, the number of stocks for which sufficient information is available is very limited. An analysis was conducted to see whether the magnitude of change in size could be linked to the intensity of the fishery (Step 3). To do this, the populations were assessed using the models of Hard (2004a) to determine the extent to which fisheries might be a factor where statistically significant patterns in size at age were identified in the first two steps. The model examined four possible scenarios:

two levels of legal size threshold (50 and 70 centimeters) and two levels of natural selection intensity (strong and weak) on size (Hard 2004b). This step compares what the trends in size at age would be under different levels of environmental and fishing conditions with the results in Step 1 to see if the observed trends are consistent with any of the scenarios. The same general conclusions with regard to increasing and decreasing trends are equally applicable to results from Step 2. A more detailed description of the method and results can be found in Section 3.3.7 of the Final Environmental Impact Statement for the 2004 Puget Sound Chinook Harvest Resource Management Plan (NMFS 2004a).

The analysis in Step 3 indicated that the expected trends estimated by the harvest model generally explained only a small fraction of corresponding observed trends. This is because both genetic and environmental effects on size and age are constant in the model over the time series. These results indicate that environmental influences on the observed size trends are large and may dominate fishery selection. For decreasing observed trends, these influences may include factors such as environmental conditions that reduce growth and size, or artificial or domestication selection in the hatchery. However, these influences also appear to vary considerably among the populations, pointing to the possibility of marked population-environment interaction effects. For increasing observed trends, these influences are likely to reflect environmental conditions that enhance growth and size, which could result from more favorable marine conditions, improvements in hatchery practices, reductions in harvest intensity, changes in migration patterns, or other factors that affect growth and size. Unfortunately, it is not possible from the present analysis to determine the directions or magnitudes of these environmental effects for any particular population with confidence because harvest and environmental effects on growth and size cannot be discriminated reliably. Overall, based on the information presented here, NMFS concludes that implementation of the RMP would not exert a deleterious effect on the biological diversity traits of Puget Sound Chinook most likely to be affected by fisheries. However, the analysis also acknowledges the limitations of the analysis and thus underscores the importance of continuing to monitor and evaluate the potential effects of fisheries on size and age of Puget Sound Chinook.

6.4.2 Genetic Diversity

At this time, based on the weight of available scientific information, NMFS believes that artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery fish and in the progeny of naturally spawning hatchery fish relative to desired levels of diversity and productivity for natural populations. Hatchery fish thus pose a threat to natural population rebuilding and recovery when they interbreed with fish from natural populations. That risk is outweighed under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. However, the extent and duration of genetic change and fitness loss and the short and long-term implications and consequences for different species, for species with multiple life-history types, and for species subjected to different hatchery practices and protocols remains unclear and should be the subject of further scientific investigation. As a result, NMFS believes hatchery intervention is a legitimate and useful tool to help avert, at least in the short-term, salmon and steelhead extinction, but otherwise managers should seek to reduce interactions between hatchery and natural-origin fish as the risk of extinction is reduced consistent with the overall recovery of the ESU, implementation of treaty Indian fishing rights, non-Indian fisheries, and harmony with other applicable laws and policies.

NMFS understands that there is interest in and concern over genetic effects when hatchery fish escape harvest and interbreed with fish from a natural population. This RMP is being evaluated under Limit 6 of the 4(d) Rule that pertains to jointly developed state and tribal management plans. The 4(d) Rule includes separate provisions that directly address questions related to hatchery operations. Limit 5 of the 4(d) Rule addresses Hatchery Genetic Management Plans (HGMPs) and requires, in part, that:

> "(E) The HGMP . . . account for the . . . program's genetic and ecological effects on natural populations, including disease transfer, competition, predation, and genetic introgression caused by the straying of hatchery fish."
>
> "(F) The HGMP describes interrelationships and interdependencies with fisheries management."

In fact, the scope of management issues and environmental effects for the system of nearly 120 hatchery programs in Puget Sound is much broader than just genetic effects and that is why a comprehensive evaluation of hatchery effects in Puget Sound is already underway. This winter, NMFS intends to invite public review and comment on a Draft Environmental Impact Statement and on two RMPs and 116 HGMPs developed by state and tribal co-managers for consideration under the Endangered Species Act. In the interim and for the purposes of the Chinook salmon harvest RMP submitted by state and tribal co-managers, NMFS offers the following comments in response to questions and comments regarding genetic effects when hatchery-origin fish interbreed with natural-origin fish.

Various types of hatchery-related genetic effects have been described (Busack and Currens 1995, Campton 1995, Waples 1999). Two categories of effects are particularly germane for hatchery programs that produce salmon primarily for harvest purposes in the Puget Sound region: outbreeding effects caused by gene flow and hatchery selection (often called domestication).

Outbreeding Effects

Hatchery fish are a risk to natural population productivity and diversity when they interbreed with natural-origin fish. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1993; Quinn 1997). Natural straying serves a valuable function in preserving diversity through genetic drift and in re-colonization of vacant habitat, and is only considered a risk when it occurs at unnatural levels or from unnatural sources. Hatchery fish straying is considered a risk because it adds to natural straying and because it is an unnatural source. In fact, hatchery fish may exhibit reduced homing fidelity relative to natural-origin fish

(Grant 1997; Quinn 1997; Goodman 2005; Jonsson *et al.* 2003), resulting in unnatural levels of gene flow into recipient populations, either in terms of sources or rates. Rearing and release practices, and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997).

Gene-flow into a natural population from naturally spawning hatchery fish can have two effects. It can increase genetic diversity (e.g., Ayllon et al. 2006) but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population's level of adaptation, a phenomenon called outbreeding depression (Edmands 2007, McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICTRT 2007), and the greater potential for outbreeding depression. Additionally, exaggerated rates of straying of fish to other populations within or beyond the population's Major Population Group (MPG) or Evolutionarily Significant Unit (ESU) or a steelhead Distinct Population Segment (DPS) can have an homogenizing effect, decreasing intra-population genetic variability (e.g., Vasemagi *et al.* 2005), and increasing risk to population diversity, one of the four parameters measured to determine population viability under the ESA. Reduction of within-population and among-population diversity can reduce adaptive potential.

Often, the number of hatchery fish entering natural spawning areas is cited as important information for determining effects on diversity and productivity from straying, but caution must be taken if that is the only information available (see the April 2011 NMFS BiOp for 3 Umatilla hatchery programs). Adult salmon may wander on their return migration, entering and then leaving tributary streams before finally spawning (Paster 2004). These "dip-in" fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer *et al.* 2008). Caution must also be taken in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite considerable presence of strays in the spawning population (Saisa *et al.* 2003; Blankenship *et al.* 2007). The causative factors for poorer breeding success of strays are likely similar to those identified as responsible for reduced productivity of hatchery-origin fish in general (see below), e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (e.g., Leider *et al.* 1990; Reisenbichler and McIntyre 1977; McLean *et al.* 2004; Williamson *et al.* 2010).

Another important consideration in evaluating risks to natural population diversity and productivity from outbreeding depression is the origin of the hatchery fish that interbreed with natural fish. The use of non-native broodstocks and egg and fish transfers between hatcheries were once common practices in Puget Sound. These practices have been curtailed, but the long-lasting effect of those past practices is the best explanation for the low levels of genetic distinction among many Puget Sound Chinook populations. Outbreeding depression involving Puget Sound Chinook salmon has not been investigated and there are no studies of the effects of subyearling Chinook hatchery programs from which to learn. In fact, little research has been done on outbreeding depression in any salmonids, and what has been done has focused on distantly related populations such as odd- and even-year pink salmon (e.g. Gilk 2004). This scientific uncertainty is a high priority for investigation and NMFS expects research on this topic to begin soon.

Hatchery Selection (Domestication)

Selection in the hatchery, often called domestication), is a threat to natural population productivity or fitness when hatchery and natural-origin fish interbreed. Hatchery selection occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program. An example of the latter is advertent or inadvertent use of earlier arriving fish for hatchery broodstock, the results of which appears to have advanced adult run timing of the aggregate natural and hatchery populations by a month over several decades for some Puget Sound coho and Chinook salmon programs (Quinn et al. 2002). Hatchery selection can range from relaxation of selection that would normally occur in the wild, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999).

Genetic change and fitness reduction resulting from hatchery selection depends on: 1) the difference in selection pressures; 2) the exposure or amount of time the fish spends in the hatchery environment; and, 3) the duration of hatchery program operation (i.e., the number of generations that fish are propagated by the program). On an individual level, exposure time in large part equates to fish culture, both the environment experienced by the fish in the hatchery and natural selection pressures independent of the hatchery environment. On a population basis, exposure is determined by gene flow proportions of natural-origin fish being used as hatchery broodstock and hatchery-origin fish spawning in the wild (Lynch and O'Hely 2001, Ford 2002), and then by the number of years the exposure takes place. In assessing risk or determining impact, all three levels must be considered. Theoretically, strong selective fish culture with low hatchery-wild interbreeding can pose less risk than relatively weaker selective fish culture with high levels of interbreeding.

Most of the empirical evidence of hatchery selection comes from studies of steelhead, a species that is reared in the hatchery environment for an extended period - one to two years - prior to release. Chinook salmon in Puget Sound are very different with the majority (94%) reared for just a few months in the hatchery environment. One especially well publicized steelhead study (Araki et al. 2007a,b; 2008), showed dramatic fitness declines in the progeny of naturally spawning hatchery steelhead. Researchers and managers alike have wondered if these results could be considered a potential outcome applicable to all salmonid species, life-history types, and hatchery rearing strategies.

To investigate this question, the RIST[29] (2009) reviewed and summarized 18 published and unpublished studies that directly estimated the fitness of hatchery-origin fish relative to natural-

[29] The Recovery Implementation Science Team (RIST) is responsible for providing NMFS with scientific assessment of technical issues related to salmon recovery planning and implementation in the Northwest.

origin salmonids. Most of the studies (17) evaluated anadromous salmonid species that exhibit a life-history pattern typified by at least one year of rearing in freshwater (i.e., yearlings). No studies have been conducted to investigate the relative reproductive effectiveness and fitness of sub-yearling hatchery Chinook salmon or to determine hatchery-related fitness effects associated with the production of subyearling Chinook salmon, like those in Puget Sound. In summarizing study results, RIST (2009) reported that, among hatchery-origin stocks that were propagated for less than five generations, average relative fitness across studies was 0.65 for steelhead (n = 3; range 0.31 to 0.85), 0.75 for Atlantic salmon (n = 1), 0.85 for Chinook salmon (n = 4; range 0.52 to 1.16) and 0.83for chum salmon (n = 1). A relative fitness of 0.83 means that hatchery fish in the study were only 83 percent as fit as a natural-origin fish. These results need to be interpreted with care in making comparisons of hatchery-origin and natural-origin fish from the same population and expected fitness loss in subsequent generations, in part, because it is unclear how much of the difference is genetic (rather than environmental), and of that, how much is heritable from one generation to the next.

The three-level approach to hatchery selection risk implies three possible approaches to risk reduction: fish culture changes, control of hatchery-wild interbreeding, and limitation of program duration. The Hatchery Scientific Review Group (HSRG) largely focused on the second level for reduction of hatchery selection risk. Based on two heuristic models for genetic change in a population affected by interbreeding with hatchery-origin fish and similar conclusions from another heuristic model (Lynch and O'Hely 2001, Ford 2002), the HSRG arrived at gene-flow recommendations for conserving fitness focusing on two parameters: pHOS, the proportion of natural spawners that are hatchery-origin fish; and pNOB, the proportion of broodstock that are natural-origin fish. For programs that have gene flow in both directions, the equilibrium point is called the proportionate natural influence (PNI), and is approximated by pNOB/(pNOB+pHOS)[30]. If a program is run at a PNI greater than 0.5, it is assumed that natural selective forces are greater than hatchery forces in determining fitness.

The HSRG model of genetic change in populations affected by hatchery operations is an important development, providing important guidance that can be used with other information to assess the relative risk of alternative hatchery-wild scenarios. NMFS considers the HSRG's principles, findings and recommendations important to the advancement and implementation of measures needed to reduce the risk of adverse hatchery-related effects to natural-origin salmon and steelhead populations. Although not the sole source of information considered by NMFS to render ESA determinations regarding harvest and hatchery actions, the HSRG's contributions to hatchery-risk related science are valuable to our evaluations. The HSRG's genetic recommendations will be fully considered with other best-science-directed information in NMFS's evaluation of two RMPs and 116 HGMPs this winter. The RMPs and HGMPs will be submitted under Limit No. 6 of the July 10, 2000 4(d) rule (65 FR 42422) and will address Puget Sound hatchery programs operated by the co-managers that affect listed Puget Sound Chinook salmon, Puget Sound steelhead, Hood Canal summer-run chum salmon, and Southern Resident Killer Whales. NMFS will issue a pending determination describing whether or not

[30] Fish numbers are surrogates for gene flow. If possible, both pNOB and pHOS should be corrected for relative reproductive success in the hatchery and natural environments, respectively.

implementation of the hatchery RMPs and HGMPs will appreciably reduce the likelihood of survival and recovery of ESA listed species and publish the pending determination for public review and comment. For a description of limit No. 6 submittal instructions, reporting requirements, and review criteria, please see NMFS' September 22, 2000 4(d) Rule Implementation Binder for Threatened Salmon and Steelhead on the West Coast.

Procedurally, NMFS intends to take into account HSRG recommendations and other hatchery effects-related issues under the ESA through its hatchery effects review process under Limit 6 of the 4(d) Rule. Through the hatchery review process, NMFS will address hatchery selection and other genetic concerns associated with hatcheries by seeking, in broad terms, to reduce adverse impacts associated with the interbreeding of hatchery-origin and natural-origin fish. The depressed status of many natural populations in the region requires a precautionary approach and careful consideration of site specific circumstances for making management decisions over hatchery programs. Limiting the number of hatchery fish that escape to spawn naturally with natural-origin fish is especially supported in watersheds when the hatchery stock is not derived from the extant natural population, the natural population is important to the recovery of the ESU or DPS and when hatchery selection may be accompanied by outbreeding effects. Under circumstances where the demographic risk faced by the natural population outweighs risks from hatchery intervention, hatchery fish derived from the local extant population may be encouraged to spawn naturally. Responses to concerns regarding the genetic impact of hatchery programs in the near term will be considered on a watershed-specific basis and take into account the demographic strength and genetic diversity of the affected natural population, the existing and projected productivity of habitat in the watershed, the effect of adjustments in hatchery production on the implementation of treaty Indian fishing rights, and other issues relevant to the viability of the populations. Currently, these considerations heavily constrain Puget Sound management actions.

NMFS seeks information on the level of interaction between hatchery and natural-origin Chinook salmon in Puget Sound and on the consequences or effects of interactions. The NMFS Northwest Region considers collection of pertinent data on fitness impacts and testing of hypotheses regarding risk reduction approaches a high priority, especially as they pertain to fish produced by sub-yearling Chinook salmon hatchery programs. In the interim, NMFS expects hatchery operators to develop and implement HGMPs that achieve meaningful reductions in genetic, ecological, and hatchery facility effects and that implement treaty Indian fishing rights. Accordingly, recent ESA consultation documents are including terms and conditions to begin collecting such information (e.g. Nisqually low impact floating weir opinion, NMFS 2010c) and to implement additional risk averse hatchery practices. We believe, however, that a coordinated, programmatic approach, spanning Puget Sound Chinook salmon population viability and habitat conditions, will benefit the development of appropriate and effective genetic diversity risk management measures for co-manager hatcheries. We have begun a research, monitoring and evaluation initiative in the Puget Sound region (the Puget Sound VSP Monitoring Initiative) directed at evaluation needs for hatchery programs. This initiative would be a natural fit for planning and implementing needed relative reproductive success and relative fitness studies specific for the species and hatchery release types in the Puget Sound region. Studies implemented to address key data gaps would provide improved guidance for managing genetic diversity risks associated with the production and escapement to natural spawning areas of Puget Sound sub-yearling hatchery program origin Chinook salmon.

7 ▪ Criterion 5: Escapement Objectives & Maximum Exploitation Rates

Section (b)(4)(i)(C) sets escapement objectives or maximum exploitation rates for each management unit or population based on its status, and assures that those rates or objectives are not exceeded. Maximum exploitation rates must not appreciably reduce the likelihood of survival and recovery of the ESU.

Table 4 identifies the proposed 2010 Puget Sound Chinook RMP's exploitation rate and critical exploitation rate ceilings, which when taken in concert with the RMP's upper management thresholds and low abundance thresholds form the framework of the co-managers' harvest strategy. The RMP establishes escapement objectives (i.e., UMT and LATs) or exploitation rate ceilings for each management unit that are responsive to the status of populations within those management units (see discussion above under Criterion 2, Performance Indicators). The general framework is similar to that of past RMPs. Based on the information provided at the conclusion of previous preseason planning in PFMC and North of Falcon forums the co-managers have consistently managed Puget Sound salmon fisheries to meet or exceed escapement objectives and/or to not exceed exploitation rate ceilings. Information provided in the annual postseason reports on the performance of those RMPs indicates the harvest plans have generally been successful at meeting those objectives (WDFW and PSTIT 2003; WDFW and PSTIT 2004; WDFW and PSTIT 2005; WDFW and PSTIT 2006; WDFW and PSTIT 2007; WDFW and PSTIT 2008; WDFW and PSTIT 2009; WDFW and PSTIT 2010). Where objectives have not been met consistently, the co-managers have assessed the causes and made adjustments depending on the cause. For example, technical management models were revised after the Puyallup exceeded its exploitation rate in several years (see pages 192-193 of RMP). In other circumstances, greater than expected impacts in Alaska and Canadian fisheries resulted in exploitation rates above total exploitation rate ceilings (Hayman 2010). Southern U.S. fisheries remained generally within the RMP limits. The Skokomish River did not achieve its natural escapement objective (1,200) from the 2004 Puget Sound Chinook RMP in the last three years; missing it in two years by relatively small margins (Table 5). The change to exploitation rate management to replace escapement goal management and the lower exploitation rate ceilings proposed in the 2010 Puget Sound RMP should result in a more robust management approach and increased escapements. Given this successful track record of implementing previous Puget Sound RMPs and the similarity of the proposed RMP with those past plans, NMFS expects the same pattern will continue should the proposed 2010 Puget Sound Chinook RMP be approved under the 4(d) Rule.

The following discussion evaluates the patterns in exploitation rates by population and major ESU region from implementation of the RMP using the results of the retrospective analysis. The results are compared with NMFS' harvest standards (i.e., critical and rebuilding thresholds and Rebuilding Exploitation Rates (RERs)). As discussed previously under the VRAP Approach, NMFS derived RERs for 10 individual populations within the ESU and for the Nooksack

Management Unit (Table 2). Surrogate standards are identified for those populations where data are currently insufficient or where NMFS has not completed population-specific analysis to establish RERs. Rates that are expected to result from the proposed RMP under the various management scenarios are compared to those RERs or RER surrogates. Generally speaking, where estimated impacts of the proposed RMP are less than or equal to the RERs, NMFS considers the RMP to present a low risk to that population. However, RERs for individual populations are not used in isolation as jeopardy standards for the ESU. Since it is the ESU and not individual populations that are the listed species, the risk to the ESU associated with an individual population not meeting its RER must be considered within the broader context of other information such as observed information on population status, environmental conditions, historic exploitation rate patterns and the practical effect of further constraints. The distribution of risk across populations based on the weight of information available is then used in making the jeopardy determination for the ESU.[31] Risk is assessed for populations within each region, for the region, and then for the ESU. The FRAM Validation scenario is again used as the basis of comparison.

Where populations exceeded RERs, NMFS analyzed the potential increased risk associated with the proposed SUS fisheries by using the RERs as the standard. The risk analysis simulates exposure of a population to a fixed brood-year exploitation rate, adjusted annually for management error and environmental variability, for a period of 25 years. When compared to NMFS-derived RERs, the risk analysis can predict: (1) the change in the probability of achieving the viable threshold; and (2) the change in probability of falling below the critical threshold. For populations exceeding RER surrogates, population specific information was not sufficient to assess the potential increased risk. As a precautionary measure, a population also will be identified in this evaluation as having a potential increased level of risk when the current average natural-origin escapement is near or below its critical threshold or when the expected escapement of that population does not meet its critical threshold. For all populations, additional discussion on the identified elevated level of risk under the implementation of the RMP to the likelihood of survival and recovery of the ESU, will be provided in the section that evaluates Criterion 6, (b)(4)(i)(D).

In assessing the potential risk of fisheries, NMFS assumes a low marine survival, which is conservative and risk adverse. Additionally, the actual brood-year exploitation rates experienced in this RMP over the next three years, from May 1, 2011 through April 2014, although fixed in the simulations, will vary. The RMP's exploitation rates or escapement goals may be modified in response to the most current information about the productivity and status of populations, or in response to better information about management error. There is also uncertainty in the risk analysis simulation about actual exploitation rates beyond the duration of the proposed RMP (April 30, 2014). The RERs are based on simulations over a more conservative 25-year period,

[31] NMFS has used RERs as part of its assessment of proposed harvest actions on the Puget Sound Chinook ESU in biological opinions and application of take limits under the ESA 4(d) Rule since 1999 (e.g., NMFS 1999; NMFS 2000b; NMFS 2001; NMFS 2003b; NMFS 2004b; NMFS 2004c; NMFS 2005a; NMFS 2008a; NMFS 2010b).

where the RMP's proposed duration is for a shorter duration, three years, from May 1, 2011 through April 2014. Given these uncertainties, the following analyses estimate the potential elevated risk associated with the exploitation rates assumed under the various scenarios when compared to the RERs as the standard for the proposed evaluation. As background, Table 21 summarizes the distribution of exploitation rates across fisheries by Puget Sound Chinook management unit within the listed Puget Sound Chinook ESU.

Table 21. The average distribution of fishery-related mortality for the management seasons from 2004 to 2008, by Puget Sound Chinook management unit based on the FRAM Validation model runs. The average percent of harvest by the treaty tribal fleet is provided for the southern U.S. fisheries.

Management unit	Alaska	British Columbia, Canada	Southern U.S. Fisheries		
			Southern US Ocean[1]	Puget Sound[1]	% Treaty harvest of SUS fisheries
Nooksack	22%	54%	3%	18%	81%
Skagit Summer/Fall	7%	71%	0%	22%	55%
Skagit Spring	2%	42%	3%	50%	47%
Stillaguamish	2%	54%	4%	35%	31%
Snohomish	2%	53%	4%	37%	31%
Lake Washington	1%	44%	3%	49%	63%
Green	1%	41%	3%	52%	67%
White	0%	10%	2%	86%	58%
Puyallup	1%	32%	3%	62%	55%
Nisqually	1%	23%	3%	69%	67%
Skokomish	0%	34%	3%	60%	49%
Mid-Hood Canal	0%	68%	6%	20%	45%
Dungeness	41%	49%	0%	10%	42%
Elwha	41%	49%	0%	10%	42%

1 These are the fisheries that are the subject of the 2010 Puget Sound Chinook RMP, although mortality in the other fishery categories is considered in deriving the objectives and implementing the RMP. In practice, all SUS fisheries, including the southern U.S. ocean and Puget Sound are managed to meet the objectives of the RMP.

Note: Table A1-1 in Appendix A provides further fishery detail using a different data source (CTC 2009). We chose to provide the information based on the FRAM model in this table because it is the tool used to analyze the 2010 Puget Sound Chinook RMP and because the CTC data source does not provide information for all of the management units. Although the distribution percentages for specific fisheries are different between the two data sources, the general overall pattern is similar.

Impacts from monitoring and research activities that directly inform fishery management decisions (test, research, update and evaluation fisheries, certain PST Sentinel Stocks projects) will be included under the exploitation rate ceilings for each management unit as assessed during preseason planning and postseason assessment. Mortality associated with other fishery-related research and monitoring activities which have broader applicability to stock assessment will be assessed separately and will not exceed a level equivalent to 1% of the estimated annual abundance (i.e. 1% ER), for each management unit (e.g., mark recapture studies designed to directly inform management decisions) (see Section 7 of the RMP). Other research activities informing Puget Sound salmon fishery management during the period of the proposed 2010 Puget Sound Chinook RMP but not directly related to fishery management decisions will be permitted under Section 7 of the ESA or Limit 7 of the 4(d) Rule (e.g., smolt monitoring and other research and studies primarily used to assess stock status or other more general, non-fishery specific objectives).

7.1 Strait of Georgia Basin Region

Exploitation rates on Nooksack spring Chinook have declined steadily since the mid-1980s (Figure 10). From 1983 to 1998 the total exploitation rate averaged 31%. Since 1998 the total exploitation rate averaged 20%. Most of the reduction in exploitation rates has come from reductions in northern fisheries in response to Canadian domestic conservation and allocation concerns. Exploitation rates in southern U.S. fisheries have been low. Since 1998 exploitation rates have been 5% or less; below the CERC of 7-9% in Puget Sound Chinook harvest RMPs implemented since 2001. The co-managers are proposing the same CERC in the 2010 Puget Sound Chinook RMP. It also is the co-managers' intent to constrain fisheries affecting the management unit so that the projected SUS exploitation rate does not exceed 7 percent more than once during the duration of the RMP (see page 92 of the RMP). Because of the limitations in the ability of FRAM to fully account for the impacts in the shift in the West Coast Vancouver Island (WCVI) fishing pattern in recent years, exploitation rates since 2003 may be underestimated. Recent coded-wire tag analysis by the Pacific Salmon Commission Joint Chinook Technical Committee (CTC 2006) showed a higher proportion of the northern fishery catch is in the WCVI troll and sport fishery than is estimated by FRAM. Federal, state, and tribal technical staffs are currently reviewing catch distribution information to develop methods for FRAM that incorporate the shift in fishing patterns in recent years (LaVoy 2010a). However, until that work is complete, FRAM is the best available technical model to conduct the analysis for this evaluation. Approximately 70 percent or more of all harvest occurs in Alaskan and Canadian fisheries (Figure 10, Table 21), primarily in the WCVI troll and Georgia Strait sport fisheries (CTC 2009; LaVoy 2010d). Tribal fisheries accounted for 81 percent of the harvest in southern U.S. fisheries from 2004 to 2008 (Table 21) (LaVoy 2010d); primarily harvested in tribal ceremonial and subsistence fisheries in the Nooksack River.

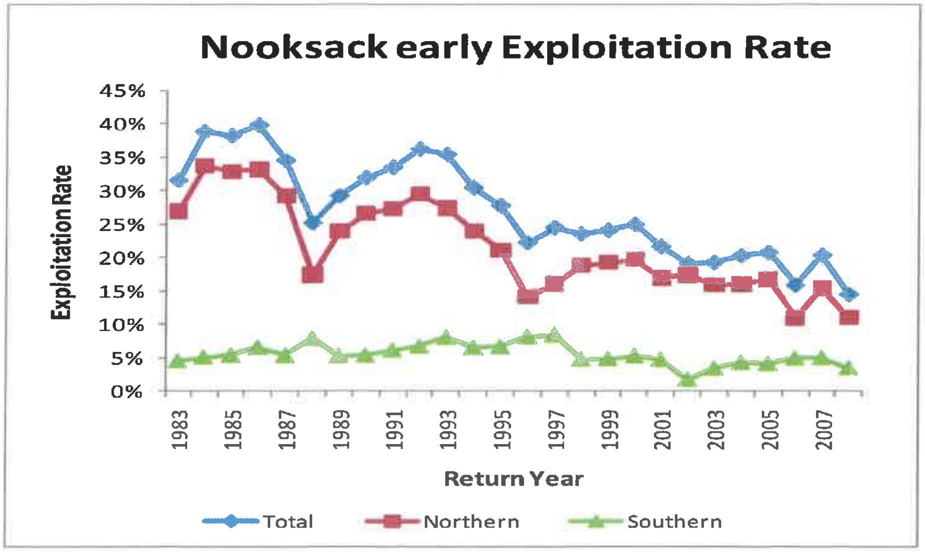


Figure 10. Comparison of total exploitation rates over time with those in southern U.S. and northern fisheries based on the most recent FRAM validation results (LaVoy 2010d).

Results from the Retrospective Analysis

Table 22 and Figure 11 provide results of the retrospective analysis for the Georgia Basin populations (results from the retrospective analysis are also shown in tabular form in Appendix 2). The resulting anticipated range of average total exploitation rates for the Nooksack Management Unit under the implementation of the RMP is 21 to 28 percent (Table 22). The RER for the Nooksack Management Unit is 23 percent (see Table 2). The average anticipated exploitation rate under the High North management scenario for the Nooksack Management Unit of 28 percent exceeds its RER by five percentage points (Table 22). Average exploitation rates are expected to fall below the RER in the 2010 RMP Likely (21%) and 40% Reduction (21%) scenarios, and to be lower than under current conditions (22%). Southern U.S. exploitation rates are very low across all management scenarios.

The 2010 RMP Likely Scenario estimates exploitation rates under the range of fishing levels that are expected over the next three years assuming continued domestic constraints in Canadian fisheries and assuming SUS fisheries are managed up to the 7% CERC.[32] The 2010 RMP Likely scenario suggests a small reduction in total exploitation rate (1%) from rates observed over the analysis period (FRAM Validation) due to the reductions in northern fisheries resulting from the 2008 PST Agreement (Figure 11, Table 22). Exploitation rates in southern fisheries could increase from an average of 5 to 7 percent (Table 22) if southern fisheries achieved the exploitation rate generally anticipated preseason and allowed under the proposed RMP. Under

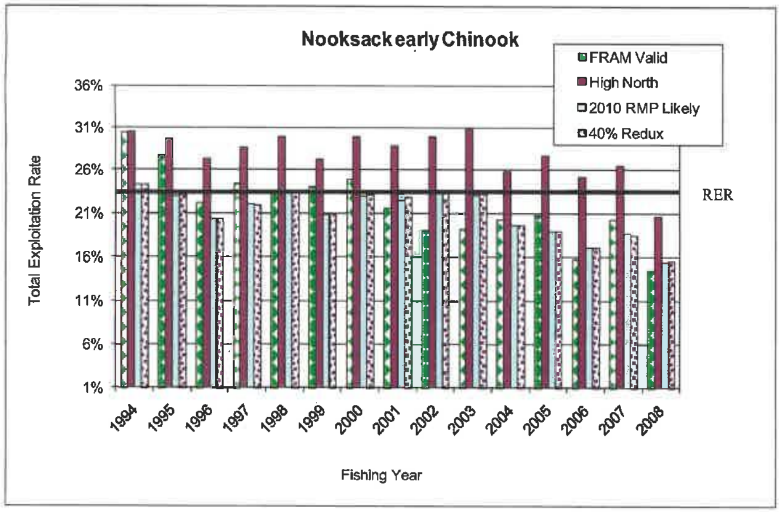
[32] Although the Nooksack early Management Unit has often been anticipated to meet its CERC at the conclusion of preseason fishery planning, actual SUS exploitation rates have been lower. This is likely to occur under implementation of the 2010 Puget Sound Chinook RMP as well, but because preseason fisheries are often shaped to meet the CERC, it is appropriate to evaluate the risk associated with the ceiling (7%) rather than a lower rate.

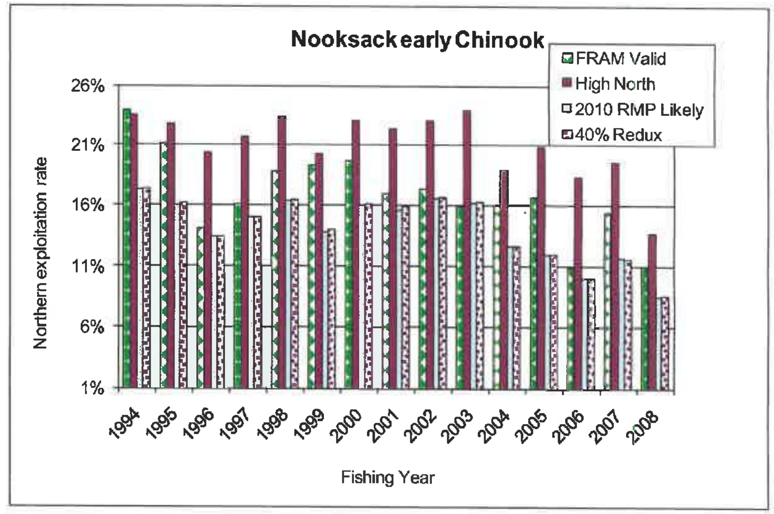
the 2010 RMP Likely scenario, assuming the 7% CERC is met, the average total exploitation rate is less than the FRAM-based RER of 23%; exceeding it in four out of 15 years by less than 1.5 percentage points (Figure 11). This compares with exceeding the RER in six of 15 years for the FRAM Validation scenario.

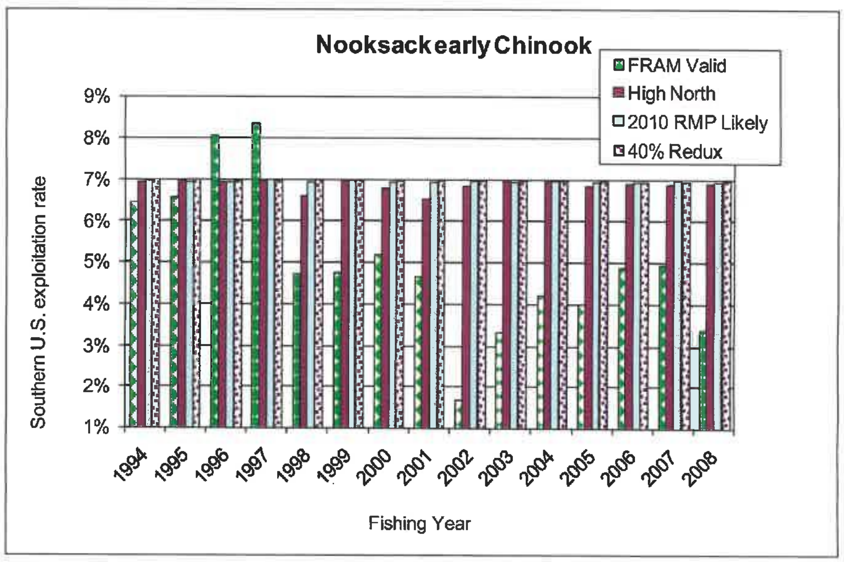
Table 22. Average exploitation rates (1994-2008) from the retrospective analysis for the population groups within the Georgia Strait Basin Region. Shaded values indicate averages exceeding RERs.

Management Unit	Fishery	FRAM Validation	High North	2010 RMP Likely	40% Reduction
Nooksack early (North Fork Nooksack South Fork Nooksack)	**Total** **North** **South**	22% 17% 5%	28% 21% 7%	21% 14% 7%	21% 14% 7%

Figure 11. Estimates of exploitation rates for Nooksack spring Chinook from the retrospective analysis for all fisheries combined (Total), northern and southern fisheries (LaVoy 2010b).







The High North scenario assumes that Alaskan and Canadian fisheries are managed to the limits allowed under the 2008 PST Agreement. Under the High North scenario, the average exploitation rate is higher than under the 2010 Likely Scenario as would be expected, exceeding the RER by five percentage points. The High North scenario represents a 28% increase in average total exploitation rates from those observed over the analysis period (FRAM Validation) (Table 22 and Figure 11) (Appendix 2). The RER is exceeded in all but one year by two to eight percentage points. Achieving the RER under this scenario would require complete to almost complete elimination of SUS fisheries in most of the years in the retrospective analysis (Figure 11, Table 22).

The 40% Reduction scenario assumes that the overall abundance of Chinook in the ocean is reduced significantly. The average exploitation rate is the same as under the 2010 RMP Likely scenario and less than under the High North scenario. Exploitation rates exceed the RER in six of the 15 years in the analysis by less than 1.5 percentage points. The 40% Reduction scenario represents a 4% reduction in average total exploitation rates from those observed over the analysis period (FRAM Validation) (Table 22 and Figure 11) (Appendix 2).

NMFS determined the increased risk associated with the SUS fisheries proposed by the co-managers in the RMP, when compared to the RER under the High North management scenario. Assuming Canadian fisheries were managed at the limits of the 2008 PST Agreement and a 7 percent SUS exploitation rate for the Nooksack River populations, the anticipated total exploitation rate represents a 14 percentage point decrease in the probability of rebuilt populations in 25 years. Modeling also suggests that there is a 24 percentage point increase in the probability that the populations will fall below their respective critical threshold level during that same 25-year period (Table 23).

Table 23. The percentage point change in probability of a rebuilt population in 25 years and the percentage point difference in probability that the population will fall below the critical threshold in 25 years when the anticipated total exploitation rates are compared to the RERs.

Management Unit	Population	High North Scenario	
		Percentage Point difference in Probability of a Rebuilt Population in 25 Years[1]	Percentage Point difference in Probability that the Population will fall below the Critical Threshold in 25 Years[2]
Nooksack		- 14%[3]	24%[3]
	N. F. Nooksack River	–	–
	S.F. Nooksack River	–	–

[1] A negative number in the difference in probability of a rebuilt population in 25 years indicates a decrease in the probability of that population being rebuilt in 25 years, when compared to its RER. Rebuilt is defined as the population's escapement meeting or exceeding its rebuilding escapement threshold under current conditions.
[2] A positive number in the difference in probability that the population will fall below the critical threshold in 25 years indicates an increase in the probability of that population will fall below the critical threshold in 25 years, when compared to the RER.

Increased risk to these populations under this scenario is of some concern. Both populations are Tier 1 populations and essential to the recovery of the Puget Sound Chinook ESU. The North Fork Nooksack is above but close to its critical threshold and the South Fork Nooksack population is below its critical threshold. Achieving the RER under the High North scenario would require almost complete elimination of SUS fisheries; particularly affecting tribal fisheries. However, because the exploitation rates anticipated under this scenario are higher than the RER, there is the potential for additional risk to the Nooksack populations. Trends in escapement and growth rate are stable or increasing. If that changes, it will be necessary to again review the full suite of factors limiting the population. With respect to harvest, virtually all of the impacts occur in northern fisheries (Tables 21 and A1-1). In the event that extraordinary circumstances related to population viability occur, Paragraph 13(h) of Annex IV, Chapter 3 of the 2008 PST Agreement provides a mechanism to consider additional actions that may be taken as part of a coordinated management plan. Analysis would need to demonstrate that further constraints would result in a meaningful benefit to the stock group of which these populations are a component. The Nooksack early Management Unit is not anticipated to exceed its RER under the other three management scenarios indicating they pose low risk to both populations in the management unit. The evaluation of effects on escapement previously discussed in this document concluded that due to the low natural productivity of the habitat (Table 8) and the small range in differences in escapement among the management scenarios (12 North Fork spawners and 3 South Fork spawners comparing the High North and 2010 RMP Likely scenarios), further fishery constraints in southern U.S. fisheries that are the subject of this RMP would not substantially reduce the genetic or demographic risks to the populations from their current status, or change the critical status of the population should very low abundance conditions occur.

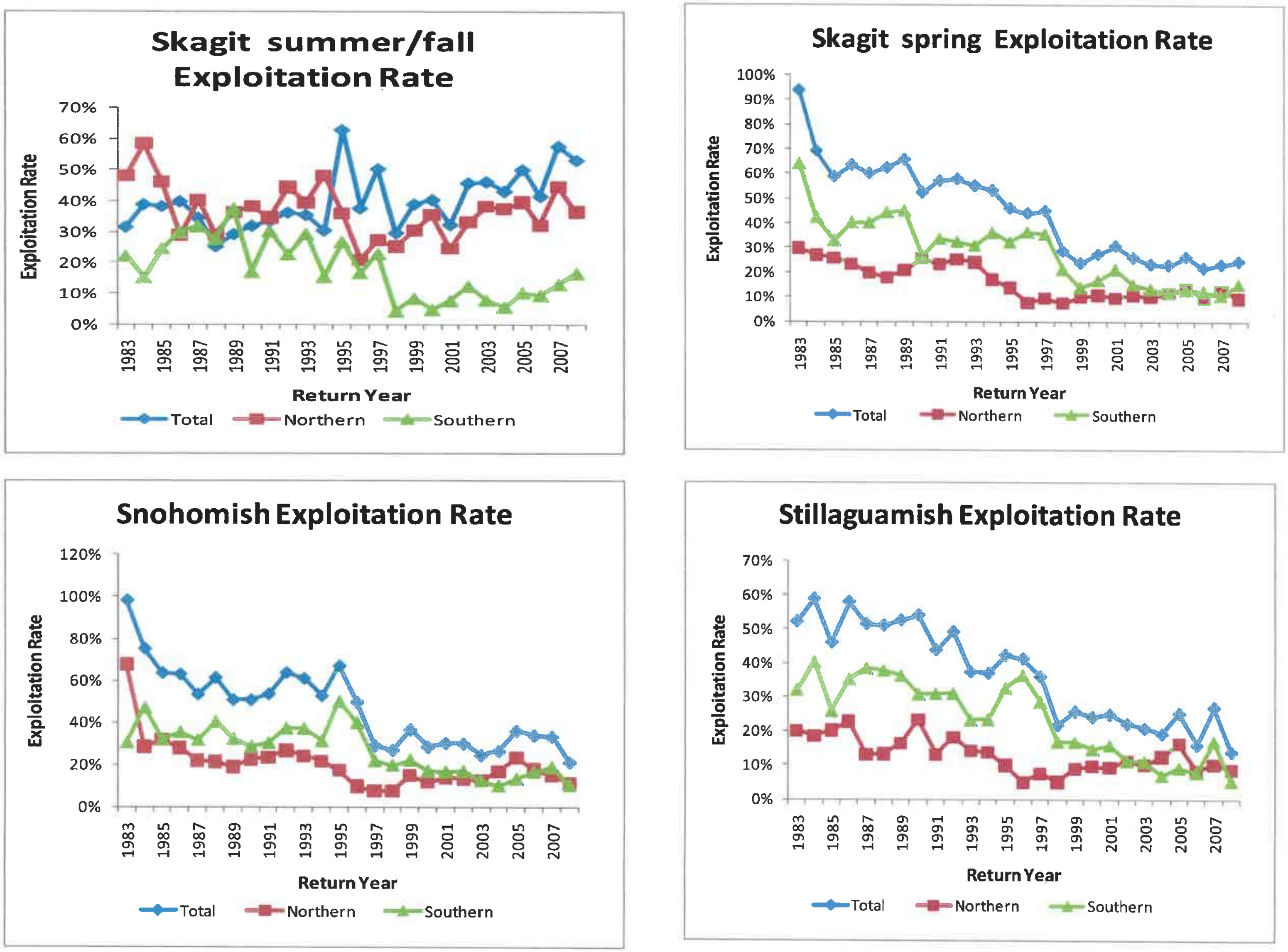
7.2 Whidbey/Main Basin Region

Total exploitation rates on all populations in the region except those in the Skagit Summer/fall Management Unit have declined steadily since the early1980s (Figure 12). Exploitation rates in southern U.S. fisheries have declined for all populations in the region during the same period (Figure 12). Table 24 summarizes the changes in exploitation rate over time for the various population groups based on the FRAM Validation scenario. From 1983 to 1998, average total exploitation rates ranged from 46 percent for Stillaguamish Chinook to 61 percent for Skagit summer/fall stocks. Since 1998, total exploitation rates have averaged 22 percent for Stillaguamish Chinook to 45 percent for Skagit summer/fall stocks, representing decreases of 27 to 57 percent in exploitation rates (Table 24). Most of the reduction in exploitation rates over time has come from reductions in southern fisheries in response to domestic conservation concerns (Figure 12). Since 2001, exploitation rates in southern U.S. fisheries have averaged 10 to 14 percent (Table 24). As with the Nooksack population, the limits of the FRAM to fully assess the impacts associated with the shift in WCVI fishing pattern may underestimate the exploitation rate in recent years for the Skagit spring populations (CTC2006). However, the underestimated amount would be less because less of the catch occurs in the WCVI troll fishery as compared with the Nooksack populations (CTC 2009). Forty-four percent or more of all harvest since 1999 has occurred in Alaskan and Canadian fisheries, primarily in the WCVI sport and troll and Georgia Strait sport fisheries (Figure 12, Table 21) (CTC 2009; LaVoy 2010d). Tribal fisheries account for 31 to 55 percent of the harvest in southern U.S. fisheries from 2004 to 2008 depending on the management unit (Table 21) (LaVoy 2010d).

Table 24. Summary of changes in exploitation rates over time for Chinook populations in the Whidbey/Main Basin Region.

Management Unit	Average Total Exploitation Rate		% Change	Southern U.S. 2001-2008 avg. exploitation rate
	1983-1998	1999-2008		
Skagit summer/fall	61%	45%	-27%	10%
Skagit spring	57%	25%	-57%	14%
Stillaguamish	46%	22%	-52%	10%
Snohomish	57%	30%	-48%	14%

Figure 12. Trends in exploitation rates for Chinook populations in the Whidbey/Main Basin Region (LaVoy 2010b).



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Results from the Retrospective Analysis

Tables 25 and 26, and Figures 13 and 14 compare the results of the retrospective analysis by management unit (results from the retrospective analysis are also shown in tabular form in Appendix 2). The 2010 RMP Likely Scenario estimates the exploitation rates under the range of fishing levels that are expected over the next three years under the RMP assuming continued domestic constraints in Canadian fisheries. Under the 2010 RMP Likely scenario, the average total exploitation rate is less than the RERs for seven of the 10 populations in the region (Skagit summer/fall, Skagit spring, North Fork Stillaguamish)(Table 25); exceeding them rarely or not at all during the analysis period (Table 26). The South Fork Stillaguamish RER is exceeded in most years by a small amount (<1% to 4%)(Table 26). The Snohomish Management Unit exceeds the RER for the Skykomish population by a large margin in all but one year (Table 25). Southern fisheries would need to be severely constrained (i.e., to 4%) to meet the RER (18%) since the average exploitation rate in northern fisheries is 14 percent. The 2010 RMP Likely scenario represents a 12-29 percent reduction in average total exploitation rates and an increased frequency in meeting RERs when compared with those observed over the analysis period (FRAM Validation)(Table 25 and Figure 13)(Appendix 2). The magnitude of the reduction depends on the population. The reductions in exploitation rate occur primarily in southern U.S. fisheries probably as a result of a combination of the provisions of the RMP and reductions in northern fisheries under the 2008 PST Agreement that make achieving the exploitation rate ceilings more feasible.

Under the High North scenario, the average total exploitation rate is less than the RERs for seven of the 10 populations in the region (Skagit summer/fall, Skagit spring, North Fork Stillaguamish) (Table 25 and 26, Figure 13). The total exploitation rate exceeds the South Fork Stillaguamish and Snohomish RERs in 12 or more of the 15 years in the analysis period (Table 26 and Figure 13). The average exploitation rate in northern fisheries alone exceeds the RER of 18 percent for the Snohomish populations (Table 25 and Figure 14). The High North scenario represents a 15 percent decrease to a four percent increase in average total exploitation rates when compared with those observed over the analysis period depending on the population (Appendix 2). The frequency of meeting RERs is generally improved for all but the Lower Skagit population when compared with current conditions (FRAM Validation scenario).

The 40% Reduction scenario assumes that the overall abundance of Chinook in the ocean is reduced significantly. Results are similar to the 2010 RMP Likely scenario (Table 25). Total exploitation rates are below their RERs in all years or almost all years for seven of the 10 populations in the region (Table 26). For the Snohomish populations, under both scenarios average exploitation rates in northern fisheries alone approach the RER of 18% (Table 25 and Figure 14) and exceed it in some years. Exploitation rates in SUS fisheries remain low (Table 25).

Table 25. Average exploitation rates (1994-2008) from the retrospective analysis for the population groups within the Whidbey/Main Basin Region.

Management Unit	Fishery	FRAM Validation	High North	2010 RMP Likely	40% Reduction
Skagit summer/fall (Upper Skagit, Lower Skagit, Lower Sauk)	Total	46%	48%	40%	41%
	North	34%	39%	31%	31%
	South	12%	9%	9%	9%
Skagit spring (Suiattle, Upper Sauk, Upper Cascade)	Total	31%	32%	22%	23%
	North	11%	21%	11%	10%
	South	20%	11%	12%	13%
Stillaguamish (North Fork Stillaguamish, South Fork Stillaguamish)	Total	26%	23%	19%	19%
	North	10%	13%	9%	9%
	South	17%	10%	10%	10%
Snohomish (Skykomish, Snoqualmie)	Total	35%	35%	27%	27%
	North	14%	23%	14%	14%
	South	21%	12%	13%	13%

Table 26. Average exploitation rates (1994-2008) from the retrospective analysis and the number of years during the period that exploitation rates exceed FRAM-based RERs for the population groups within the Whidbey/Main Basin Region. Values shown in bold indicate averages exceeding RERs.

Management Unit	Population	FRAM-Based RER	FRAM Validation		High North		2010 RMP Likely		40% Reduction	
			Avg. Rate	# years above	Avg. Rate	# years above	Avg. Rate	# years above	Avg. Rate	# years above
Skagit summer/fall	Upper Skagit	60%	46%	2/15	48%	0/15	40%	0/15	41%	0/15
	Lower Skagit	51%		4/15		6/15		0/15		0/15
	Lower Sauk	49%		6/15		6/15		4/15		4/15
Skagit spring	Suiattle	41%	31%	4/15	32%	0/15	22%	0/15	23%	0/15
	Upper Sauk	38%		4/15		0/15		0/15		0/15
	Upper Cascade	38-41%								
Stillaguamish	N.F. Stillaguamish	30%	**26%**[a]	4/15	**23%**[a]	0/15	**19%**[a]	0/15	**19%**[a]	0/15
	S.F. Stillaguamish	18%		13/15		12/15		11/15		11/15
Snohomish	Skykomish Snoqualmie	18%	**35%**	15/15	**35%**	14/15	**27%**	14/15	**27%**	14/15

[a] Exceeds the South Fork Stillaguamish RER (18%), but not the North Fork Stillaguamish RER (30%)

Figure 13. Estimates of total exploitation rates for the Chinook population groups within the Whidbey/Main Basin Region from the retrospective analysis (LaVoy 2010b).

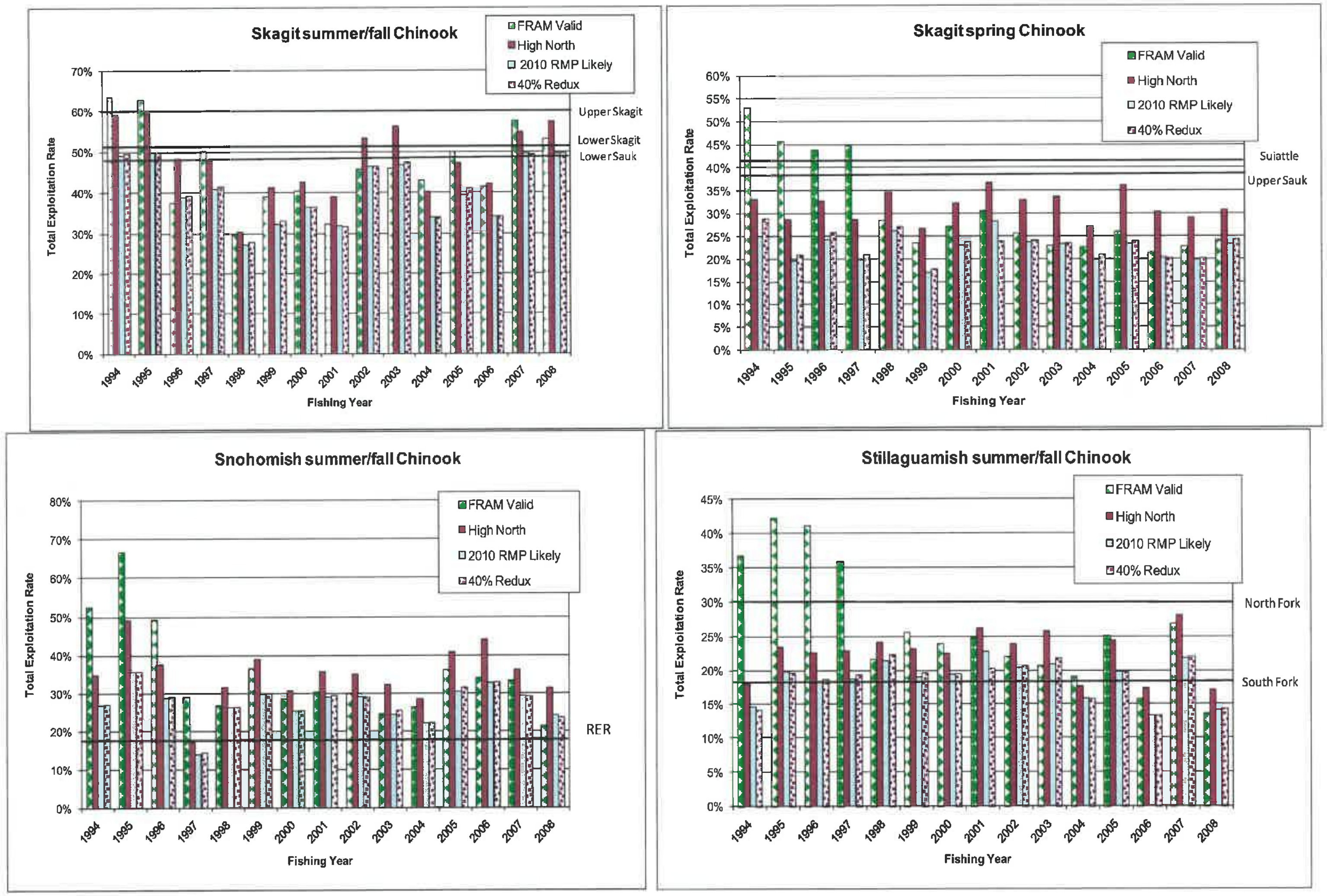
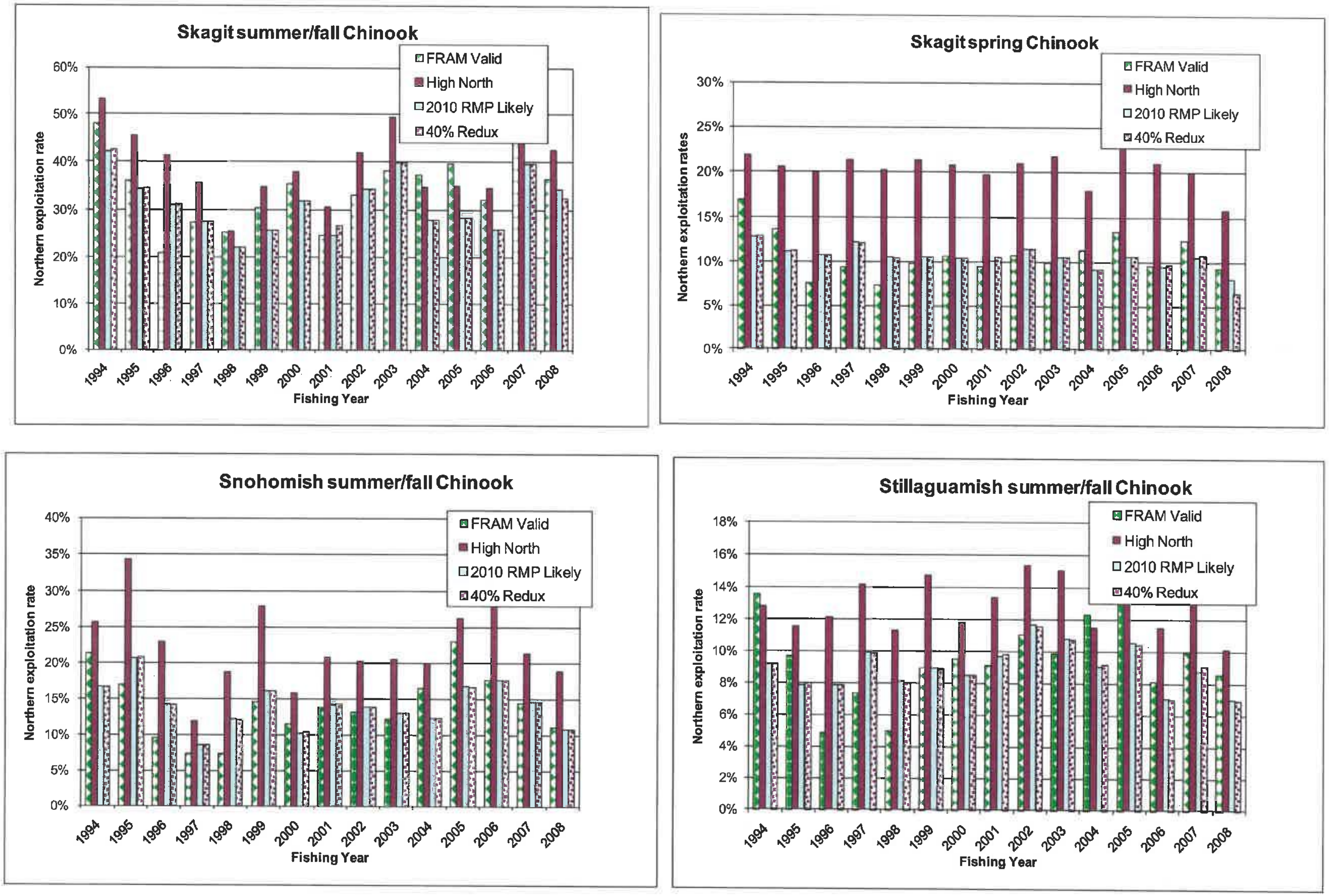


Figure 14. Estimates of exploitation rates in northern fisheries for the Chinook population groups within the Whidbey/Main Basin Region from the retrospective analysis (LaVoy 2010b).



The resulting anticipated range of average total exploitation rates for the Skagit summer/fall, Skagit spring and North Fork Stillaguamish populations are below their RERs or RER surrogates (Table 25). The level of risk to survival and recovery associated with the anticipated range of exploitation rates for these populations is thus considered low.

The range of anticipated exploitation rates possible under the implementation of the 2010 Puget Sound Chinook RMP exceeds the RERs for the South Fork Stillaguamish, Skykomish, and Snoqualmie populations. Southern U.S. exploitation rates are low across management scenarios. NMFS determined the increased risk to these populations associated with the exploitation rates anticipated from implementation of the 2010 Puget Sound Chinook RMP, when compared to the RER (Table 27).

The co-managers propose to manage the Stillaguamish Management Unit for a 25 percent total exploitation rate ceiling, and a 15 percent SUS critical exploitation rate ceiling (see Table 4). The range of anticipated total exploitation rates for the South Fork Stillaguamish population under the implementation of the RMP is 19 to 23 percent (Table 25) compared with an observed average total exploitation rate of 26 percent. The most likely exploitation rate is 19 percent. The range exceeds the RER of 18 percent for the Skykomish River population; by one to four percentage points.

Through modeling, NMFS determined the increased risk to the South Fork Stillaguamish River population associated with the overall fishing-related mortality potentially resulting from the implementation of the 2010 Puget Sound Chinook RMP. The 2010 RMP Likely scenario would represent a 4 percentage point decrease in the probability of a rebuilt South Fork Stillaguamish population in 25 years. Modeling also suggests that there is a negligible change in the probability that the population will fall below the critical level during that same 25-year period (Table 27) and that it would remain less than the RER criteria of 5%. Should northern fisheries increase, the risks would be higher (Table 27). However, the probabilities for the three implementation scenarios would be improved over current conditions as represented by the FRAM Validation scenario (Tables 25 and 26).

The South Fork Stillaguamish is below its critical threshold with declining escapement trend and growth rates. The analysis of exploitation rates indicates a small increased risk to the probability of rebuilding and a reduced risk to both survival and rebuilding under the most likely scenario compared to observed exploitation rates during the analysis period. Exploitation rates are anticipated to be lower under the three alternative scenarios when compared with the observed exploitation rates (FRAM Validation); particularly in SUS fisheries which are the subject of the proposed RMP. It is a Tier 2 population whose life history is represented by three other populations in the region that are in much healthier condition and anticipated to be below their RERs or RER surrogates. Therefore, any increased risk to this population would not impede achieving viability for the region based on NMFS' delisting criteria.

Table 27. The percentage point change in probability of a rebuilt population in 25 years and the percentage point difference in probability that the population will fall below the critical threshold in 25 years when the range of anticipated total exploitation rates is compared to the RERs.

Management Unit	Population	FRAM Validation		2010 RMP Most Likely		[redacted] High North		40 % Reduction	
		Percentage Point difference in Probability of a Rebuilt Population in 25 Years[1]	Percentage Point difference in Probability that the Population will fall below the Critical Threshold in 25 Years[2]	Percentage Point difference in Probability of a Rebuilt Population in 25 Years[1]	Percentage Point difference in Probability that the Population will fall below the Critical Threshold in 25 Years[2]	Percentage Point difference in Probability of a Rebuilt Population in 25 Years[1]	Percentage Point difference in Probability that the Population will fall below the Critical Threshold in 25 Years[2]	Percentage Point difference in Probability of a Rebuilt Population in 25 Years[1]	Percentage Point difference in Probability that the Population will fall below the Critical Threshold in 25 Years[2]
Stillaguamish	S.F. Stillaguamish R.	-18%	11%	-4%	0.5%	-8%	6.2%	-4%	0.5%
Snohomish	Skykomish R. Snoqualmie R.	-51%	30%	-30%	8%	-51%	30%	-30%	8%

[1] A negative number in the difference in probability of a rebuilt population in 25 years indicates a decrease in the probability of that population being rebuilt in 25 years, when compared to its RER. A positive number in the difference in probability of a rebuilt population in 25 years indicates an increase in the probability of that population being rebuilt in 25 years, when compared to the RER. Rebuilt is defined as the population's escapement meeting or exceeding its rebuilding escapement threshold under current conditions.

[2] A negative number in the difference in probability that the population will fall below the critical threshold in 25 years indicates a decrease in the probability of that population will fall below the critical threshold in 25 years, when compared to the RER. A positive number in the difference in probability that the population will fall below the critical threshold in 25 years indicates an increase in the probability of that population will fall below the critical threshold in 25 years, when compared to the RER.

The co-managers propose to manage fisheries affecting the Snohomish Management Unit by applying a 21 percent total rebuilding exploitation rate and a 15 percent SUS critical exploitation rate ceiling (see Table 4). The resulting range of anticipated total exploitation rates under the implementation of the 2010 Puget Sound Chinook RMP is 27 to 35 percent (Table 25) compared with an observed average total exploitation rate of 35 percent. The most likely exploitation rate is 27 percent. The entire range exceeds the RER of 18 percent for the Skykomish River population by nine to 17 percentage points (Table 25).

Through modeling, NMFS determined the increased risk to the Skykomish River population associated with the total fishing-related mortality potentially resulting from the implementation of the 2010 Puget Sound Chinook RMP, when compared to the RER as the standard. The 2010 RMP Likely scenario would represent a 30 percentage point decrease in the probability of a rebuilt Skykomish population in 25 years. Modeling also suggests an eight percent increase in the probability that the population will fall below its critical level during that same 25-year period (Table 27). Should northern fisheries increase, the risks would be substantially higher (Table 27). NMFS was unable to determine the increased risk associated with the anticipated exploitation rates under the implementation of the RMP exceeding the RER for the Snoqualmie population. However, the level of risk is assumed to be no greater than that estimated for the Skykomish population (Snohomish RER Workgroup 2002; PSIT and WDFW 2010).

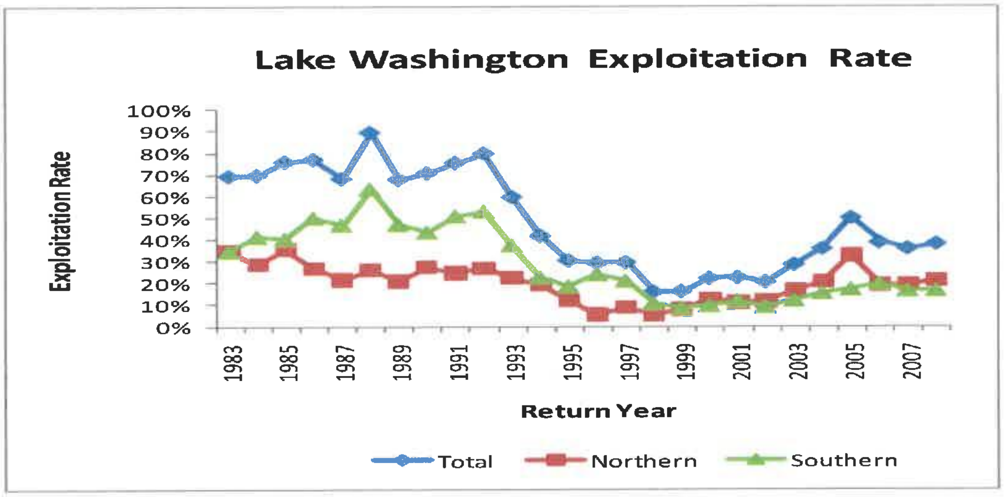
Both populations have stable or increasing escapement trends and growth rates. The previous analysis of escapements concluded that the populations should see minor improvements in status from current conditions. The analysis of exploitation rates indicates a moderate increased risk to the probability of rebuilding and low increase in the probability of falling below the critical threshold under the most likely scenario. These results represent a reduction in risk to the population from the observed rates during the analysis period (FRAM Validation). Exploitation rates are anticipated to be lower under the most likely and reduced scenarios when compared with current status (FRAM Validation); particularly in SUS fisheries which are the subject of the proposed RMP. Although the overall risk would remain the same as under observed rates under the High North scenario, SUS fishery exploitation rates are anticipated to decrease under that scenario as well. Both are Tier 2 populations whose life history is represented by the Lower Skagit population in the region which is in much healthier condition and anticipated to be below its RER. Therefore, any increased risk to this population would not impede viability for the region based on NMFS' delisting criteria. Additional discussion on the identified elevated level of risk to the Snohomish populations under the implementation of the RMP, in regards to the likelihood of survival and recovery of the ESU, will be provided in the discussion of Criterion 6, (b)(4)(i)(D).

7.3 Central/South Sound Region

Exploitation rates on the Chinook populations in Lake Washington, the Duwamish-Green and White rivers have declined since the mid 1990s (Figure 15). Table 28 summarizes the changes in exploitation rate over time for the various populations. From 1983 to 1998, average total exploitation rates ranged from 26 to 86 percent. Since 1999, total exploitation rates have averaged 19 to 77 percent representing a decrease of 11 to 48 percent in exploitation rates. Most of the reduction in exploitation rates has come from reductions in southern fisheries as a response to domestic conservation concerns (Figure 15). Since 2001, exploitation rates in southern U.S. fisheries for the six Central/South Sound populations have averaged between 15 and 61 percent. Total exploitation rates remain high for the Nisqually and Puyallup River populations.

Unlike populations in the Strait of Georgia and Whidbey/Main Basin regions, most of the harvest of the Central/South Sound populations occurs in southern U.S. fisheries (Figure 21) (CTC 2009; LaVoy 2010d). Tribal fisheries accounted for 55 to 67 percent of the harvest in southern U.S. fisheries from 2004 to 2008 depending on the management unit (Table 21) (LaVoy 2010d).

Figure 15.Trends in exploitation rates for Chinook populations in the Central/South Sound Region (LaVoy 2010b).



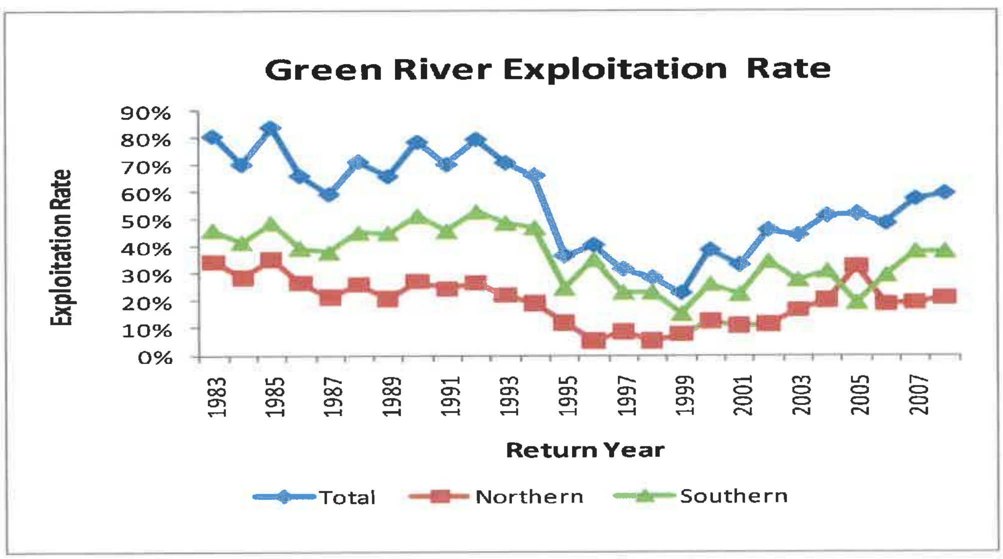
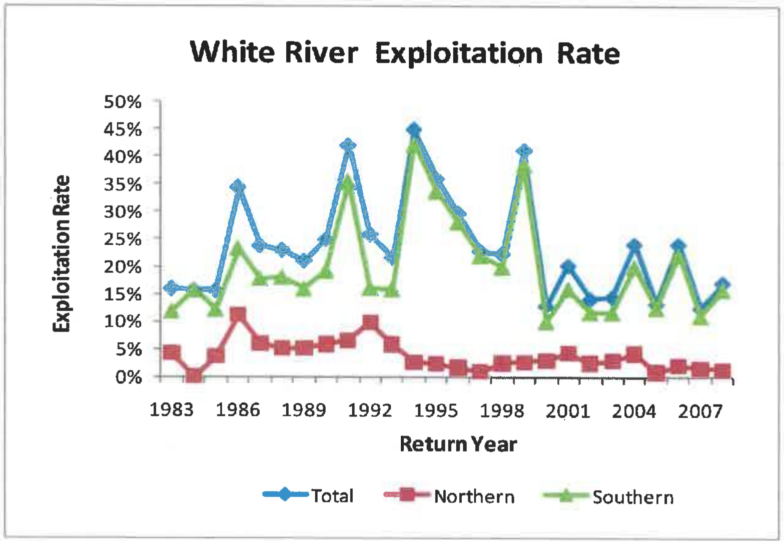
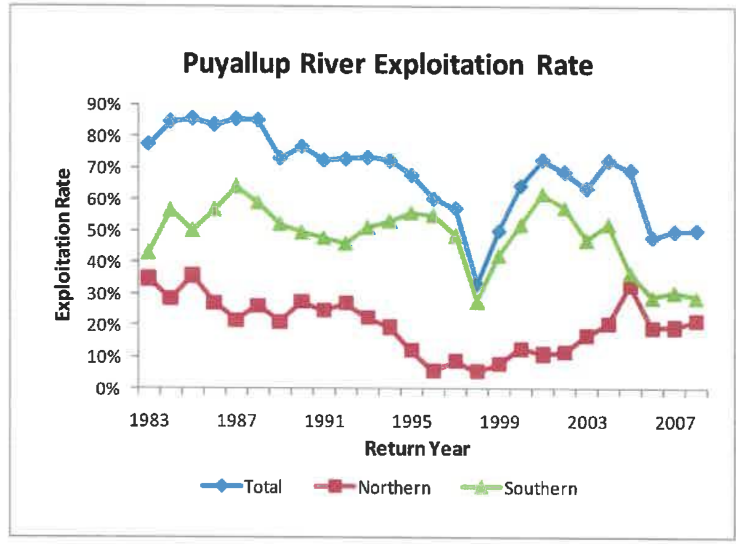


Figure 15 continued. Trends in exploitation rates for Chinook populations in the Central/South Sound Region (LaVoy 2010b).





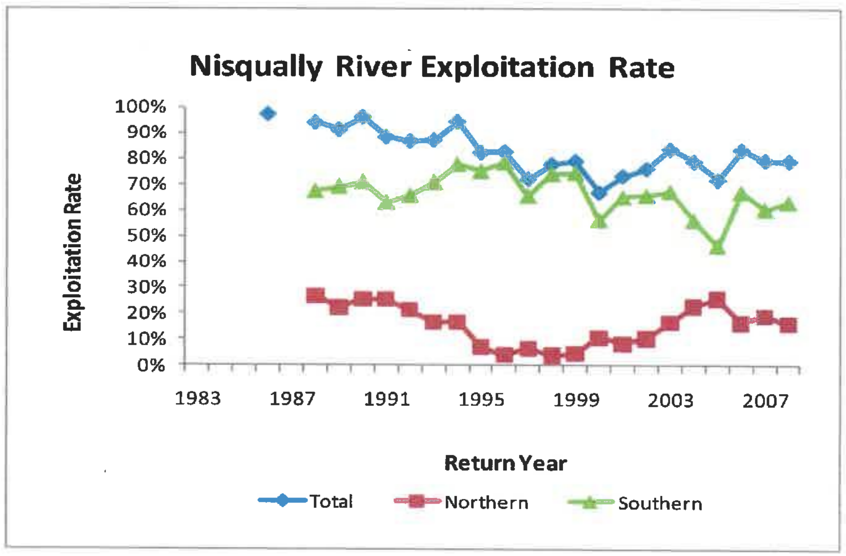


Table 28. Summary of changes in exploitation rates over time for Chinook populations in the Central/South Sound Region.

Management Unit	Average Total Exploitation Rate		% Change	Southern U.S. 2001-2008 avg.
	1983-1998	1999-2008		
Lake Washington (Cedar, Sammamish)	59%	31%	-48%	15%
Green River	62%	45%	-27%	30%
White River	26%	19%	-26%	15%
Puyallup	72%	61%	-16%	43%
Nisqually	86%	77%	-11%	61%

Results from the Retrospective Analysis

Tables 29 and 30 and Figure 16 compare the results of the retrospective analysis by management unit (results from the retrospective analysis are also shown in tabular form in Appendix 2). The 2010 RMP Likely Scenario estimates the exploitation rates under the range of fishing levels that are expected under the RMP over the next three years, assuming continued domestic constraints in Canadian fisheries. The 2010 RMP Likely scenario represents a 12 to 38 percent reduction in average total exploitation rates and, except for the White River, little change in the frequency in meeting RERs when compared with those observed over the analysis period (FRAM Validation). The magnitude of the reduction depends on the population (Table 29 and Figure 16) (Appendix 2). Average total exploitation rates are reduced for all populations and substantially so for three of the six populations (White, Puyallup, and Nisqually) when compared to the FRAM Validation scenario (Table 29). The reductions are almost exclusively due to anticipated reductions in southern fishery impacts. Under the 2010 RMP Likely scenario, average total exploitation rates are below the RER or RER surrogates for four of the six populations in the region (Table 30 and Figure 16). Exploitation rates are below the RER surrogate for the White River, Duwamish-Green, and Lake Washington populations in most years (Table 30). The White River is below its RER surrogate in all years, an improvement over the FRAM Validation scenario (Table 30). Average total exploitation rates are significantly above the surrogate RERs for the Puyallup and Nisqually populations in all or almost all years (Table 30).

The results of the High North and 40% Reduction scenarios are similar to that of the 2010 RMP Likely scenario (Tables 29 and 30). Exploitation rates for the Lake Washington and Duwamish-Green populations are higher under the High North and lower under the 40% Reduction scenarios and frequency of exceeding the RER or RER surrogate is reduced under the 40% Reduction scenario. A key element of the abundance based management regime that characterizes the Puget Sound Chinook RMPs is that fisheries are responsive to declining abundance, i.e., different exploitation rates are implemented for different abundances. The retrospective analysis indicates that the management regime does compensate for reduced abundance as intended.

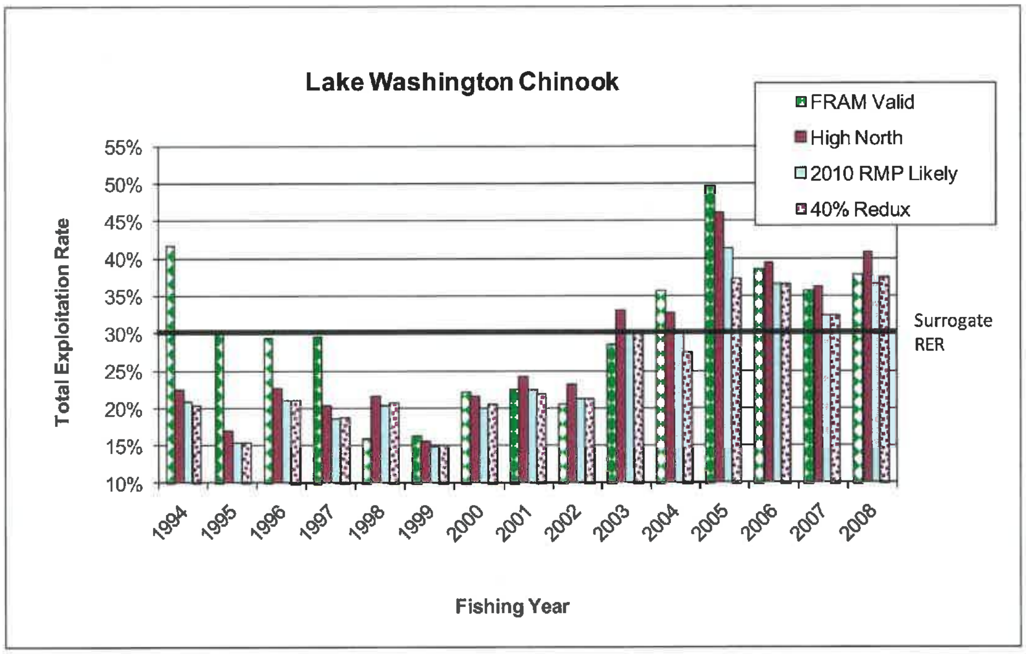
Table 29. Average exploitation rates (1994-2008) from the retrospective analysis for the population groups within the Central/South Sound Region.

Population	Fishery	FRAM Validation	High North	2010 RMP Likely	40% Reduction
Lake Washington (Sammamish, Cedar River)	Total North South	30% 15% 15%	28% 16% 12%	25% 14% 12%	25% 14% 11%
Duwamish-Green River	Total North South	44% 15% 30%	40% 16% 28%	38% 14% 29%	32% 14% 24%
White River	Total North South	23% 2% 21%	15% 5% 10%	14% 3% 12%	15% 3% 12%
Puyallup River	Total North South	60% 15% 45%	48% 16% 32%	48% 14% 34%	49% 14% 35%
Nisqually	Total North South	78% 12% 66%	58% 18% 40%	58% 12% 45%	58% 12% 45%

Table 30. Average exploitation rates (1994-2008) from the retrospective analysis for the populations within the Central/South Sound Region. Values shown in bold indicate averages exceeding RERs.

Population/ Management Unit	FRAM-Based RER	FRAM Validation		High North		2010 RMP Likely		40% Reduction	
		Avg. Rate	# years above	Avg. Rate	# years above	Avg. Rate	# years above	Avg. Rate	# years above
Lake Washington (Sammamish, Cedar River)	30%	30%	7/15	28%	6/15	25%	6/15	25%	4/15
Duwamish-Green River	46%	44%	6/15	40%	6/15	38%	6/15	32%	3/15
White River	23%	23%	6/15	15%	0/15	14%	0/15	15%	0/15
Puyallup River	33% 46%	**60%**	14/15 14/15	**48%**	15/15 13/15	**48%**	15/15 13/15	**49%**	15/15 13/15
Nisqually	33%- 46%	**78%**	15/15 15/15	**58%**	15/15 15/15	**58%**	15/15 15/15	**58%**	15/15 15/15

Figure 16. Estimates of total exploitation rates for the Chinook population groups within the Central/South Sound Region from the retrospective analysis (LaVoy 2010b).



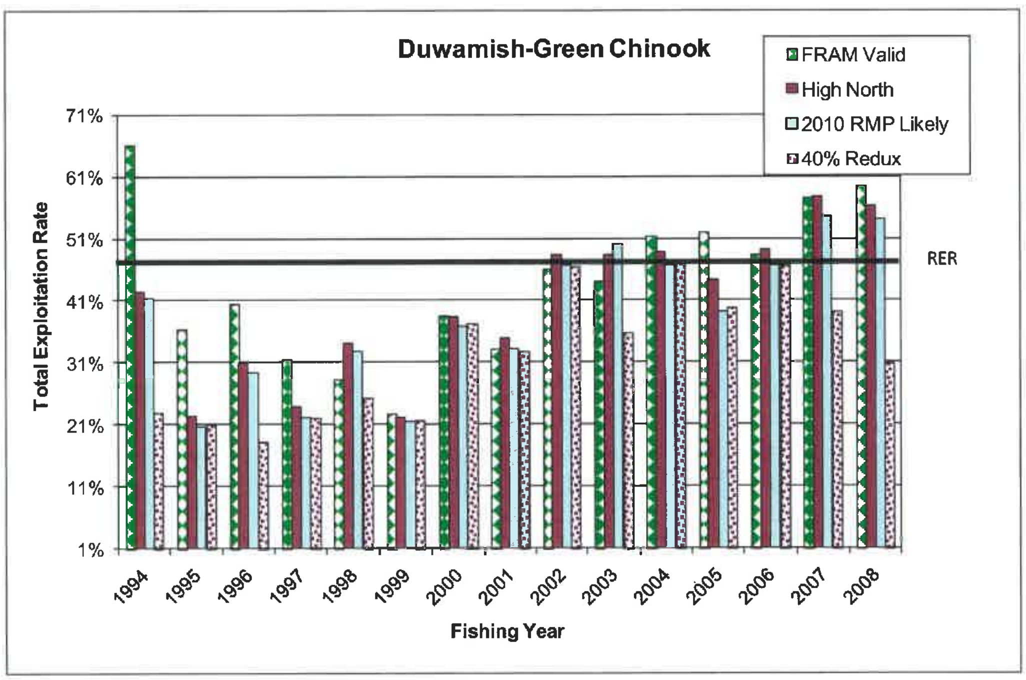


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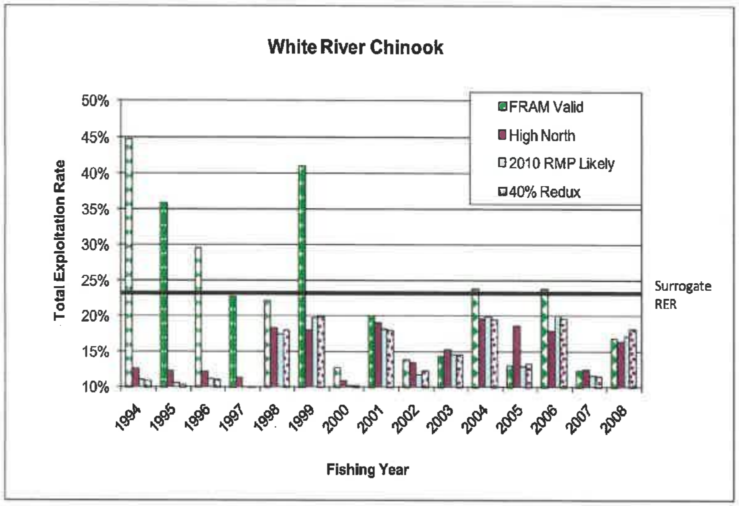
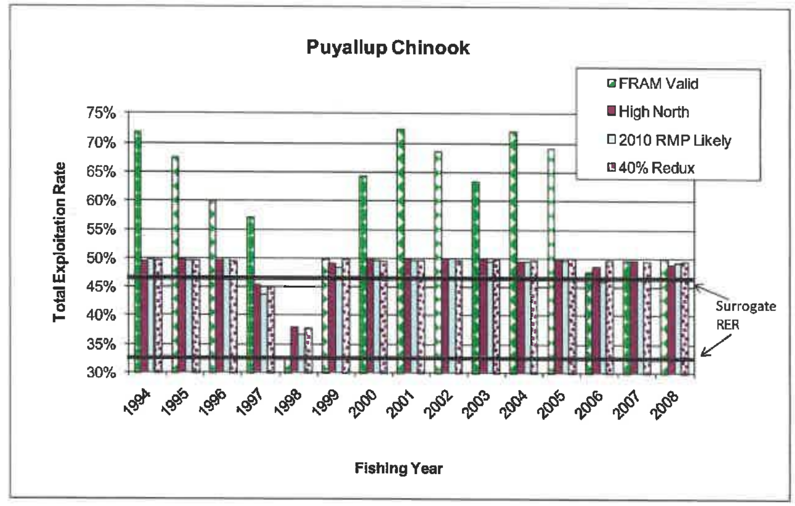
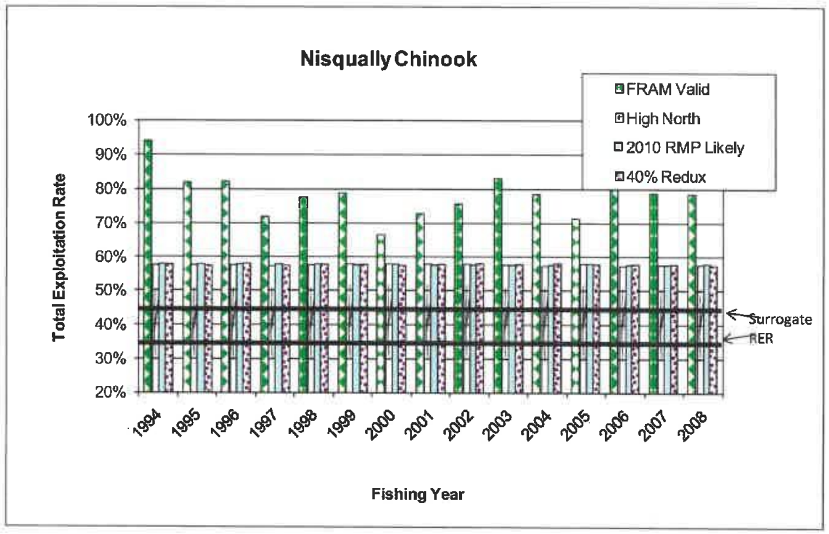
Figure 16 continued.







Of the six populations in the region, the Puyallup and Nisqually populations exceed their surrogate RERs across all scenarios. Total exploitation rates are anticipated to decline substantially for the Nisqually population due to the adoption of reduced exploitation rate ceilings in the 2010 Puget Sound Chinook RMP compared to previous harvest plans. Exceeding the RER infers an increased risk to the survival and recovery of the population but NMFS cannot quantify it at this time with the available information. Other information may give some insight to the likelihood and degree of increased risk. Both populations have a long history of high exploitation rates and significant hatchery production. The hatchery and wild spawners are genetically indistinguishable and resemble the other fall populations in the region due to extensive outplanting of Green River lineage Chinook. Habitat has been degraded through urbanization, agricultural, residential and industrial use. The natural escapement trend and growth rates are increasing or stable for both populations (Table 9).

The Puyallup River population is a Tier 3 population which is managed for a slower trajectory toward recovery compared to the Tier 1 and 2 populations in the region. The previous analysis of escapements concluded that the population should see substantial improvements in status from current conditions and remain above its rebuilding threshold even under low abundance. Exploitation rates are anticipated to decrease moderately, almost exclusively in SUS fisheries which are the basis of the proposed 2010 Puget Sound Chinook RMP. Based on the population's category and status, the stable escapement trend, and anticipated reductions in exploitation rates, the increased level of risk to the Puyallup River population possible under the anticipated range of exploitation rates under the implementation of the RMP would not impede viability for the region based on NMFS' delisting criteria.

The Nisqually is a Tier 1 population and essential for recovery of the ESU. Since 1999, the co-managers have successfully achieved the upper management threshold in the 2004 Puget Sound Chinook RMP of 1,200 natural spawners in the Nisqually River in all but three years (Table 6). Natural-origin escapement has been much lower but the proposed RMP contains provisions designed to increase the number of natural-origin spawners over time (see Nisqually Management Unit Profile in the RMP). Modeling of the Nisqually Management Unit indicates that natural escapements will increase over those observed during the analysis period under the implementation of the RMP. NMFS anticipates this will also improve natural-origin escapement. The co-managers propose a stepped reduction in total exploitation rates from 65 to 47 percent over the duration of the RMP and other provisions to reduce the level of and potential risks associated with hatchery fish spawning naturally[33]. Significant habitat improvements have been made to the watershed and estuary. Given the history and current conditions in the watershed, the appropriate course is a transitional strategy implemented over time that reduces the effects of

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[33] The RMP indicates the Nisqually Management Unit will be managed for a total exploitation rate that incrementally decreases through the life of the plan (65% in 2011, 56% in 2012-2013 and 47% in 2014). Although the provision for a 47% exploitation rate during the 2014 fishing year is outside the duration of the RMP, NMFS envisions that the co-managers will constrain fisheries to 47% during 2014 based on co-manager statements that they intend to implement the full suite of actions described in the RMP (Pattillo and Graves 2011).

hatchery straying and harvest, and improves habitat to the degree necessary for the population to adapt and rebuild natural production. The timing and magnitude of changes in harvest that occur must be coordinated with the pace of habitat recovery and with the implementation of hatchery actions, and take into account the status of the population. Based on the current abundance status, the increasing escapement trend for the Nisqually River population, the anticipated level of escapement under the implementation of the RMP and the stepped reduction in exploitation rates provided in the RMP, the level of risk to the Nisqually River population due to the anticipated range of total exploitation rates is consistent with such a transitional strategy.

7.4 Hood Canal Region

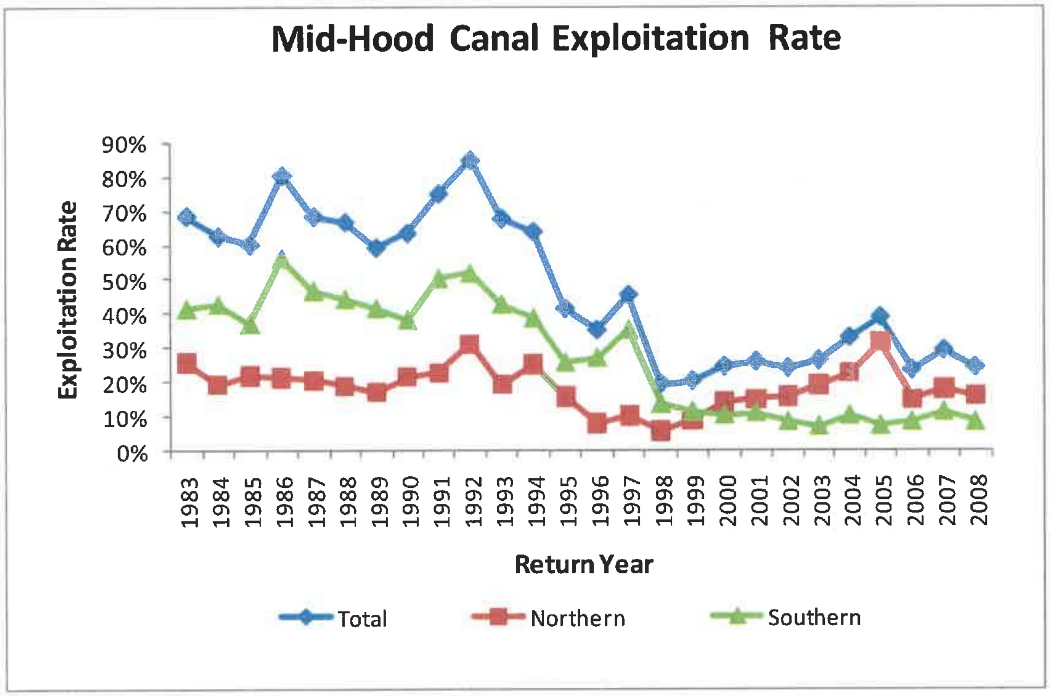
Exploitation rates on the Hood Canal populations declined since the late 1980s. Compared with years prior to 1999, average total exploitation rates have been reduced by 55 and 25% for the Mid-Hood Canal and Skokomish populations, respectively (Table 31). From 1987 to 1998, total exploitation rates averaged 60% and 72% for the Mid-Hood Canal and Skokomish populations, respectively (Table 31). By comparison, total exploitation rates since 1999 averaged 27% and 55% for the Mid-Hood Canal and Skokomish populations, respectively. Exploitation rates have increased in recent years (Figure 17), particularly for the Skokomish population. Increases in Skokomish exploitation rates have occurred in both northern and southern fisheries, but the largest increases are in southern fisheries. Increases in exploitation rates for Mid-Hood Canal are due to increased rates in northern fisheries. Terminal-area harvest impacts in southern U.S. fisheries have been virtually eliminated for the Mid-Hood population.

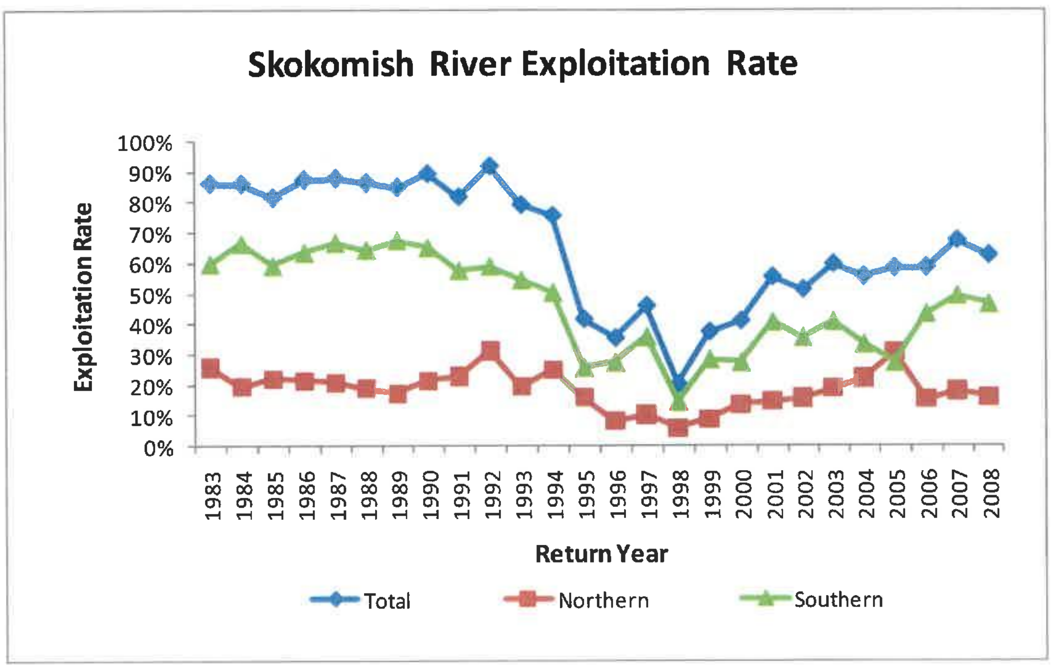
Since 1999, over 60% of the harvest of Mid-Hood Canal population (up to 77% in recent years) and approximately 40% of the harvest of the Skokomish population occurs in northern fisheries on average (Figure 17, Table 21) (CTC 2009; LaVoy 2010d). Tribal fisheries accounted for 45 to 49 percent of the harvest in southern U.S. fisheries from 2004 to 2008 for the Mid Hood Canal and Skokomish populations, respectively (Table 21) (LaVoy 2010d).

Table 31. Summary of changes in exploitation rates over time for Chinook populations in the Hood Canal Region.

Management Unit	Average Total Exploitation Rate		% Change	Southern U.S. 2001-2006 avg.
	1987-1998	1999-2008		
Mid-Hood Canal	60%	27%	-55%	9%
Skokomish	72%	55%	-25%	40%

Figure 17. Trends in exploitation rates for Chinook populations in the Central/South Sound Region (LaVoy 2010b).





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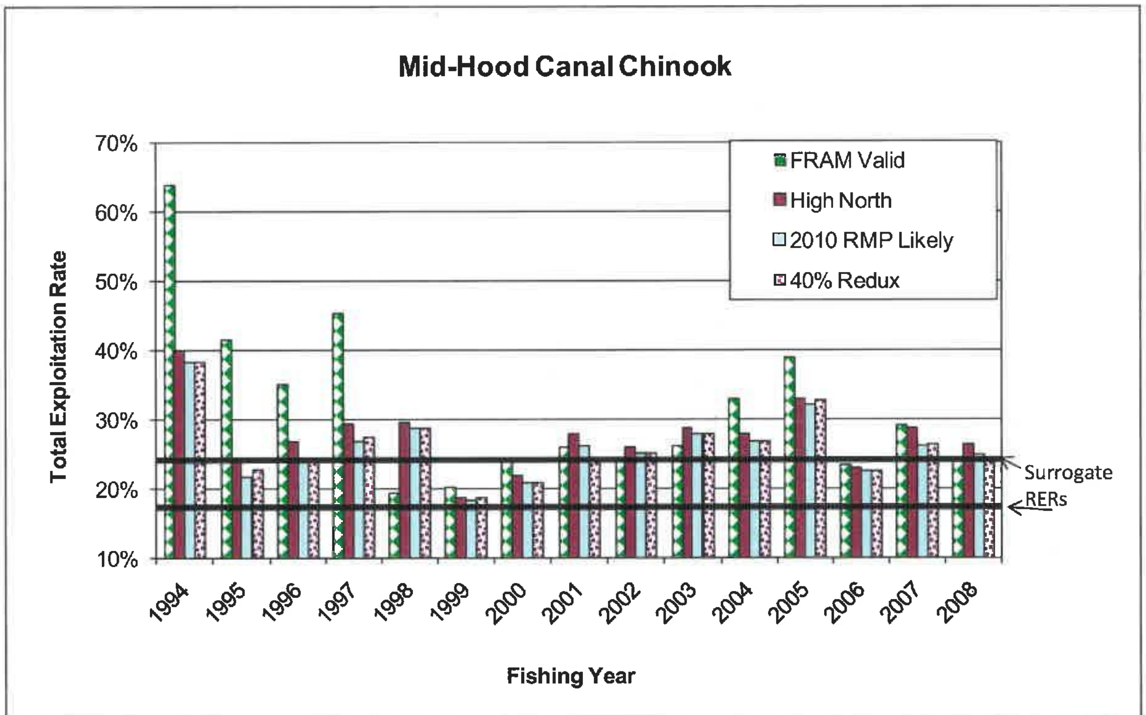
Results from the Retrospective Analysis

Table 32 and Figure 18 summarize information from the retrospective analysis for the Skokomish and Mid-Hood Canal populations (results from the retrospective analysis are also shown in tabular form in Appendix 2). Total exploitation rates exceed the Skokomish RER and the Mid-Hood Canal RER surrogates in almost all years for all scenarios (Figure 18), particularly in recent years for the Skokomish population. Northern rates alone approach or exceed the surrogate RERs for the Mid-Hood Canal population in many years under all scenarios.

Table 32. Average exploitation rates (1994-2008) from the retrospective analysis for the population groups within the Hood Canal Region.

Population	Fishery	FRAM Validation	High North	2010 RMP Likely	40% Reduction
Mid-Hood Canal	Total	32%	27%	26%	26%
	North	16%	18%	17%	16%
	South	16%	10%	9%	10%
Skokomish	Total	51%	42%	41%	39%
	North	16%	17%	16%	16%
	South	38%	31%	31%	28%

Figure 18. Estimates of exploitation rates for Hood Canal populations from the retrospective analysis for all fisheries combined (Total), for northern and southern fisheries (LaVoy 2010b).



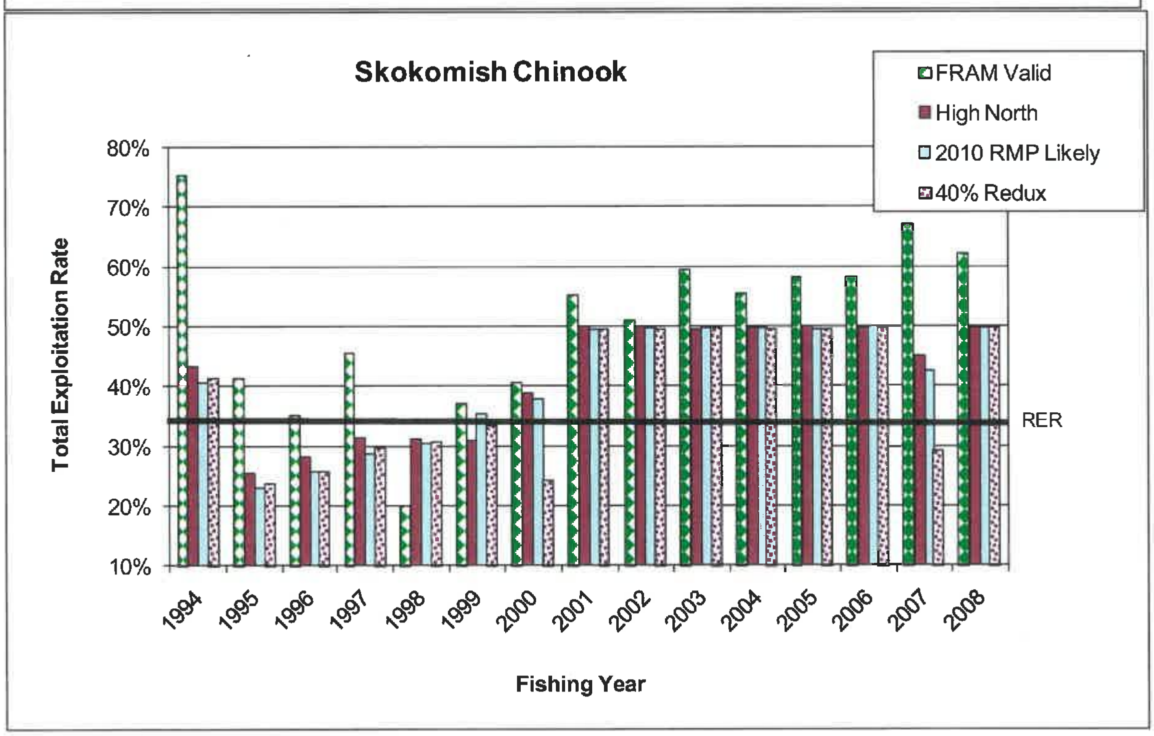


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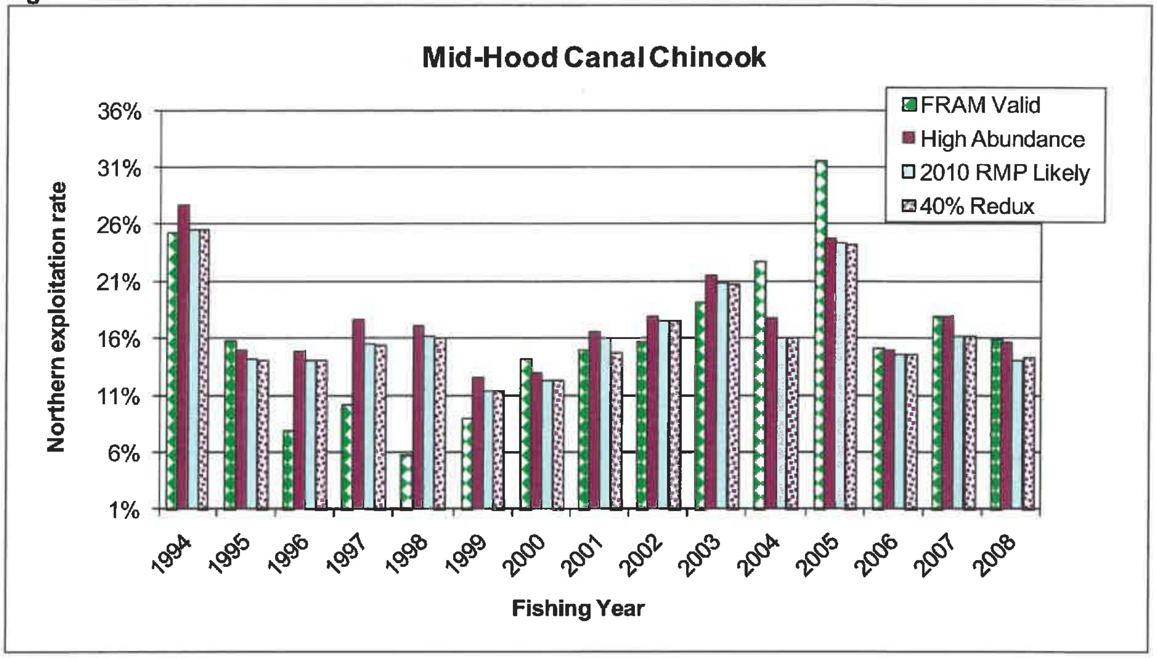
Figure 18 continued.



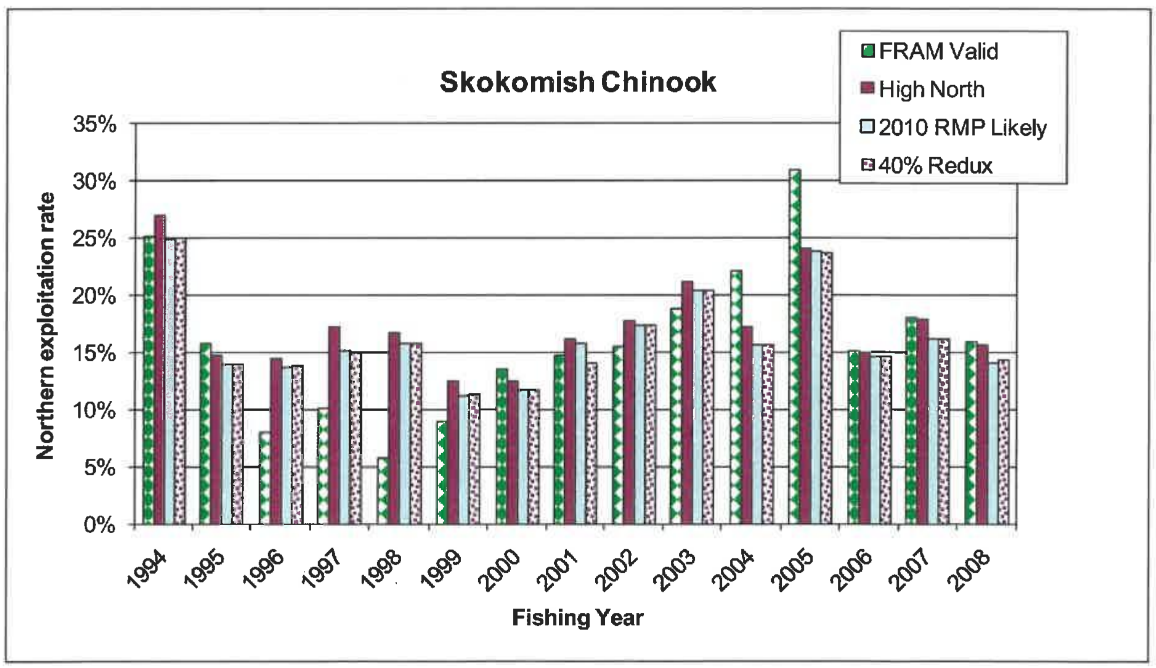
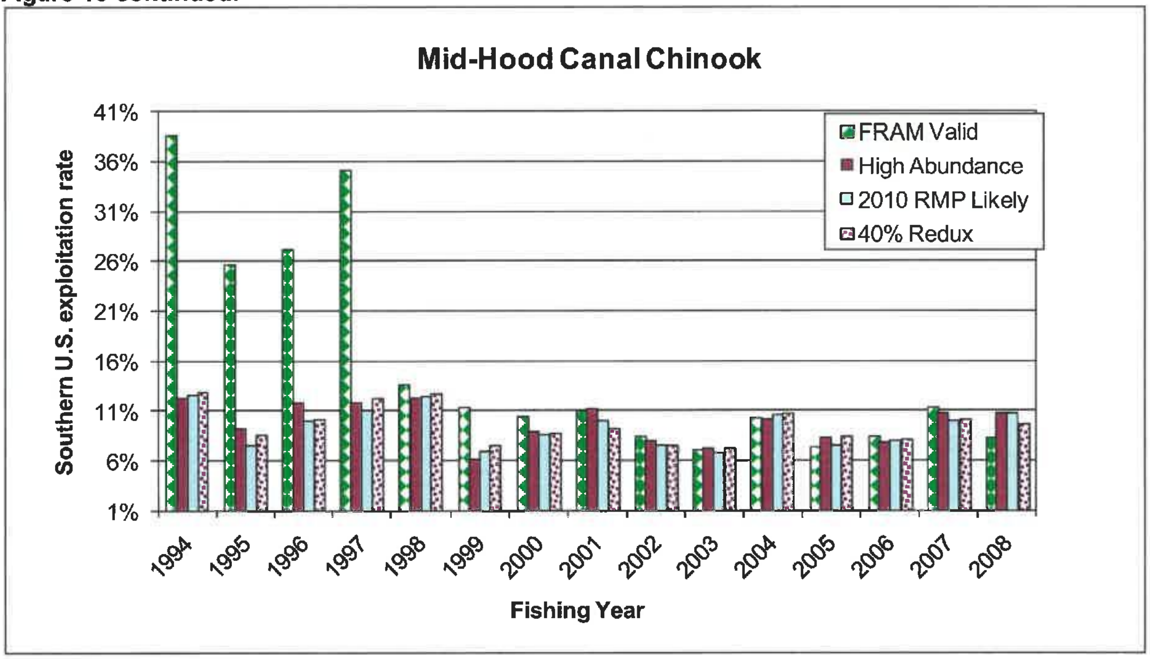
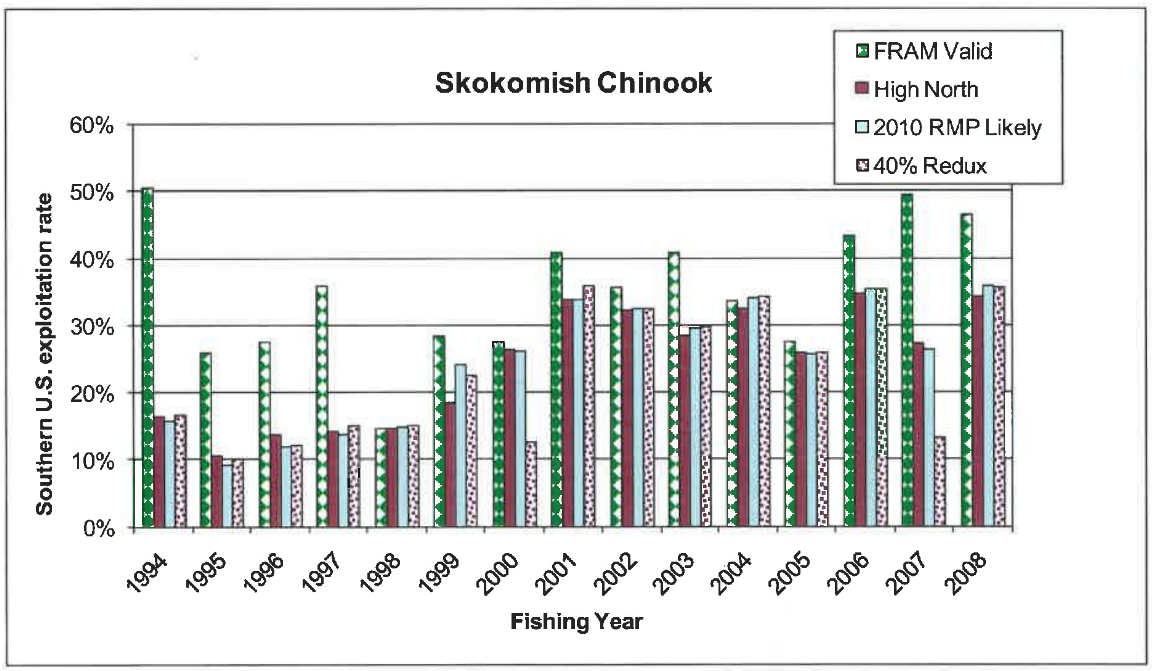


Figure 18 continued.





The 2010 RMP Likely Scenario estimates the exploitation rates under the range of fishing levels that are expected over the next three years under the RMP assuming continued domestic constraints in Canadian fisheries. The total average exploitation rates of 41 and 26 percent exceed the Skokomish RER (33%) and the Mid-Hood Canal RER surrogates (18/23%), respectively (Table 32). Total exploitation rates exceed RERs in nearly all years in the analysis period (Figure 18). Compared with the FRAM Validation scenario, total exploitation rates under the 2010 RMP Likely scenario would be reduced from 32 percent to 26 percent for the Mid-Hood Canal population, and from 51 percent to 41 percent for the Skokomish population (Table 29) because of lower rates in southern U.S. fisheries. Under the 2010 RMP Likely scenario exploitation rates in southern fisheries would be reduced substantially to moderately relative to the FRAM Validation scenario; from 16 percent to 9 percent for the Mid-Hood Canal population, and from 38 percent to 31 percent for the Skokomish population. Northern exploitation rates are relatively unchanged, approaching the RER surrogates for the Mid-Hood Canal Rivers population (Table 29, Figure 18). The 2010 RMP Likely scenario represents an 18 to 20 percent decrease in average total exploitation rates for the Mid-Hood Canal and Skokomish populations compared with those observed over the analysis period (FRAM Validation) (Appendix 2). The frequency of exceeding the RERs is marginally reduced for both populations.

The results of the High North and 40% Reduction scenarios are similar to that of the 2010 RMP Likely scenario (Tables 32). Total exploitation rates for both populations are one percentage point higher under the High North scenario and lower under the 40% Reduction scenarios when compared with the 2010 RMP Likely scenario. Exploitation rates continue to exceed RERs in most years. The purpose of the abundance based management regime that characterizes the Puget Sound Chinook RMPs is that fisheries are responsive to declining abundance. The retrospective analysis indicates that there is little overall response to reduced abundance. However, the Mid-Hood Canal Rivers population is already at critically low abundance regardless of scenario. In the years that resulted in critical escapements for the Skokomish population, southern U.S. exploitation rates were already relatively low (12-16%) (1994-1996-98) in response to lower abundances under the 2010 RMP Likely scenario or southern U.S. rates were reduced substantially (from 26% to 13% in 2000 and 2007).

The range of anticipated exploitation rates possible under the implementation of the 2010 Puget Sound Chinook RMP exceeds the RER or RER surrogate for both populations in the Hood Canal Region. NMFS determined the increased risk to the Skokomish population associated with the total fishing mortality proposed by the co-managers in the 2010 Puget Sound Chinook RMP, when compared to the RER (Table 33). Although exceeding the RER infers an increased risk to the survival and recovery of the population, NMFS cannot quantify it at this time with the available information. Other information may give some insight to the likelihood and degree of increased risk.

For the Mid-Hood Canal population, northern fisheries account for the majority of harvest and approach or exceed the surrogate RER which is a concern for a population at such low abundance. In some years, achievement of the surrogate RERs would not be feasible because northern fisheries alone exceed the surrogate RERs or would require southern U.S. fisheries to close entirely. Along with its status as a Category 2 population (i.e., hatchery and wild spawners are indistinguishable), it is important to consider the practical benefits of further fishery reductions in the fisheries that are the subject of the 2010 Puget Sound Chinook RMP. Using the 2010 RMP Likely scenario, we conservatively assume that escapements will remain more closely aligned to the 2004-2008 estimated average escapement in the retrospective analysis (111 fish) than the 1994-2008 average (195 fish), which includes years of substantially higher abundance. Given the ratio of recent year escapements into the individual river systems in the Mid-Hood Canal population, a total closure of southern U.S. fisheries (including Puget Sound) would result in an estimated increase of at most 14 adults to the Mid-Hood Canal population including 9 to the Hamma Hamma, 4 to the Dosewallips, and 1 to the Duckabush. These estimates do not account for natural mortality of the fish that would go uncaught. As a result, these estimates are higher than the number that would actually return if southern U.S. fisheries were eliminated. Therefore, further restrictions in southern fisheries would result in little benefit to the Mid-Hood Canal population. Nevertheless, exceeding the surrogate RER is a concern for a population at such low abundance which is essential to recovery of the ESU.

The co-managers propose to manage the Skokomish Management Unit with a 50 percent total exploitation rate, and a 12 percent pre-terminal SUS critical exploitation rate ceiling (Table 4). The resulting anticipated range of total exploitation rates for the Skokomish Management Unit under the implementation of the RMP is 39 to 42 percent (Table 32) compared with an observed average total exploitation rate of 51 percent. The most likely average exploitation rate is 41 percent. Lower exploitation rates in the mid-1990s influence the average rate under the 2010 RMP Likely scenario. If exploitation rates continue to be higher, i.e., the most recent years of the retrospective analysis, the average exploitation rate (and associated risks) would be closer to that observed under the FRAM Validation scenario. The entire range of anticipated total exploitation rates exceeds the RER of 33 percent for the Skokomish River population by six to nine percentage points.

Table 33. The percentage point change in probability of a rebuilt population in 25 years and the percentage point difference in probability that the population will fall below the critical threshold in 25 years when the anticipated total exploitation rates are compared to the RERs.

Management Unit	Population	FRAM Validation		2010 RMP Likely		High North		40% Reduction	
		Percentage Point difference in Probability of a Rebuilt Population in 25 Years[1]	Percentage Point difference in Probability that the Population will fall below the Critical Threshold in 25 Years[2]	Percentage Point difference in Probability of a Rebuilt Population in 25 Years[1]	Percentage Point difference in Probability that the Population will fall below the Critical Threshold in 25 Years[2]	Percentage Point difference in Probability of a Rebuilt Population in 25 Years[1]	Percentage Point difference in Probability that the Population will fall below the Critical Threshold in 25 Years[2]	Percentage Point difference in Probability of a Rebuilt Population in 25 Years[1]	Percentage Point difference in Probability that the Population will fall below the Critical Threshold in 25 Years[2]
Skokomish	Skokomish.	-50%	1%	-18%	0.2%	-18%	0.2%	-11%	0%

[1] A negative number in the difference in probability of a rebuilt population in 25 years indicates a decrease in the probability of that population being rebuilt in 25 years, when compared to its RER. A positive number in the difference in probability of a rebuilt population in 25 years indicates an increase in the probability of that population being rebuilt in 25 years, when compared to the RER. Rebuilt is defined as the population's escapement meeting or exceeding its rebuilding escapement threshold under current conditions.

[2] A negative number in the difference in probability that the population will fall below the critical threshold in 25 years indicates a decrease in the probability of that population will fall below the critical threshold in 25 years, when compared to the RER. A positive number in the difference in probability that the population will fall below the critical threshold in 25 years indicates an increase in the probability of that population will fall below the critical threshold in 25 years, when compared to the RER.

The 2010 RMP Likely scenario would represent an 18 percentage point decrease in the probability of a rebuilt Skokomish population in 25 years. Modeling also suggests that there is a negligible change in the probability that the population will fall below the critical level during that same 25-year period (Table 33) and that it would remain less than the RER criteria of 5%. Should SUS fisheries be managed for exploitation rates more similar to recent years, the risks would be higher (see risks under FRAM Validation scenarios in Table 33). However, the anticipated risks for the three implementation scenarios are improved over current conditions as represented by the FRAM Validation scenario (Table 32).

Increased risk to these populations is of concern. Both populations are Tier 1 populations and essential to the recovery of the Puget Sound Chinook ESU. Both populations are below their critical thresholds although the aggregate escapement to the Skokomish is much higher. The natural escapement trends are stable for both populations (Table 9). Growth rates for natural-origin return are declining for both populations (i.e., < 0.98). Growth rates for natural-origin escapement are stable for Mid-Hood Canal and declining for the Skokomish (Table 9). The hatchery and wild spawners are genetically indistinguishable and resemble the other fall populations in the region due to extensive outplanting of Green River lineage Chinook. Habitat has been degraded through agricultural and residential use and, on the Skokomish, impacts associated with dams that blocked anadromous habitat and reduced in-stream flow. A settlement agreement in 2008 between the Skokomish Tribe and the dam operator resulted in a plan to restore normative flows to the river, improve habitat and restore an early Chinook life history in the river using supplementation (Tacoma Public Utilities 2009; NMFS 2010d). In addition, significant work is occurring to improve and restore estuarine habitat through land acquisition, levee breaching, and similar projects (Puget Sound Nearshore Ecosystem Restoration Project 2010, NMFS 2010d).

Historically, harvest rates for the Skokomish River population have been too high to rebuild a self-sustaining population. The co-managers have proposed an exploitation rate ceiling in the proposed 2010 Puget Sound Chinook RMP that would reduce exploitation rates from the most recent year average of 60 percent to 50 percent. Modeling of the Skokomish River population indicates a small increase in total escapements over current conditions. We anticipate this will also improve natural-origin escapement. Given the history and current conditions in the watershed, the appropriate course is a transitional strategy implemented over time that reduces the effects of hatchery straying and harvest, and improves habitat to the degree necessary for the population to adapt and rebuild natural production. The timing and magnitude of changes in harvest that occur must be coordinated with the pace of habitat recovery and with the implementation of hatchery actions, and take into account the status of the population. Based on the current abundance status, the stable escapement trend for the Skokomish River population and the anticipated level of escapement under the implementation of the RMP, the level of risk to the Skokomish River population due to the anticipated range of total exploitation rates is consistent with such a transitional strategy. Hatchery and wild spawners are indistinguishable genetically and so hatchery fish should provide some buffer to genetic and demographic risks at low abundances and during the transitional period (Jones 2006, NMFS 2004d)[34]. However, given its current status and role in the recovery of the ESU, and in particular the declining trend in natural-origin escapement, the population should be monitored closely to affirm the anticipated benefits occur.

The Mid-Hood Canal Rivers population includes Chinook salmon spawning aggregations in the Hamma Hamma, Duckabush, and the Dosewallips Rivers. Since listing, the Mid-Hood Canal rivers population has exhibited a stable escapement trend (Table 9), although trends in individual spawning aggregates of the population are varied (Table 14). Growth rate for natural-origin escapement is also stable although the growth rate for natural-origin return is decreasing. The low abundances particularly for the individual river systems are a concern. The co-managers propose to manage the Mid-Hood Canal Management Unit by applying a 15 percent pre-terminal SUS rebuilding exploitation rate and a 12 percent pre-terminal SUS critical exploitation rate ceiling (Table 4). These objectives are identical to previous Puget Sound Chinook harvest RMPs when actual pre-terminal SUS fisheries, averaged 9 percent (NMFS unpublished data). Terminal-area harvest impacts have been virtually eliminated for the Mid-Hood Canal rivers Chinook salmon population. Mortality in terminal area fisheries has averaged 0.3% in recent years due to closures of most terminal area fisheries affecting Mid-Hood Canal Chinook. These patterns are expected to continue over the duration of the proposed 2010 Puget Sound Chinook RMP (page 207 of the RMP).

The entire range of anticipated total exploitation rates exceeds the RER surrogates for the Mid-Hood Canal Rivers population by three to nine percentage points (Table 32). The average exploitation rate in northern fisheries alone meets or approaches the RER surrogates. Achieving the lower RER surrogate would require essentially elimination of SUS fisheries. The evaluation of effects on escapement and spatial structure previously discussed in this document concluded that due to the low natural productivity of the habitat, the small range in escapement among the management scenarios and the practical effect of fishery reductions, further fishery constraints in the southern U.S. fisheries that are the subject of the proposed 2010 Puget Sound Chinook RMP would not substantially reduce the genetic or demographic risks to the populations from their current status, or change the critical status of the population.

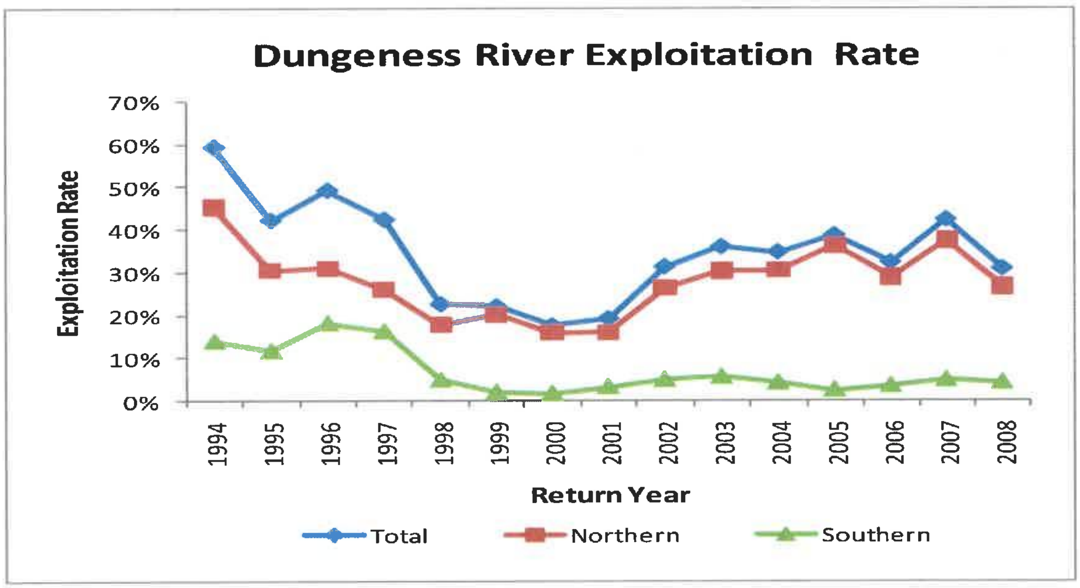
Additional discussion on the increased concern for the Hood Canal populations in regards to the likelihood of survival and recovery of the ESU will be provided in the following discussion of Criterion 6, (b)(4)(i)(D).

[34] In 2006 NMFS updated its 2004 SHIEER document (NMFS 2004d) which determined the relationship of each Puget Sound hatchery program to the ESU. In the 2006 update, the Hood Canal fall Chinook hatchery populations were included in the Puget Sound ESU. Although NMFS did not update its assessment of VSP effects at the time, the updated status and character of the programs are similar to that determined for hatchery programs for the Nisqually River and other transplanted Green River populations and so it is reasonable to expect that the VSP effects would also be similar.

7.5 Strait of Juan de Fuca Region

Exploitation rates on the Strait of Juan de Fuca populations have declined overall since the late 1980s, but have increased in recent years due to increases in northern fishery impacts (Figure 19). From 1983 to 1998, total exploitation rates averaged 57%. Since 1999, total exploitation rates averaged 30%. Exploitation rates in southern fisheries have been very low, averaging 4% since 2001 (Table 34). Since 1999, 80% or more of the harvest of the Dungeness and Elwha populations has occurred in northern fisheries (Figure 19, Table 21) (LaVoy 2010b; LaVoy 2010d). Tribal fisheries accounted for 42 percent of the harvest in southern U.S. fisheries from 2004 to 2008 (Table 21) (LaVoy 2010d).

Figure 19. Trends in exploitation rates for Chinook populations in the Strait of Juan de Fuca Region (LaVoy 2010b).



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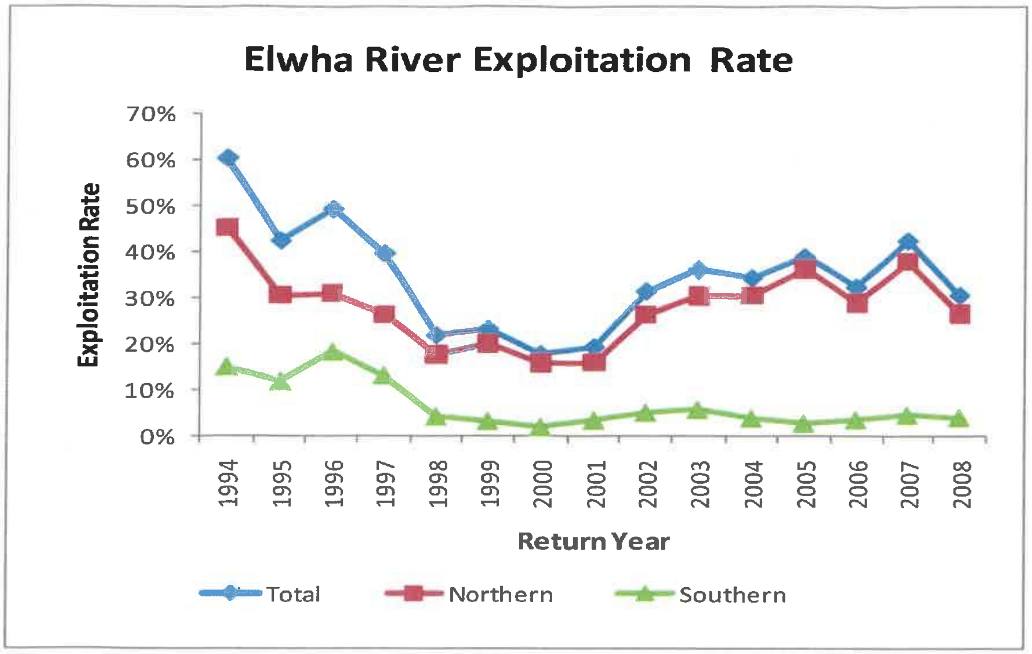


Table 34. Summary of changes in exploitation rates over time for Chinook populations in the Hood Canal Region.

Management Unit	Average Total Exploitation Rate		% Change	Southern U.S. 2001-2008 avg.
	1983-1998	1999-2008		
Dungeness	57%	30%	-47%	4%
Elwha	59%	31%	-48%	4%

Results from the Retrospective Analysis

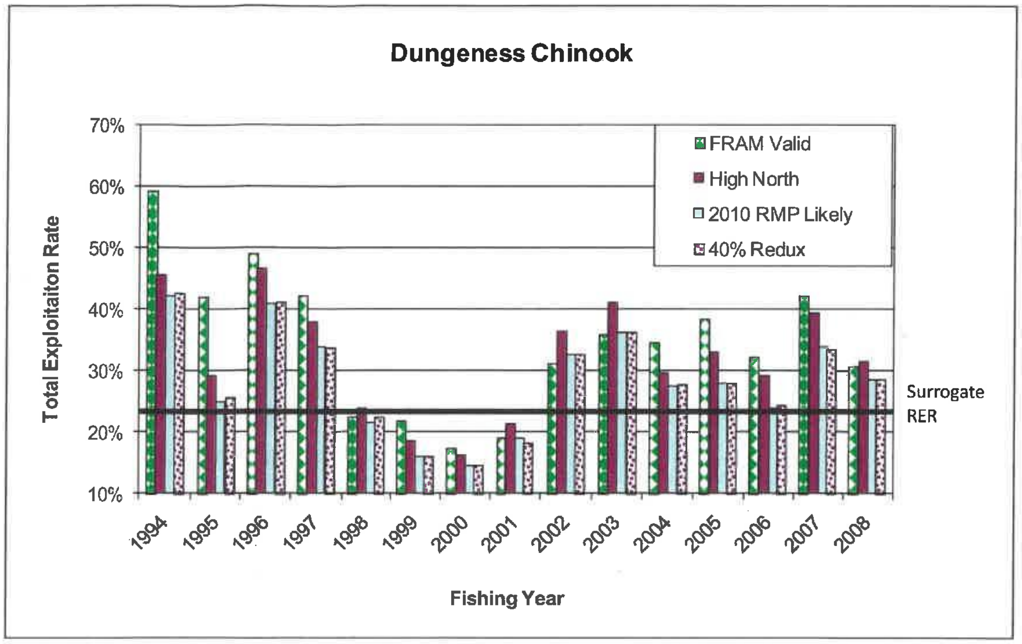
Figure 20 and Table 35 summarize information from the retrospective analysis for the Elwha and Dungeness populations (results from the retrospective analysis are also shown in tabular form in Appendix 2). Total exploitation rates exceed the RER surrogates of 23 percent in nearly all years for all scenarios (Table 35, Figure 20). In most years, the rates in northern fisheries alone exceed the RER surrogates (Table 35, Figure 20).

Table 35. Average exploitation rates (1994-2008) from the retrospective analysis for the population groups within the Strait of Juan de Fuca Region.

Population	Fishery	FRAM	High North	2010 RMP	40%

		Validation		Likely	Reduction
Dungeness	Total North South	35% 28% 7%	32% 28% 4%	28% 25% 4%	28% 25% 4%
Elwha	Total North South	35% 28% 7%	32% 28% 4%	28% 25% 4%	29% 25% 4%

Figure 20. Estimates of exploitation rates for Strait of Juan de Fuca populations from the retrospective analysis for all fisheries combined (total), for northern and southern fisheries (LaVoy 2010b).



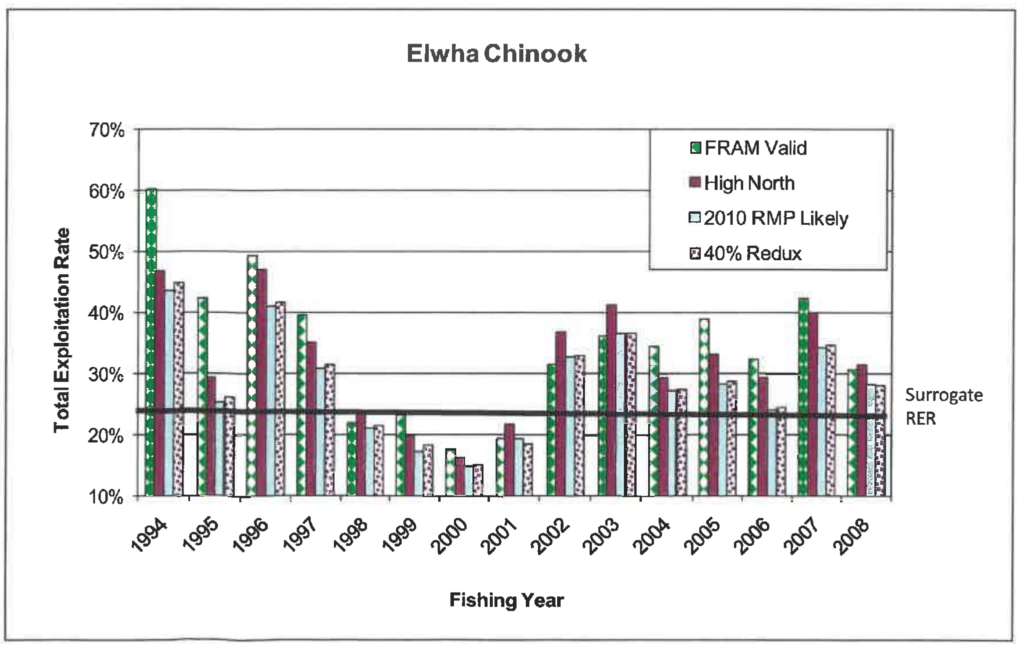
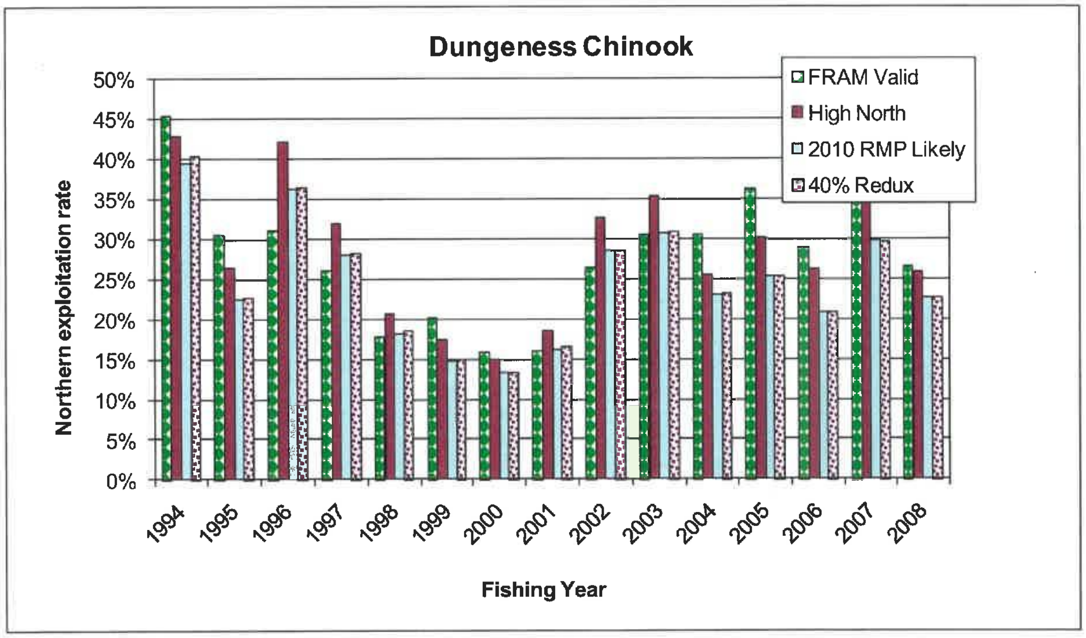


Figure 20 continued.



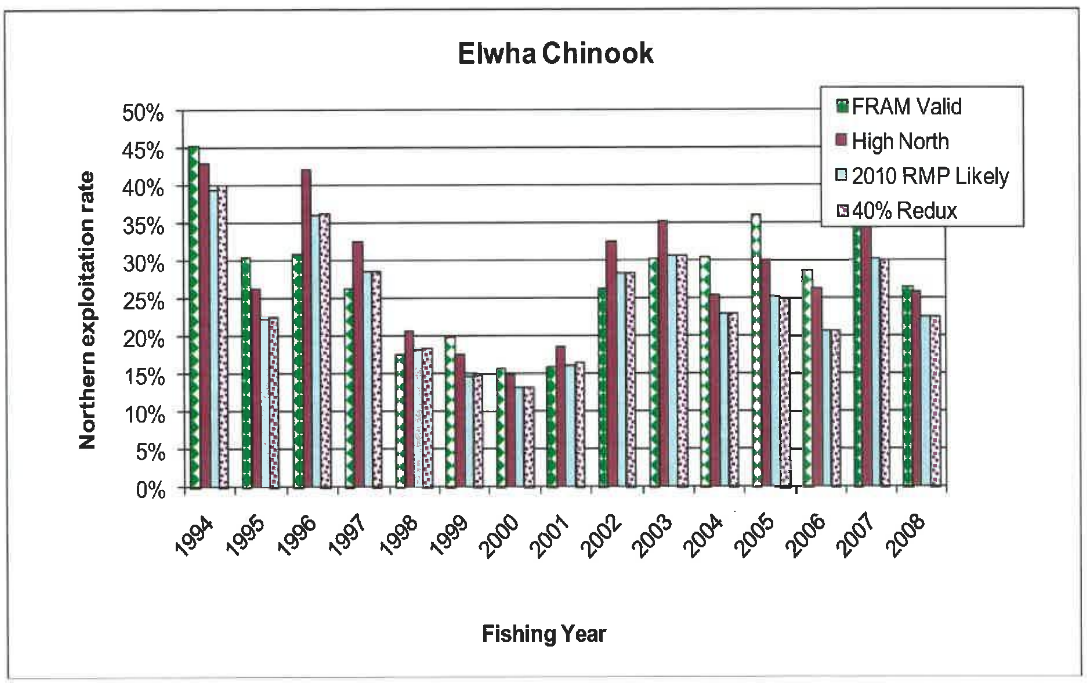


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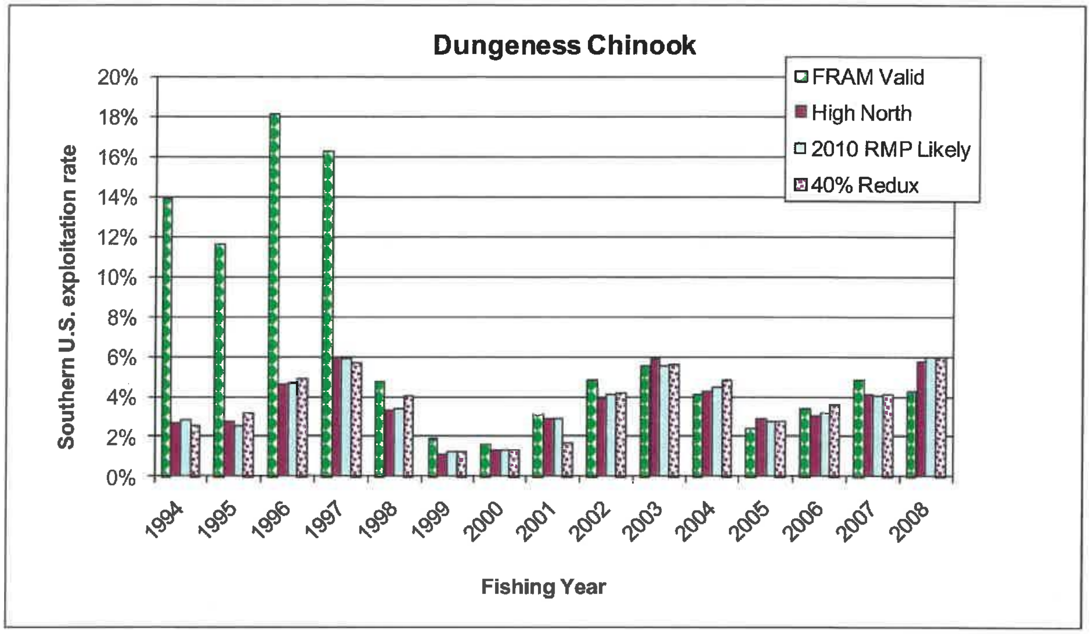
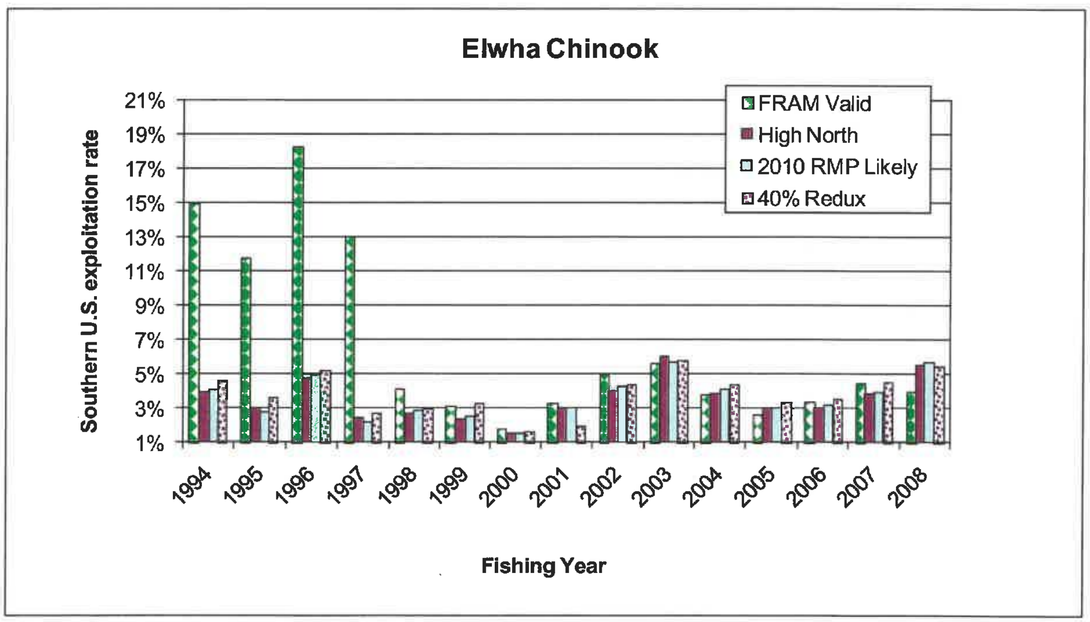
Figure 20 continued.





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The 2010 RMP Likely Scenario estimates the exploitation rates under the range of fishing levels that are expected over the next three years under the RMP assuming continued domestic constraints in Canadian fisheries. The total average exploitation rates of 28 percent exceeds the RER surrogates (23%)(Table 35) in almost all years in the analysis period (Figure 20). The 2010 RMP Likely scenario represents an 18 percent reduction in average total exploitation rates from those observed during the analysis period (i.e., from 35 to 28 percent). In northern fisheries exploitation rates would be reduced by three percentage points for both populations from 28 percent to 25 percent due to the terms of the 2008 PST Agreement. Exploitation rates in southern fisheries would remain very low (Table 35).

The results of the High North and 40% Reduction scenarios are similar to those of the 2010 RMP Likely scenario (Table 35). The total average exploitation rates of 28 percent exceeds the RER surrogates (23%)(Table 35) in almost all years in the analysis period (Figure 20). Total exploitation rates for both populations are four percentage points higher under the High North scenario and essentially the same under the 40% Reduction scenarios when compared with the 2010 RMP Likely scenario. The purpose of the abundance based management regime that characterizes the Puget Sound Chinook RMPs is that fisheries are responsive to declining abundance. The retrospective analysis indicates that the response to reduced abundance is unchanged because the exploitation rates in southern U.S. fisheries are already very low. Lower rates would not be feasible without essentially eliminating southern U.S. fisheries. Northern fishery exploitation rates approach or exceed the surrogate RERs for these populations in most years (Figure 20)

The co-managers propose to manage each management unit for a 10 percent SUS rebuilding exploitation rate and a 6 percent SUS critical exploitation rate ceiling (see Table 4). The RMP's SUS exploitation rate ceiling and the SUS critical exploitation rate ceiling do not include impacts in Alaska and Canadian fisheries which account for most of the fishery related mortality on these populations. Simulation modeling indicates the range of total exploitation rates that may be anticipated for the Dungeness and Elwha Management Units under the implementation of the RMP is 28 to 32 percent (Table 35) compared with an observed average total exploitation rate of 35 percent. The most likely total exploitation rate within this range is 28 percent (see 2010 RMP Likely scenario, Table 35). However, the anticipated SUS exploitation rate for the entire SUS fishery affecting this population is most likely only 4 percent (Table 35). Exceeding the RER surrogate of 23 percent infers an increased risk to the survival and recovery of the population but NMFS cannot quantify it at this time with the available information, i.e., a population-specific RER has not been derived from which to do the risk assessment. Other information may give some insight to the likelihood and degree of increased risk.

Increased risk to these populations under this scenario is of concern. Both populations are Tier 1 populations and essential to the recovery of the Puget Sound Chinook ESU. The Elwha population is above its rebuilding threshold although hatchery contribution is likely substantial. Escapement is stable although growth rates are declining (Table 9). Most relevant is the significant disruption to the watershed that will occur with removal of the Elwha dams, preparation for which is currently underway (NMFS 2006c; NMFS 2010e). Given the current constrained and degraded condition of habitat available for natural Chinook salmon production in the Elwha River, and the severe disruption to the system caused by the scheduled dam removals, the population will rely on the hatchery production to sustain the population and restore natural production for the foreseeable future. The current average natural-origin escapement for the Dungeness population is estimated to be below its critical threshold (Table 8). However, current fishing levels do not appear to be impeding the ability of the population to rebuild considering the observed increasing escapement and growth trends for the Dungeness population. The RER surrogates could not be achieved even with complete elimination of SUS fisheries. Because, the exploitation rates anticipated under the 2010 RMP Likely scenario are higher than the surrogate RER, there is the potential for additional risk to the Dungeness population. Its current status and role in the recovery of the ESU further underscores the need to monitor trends in escapement and growth rate. Trends in escapement and growth rate are increasing. If that changes, it will be necessary to again review the full suite of factors limiting the population. With respect to harvest, virtually all of the impacts occur in northern fisheries (Tables 21 and A1-1). In the event that extraordinary circumstances related to population viability occur, Paragraph 13(h) of Annex IV, Chapter 3 of the 2008 PST Agreement, provides a mechanism to consider additional actions that may be taken as part of a coordinated management plan. Analysis would need to demonstrate that further constraints would result in a meaningful benefit to the larger stock group of which these two populations are a component. Benefits to these populations by reductions in SUS fishery-related impacts are limited. The anticipated SUS exploitation rate on these populations is very low, at 4 percent.

The previous evaluation of escapements concluded that due to the low natural productivity of the habitat (Table 8) and the small range in escapement across management scenarios, further fishery constraints in southern U.S. fisheries would not substantially reduce the genetic or demographic risks to the populations from their current status, or change the critical status of the population. The additional returns of hatchery spawners from the hatchery programs should continue to mitigate to some degree risks to the low escapement of natural-origin fish to the Dungeness and through dam removal on the Elwha River (NMFS 2004d). Based on the current status and escapement trends of the populations, the anticipated level of escapement under the implementation of the 2010 Puget Sound Chinook RMP, the mitigation role of the hatchery programs, and consideration of the low anticipated SUS exploitation rate, the level of risk to the Strait of Juan de Fuca populations anticipated under the implementation of the RMP would not substantially reduce the genetic or demographic risks to the populations from their current status. Additional discussion on the increased concern for this population in regards to the likelihood of survival and recovery of the ESU will be provided in the discussion of Criterion 6, (b)(4)(i)(D).

In summary, the range of anticipated exploitation rates under the implementation of the RMP is equal to or less than the RER or RER surrogate for 11 populations. These 11 populations are: the Upper Skagit River, Lower Sauk River and Lower Skagit River in the Skagit Summer/Fall

Management Unit; the Upper Sauk River, Suiattle River and Upper Cascade populations in the Skagit Spring Management Unit; the North Fork Stillaguamish River in the Stillaguamish Management Unit, the Cedar and Sammamish populations in the Lake Washington Management Unit, the Duwamish-Green River in the Green River Management Unit, and the White River in the White River Management Unit. The level of risk to survival and recovery associated with the anticipated range of exploitation rates for these 11 populations are consistent with the NMFS RERs or RER surrogates and thus assumed to be low.

The entire range of anticipated exploitation rates for the South Fork Stillaguamish, Snohomish, Puyallup, Nisqually, Mid-Hood Canal, Skokomish, Dungeness and Elwha Management Units exceeds their corresponding RER or RER surrogate. In addition, the anticipated exploitation rate under the High North management scenario for the Nooksack population exceeds its corresponding RER. In these populations, there is a decreased probability that the populations will rebuild within 25 years and/or an increase in the probability that the population will fall below their critical thresholds during that same 25-year period, when compared to the RER or RER surrogate as the standard. NMFS assessed that risk in the context of additional information in the discussion above. Further discussion on the identified elevated level of risk to these populations under the implementation of the RMP, in regards to the likelihood of survival and recovery of the ESU, will be provided in the discussion of Criterion 6, 50 CFR 223.203(b)(4)(i)(D).

8 ▪ Criterion 6: Biological Rational for Harvest Management Strategy

Section (b)(4)(i)(D) displays a biologically based rationale demonstrating that the harvest management strategy will not appreciably reduce the likelihood of survival and recovery of the Evolutionarily Significant Unit in the wild, over the entire period of time the proposed harvest management strategy affects the population, including effects reasonably certain to occur after the proposed actions cease.

Although component populations contribute fundamentally to the structure and diversity of the ESU, it is the ESU, not its component populations, that is the listed "species" under the ESA. The final ESU-wide scenario for delisting will include populations with a range of risk levels, but when considered in the aggregate, the collective risk will be sufficiently low to ensure persistence of the ESU. NMFS determined in its final supplement to the Puget Sound Salmon Recovery Plan that an ESU-wide recovery scenario should include at least two to four viable Chinook salmon populations in each of the five geographic regions within Puget Sound, depending on the historical biological characteristics and acceptable risk levels for populations within each region (NMFS 2006a). Three of the five regions within the ESU (Strait of Juan de Fuca, Georgia Strait, and Hood Canal) contain only two populations. An ESU-wide recovery scenario should also include within each of these geographic regions one or more viable populations from each major genetic and life history group historically present within that geographic region (NMFS 2006a). NMFS has specified which populations within each region must be at low risk to recover the ESU (NMFS 2006a) and developed the Population Rebuilding Approach to assess risk relative to viability to the remaining populations in the ESU. An ESU with well-distributed viable populations avoids the situation where populations succumb to the same catastrophic risk(s) (e.g., a volcanic eruption of Mount Rainier), allows for a greater potential source of diverse populations for recovery in a variety of environments (i.e., greater options for recovery), and will increase the likelihood of the ESU's survival in response to rapid environmental changes. Geographically diverse populations in different regions also distribute the ecological and ecosystem services provided by salmon across the ESU.

All of the populations in the ESU are high risk (NMFS 2006a). However, measures of abundance, trends in abundance, productivity (Tables 8-10), and other information give an indication of the relative status of populations in the ESU. In general, populations in the Strait of Juan de Fuca, Georgia Basin, and Hood Canal regions are at greater risk due to critically low abundance and/or declining growth rates in natural-origin return and escapement (<0.98) of at least one of the two populations in each region.

Limiting factors for the Puget Sound Chinook populations include a range of adverse effects associated with land use activities including urbanization, forestry, agriculture, and development. The adverse effects of hatchery operations and harvest also limit populations. The severity and relative contribution of these factors varies by population. Exploitation rates for most of the

Puget Sound Chinook populations have been reduced substantially since the early to mid-1990s. The trends in harvest mortality for the populations in each region are discussed in more detail in the previous criterion. The effect of these overall reductions in harvest has been to improve the baseline condition and help to alleviate the effect of harvest as a limiting factor.

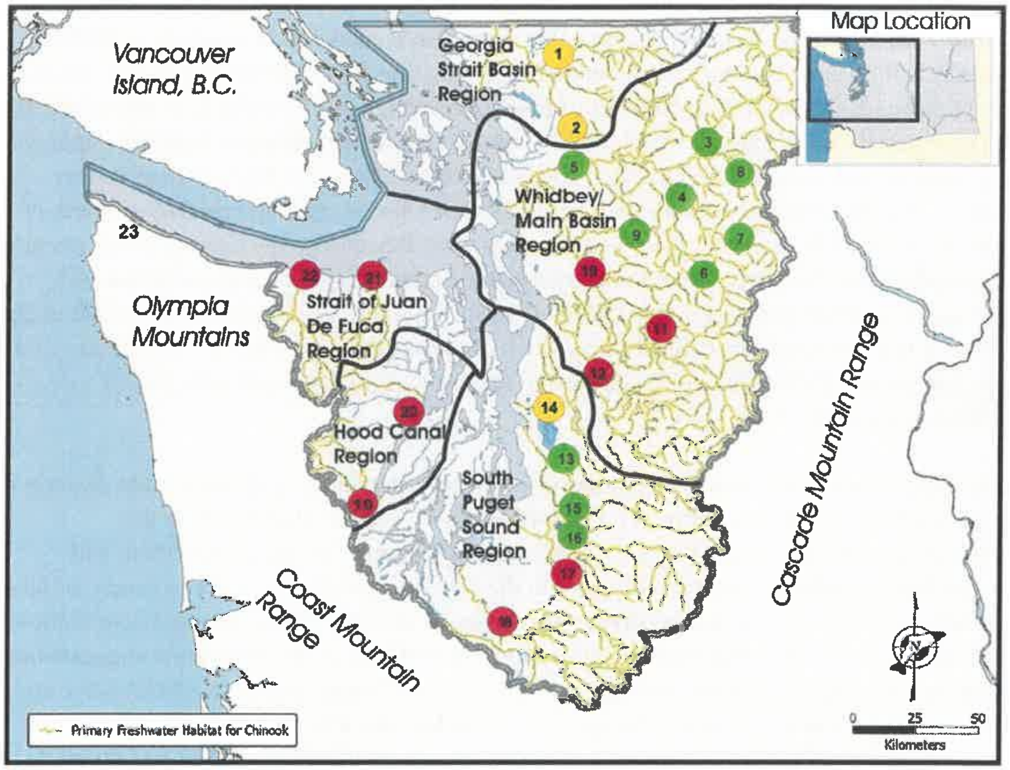
NMFS considers the distinctions in genetic legacy and watershed condition in assessing the risks to survival and recovery of proposed actions across populations within the Puget Sound Chinook ESU. It is important to take into account whether the genetic legacy of the population is intact or if it is no longer distinct. Populations are defined by their relative isolation from each other, and by the unique genetic characteristics that evolve as a result of that isolation to adapt to their specific habitats. If these are populations that still retain their historic genetic legacy, then the appropriate course to insure their survival and recovery is to preserve that genetic legacy and rebuild those populations. Preserving that legacy requires both a sense of urgency and the actions necessary and appropriate to preserve the legacy that remains. However, if the genetic legacy is gone, then the appropriate course is to recover the populations using the individuals that best approximate the genetic legacy of the original population, reduce the effects of the factors that have limited their production, and provide the opportunity for them to readapt to the existing conditions. NMFS has incorporated this approach in its previous 4(d) determination on the 2004-2009 Puget Sound Chinook RMP (NMFS 2005a) and in several other recent opinions (NMFS 2008a; NMFS 2008c; NMFS 2010a; NMFS 2010b). NMFS developed the Population Rebuilding Approach to refine its approach to the Puget Sound Chinook ESU using information on genetic characteristics and habitat condition to assign populations to different risk tiers in assessing risk across the ESU from proposed actions that may affect listed Puget Sound Chinook (see previous discussion under Analytical Approach).

The retrospective analysis provides estimates of how exploitation rates and escapements are likely to change under various management scenarios and, therefore, an assessment of risk across the populations of the ESU. The scenarios generally represent (1) what actually occurred based on post season estimates of stock abundance and fishery catches (FRAM Validation); (2) what would occur under the 2010 Puget Sound Chinook RMP if Alaskan and Canadian fisheries were managed at the limits allowed under the 2008 Pacific Salmon Treaty Agreement (High North); (3) what we can reasonably expect to occur under the 2010 Puget Sound Chinook RMP given an informed assessment of how fisheries are likely to be managed in the future (2010 RMP Likely); and (4) how the 2010 Puget Sound Chinook RMP would perform if there was an unexpected and broad scale reduction of 40% in the abundance of Chinook salmon resulting from large scale environmental events such as significant declines in marine survival or climate change. In the previous sections of the evaluation, anticipated escapements and exploitation rates resulting from implementation of the various management scenarios were compared with NMFS' standards of escapement thresholds and RERs. As discussed previously, escapements estimated by FRAM for the retrospective analysis are not directly comparable to the NMFS thresholds in terms of natural-origin production. However, using the FRAM Validation scenario as the basis for comparison in the retrospective analysis indicates how relative abundance might change from current levels under the three alternative management scenarios under the implementation of the 2010 Puget Sound Chinook RMP.

The results of the retrospective analysis vary across the management scenarios. The results indicate that the High North scenario on average exceeds RERs or surrogate RERs for 11 of the 22 populations in the ESU. In two cases (Lower Skagit, Lower Sauk), the resulting decreases in escapement could change the status of the population relative to meeting its rebuilding threshold although the differences are small. Management consistent with the 2010 RMP appears robust to significant decreases in abundance as reflected under the 40% Reduction scenario. The greatest practical effect of such a substantial reduction in returning Chinook salmon abundance bears on achievement of the population rebuilding thresholds. Average escapements for five of the 14 populations expected to exceed their rebuilding thresholds will continue to do so. Eighteen of the 20 populations expected to exceed their critical escapement thresholds on average will continue to do so in years of reduced abundance and most by large margins. Of the populations essential to recovery of the ESU and expected to meet their critical thresholds, the North Fork Nooksack population would not continue to meet its critical threshold. All populations meeting their RERs, including the North Fork Nooksack, will continue to do so.

The 2010 RMP Likely scenario results in generally low to moderate reductions in fishery harvest impacts and small improvements in escapements for most Puget Sound Chinook salmon when compared with the FRAM Validation scenario. Reductions in southern U.S. fisheries are expected to be substantial for most management units, particularly when compared with the early years of the retrospective analysis. Management consistent with the 2010 RMP Likely scenario on average is expected to meet RERs or RER surrogates for 13 of the 22 populations, decrease exploitation rates, and increase escapements compared with those anticipated under the High North scenario although in many cases the differences between scenarios are relatively small. In deciding how to weigh the information from the various analyses in making its jeopardy determination, NMFS considered the likelihood of the various scenarios occurring. A 40 percent reduction in abundance of all management units is not likely for the immediate three-year duration of the 2010 Puget Sound RMP given the general trend of stable to increasing abundance described in earlier sections. It is reasonable to expect that some less draconian reduction in abundance could occur in general or for some individual populations from those observed in recent years. Both the High North and 2010 RMP Likely management scenarios consider a range of abundances, including lower abundances, during the period of the retrospective analysis. In addition, the U.S. and Canada will continue to manage their fisheries to meet conservation and allocation objectives beyond those specified in the 2008 PST Agreement that is the basis of the High North management scenario. As a result, the fisheries would more closely resemble the types of actions and fishing levels observed in recent years on which the 2010 RMP Likely management scenario is based. It is reasonable, therefore, to focus the assessment of jeopardy on management as it is expected to occur under the 2010 RMP Likely scenario.

Estimated impacts from the fisheries proposed by the RMP will vary by region depending on the population-specific management objectives specified in the RMP. Consistent with the requirements of the ESA and this criterion to assess ESU-wide effects, the following is an evaluation of the estimated impacts resulting from the fisheries proposed by the RMP under the 2010 RMP Likely scenario. The risk assessment is presented in two stages. In the first stage, a potential area of concern or risk is identified by region based on the status of the populations relative to their escapement thresholds and RERs under the 2010 RMP Likely scenario as assessed previously in Criteria 4 and 5 (Figure 21). Populations designated as green meet their RERs or RER surrogates on average and they are above and are anticipated to remain above their critical escapement thresholds in the majority of years in the analysis. Populations designated as yellow meet their RERs or RER surrogates on average but are currently near or below their critical thresholds or are likely to fall below their critical thresholds based on the retrospective analysis. Populations designated as red do not meet their RERs or RER surrogates on average. The second stage of the analysis considers all of the populations in each region, with particular attention to those identified to be at higher risk in stage one. NMFS considers the factors and circumstances that mitigate the risks identified in the first stage leading to conclusions regarding the viability of each region and the ESU as a whole. We evaluate the likelihood of that concern or risk occurring and consider the practical influence harvest may have on the potential concern or risk. The risk assessment summarizes information presented in more detail in previous sections.



Key: Chinook salmon populations, Puget Sound Comprehensive Chinook Management Plan, 2010

Nooksack River
1-North Fork Nooksack River
2-South Fork Nooksack River

Skagit River
3-Uper Skagit River
4-Lower Sauk River
5-Lower Skagit River
6-Upper Sauk River
7-Siuattle River
8-Upper Cascade River

Stillaguamish River
9-North Fork Stillaguamish
10-South Fork Stillaguamish

Snohomish River
11-Skykomish River
12-Snoqualmie River

Lake Washington
13-Cedar River
14-Sammamish River

Single Population Rivers
15-Duwamish-Green River
16-White River
17-Puyallup River
18-Nisqually River
19-Skokomish River
20-Mid-Hood Canal Rivers
21-Elwha River
22-Dungeness River
23-Hoko River (Not within ESU)

Population risk based on NMFS' evaluation of the most likely management scenario with implementation of the 2010 RMP:

- **Populations at low risk - the exploitation rate meets the RER under the 2010 RMP Likely scenario**
- **Populations with an increased level of concern - the exploitation rate meets the RER, but the anticipated escapement approaches the critical threshold or the population is currently at or near critical status**
- **Populations at higher risk - the exploitation rate exceeds the RER under the 2010 RMP Likely scenario**

Figure 21. Map of the geographic regions within the Puget Sound Chinook Salmon Evolutionarily Significant Unit. Based on NMFS' proposed evaluation, identified within the figure are populations with an increased level of concern, when compared to NMFS' standards and populations where the anticipated range of exploitation rates resulting from the implementation of the RMP exceeds RERs or RER surrogates.

In addition to the biological requirements outlined in Limit 6 of the ESA 4(d) Rule, NMFS' federal trust responsibilities to treaty Indian tribes were also considered in developing NMFS' proposed evaluation and resultant recommended determination for the RMP. In recognition of treaty right stewardship, NMFS, as a matter of policy, has sought not to entirely eliminate tribal harvest (Secretarial Order 3206). Instead, NMFS' approach is to accept some fisheries impacts that may result in increased risk to the listed species in order to provide limited tribal fishery opportunity. This approach recognizes that the treaty tribes have a right and priority to conduct their fisheries within the limits of conservation constraints. Because of the Federal government's trust responsibility to the tribes, NMFS is committed to considering the tribal co-managers' judgment and expertise regarding conservation of trust resources. Limit 6 of the 4(d) Rule under which NMFS is conducting this evaluation explicitly requires this.[35] However, the opinion of the tribal co-managers and their immediate interest in fishing must be balanced with NMFS' responsibilities under the ESA.

For some populations, NMFS identified areas of potential risk that are addressed more directly in the region-specific subsections below. The results of this evaluation also highlight the importance of habitat actions and hatchery conservation programs for the preservation and recovery of these populations specifically, and to the ESU in general. The status of many of these stocks is largely the result of reduced productivity in the wild from habitat loss and degradation and from other sources of human induced mortality. The analysis in this evaluation suggests that it is unrealistic to expect to achieve substantive increases in Chinook population abundance and productivity and population recovery through harvest reductions alone without also taking substantive action in other areas to improve the survival and productivity of the populations. Likely implementation of the 2010 Puget Sound Chinook Harvest RMP will help ensure that Puget Sound salmon fisheries are managed conservatively, but recovery of the Puget Sound Chinook ESU depends on implementation of a broad based program that addresses the identified major limiting factors of decline.

After considering the results of the retrospective analysis and other relevant information discussed in this evaluation, NMFS concludes that implementation of the 2010 Puget Sound Chinook Harvest RMP would not appreciably reduce the likelihood of survival and recovery of the Puget Sound Chinook Salmon ESU in the wild. The following analysis summarizes in more detail the information that formed the basis for this conclusion.

[35] (6)(i) The Secretary has determined pursuant 50 CFR 223.209 [Tribal Plans] and the government to government processes therein that implementing and enforcing the joint tribal/state plan will not appreciably reduce the likelihood of survival and recovery of affected threatened ESUs.

8.1 Strait of Georgia Basin Region

There are two populations within the Strait of Georgia Basin: the North Fork Nooksack River and the South Fork Nooksack River early Chinook salmon populations (Figure 21). Both are classified as Tier 1 populations and both are essential to recovery of the Puget Sound Chinook ESU. Escapement trends are increasing and growth rates for natural-origin fish are stable or increasing (i.e., >0.98) for both populations (Table 9). However, natural-origin escapement for both populations remains close to or below their critical escapement thresholds (Table 8). If naturally spawning listed hatchery-origin adults from the Kendall Creek Hatchery supplementation program are included, the escapement of Chinook salmon has averaged 1,701 fish in the North Fork Nooksack in recent years, an 800 percent increase since the ESU was listed. Over the same period, natural-origin Chinook escapement has increased by only 130 percent (227 adults). The total exploitation rate on the management unit has declined by 36 percent since the 1980s, averaging 22 percent since 1994, which is below the FRAM-equivalent RER of 23 percent. Approximately 70 percent or more of all harvest occurs in Alaskan and Canadian fisheries (Figure 10), primarily in the WCVI troll and Georgia Strait sport fisheries (CTC 2009). Similar to recent years, it is likely that the vast majority of the SUS fishery harvest impacts on the Nooksack Management Unit populations under the RMP would occur in treaty Indian fisheries. Since 2004, on average, 81 percent of the SUS harvest on the Nooksack Management Unit has occurred in tribal fisheries; primarily taken in tribal ceremonial and subsistence fisheries in the Nooksack River.

Under the 2008 Likely scenario NMFS expects that the RER of 23 percent will be met. The results anticipate a minor reduction in the average exploitation rate (from 22% to 21%) from rates observed over the analysis period (FRAM Validation) due to the reductions in northern fisheries resulting from the 2008 PST Agreement. This includes a potential increase in SUS exploitation rates from an average of five to seven percent if southern fisheries achieved the exploitation rate generally anticipated preseason and allowed under the proposed RMP. Recall that actual SUS exploitation rates were five percent or less under the 2004 RMP which includes provisions similar to the proposed 2010 Puget Sound Chinook RMP. So evaluation of the potential seven percent SUS exploitation rate is likely a conservative assumption. The retrospective analysis indicates that natural-origin escapements for both populations are expected to remain at depressed levels, and for the South Fork Nooksack below its critical threshold. Because of the potential increase in average exploitation rates, in SUS fisheries, the 2010 RMP Likely scenario is expected to result in a slight decrease in average escapement (5 natural-origin spawners to both populations combined). Although both populations are anticipated to meet their RER which generally indicates low risk to the population, NMFS has noted concern for the Nooksack populations because of their anticipated status near or below their critical thresholds (Figure 21).

Based on the observed data and model results and assuming impacts will be similar to those anticipated under the 2010 RMP Likely scenario over the duration of the Puget Sound Chinook RMP, harvest resulting from the proposed action (i.e., Puget Sound salmon fisheries) does not appear to be a limiting factor for the Nooksack populations. Both populations currently exhibit increasing escapement trends and stable or increasing growth rates. The evaluation of effects on escapement previously discussed in this document indicated the practical effects of further reductions in SUS exploitation rates would be negligible. Due to the low natural productivity of the habitat and the low SUS exploitation rate, further constraints in southern U.S. fisheries would not substantially reduce the genetic or demographic risks to the populations from their current status. Any further reductions would significantly impact tribal fisheries without substantive conservation benefit to the Nooksack populations. Past reductions in harvest and benefits from the supplementation program have contributed to increased escapement of fish into the North and South Fork Nooksack Rivers. However, the relative lack of response in terms of natural-origin production for both populations suggests natural-origin recruitment will not increase much beyond existing levels unless constraints limiting marine, freshwater, and estuary survival for the Nooksack early populations are alleviated. Augmentation of natural-origin spawners on the North Fork Nooksack River, with conservation hatchery-origin spawners, will continue to test the natural production potential of the watershed at higher escapement levels. The escapement of hatchery-origin fish may also enhance natural-origin production by capitalizing on favorable freshwater and marine survival conditions in some years, particularly as the benefits of habitat improvements materialize. The broodstock used for the Kendall Creek Hatchery program retains the genetic characteristics of the original, donor, wild population. Therefore, early Chinook produced by the Kendall Creek Hatchery program serves as a reserve that buffers genetic and demographic risks to the natural-origin North Fork Nooksack River population (NMFS 2004d). The captive-brood stock program implemented in 2007 for the South Fork Nooksack early Chinook population is essential to protecting and rebuilding the remaining indigenous component of this population until benefits to natural productivity from habitat improvements are realized. It should provide further protection to mitigate any near-term risk for that population.

NMFS concludes that the implementation of the RMP from May 1, 2011 through April 30, 2014, will adequately protect Chinook salmon populations in the Georgia Straight Region based primarily on the expectation that the RER will be met under the most likely management scenario, the stable and increasing trends in escapement and growth rate, the additional contributions of hatchery-origin spawners to the natural spawning areas, and the low SUS exploitation rate that are associated with implementation of the proposed 2010 Puget Sound Chinook RMP. Additionally, NMFS' conclusion is based on information suggesting that past harvest constraints have had limited effect on increasing escapement of returning natural-origin fish, when compared with the return of hatchery-origin fish, and taking into consideration NMFS' treaty trust responsibility. Eighty percent of the harvest of Nooksack early Chinook in SUS fisheries occurs in tribal fisheries; primarily in ceremonial and subsistence fisheries. The proposed 2010 Puget Sound RMP describes additional actions the tribes have taken and will take to minimize impacts to Nooksack early Chinook. However, as described in the preceding paragraphs, NMFS' approach is to accept some fisheries impacts that may result in increased risk to the listed species in order to provide limited tribal fishery opportunity. This approach recognizes that the treaty tribes have a right and priority to conduct their fisheries within the limits of conservation constraints.

8.2 Whidbey/Main Basin Region

There are 10 populations in the Whidbey/Main Basin Region representing a range of life history types (Figure 21). The six Skagit Chinook salmon population are all Tier 1 populations. The four Stillaguamish and Snohomish populations are Tier 2 populations (Table 3). NMFS has determined that the Suiattle and one each of the early (Upper Sauk, North Fork Stillaguamish), moderately early (Upper Skagit, Lower Sauk, Upper Cascade, South Fork Stillaguamish), and late (Lower Skagit, Skykomish, Snoqualmie) run time forms will need to be viable for the Puget Sound Chinook ESU to recover.

Escapement trends are stable or positive for nine of the 10 populations within the region. The exception is the South Fork Stillaguamish population. Growth rates for natural-origin escapement are stable or increasing for eight of the 10 populations (i.e., >0.98) although growth rates of natural-origin return of seven of the 10 populations are declining (<0.98) (Table 9). The fact that growth rates for escapement (i.e., fish through the fishery) are greater than growth rates for return indicates some stabilizing influence on escapement from past reductions in fishing-related mortality. Six of the 10 populations currently exceed their rebuilding escapement thresholds, and all exceed their critical escapement thresholds by 56 to 1,000 percent, with the exception of the South Fork Stillaguamish population (Tables 8 and 10). Exploitation rates on populations in the Whidbey/Main Basin Region have decreased 27 to 57 percent since the 1980s (Table 24). Fifty-three percent or more of all harvest of the populations from this region has occurred in Alaskan and Canadian fisheries since 1999, primarily in the WCVI sport and troll and Georgia Strait sport fisheries. Tribal fisheries account for 31 to 55 percent of the harvest in southern U.S. fisheries depending on the management unit.

Management under the 2010 RMP Likely scenario would contribute to rebuilding seven of the 10 populations in the region. The analysis indicates that seven of the 10 RERs or RER surrogates would be met under the 2010 RMP Likely scenario (Table 26), and thus considered at low risk (Figure 21). The Skykomish, Snoqualmie, and South Fork Stillaguamish populations are considered at higher risk because they do not meet their RERs (Figure 21). The average exploitation rate in northern fisheries alone approaches the RER for the Snohomish populations (Skykomish and Snoqualmie). Through modeling, NMFS assessed the increased risk to these populations under implementation of the proposed 2010 Puget Sound Chinook RMP. For the Snohomish populations, the most likely total exploitation rate is 27 percent (see Table 25). This rate exceeds the NMFS-derived rebuilding exploitation rate of 18 percent for this population. Under the 2010 RMP Likely scenario, a 27 percent exploitation rate would result in a 30 percentage point decrease in the probability of a rebuilt population in 25 years under current conditions. This modeling also suggests an eight percent increase in the probability that the population will fall below the critical level during that same 25-year period (see Table 27). For the South Fork Stillaguamish population, the most likely total exploitation rate is 19 percent (see Table 25). This rate exceeds the NMFS-derived rebuilding exploitation rate of 18 percent for this population. Under the 2010 RMP Likely scenario, a 19 percent exploitation rate would result in a 4 percentage point decrease in the probability of a rebuilt population in 25 years under current conditions. This modeling also suggests a negligible change in the probability that the population will fall below the critical level during that same 25-year period (see Table 27).

The first stage of the analysis identified higher risk associated with the Skykomish, Snoqualmie and South Fork Stillaguamish populations because they are not expected to meet their RERs under the 2010 RMP Likely scenario (Figure 21). We now consider the degree to which other factors and circumstances mitigate the risks identified in the first stage analysis. Both the Skykomish and Snoqualmie populations have stable or increasing escapement trends and growth rates. Natural-origin escapement for the Snoqualmie population is currently above its rebuilding threshold. Based on the retrospective analysis, eight of the 10 populations are expected to exceed their rebuilding thresholds (including the Skykomish and Snoqualmie populations) and all except the South Fork Stillaguamish are expected to remain above their critical thresholds even with a substantial reduction in abundance. Average escapement for the South Fork Stillaguamish is expected to remain close to its critical threshold. The 2010 RMP Likely scenario represents a 12 to 29 percent reduction in exploitation rates from those observed over the analysis period as represented by the FRAM Validation scenario. The analysis indicates this reduction in exploitation rate would reduce the risk to the South Fork Stillaguamish population by a small increase in escapements. In addition, it is a Tier 2 population whose life history is represented by three other populations in the region that are in much healthier condition. Therefore, any increased risk to this population would not impede viability for the region based on NMFS' delisting criteria. The South Fork Stillaguamish conservation hatchery program using native broodstock funded through the PST Critical Stocks Program will further reduce risks to the South Fork Stillaguamish population. Although three populations in the region may experience some higher risk, NMFS concludes that implementation of the 2010 Puget Sound Chinook RMP should adequately protect the populations within the Whidbey/Main Basin Region of the ESU.

8.3 Central/South Sound Region

There are six populations within the Central/South Sound Region (Figure 21). Most populations are genetically similar, likely reflecting the extensive influence of transplanted hatchery releases, primarily from the Green River population. NMFS has classified the White and Nisqually Chinook salmon populations as Tier 1 populations. The Duwamish-Green is a Tier 2 population and the Sammamish, Puyallup and Cedar River Chinook populations are Tier 3 populations (Table 3). NMFS determined the Nisqually[36] and White River populations are essential to recovery of the ESU. Escapement trends are stable or positive for all six populations (Table 9). Growth rates of natural-origin return are positive for three of the six populations (i.e., >0.98) and growth rates of natural-origin escapement are positive or stable for five of the six populations (Table 9). The fact that growth rates for escapement are greater than growth rates for return indicates some stabilizing influence on escapement from past reductions in fishing-related mortality. Natural-origin escapements for two of the six populations (White and Puyallup) currently exceed their rebuilding escapement thresholds. All exceed their critical escapement thresholds although the Sammamish population is close to its threshold (Tables 8 and 10) (identified as yellow in Figure 21). Current productivity is very low for the Sammamish, Puyallup, and likely Nisqually populations (Table 8). Exploitation rates on populations in the Central/South Sound Region have declined 11 to 48% since the 1980s. Unlike populations in the Strait of Georgia and Whidbey/Main Basin regions, most of the harvest of the Central/South Sound populations occurs in southern U.S. fisheries. Tribal fisheries accounted for 55 to 67 percent of the harvest in southern U.S. fisheries from 2004-2008 depending on the management unit.

Management under the 2010 RMP Likely scenario would adequately protect four (White, Cedar, Sammamish, Duwamish-Green) of the six populations and increase protection for all six populations. Management under the 2010 RMP Likely scenario is expected to result in reductions in exploitation rates of 12 to 38% from the observed 1994-2008 average. Exploitation rates for four of the six populations are expected to fall below their RERs or RER surrogates (Table 30) and these populations are considered at low risk under the 2010 RMP Likely scenario (Figure 21). Average exploitation rates are anticipated to exceed the RER surrogates for the Puyallup and Nisqually populations. Exceeding the RER infers an increased risk to the survival and recovery of the population (Figure 21) but NMFS cannot quantify it at this time with the available information. All six populations are anticipated to exceed their critical escapement thresholds under the 2010 RMP Likely scenario. Four are anticipated to exceed their rebuilding thresholds. The status of five of the populations relative to their rebuilding thresholds is not anticipated to change, although escapements and the frequency of meeting the rebuilding threshold are expected to increase as a result of the anticipated decreases in exploitation rates.

[36] The TRT noted that the Nisqually watershed is in comparatively good condition, and thus the certainty that the population could be recovered is among the highest in the Central/South Region. NMFS concluded in its supplement to the Puget Sound Salmon Recovery Plan that protecting the existing habitat and working toward a viable population in the Nisqually watershed would help to buffer the entire region against further risk (NMFS 2006a).

The average escapement for the Nisqually will exceed its rebuilding threshold compared with the FRAM Validation scenario. Expectations are that escapements of at least 500 Chinook to South Prairie Creek will result in escapements of 1,000 or more to the full Puyallup system. However, if total Puyallup River escapement is lower than 1,000 even when South Prairie Creek escapement is 500 or above, NMFS expects the co-managers to take measures intended to increase escapement to the full system as provided in the adaptive management provisions of the RMP.

We now consider the degree to which other factors and circumstances mitigate the risks identified in the first stage analysis for the Nisqually, Puyallup, and Sammamish populations. The indigenous stock in these watersheds has been extirpated from a variety of causes and the current populations are not genetically distinct from other hatchery-origin Green River lineage stocks. For these populations, particularly the Nisqually population which is essential to recovery of the Puget Sound Chinook ESU, the focus of recovery is on re-introduction and transition to natural-origin management over time as the existing Green River lineage population adapts to the watershed, and as habitat conditions improve to support natural production. The timing and magnitude of changes in harvest that occur in these watersheds must be coordinated with the pace of habitat recovery and with the implementation of hatchery actions. The escapement and exploitation rates anticipated to result from the likely implementation of the 2010 Puget Sound Chinook RMP for the Nisqually are consistent with such a transitional strategy. Such a strategy is also consistent with NMFS' responsibility to balance its tribal trust responsibility and conservation mandates by achieving conservation benefits while reducing disruption of treaty fishing opportunity. Tribal fisheries account for 67 percent of the harvest of Nisqually Chinook. The Puyallup is a Tier 3 population whose life history is represented by other populations in the region and is managed for a slower trajectory toward recovery compared to the Tier 1 and 2 populations in the region. The retrospective analysis indicates that the population should see substantial improvements in status from current conditions and remain above its rebuilding threshold even under low abundance. Exploitation rates are anticipated to decrease moderately almost exclusively in SUS fisheries. Therefore, any increased risk to this population would not impede viability for the region based on NMFS' delisting criteria.

Although the retrospective analysis indicates escapements should remain above the critical threshold and exploitation rates will remain below the RER surrogate under all scenarios, several points of concern were identified for the Sammamish population in previous sections of the evaluation: (1) natural-origin escapement is currently close to its critical threshold; (2) growth rates are declining; and, (3) the RMP provides no explicit management objectives for the population. NMFS' analysis assumes that impacts on the Sammamish population are the same as that for the Cedar River in SUS fisheries, i.e., the co-managers will not target the Sammamish population in Lake Washington or pre-terminal SUS fisheries. NMFS' assumption that the impacts will be the same on both populations is consistent with the co-managers statements of intent in the RMP and the limitations of the data and analysis. The RMP presents the terminal conservation management measures the co-managers will impose if the Cedar River population falls below its low abundance threshold of 200 fish. These terminal conservation management measures include non-retention in recreational fisheries, no directed fisheries, and the reduction in incidental impacts by other fisheries through time and area restrictions. The Cedar River and Sammamish River populations share the same terminal fisheries in Lake Washington. Therefore, terminal conservation management measures directed at migrating fish returning to the Cedar River should also benefit fish returning to the Sammamish River. As a result of these assumptions, the retrospective analysis indicates escapements should remain above the critical threshold and exploitation rates will remain below the RER surrogate. The Sammamish is a Tier 3 population whose life history is represented by other populations in the region that are in healthier condition. Therefore, any increased risk to this population would not impede viability for the Central/South Sound Region based on NMFS' delisting criteria. The substantial contribution of hatchery-origin fish to the natural escapement in the Sammamish River tributaries which are genetically indistinguishable from the wild spawners should buffer demographic risks.

Although two populations in the region may experience some higher risk and additional concern was noted for the Sammamish population, based on the above and information provided in the evaluation of the preceding criteria, NMFS concludes that the RMP's management objectives are adequately protective of the populations within the South Puget Sound Region of the ESU.

8.4 Hood Canal Region

There are two populations within the Hood Canal Region (Figure 21): the Skokomish River and the Mid-Hood Canal Rivers populations. NMFS determined that both populations will eventually need to be at low risk to recover the ESU (NMFS 2006a) and has categorized them in Tier 1. The two extant populations reflect the extensive influence of inter-basin hatchery stock transfers and releases in the region, mostly from the hatchery-origin Green River broodstock (Ruckelshaus et al. 2006) and the extirpation of the original indigenous population. Escapement trends are stable for both populations although the trend in growth rates of natural-origin return and escapement are less than 1.0 (Table 9). Growth rate of escapement is greater than the growth rate of return for both populations within the region (Table 9), suggesting some stabilizing influence on escapement from past reductions in fishing-related mortality. Very low escapements in recent years for the Mid-Hood Canal population as a whole and to its component rivers raise concerns about the abundance, productivity, and spatial integrity of that population. Natural-origin escapements for both populations are below their critical threshold (Table 10). When hatchery-origin spawners in the Skokomish escapement are taken into account the average total natural escapement of 1,311 (range = 531-2,398) exceeds the rebuilding escapement threshold of 1,160 (Table 8). Since the 1980s, exploitation rates on populations in the Hood Canal Region have declined by 25 to 55%. Tribal fisheries accounted for 45 and 49 percent of the harvest in southern U.S. fisheries from 2004-2008 for the Mid-Hood Canal Rivers and Skokomish populations, respectively.

Total exploitation rates under the 2010 RMP Likely scenario would be reduced moderately from rates observed during the analysis period. Nonetheless, exploitation rates for both populations are expected to substantially exceed their RER or RER surrogate in most years. Exploitation rates in northern fisheries alone approach or exceed the RER surrogate for the Mid-Hood Canal population. Exceeding the RER infers an increased risk to the survival and recovery of the Mid-Hood Canal Rivers population but NMFS cannot quantify it at this time with the available information. For the Skokomish population, the most likely total exploitation rate is 41 percent (see Table 32). This rate exceeds the NMFS-derived rebuilding exploitation rate of 33 percent for this population. Through modeling, NMFS assessed the increased risk to the Skokomish population under implementation of the proposed 2010 Puget Sound Chinook RMP. Under the 2010 RMP Likely scenario, a 41 percent average exploitation rate would result in an 18 percentage point decrease in the probability of a rebuilt population in 25 years under current conditions. This modeling also suggests a negligible change in the probability that the population will fall below the critical level during that same 25-year period (see Table 33).
Both populations are higher risk because they exceed their RERs and they currently are below their critical escapement thresholds. We now consider the degree to which other factors and circumstances mitigate the risks identified in the first stage analysis. The reduction in exploitation rates from observed levels is expected to result in small increases in escapement compared with observed levels. Under the 2010 RMP Likely scenario, the Skokomish Chinook escapement is expected to exceed its rebuilding threshold abundance in nine of the 15 years in the analysis period. As mentioned previously, the indigenous stocks in these watersheds have been extirpated from a variety of causes and the current populations are not genetically distinct from other Green River lineage stocks. For these populations, which are essential to recovery of the Puget Sound Chinook ESU, the focus of recovery is on re-introduction and transition to natural-origin management over time as the existing Green River lineage population adapts to the watershed, and as habitat conditions improve to support natural production. The timing and magnitude of changes in harvest that occur in these watersheds must be coordinated with the pace of habitat recovery and with the implementation of hatchery actions. The escapement and exploitation rates anticipated to result from the likely implementation of the 2010 Puget Sound Chinook RMP for the Skokomish River are consistent with such a transitional strategy.

For the Mid-Hood Canal population, northern fisheries account for the majority of harvest, and the resultant exploitation rate would approach or exceed the RER surrogate, which is a concern for a population essential to recovery of the ESU and at such low abundance. However, analysis presented in previous sections of this document concluded that further reductions in southern U.S. fisheries that are the subject of the proposed 2010 Puget Sound Chinook RMP would have little substantive effect on the persistence of the spawning aggregations within the Mid-Hood Canal population. The general characteristics of the Mid-Hood Canal Rivers population, including genetic lineage, life history, and run timing, are also found in the Skokomish River population. Improvements in the operating protocols of the Hamma Hamma supplementation program in recent years may increase the contribution of the program to recovery of the population. Genetically similar stocks are also sustained by two hatchery facilities in the Hood

Canal area and in hatcheries in the South Puget Sound Region where Green River-lineage fall-run Chinook salmon are naturally or artificially sustained. These populations and programs serve as reserves that could be used to support further supplementation and recovery programs for the Mid-Hood Canal population. Based on the above and information provided in the evaluation of the preceding criteria, NMFS concludes that the RMP's management objectives are adequately protective of the populations within the Hood Canal Region of the ESU.

8.5 Strait of Juan de Fuca Region

The Strait of Juan de Fuca Region has two populations including an early-timed population on the Dungeness, and a fall-timed population on the Elwha (Ruckelshaus et al. 2006) (Figure 21). NMFS determined that both populations must be viable to recover the ESU and has categorized them in Tier 1. The status of both populations is constrained by significant habitat-related limiting factors that are in the process of being addressed. Survival and productivity of the Dungeness population are adversely affected by low flows from agricultural water withdrawals and by other land use practices. Recently, a water conservation project funded through the Critical Stocks Program developed as part of the 2008 PST Agreement negotiations was implemented to address part of the concerns about water withdrawals. The project involves piping the entire distribution system of the Dungeness Irrigation District and is expected to result in anticipated in-river water savings of 3-4 cubic feet per second (WDFW and NWIFC 2010a).[37] A captive brood stock program for the Dungeness population has been successful in increasing natural spawning escapement, contributing 80% of the total annual natural spawners on average in recent years. All but the lower 5 miles of the Elwha River is blocked to anadromous fish migration by two dams and the remaining habitat in the lower river is severely degraded. An ambitious plan to remove the dams and restore natural habitat in the watershed have been completed, with preparations underway for dam removal scheduled to begin in 2012. Listed, native-origin Chinook salmon maintained and produced by the hatchery mitigation program in the Elwha River system will be a key component of watershed rehabilitation and population preservation and restoration before, during, and after dam removal. Given the condition of the salmon habitat in the watersheds, the prospects for the survival and recovery of the Elwha population depend on maintaining the hatchery program in the short term, and using it for reintroduction into pristine areas in the Olympic National Park once the dams are removed. Both the Dungeness and Elwha conservation hatchery programs will be key to restoring the Chinook populations in the Strait of Juan de Fuca Region.

Escapement trends are stable for the Elwha population and increasing for the Dungeness population, although the underlying growth rates for natural-origin fish for the Elwha population is negative (i.e., <0.98) (Table 9). The Elwha population is above its rebuilding threshold in terms of natural escapement. Average natural-origin escapement for the Dungeness population is below its critical threshold. Hatchery origin fish contribute heavily to escapements for both

[37] The objective of this project and others in the Critical Stocks Program i to implement hatchery and habitat actions to address immediate threats to these stocks to improve the likelihood of their persistence.

populations, but for the Dungeness in particular the increase in escapement trend primarily reflects the success of the supplementation program which is designed to help rebuild the population. Exploitation rates on the Strait of Juan de Fuca populations have declined by approximately 50 percent since the 1980s. Exploitation rates in southern fisheries have been very low since 1998 ranging from two to six percent. Eighty percent or more of the harvest of the Dungeness and Elwha populations currently occurs in northern fisheries. Tribal fisheries accounted for 42 percent of the harvest of the populations in this region in southern U.S. fisheries from 2004-2008.

Management under the 2010 RMP Likely scenario is expected to result in an 18% reduction in total exploitation rates for the Strait of Juan de Fuca populations relative to those observed in past years. The anticipated reductions are due to benefits from implementation of the 2008 PST Agreement and continuing constraints in southern fisheries. The average exploitation rate (28%) for both populations are expected to exceed their RER surrogate of 23 percent by five percentage points on average. Exceeding the RER infers an increased risk to the survival and recovery of the population but NMFS cannot quantify it at this time with the available information. The northern fisheries in Alaska and Canada alone exceed the RER. Therefore, RER surrogates could not be achieved even with complete elimination of SUS fisheries. Analyses in previous sections of this document demonstrated that benefits to this population by reductions in SUS fishery-related impacts are limited. The anticipated SUS exploitation rate on this population is very low, at 4 percent. Current fishing levels do not appear to be impeding the ability of the Dungeness population to rebuild given its increasing escapement trend and growth rates.

The conservation hatchery program operating in the Dungeness River will continue to help rebuild the population and mitigate the demographic and genetic risks to the Dungeness River population (NMFS 2004d). The recently implemented irrigation-related flow improvement project should also improve survival over the long term. However, because the exploitation rates anticipated under the 2010 RMP Likely scenario are higher than the surrogate RER, there is the potential for additional risk to the Dungeness population. Its current status and role in the recovery of the ESU, further underscores the need to monitor trends in escapement and growth rate. Trends in escapement and growth rate are increasing. If that changes, it will be necessary to again review the full suite of factors limiting the population. With respect to harvest, virtually all of the impacts occur in northern fisheries (Tables 21 and A1-1). In the event that extraordinary circumstances related to population viability occur, Paragraph 13(h) of Annex IV, Chapter 3 of the 2008 PST Agreement provides a mechanism to consider additional actions that may be taken as part of a coordinated management plan. Given the current constrained and degraded condition of habitat available for natural Chinook salmon production in the Elwha River, and the severe disruption to the system caused by the dam removals now underway, the population will rely on the hatchery production to sustain the population and restore natural production for the foreseeable future.

NMFS concludes that the RMP will provide adequate protection for Chinook salmon originating from the Strait of Juan de Fuca Region. This recommended determination is based on the status and escapement trends of the populations, the low anticipated SUS exploitation rates, the likelihood that any further decrease in the SUS fisheries-related impacts would have marginal benefits to the persistence of these two populations, and on consideration that the hatchery-origin fish produced for conservation purposes in the two watersheds within this region share the ecological and genetic traits of the natural-origin populations.

Based on the analysis presented previously and these considerations, NMFS concludes likely actions associated with implementation of the 2010 Puget Sound Chinook RMP in combination with other ongoing habitat and hatchery efforts discussed in the region specific sections of Criteria 5 and 6 provides adequate protection for Chinook salmon originating from the five regions within the Puget Sound ESU and that the RMP's management objectives adequately address the biological criteria outline in the ESA 4(d) Rule. Therefore, the NMFS Northwest Region, Salmon Management Division concludes that implementation of the RMP from May 1, 2011 through April 2014 would not appreciably reduce the likelihood of survival and recovery of the Puget Sound Chinook Salmon ESU in the wild. This conclusion is supported by the number and diversity of life history characteristics of populations within each region anticipated to meet their RERs or escapement thresholds over the duration of the RMP, expected increasing escapement trends for key populations, and the current status of populations when compared to the ESU delisting criteria.

9 ▪ Criterion 7: Monitoring and Evaluation Programs

Section (b)(4)(i)(E) includes effective (a) monitoring and (b) evaluation programs to assess compliance, effectiveness, and parameter validation (Minimum requirement: collect catch and effort data, information on escapements, and information on biological characteristics, such as age, fecundity, size and sex data, and migration timing).

One of the RMP's objectives is to "reduce the risks associated with harvest management imprecision and uncertainties in estimates of the productivity and survival of Chinook populations." In doing so, the Puget Sound Indian Tribes and WDFW, independently and jointly conduct a variety of research and monitoring programs. Chapter 7 of the RMP describes these monitoring programs which are used to assess effectiveness of the management actions in achieving the management objectives of the RMP and to validate the assumptions used in deriving the objectives. Information from research and monitoring programs will be used in conjunction with the performance indicators to assess the effectiveness of the RMP and revise management objectives and actions accordingly. Impacts from monitoring and research activities that directly inform fishery management decisions (test, research, update and evaluation fisheries, certain PST Sentinel Stocks projects) will be included under the exploitation rate ceilings for each management unit as assessed during preseason planning and postseason assessment. Mortality associated with other fishery-related research and monitoring activities which have broader applicability to stock assessment will be assessed separately and will not exceed a level equivalent to 1% of the estimated annual abundance (i.e., 1% exploitation rate (ER)), for each management unit (e.g., mark recapture studies designed to directly inform management decisions) (see Chapter 7 of the RMP). Other research activities informing Puget Sound salmon fishery management during the period of the proposed 2010 Puget Sound Chinook RMP but not directly related to fishery management decisions will be consulted on under Section 7 of the ESA or Limit 7 of the 4(d) Rule (e.g., smolt monitoring and other research and studies primarily used to assess stock status or other more general, non-fishery specific objectives).

Chinook salmon harvest in all fisheries, including incidental catch and fishing effort, is monitored by the co-managers. Commercial, ceremonial, and subsistence and test fishery catches within the Puget Sound Action Area are recorded on sales receipts ('tickets'), copies of which are sent to the WDFW and tribal agencies and recorded in a jointly-maintained database. A preliminary summary of catch and effort is available four months after the season, although a final, error-checked record may require a year or more to develop.

For Puget Sound fishing areas, recreational harvest is estimated from either creel census or from a sample of catch record cards obtained from anglers. The recreational fishery baseline sampling program provides auxiliary estimates of species composition, effort, and catch-per-unit-effort (CPUE) to the Salmon Catch Record Card System. The baseline sampling program is geographically stratified among the marine catch areas in Puget Sound with identified target sample levels for the number of fish and level of boat effort across the strata. Creel sampling regimes have been developed to meet acceptable standards of variance for estimates of weekly catch.

Non-landed mortality of Chinook is a component of fishing-related mortality in both commercial and recreational fisheries. Non-retention mortality results from both intentional (regulations require release) and unintentional circumstances (encounter with gear without being brought to the boat). Non-landed mortality is primarily addressed in the RMP's Section 2.5 (Non-Landed Fisheries Mortality, starting on page 18 in the RMP) as well as in Chapter 7. Estimates of non-landed mortality are included in the overall assessment of fishing-related mortality (i.e., exploitation rates) for each management unit but because the fish are observed for a short period if at all, the mortality rates are less certain. With increasing use of non-retention regulations and mark-selective fisheries, non-landed mortality comprises an increasing proportion of the overall fishing-related mortality on Puget Sound Chinook populations. The RMP states that studies will be periodically conducted to estimate encounter rates and hooking mortality for these fisheries using on-board observations, angler interviews at landing ports or marinas, and remote observation of some recreational fisheries. In addition, the co-managers and technical advisory groups for the Pacific Fishery Management Council review the scientific literature as to the best estimates and methodologies for assessing non-landed mortality. The RMP indicates these findings would then be used to validate, or adjust the encounter rates and release mortality rates used in fishery simulation models. 'Drop-out' mortality in gillnet fisheries is accounted at 3% or 2% of landed catch in pre-terminal and terminal fisheries, respectively.

Catch and effort summaries allow an assessment of the performance of fishery regulations in constraining catch to the desired levels. Time and area constraints, and gear limitations, are imposed by regulations, but with some uncertainty regarding their exact effect on harvest. For many management units, catch is often projected pre-season based on the modeled effect of specific regulations. Post-season comparison of estimated and actual catch allows for the assessment of the true effect of those regulations, and guides their future application or modification (WDFW and PSTIT 2003; WDFW and PSTIT 2004; WDFW and PSTIT 2005; WDFW and PSTIT 2006; WDFW and PSTIT 2007; WDFW and PSTIT 2008; WDFW and PSTIT 2009; WDFW and PSTIT 2010). Based on the co-manager postseason reports, commercial catches have been less than anticipated preseason in three of five years (2004-2008) by an average of 21,400 (WDFW and PSTIT 2005; WDFW and PSTIT 2006; WDFW and PSTIT 2007; WDFW and PSTIT 2008; WDFW and PSTIT 2009; WDFW and PSTIT 2010). Fisheries in Hood Canal, Duwamish-Green, Lake Washington, and the Puyallup terminal areas consistently exceeded preseason catch expectations but generally met their management objectives. Recreational marine area catches have also been less than anticipated preseason in three of five years (2004-2008) by an average of 13,150 although this does not include estimated non-landed mortality (WDFW and PSTIT 2005; WDFW and PSTIT 2006; WDFW and PSTIT 2007; WDFW and PSTIT 2008; WDFW and PSTIT 2009; WDFW and PSTIT 2010). Fisheries in Hood Canal terminal areas consistently exceeded preseason catch expectations but met management objectives in three of the five years (2004-2008). Although freshwater sport catch is monitored and accounted for in assessing mortality on a post-season basis, preseason information is not available to conduct the same pre vs. post-season comparisons for freshwater sport fisheries.

The co-managers annually estimate Chinook salmon escapement from surveys in each river system. Escapement surveys provide information on hatchery- and natural-origin composition, run timing and population status. A variety of sampling and computational methods are used to calculate escapement, including cumulative redd counts, peak counts of live adults, cumulative carcass counts, and integration under escapement curves drawn from a series of live fish or redd counts. A more detailed description of methods used for Puget Sound systems is included in Appendix E: Puget Sound Chinook Escapement Estimates: Description and Assessment of the 2004 RMP (PSIT and WDFW 2004). Catch sampling, escapement surveys, and sampling at hatchery racks, traps, and weirs also provide biological data on age, length, sex, and size.

The co-managers will evaluate compliance, effectiveness, and parameter validation of the primary components of the RMP through annual postseason reports (Section 7.5 of the RMP) and longer-term retrospective assessment reports (Section 7.6). The performance of the fisheries during the life of the RMP will be assessed to determine the extent to which catch and fishing effort conform to the quotas, ceilings, or projections that were defined in pre-season planning for each fishing area and season. The reports will compare escapements by management unit and population to preseason projections and RMP thresholds, and assess hatchery- and natural-origin contribution to escapement. Information provided in the co-managers postseason reports contributed to the development of the 2010 RMP and the evaluation of Criteria 4 through 6 above. The assessment may lead to further evaluation of the effectiveness of fishing regulations (e.g., time or area constraints, gear restrictions, or bag limits) in future management plans. The causes of discrepancy between expected and actual catch and effort will be identified by the co-managers with a view to understand the reason for the discrepancies and to changing regulatory measures, and methods for projecting catch and fishing effort, to improve their accuracy where appropriate. Sampling rates will be compared to target sampling rates. The commercial catch sampling rate target of 20% was met in all fisheries with substantial catches during 2004-2008, except for the White River (C & S catch) and Hood Canal fisheries. However, the co-managers indicate sampling programs in those areas were improved in recent years in order to achieve the target sampling rates (Gray 2009; Mahovlich 2010; Phinney 2010).

Assessment of the total return (cohort reconstruction) produced from each brood year of parent spawners requires accurate estimation of escapement, hatchery- and natural-origin contribution, age structure and reconstruction of fishing-related mortality from coded-wire tag data or fishery simulation models. A 10% and 20% sampling objective by strata is in place for recreational and commercial fisheries, respectively. There will be a time lag of approximately 18 months, after the conclusion of the fall fisheries, before coded-wire tag recovery data are available to researchers. Accounting of the harvest fishing-related mortality and escapement for each management unit will enable the calculation of exploitation rates, which may be compared with the pre-season projections and objectives. Ultimately, reconstruction of all cohorts associated with a given brood year enables the calculation of brood-year exploitation rates.

Cohort reconstruction and estimation of exploitation rates from tag recovery data will also provide a means of assessing the accuracy of the fishery simulation models. Coded-wire tag-based run reconstruction provides an alternative and independent estimate of the total fishing-related mortality and harvest distribution of each management unit or population. The RMP indicates that periodically the co-managers will assess the accuracy and bias in the simulation models used for harvest management.

Cohort reconstruction for each population is the fundamental indicator of productivity. The productivity of each management unit or population is an important component in the development and adjustment of exploitation rate objectives. Those objectives must conform to the most recent values and trends in population productivity. However, many management units do not have sufficient data on productivity to detect changes. Smolt traps are operated in the Nooksack, Skagit, Stillaguamish, Skykomish, Snoqualmie, Puyallup, Nisqually, Skokomish, Dungeness, and Elwha rivers to estimate smolt production and survival. Smolt production may inform abundance forecasting, test the influence of environmental parameters on survival, and monitor the effectiveness of habitat restoration programs. Periodically, the population/recruit function will be updated using a combination of the cohort reconstruction and smolt monitoring data, and the exploitation rates and thresholds re-assessed, for each management unit. The tasks involved in monitoring abundance and productivity, and assessing the performance of annual fishing regimes, is mandated by the Puget Sound Salmon Management Plan (PSSMP 1985).

In addition to the monitoring programs discussed in the RMP, there are numerous other ongoing projects funded by other agencies or programs which provide additional information useful for fisheries management. Each year, the Salmon Recovery Funding Board provides funding for projects designed to further salmon recovery. Watershed recovery groups develop three year work plans based on the recovery actions and priorities in the Puget Sound Salmon Recovery Plan to test assumptions and reduce information gaps. Data collection and monitoring programs included in Hatchery and Genetic Management Plans implemented within the Puget Sound region will also provide valuable information on stray rates and patterns, ecological interactions of wild and hatchery juveniles, and contribution of natural-origin fish to escapements. The provisions in the RMP, together with the other programs described above, will provide the monitoring and evaluation necessary to assess whether the RMP is effective in meeting its objectives and to revise technical tools and analysis as the information becomes available.

10 - Criterion 8: Evaluation and Adaptive Management

Section (b)(4)(i)(F) provides for (a) evaluating monitoring data; and (b) making any revisions of assumptions, management strategies, or objectives that data show are needed.

The 2010 Puget Sound RMP "...commits the co-managers to ongoing monitoring, research and analysis, to better quantify and determine the significance of uncertainty and management error, and to modify the RMP as necessary to minimize associated risks….Improved technical understanding of the biological parameters of populations, and assessment of the actual performance of management regimes in relation to management objectives and the status of stocks, will result in continuing modification of harvest objectives" (pages 7 and 20 of the RMP). A description of how the co-managers will evaluate the monitoring data and compile reports of the findings can be found in Section 5.7 and Chapter 7 of the RMP. Provisions for revision of assumptions, management strategies and management objectives discussed under Criterion 7 above are described further in this section.

State and tribal technical staff will meet periodically in season to exchange information and data, achieve consensus on in-season management actions, and prepare post-season reports. In-season modifications shall be in accordance with the procedures specified in the Puget Sound Salmon Management Plan and subsequent court orders. In each case, the co-managers will assess the effect of proposed in-season changes with regard to their impact on natural Chinook management units, and determine whether the management action is compliant with the harvest limits stated in this plan. Particular attention will be directed to in-season changes that impact management units or populations in critical status, or where the pre-season plan projections indicated that total impacts were close to ceiling exploitation rates or projected escapement close to the respective escapement goals. Additional meetings and exchanges will occur as needed to develop recommendations for management units' harvest regimes pertinent to the RMP, resolve differences in approach, and review monitoring program results. Data from the monitoring programs form the basis for development and refinement of forecasting and assessment efforts.

The co-managers will notify NMFS when in-season actions cause an increase in exploitation rate, or lower escapement, for a particular management unit, relative to the pre-season projection (see page 42 of the RMP). The notification will include a description of the regulatory change, an assessment of the resulting fishing mortality, and technical or other demonstration that the management action is in accordance with harvest guidelines (i.e. exploitation rate ceilings and/or thresholds) and principles established by the RMP.

The co-managers will review Chinook fisheries management and spawning escapement, in an annual postseason report. A summary of previous years' escapement and landed catch, compared to pre-season projections, will be distributed in March of each year. The annual report will be completed in May of each year over the term of the RMP (page 64 of the RMP). A copy will be provided to NMFS. The annual review of the harvest management plan will include: a fisheries summary, harvest levels, non-landed mortality, estimated escapement and hatchery/natural-origin composition, and a summary of coded-wire tag sampling rates.

The co-managers will also assess the longer-term performance of the RMP through a retrospective assessment of accumulated data and information related to population abundance and productivity, harvest rates, sampling and monitoring objectives. Such an assessment will be completed by July 2012 to inform revision of the 2010 Puget Sound Chinook RMP and in preparation for development of the next harvest plan. The retrospective assessment will include: trends in abundance and/or survival rates, and a summary of age structure for populations; description of biological sampling and coded-wire tag sampling rates compared with sampling objectives; comparison and discussion of FRAM exploitation rate estimates with coded wire tagging (CWT) or other methods; comparison of annual FRAM-based exploitation rates with preseason projection estimates and RMP ceilings; evaluation of potential bias in catch, escapement, or exploitation rates with discussion of potential remedies; and, a summary of data gaps described in Appendix A of the RMP that have been addressed and update additional requirements.

The retrospective assessment will also evaluate productivity. The information will be used to update recruitment functions derived from cohort reconstruction or other methods and applied to re-calibration of escapement thresholds and exploitation rate ceilings. Such re-assessment will occur, subject to data availability, and if there is evidence in data or analyses used in forecasting, or other information suggesting that survival has changed.

The annual post-season review of the management plan is part of the annual pre-season planning process. The post-season review is necessary to permit an assessment of the co-managers' annual management performance in achieving spawning escapement, harvest, and allocation objectives. The co-managers will review each population's status annually and, where needed, identify actions required to improve estimation procedures and correcting bias. Examples of revisions and improvements made as a result of post-season assessments and other data reviews are provided in the main body of the RMP (e.g., hooking mortality, page 18 of the RMP; and in some of the management unit profiles in Appendix A, e.g., Puyallup. In 2010, the co-managers began to integrate hatchery- and natural-origin escapement contribution information into preseason forecasts for some Chinook stocks (Hagen-Breaux 2010). As appropriate, measures will be derived to address deleterious effects on size, age, or sex selectivity. Such improvements provide greater assurance that management objectives will be achieved in future seasons. The effort builds a remedial response into the pre-season planning process to prevent excessive fishing-related mortality levels relative to the conservation of a management unit. As new information becomes available the co-managers will periodically reassess management guidelines and harvest strategies, in response to changes in the status and productivity of Chinook populations. If the RMP is amended, changes will be submitted to the NMFS for evaluation, well in advance of their implementation (Chapter 8 of the RMP). Because these provisions are a component of the RMP itself, by themselves, amendments to the RMP would not require a new evaluation by NMFS under the 4(d) Rule.

These provisions of the RMP are a continuation of the annual performance assessment the co-managers conducted during the implementation of the 2004 RMP through a series of annual postseason reports and preseason planning. A preliminary draft retrospective assessment of the 2004 RMP was provided to NMFS but was withdrawn when errors were found in some of the analysis. It was not finalized. However, information provided in the postseason reports for the 2004 RMP cumulatively informed development of the 2010 RMP and has been used by NMFS in the evaluation of the 2010 RMP (see discussion in Criteria 2 though 5, as well as Criterion 9). NMFS concluded from its review of the post-season reports that the harvest limits established in the RMP were followed for all management units over the duration of the 2004 RMP. Revisions to fishery planning tools were made to correct biases identified through evaluation. Additional work is needed to improve annual abundance forecasts. In addition, the co-managers implemented a significant amount of monitoring and reporting, with work on-going each year. Sampling targets were met for the marine recreational fishery based on the limited available information and in most areas and years in the commercial fishery. As noted in previous sections, the co-managers have improved sampling in the few areas that did not consistently meet sampling targets.

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11 · Criterion 9: Enforcement, Education & Coordination

Section (b)(4)(i)(G) provides for (a) effective enforcement, (b) education, and (c) coordination among involved jurisdictions.

The description of the RMP's enforcement and education programs can be found in Section 5.4 (Pre-season Planning), Section 5.6 (Regulation Implementation), Section 5.7 (In-season Management), and Section 5.8 (Enforcement). These discussions begin on page 39 of the RMP. The RMP relies on a pre-season planning process to set the initial harvest regimes (fishing schedules and seasons) for all management units. The setting of the Puget Sound fisheries schedules and seasons occurs concurrently with the planning of the Washington and Oregon coastal fisheries. The pre-season planning process occurs from March through early April, during the Pacific Fishery Management Council and North of Cape Falcon forums. The forums are open to the public, allowing the public access to salmon status information, and providing the public an opportunity to interact with the co-managers and participate in shaping annual fishery regimes.

Regulations enacted during the season will implement guidelines established during the pre-season planning process described above, but may be modified based on in-season assessments of effort, catch, abundance, and escapement. However, in many areas, the co-managers lack the necessary tools to detect in-season deviations from the pre-season forecast in time to adjust regulations. Any in-season modifications will be in accordance with the procedures specified in the Puget Sound Salmon Management Plan (PSSMP 1985), subsequent court orders and the provisions in the RMP.

WDFW and individual treaty tribes are responsible for regulation of harvest in fisheries under their authority, consistent with the principles and procedures set forth in the Puget Sound Salmon Management Plan. Fisheries will be regulated to achieve sharing and production objectives based on four fundamental elements: (1) acceptably accurate determination of the appropriate exploitation rate, harvest rate, or numbers of fish available for harvest; (2) the ability to evaluate the effects of specific fishing regulations; (3) a means to monitor fishing activity in a sufficient, timely and accurate fashion; and (4) effective regulation of fisheries to meet objectives for spawning escapement, harvest sharing, and fishery impact limitations. The first two elements are the focus of the Pacific Fishery Management Council and North of Falcon preseason planning processes, and inseason assessment and modification where feasible. The co-managers also evaluate the effects of the fishing regulations and determine whether conservation and use objectives have been met (element 4) as part of their postseason assessments (WDFW and PSTIT 2003; WDFW and PSTIT 2004; WDFW and PSTIT 2005; WDFW and PSTIT 2006; WDFW and PSTIT 2007; WDFW and PSTIT 2008; WDFW and PSTIT 2009; WDFW and PSTIT 2010). Criterion 7 above describes the programs in place to monitor fishing activity (element 3) which provides the information used in evaluating the other three elements.

The co-managers maintain a system for transmitting, cross-indexing, and storing fishery regulations affecting harvest of salmon. Both WDFW and the Puget Sound Tribes monitor and enforce compliance with these regulations as part of more extensive enforcement programs. NMFS expects the state, tribal, and federal court systems are sufficient to ensure that enforcement is followed through with appropriate prosecution of violators. The RMP anticipates that, for the duration of the plan, enforcement activities will continue at levels similar to recent years.

Non-tribal commercial and recreational fishery regulations are enforced by WDFW. The WDFW Enforcement Program includes 137 fully commissioned Fish and Wildlife staff who ensure compliance with licensing and habitat requirements, enforce prohibitions against the illegal taking or poaching of fish and wildlife, prevent and manage human/wildlife contacts and conduct outreach and education activities. The Fish and Wildlife Enforcement Program is primarily responsible for enforcing the Washington State Fish and Wildlife Code (e.g., RCW Title 77-Fish and Wildlife). However, officers are also charged with enforcing many other codes as well, and are often called upon to assist their local city/county, and other state law enforcement agencies, and tribal authorities. On average, officers currently make more than 225,000 public contacts annually (WDFW Enforcement 2010). The WDFW Enforcement staff also works cooperatively with a variety of state and federal agencies to enforce laws and regulations including the U. S. Fish and Wildlife Service (USFWS), NOAA's Office of Law Enforcement, U.S. Forest Service, Federal Bureau of Investigation, Bureau of Land Management, tribal police, the Department of Homeland Security and the United Sates Coast Guard.

The WDFW has provided summaries of its fishery enforcement activities in ocean and Puget Sound marine recreational fisheries as part of the co-managers postseason reports on the performance of the RMP since 2002 (WDFW and PSTIT 2003; WDFW and PSTIT 2004; WDFW and PSTIT 2005; WDFW and PSTIT 2006; WDFW and PSTIT 2007; WDFW and PSTIT 2008; WDFW and PSTIT 2009; WDFW and PSTIT 2010). Enforcement reports have also included some Puget Sound freshwater recreational fisheries. The reports are used to deploy enforcement resources, identify the most common violations, and assess trends over time. The information could also be used to develop or refine public outreach and education programs. During the period of the last RMP (2004-2009), compliance[38] ranged from 84 to 93% averaged across areas for each year. Across catch areas within individual years, compliance ranged from 69 to 100%. The most common violations were similar across catch areas and years, i.e., gear, license, failure to record catch, and fishing in closed areas. Patrols occurred both on the water and dockside. The total number of enforcement hours was relatively stable across years, although the number of hours associated with individual catch areas varied. The number of contacts varied over the years. This was likely related to factors driving fishing effort (e.g., abundance, weather, regulations). South Puget Sound (Areas 10, 11, 13) appears to have somewhat lower compliance rates (80-84%) than other areas in Puget Sound (88-97%). The number of violations was down in

[38] (total contacts) – (salmon violations) / (total contacts) x 100.

2008 and 2009 from previous years. Information on commercial fishery enforcement was not included in the report.

Each tribe exercises authority over enforcement of tribal commercial fishing regulations, whether fisheries occur on or off their reservation. Enforcement officers of one tribal agency may be cross-deputized by another tribal agency, where those tribes fish in common areas. Tribes and WDFW coordinate enforcement of some fisheries. Prosecution of violations of tribal regulations occurs through tribal courts and governmental structures. The Puyallup Tribe has provided summaries of its fishery enforcement activities as part of the co-managers postseason reports on the performance of the RMP since 2008 (WDFW and PSTIT 2009; WDFW and PSTIT 2010). The mission of the Puyallup Tribal Fish and Wildlife Enforcement Program includes public safety, fish and fish habitat protection and public education of tribal fishing rights. Similar to the WDFW enforcement reports, the most common violations were gear (e.g., illegal or unmarked nets) and fishing in closed waters. The WDFW 2009 report also noted cooperative enforcement efforts with Puyallup Tribal enforcement. The 2009 WDFW enforcement report described joint efforts with Nisqually Tribal enforcement and USFWS to identify and remove derelict gear on the Nisqually River. The report indicates the Nisqually Tribe has dedicated funds for the program. Information regarding fishery enforcement activities from other tribes that are party to the RMP has not been provided on which to assess the effectiveness of those tribal enforcement programs.

Both the Pacific Fishery Management Council and North of Falcon fishery planning processes are open to the public. The Council takes public comment and input throughout its development of fishing regimes for the ocean fisheries off Washington, Oregon, and California. Representatives from the commercial and recreational fishing constituencies are active participants in the North of Falcon planning process.

Participation by recreational and commercial fishers in pre-season fishery planning (through the PFMC and North of Falcon processes) and through interaction with WDFW staff at local meetings of commercial fishing, sport fishing, and conservation interest groups provide opportunity for angler education . These meetings promote awareness of priority conservation concerns, regulation changes, techniques for minimizing mortality of non-target stocks and species, and the importance of collecting accurate catch and encounter data in fisheries. WDFW also operates information booths at events such as fairs, sportsman's shows, and boat shows. The booths at these shows often include angler education displays, and WDFW staff working at the booths answer questions about fishery regulations and conservation issues, and distribute materials including regulation pamphlets, salmon identification cards, and fish dehookers. Much of the educational information mentioned above, are available on the WDFW website (e.g., http://wdfw.wa.gov/fishing/salmon/selective/ - Selective fishing release techniques, http://wdfw.wa.gov/fishing/salmon/identification.html - Salmon species identification).

In addition to interactions mentioned above during pre-season planning and industry group meetings, non-treaty commercial fishers are required to receive 'Fish Friendly' certification to participate in fisheries in Areas 7 and 7A, per WAC 220-47-301, 220-47-302, and 220-47-303. Cards are issued upon completion of a "Fish Friendly" workshop, which helps to improve the level of understanding and compliance of selective fishing techniques and legal requirements associated with using commercial gear for salmon fishing in Puget Sound. Since its inception in 2004, 450 commercial salmon licenses holders and alternate operators have completed the fish friendly certification program. The workshops also cover conservation measures including prohibition of landing salmon directly into the hold for fishers using purse seine gear (WAC 220-47-325).

Tribes educate their children about ancestral fishing practices, and tribal schools emphasize this theme (Wa-he-lute at Nisqually, Lummi Indian College). Experienced fishers mentor younger tribal members about using modern gear and seamanship to perpetuate skills and values that might otherwise be lost. Outreach to the public about tribal fishing and treaty rights is the primary purpose of the Northwest Indian Fisheries Commission (NWIFC) Information Division (e.g., NWIFC website, quarterly newsletter, and participation on editorial boards of local papers). Various tribes participate in or host community events centered on fishing or conservation stewardship themes, provide information through their websites, and speak to the public at various conferences and community meetings.

Commercial fishery regulations are promulgated by WDFW and by each tribe. The co-managers maintain a system for transmitting commercial fishing regulations electronically to all interested parties (including NMFS) in a timely manner, prior to and during all fisheries. Regulations are stored in paper and electronic format by WDFW, each tribe, and the Northwest Indian Fisheries Commission. Public notification of fishery regulations is achieved through press releases, regulation pamphlets, telephone hotlines, and Federal Register notices. WDFW and many of the tribes also publish regulations, and in-season regulation changes, on their websites (*www.wa.gov/wdfw,* www.puyallup-tribe.com/documents/pti_fishing_regulations_2010-2011.pdf, www.skokomish.org/Harvest Regulations.html, www.squaxinisland.org).

The PSTT and WDFW have direct management authority over fisheries harvesting Puget Sound Chinook salmon in Puget Sound. The Pacific Salmon Commission, Pacific Fishery Management Council, and North of Falcon meetings will provide the forums for coordination among jurisdictions impacting Puget Sound Chinook salmon populations. The fishery regimes developed each year as an outcome of these planning forums account for fishing-related mortality in all fisheries in the United States and Canada. They also help to ensure that fisheries are consistent with the management objectives and approach described in the RMP. Fishing-related mortality of Puget Sound Chinook salmon in Alaska and Canadian fisheries is constrained by the terms of the Pacific Salmon Treaty agreement (PST 2008).

12 ▪ Criterion 10: Minimizing Take

Section (b)(4)(i)(H) includes restrictions on resident and anadromous species fisheries that minimize any take of listed species, including time, size, gear, and area restrictions.

The RMP's exploitation rates, upper management thresholds, low abundance thresholds, and the critical exploitation rate ceilings are the primary elements of the harvest plan. Time, size, gear, area and retention restrictions are all among the actions taken to ensure that salmon fishing-related mortality is consistent with these management objectives. Chinook salmon-directed fisheries in some terminal areas have been closed for years, and in other areas, fisheries on other species and healthy hatchery populations are restricted or delayed to protect naturally spawning Chinook salmon.

Actions the co-managers have taken in the past and that will be considered under the RMP to protect listed species include: closures in the April, May, and June recreational fisheries and size limits to protect spring Chinook salmon; closure of the July Nooksack C&S fishery to provide additional protection to South Fork Nooksack early Chinook; closed spawning grounds to fishing; and required non-retention of Chinook salmon. Both commercial and recreational fisheries have instituted closures around river mouths where Chinook salmon concentrate before moving upstream. Managers have delayed fisheries directed at other salmon species or stronger stocks until Chinook or weaker Chinook stocks have cleared the area, e.g., Nooksack fishery for fall Chinook, Green River coho fishery. Mark-selective recreational fisheries occur in many areas to target returning hatchery adults and increase fishing opportunity while achieving management objectives.

Juvenile life stage spring Chinook salmon are not typically vulnerable to being caught in the fisheries subject to the RMP because of the juvenile's feeding habits and small size. Juvenile Chinook salmon are rarely caught in any Puget Sound fishery. Nets are the primary commercial gear used in Puget Sound and the mesh is generally too large to ensnare juveniles. Recreational fisheries in areas throughout Puget Sound have regulations that will reduce the potential mortality of juvenile Chinook salmon. These regulations include the use of barbless hooks, minimum size requirements, and catch-and-release-only fishing. Puget Sound freshwater salmon recreational fisheries are concentrated during the period of adult return (July, August, September, and October), typically well after the majority of juveniles have emigrated from freshwater.

Collectively, implementation of these actions has enabled the co-managers to target strong stocks and species while minimizing impacts on listed Puget Sound Chinook such that they do not exceed the harvest objectives under previous Puget Sound Chinook RMPs. The co-managers have included similar management measures in the 2010 Puget Sound RMP and these measures should continue to protect listed species which is also supported by the past pattern of successful performance.

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13 ▪ Criterion 11: Consistency with Federal Jurisdiction Regarding Tribal Harvest

Section (b)(4)(i)(I) is consistent with other plans and conditions established within any Federal court proceeding with continuing jurisdiction over tribal harvest allocations.

The RMP explicitly states in its general principles that it will comply with the requirements of *U.S. v. Washington* Case No. CV-70-9213 (W.D. Wash), *U.S. v. Oregon,* Case No. CV-68-513 (D. Or.), other applicable federal court orders, and the Pacific Salmon Treaty (see page 6 of the RMP).

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14 ▪ Recommended Determination

Recommended Determination:

The co-managers' RMP for Puget Sound salmon fisheries potentially affecting listed Puget Sound Chinook salmon from May 1, 2011 through April 30, 2014 has been evaluated, pursuant to 50 CFR 223.209 (Tribal Rule) and the government-to government processes therein.

NMFS Northwest Region's Salmon Management Division recommends that the National Marine Fisheries Service determine under 50 CFR 223.203(b)(6) that:

1. implementing and enforcing the RMP will not appreciably reduce the likelihood of survival and recovery of the Puget Sound Chinook Salmon ESU; and
2. the RMP will be implemented and enforced within the parameters set forth in *United States v. Washington* or *United States v. Oregon.*

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Comprehensive Management Plan for Puget Sound Chinook
Harvest Management Component

Appendix 1

Technical Assessment Methodologies

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Analytical Approach to Assessment of Salmon Impacts for the 2010 Puget Sound Chinook Harvest Resource Management Plan

General Approach

The analytical approach to assess potential impacts to listed salmon for the 2010 Puget Sound Chinook Harvest Plan uses a retrospective analysis similar to that used in the 2008 Pacific Salmon Treaty Agreement biological opinion. The multi-year approach is a more robust analysis than approaches based on a single year or a few years because it looks at a wider range of abundances and fishery regimes. The analysis looks at a series of past years reflecting a range in abundance and fishing regimes likely to be encountered in the duration of the RMP. For each year, the analysis explores the potential impacts to listed salmon under several management scenarios. The Fishery Regulation Assessment Model (FRAM) is used to do the analysis. Results are reported in terms of natural escapements and total, southern US and northern fishery exploitation rates.

The FRAM is a single-pool deterministic fishery simulation model that is based on stock-specific escapement and catch data from analysis of coded-wire-tags recovered in fisheries and escapement areas (PFMC and MEW 2008).[1] The FRAM essentially is an accounting tool that links the year-specific stock abundances with the catches by fishery according to historic catch distribution data from CWTs. There are 38 Chinook stocks and their marked and unmarked subcomponents in FRAM, representing production from southern British Columbia to California. FRAM contains 73 pre-terminal and terminal fisheries from southeast Alaska, Canada, Puget Sound, and off the coasts of Washington, Oregon, and California. Each run of FRAM incorporates the stock abundances and catches covering one management year that runs from May through the following April.

The Chinook FRAM model has four time steps: October through April, May through June, July through September, and October through April of the next year. The initial age-specific cohort size for each stock is set at the beginning of the first time period (October through April) based on the year specific estimates of abundance from post-season run reconstruction. At the start of each time period 'pre-fishing' abundances are first reduced by applying an age specific natural mortality rate, then reduced again by impacts in pre-terminal fisheries derived from the FRAM data set of stock, age, and fishery specific exploitation rates. After pre-terminal fishery impacts are subtracted, an age and stock specific maturation rate is applied to the remainder to produce a mature cohort representing the portion of the run that is returning to spawn in that time period and subject to fisheries in the terminal areas. The non-mature remainder becomes the initial starting cohort in the next time step and the same stepwise accounting continues in the next time period. Most stocks only mature during the July to September time period; hence, the mature cohort is zero in October through June. This general stepwise accounting system in FRAM

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[1] The FRAM is the tool used primarily for assessing Chinook and coho fisheries south of Canada during the annual Pacific Fishery Management Council and North of Cape Falcon management processes.

produces stock, age, and time specific estimates of cohort abundances and fishing impacts for each model run year. Each year this is evaluated independently; there is no direct connection between adjacent years.

The FRAM model uses the CWTs and fishing patterns during a base period when fisheries were widespread in time and area. The base period information is then scaled to reflect a year specific fishery pattern relative to the base years, and the abundance of the Chinook stocks in each year. An alternative approach that provides a more direct assessment of mortalities is to use CWT recoveries in each year to assess impacts on tag groups representing individual stocks or stock aggregates. The Pacific Salmon Commission Joint Chinook Technical Committee (CTC) does this as part of an annual exploitation rate analysis. However the data are often limited by inadequate escapement sampling or discontinuous or limited time series that may limit its utility in assessing harvest trends over time. Because its purpose is to assess the observed exploitation rates, the CTC exploitation rate analysis from CWT recoveries is not easily adapted to 'what-if' scenario comparisons. Estimates of observed exploitation rate for a given stock derived from FRAM and the CWT data may differ, sometimes significantly. Neither method can be considered the preferred method. Where differences exist it is necessary to look at the source data for the stock and consider why the difference may occur. The computation of escapements and exploitation rates for the FRAM Validation scenario described below and a comparison of the composition of the 2010 Puget Sound RMP thresholds with those in FRAM are summarized in Tables FRAM-1 and FRAM-2 below. Table FRAM-2 also includes changes in the composition of escapements as estimated by FRAM instituted in 2010.

Management Scenarios

The salmon analysis includes four management scenarios for analysis. The scenarios are similar to those evaluated in the 2008 PST Agreement biological opinion (NMFS 2008) and reflect the same parameters evaluated for the 2004 Puget Sound Chinook RMP (NMFS 2005) and the 2008 PST Agreement (range in abundance and Canadian fisheries)(NMFS 2008). Using the 2008 Likely FRAM modeling from the 2008 PST Agreement biological opinion as a starting point, the analysis incorporates the work from the 2008 PST Agreement biological opinion, terms of the 2008 PST Agreement, and provides consistency with how fishery revisions were made to fisheries outside the Puget Sound Action Area.

FRAM Validation

The FRAM Validation scenario approximates the fishing-related impacts to listed Puget Sound Chinook salmon that occurred during the analysis period based on post-season information. These runs are also used in other forums to evaluate the model and the management system and their relative success in meeting fishery and stock specific management objectives.

2010 RMP Likely

This scenario uses the 2008 Likely FRAM approach from the 2008 PST Agreement biological opinion and adjusts Puget Sound fisheries to meet the RMP objectives (see below). In the 2010

RMP Likely scenario we approximate our expectation of future constraints by assuming that fish levels will be similar to those observed in recent years. ISBM fisheries[2] in the U.S. and Canada have been constrained well below ISBM limits in recent years because of domestic concerns within each country. The 1994 to 1998 ISBM fishing levels were based on the average fishing effort rates for 1999-2002. The ISBM fishing levels for 1999 to 2008 were based on the annual fishing effort rates as estimated in the FRAM Validation runs. In this scenario, WCVI sport was modeled at 50,000 fish quota in all years with the troll catch as the difference between this and the overall TAC under the 2008 Agreement. Also, the WCVI troll fishery was modeled with adjustments to stock impacts as derived by the PSC Chinook Technical Committee reflecting the "shoulder" fishing pattern observed in recent years.

Since the early 2000s, the WCVI troll fishery has shifted its season structure from a summer fishery to the fall and spring ("shoulder fishing pattern"). Because WCVI fisheries in the base period occurred primarily during the summer, FRAM calculates impacts assuming there is no effect from shifting to a shoulder pattern unless adjustments are made to the model data that incorporate this effect. The stock specific effect of this shoulder fishing pattern has been estimated by the CTC and incorporated into the 2010 Likely and 40% Reduction scenarios. Both higher and lower impacts were estimated as a result of the changed pattern depending on the stock. The overall effect of the shoulder fishing pattern on the total exploitation rate will depend on the proportion of each stock's total exploitation in the WCVI troll fishery, and how the catch of that stock is distributed among the summer, spring, and fall fishing seasons.

2010 RMP High North

This scenario uses 2010 RMP Likely scenario and increase Canadian ISBM fisheries to the maximum allowed under the 2008 PST Agreement (0.63 of base General Obligation). The Alaskan and Canadian AABM fisheries are already maximized under the 2010 RMP Likely scenario. Southern US ocean fisheries would be modeled using the observed fishing effort scalars from the validation runs. Puget Sound fisheries were adjusted if necessary to meet the 2010 RMP objectives (see below).

The level of Canadian fisheries is an important consideration in anticipating potential impacts into the future. Depending on the management unit, Canadian fisheries, on average, can account for the majority of the total fishery-related mortality (Table A1-1). The proportion of fishery-related mortality on individual populations within the ESU by Canadian fisheries has ranged from 7 percent for the population in the White River Management Unit to 81 percent for the Nooksack Management Unit. The management of Canadian fisheries is outside the jurisdiction of the co-managers. In recent years, Canadian fisheries have not harvested Chinook salmon at levels allowed under the Pacific Salmon Treaty due to internal Canadian conservation issues.

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[2] An ISBM fishery is a regime that constrains to a numerical limit the total catch or total adult equivalent mortality rate within the fisheries of a jurisdiction for a naturally spawning Chinook stock or stock group. Because all fisheries that are not AABM fisheries are ISBM fisheries, this provision essentially results in accounting for all Chinook impacts, whether they are the result of directed fisheries or are only incidental to fisheries directed at other stocks.

These conservation concerns primarily pertain to depressed west coast Vancouver Island and Georgia Strait Chinook salmon, and upper Fraser and Thompson River coho salmon populations (LaVoy 2010c).

Table A1-1. The average distribution of fishery-related mortality for the management seasons 1999 to 2007, by management unit (CTC 2009). Canadian fisheries, on average, have accounted for over 50 percent of the fishery-related mortality in the Nooksack, Skagit Spring, Skagit Summer/Fall, Stillaguamish, and Elwha Management Units.

Management unit	Alaska	British Columbia, Canada	Southern US troll/sport	Puget Sound Net	Washington Troll/Recreational
Nooksack[1]	10.0/0.6%	80.7/66.0%	2.4/1.7%	1.7/0.2%	5.3/21.5%
Skagit Summer/Fall	28.3%	60.1%	0.8%	5.1%	5.7%
Skagit Spring[2]	5.6/1.1%	65.0/53.1%	2.1/1.3%	2.7/2.6%	24.6/43.0%
Stillaguamish	12.0%	57.0%	2.3%	5.8%	23.0%
Snohomish	-	-	-	-	-
Lake Washington	-	-	-	-	-
Green[3]	1.0%	37.9%	11.7%	25.1%	24.3%
White	0.0%	7.3%	2.2%	4.5%	86.0%
Puyallup	-	-	-	-	-
Nisqually	0.0%	15.6%	7.6%	50.1%	26.6%
Skokomish	1.5%	37.8%	11.6%	15.6%	33.6%
Mid-Hood Canal	-	-	-	-	-
Dungeness	-	-	-	-	-
Elwha [4]	15.3%	58.7%	2.0%	1.1%	22.9%

[1] Ranges provided for fingerling and yearling components of Nooksack spring populations (fingerling/yearling)
[2] Ranges provided for fingerling and yearling components of Skagit spring populations (fingerling/yearling)
[3] South Puget Sound fingerling indicator stock used to represent Green River
[4] 1993 to 1997 average distribution of fishery-related mortality. Tagging discontinued in mid 1990s.

40% Abundance Reduction

Under this scenario, abundance of each FRAM stock would be reduced by 40% using the same basis for abundance reduction and approach as used in the PST biological opinion (Bishop 2008; LaVoy 2008; Battin et al. 2007). The scenario would start using the fishing effort scalars in the 2010 RMP Likely runs and adjust Puget Sound fisheries if necessary to meet the RMP objectives under the reduced abundances (see below). This addresses the question of how the RMP would perform if overall abundance was lower than observed in the past which could happen as a result of climate change, continued environmental degradation, or extended poor marine survival.

The 40% reduction scenario is best compared to the 2010 RMP Likely scenario to provide a perspective on how the AABM provisions in the proposed RMP would respond to reduced abundance in terms of affect on exploitation rates in those fisheries and resulting escapements. The ISBM fisheries are modeled as rates in FRAM. If the abundance of Chinook did in fact decline by 40%, catches in ISBM fisheries would likely be reduced relative to the rates used in these model runs to address stock specific conservation concerns. Because of the many stocks and fisheries involved, it was not possible to analyze alternative outcomes for ISBM fisheries given the available time.

To adjust Puget Sound fisheries, under a given scenario (except the FRAM validation scenario), for each year in the analysis, the FRAM results were compared to the RMP objectives for exploitation rates and/or escapements. If the results did not meet the objectives, salmon fisheries within Puget Sound were reduced to meet the 2010 Puget Sound Chinook RMP objectives. If the FRAM results met the RMP objectives, further adjustments were not made. The only exception was for the Nooksack spring, Mid-Hood Canal, Dungeness, and Snohomish management units that have consistently been managed preseason for their Critical Exploitation Rate Ceiling (CERC)(see discussion on performance predictors). For these units, if the results were below the CERC, terminal fisheries were adjusted upward until the exploitation rate met the CERC for Nooksack spring, and pre-terminal fisheries were adjusted upward such that at least one of Mid-Hood Canal, Dungeness, or Snohomish exploitation rates was at its CERC. We did not adjust fisheries upward to assess "fishing up" to the RMP objectives for every stock. The 2010 Puget Sound Chinook RMP explicitly states that exploitation rates are ceilings, not annual targets (Section 5.2 of the RMP). More to the point, the RMP is structured around a weak stock management approach which means that the allowable exploitation rate on the weakest stocks limits harvest on healthier stocks that could sustain higher harvest rates. Differences in abundance and status of commingled stocks mean that it would not be possible to fish every stock to its ceiling without exceeding the limits on the weakest stocks. We assessed fishery increases for an individual stock if the reductions needed to achieve other RMP objectives resulted in a substantial level of additional fishing opportunity within the limits of the 2010 Puget Sound Chinook RMP for that stock.

In order to meet the 2010 Puget Sound Chinook RMP numerical objectives for exploitation rates and/or escapements, reductions to specific fisheries were made using the overall approach of making reductions in those fisheries that most efficiently achieve the RMP objectives (i.e., minimize loss on harvestable stocks/species):

1. For stocks with total fishery exploitation rate ceilings or southern U.S. exploitation rate ceilings, reductions were first made in freshwater fisheries before reductions were made in pre-terminal or marine terminal fisheries. The same percentage reductions were made to treaty and non-treaty terminal fisheries. Freshwater fisheries were reduced to the lesser of the lowest exploitation rate in the time series or 5% exploitation rate to allow for incidental impacts on Chinook in fisheries directed on other species.

2. For stocks with southern U.S. pre-terminal exploitation rate ceilings or when freshwater fishery reductions were not able to achieve the 2010 Puget Sound Chinook RMP

objectives, marine sport fisheries and marine terminal net fisheries within Puget Sound were reduced. Pre-terminal net fisheries in Puget Sound directed at other species were reduced only if the previous reductions did not achieve the 2010 Puget Sound Chinook RMP objectives.

3. Fisheries were not changed from their original gear/regulation structure (i.e., non-selective fisheries will not be converted to mark selective).

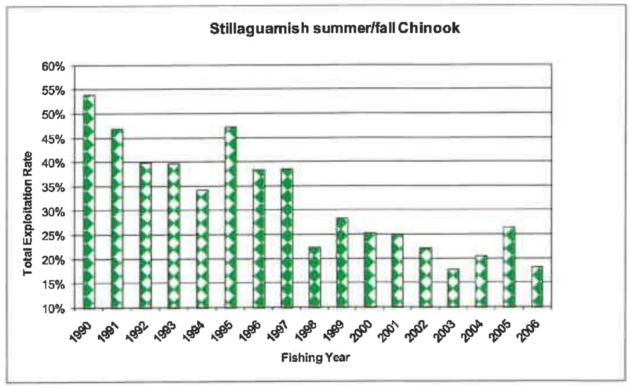

Figure A1-1. Estimated exploitation rates for the Stillaguamish Chinook Management Unit. This example illustrates the changes in exploitation rates since 1990 that have occurred for many Puget Sound Chinook populations.

Range of years in analysis

The analysis includes the years 1994-2008, rather than the 1990-2006 period used in the 2008 PST Agreement biological opinion.[3] Decisions about fishery adjustments for each management scenario become more difficult for earlier years when the fisheries were much different than the current regime. Using the retrospective analysis for the 2008 PST Agreement involved applying some general rules to adjust fisheries, i.e., following the Abundance Indices rules for the AABM fisheries or using average or individual year ISBM indices. The 2010 Puget Sound Chinook RMP includes management unit specific management objectives and more detailed management rules on a stock or population basis but not with fishery specific rules in most cases. Refinement of fishing regimes for the analysis of the 2010 Puget Sound RMP requires a substantially greater amount of work for each year and management scenario in the retrospective analysis. Without fishery specific rules in the RMP, our scientists expressed concern about whether their adjustments would be in alignment with those of the RMP applicant to meet the RMP rules in the early 1990s when exploitation rates were much higher (Figure A1-1) and fisheries were very different than in more recent years. Changes in stock status, management objectives, and refinements in harvest management make it unlikely that fisheries seen in the early 1990s would occur during the implementation of the RMP.

[3] For the 2008 PST Agreement analysis, 1990 was the earliest year in the available data set for which a consistent set of exploitation rates was available for all stocks in the analysis and had the highest data certainty. Results in prior years for some stocks included exploitation rates greater than 100% because of incomplete or uncertain data. Complete data sets and results for 2007 and 2008 were not available and prior years have been updated from the data set used in the biological opinion on the 2008 PST Agreement.

A closer look at Puget Sound abundances over the 1990-2008 time frame (Figure 2) based on the FRAM validation results shows the 1994-2008 period provides the same range of abundance for the analysis as the 1990-2006 period, except for 1990. The 1990 abundance is unlikely in the near future and plan performance is more critical at low abundances when the risk to listed salmon is greater.

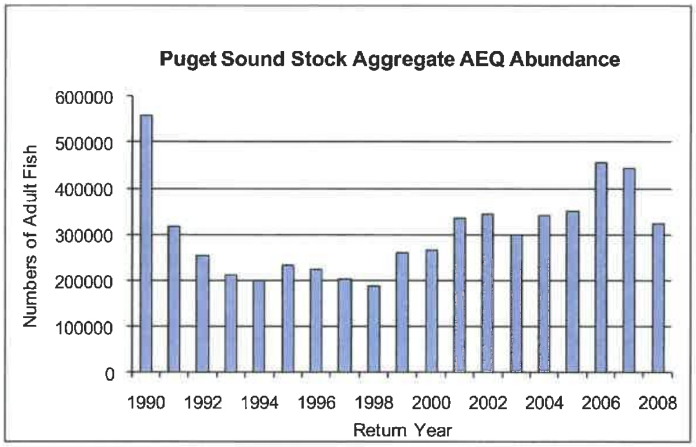

Figure A1-2. Range in Puget Sound aggregate abundance over time.

The 1994-2008 period would address most of the concerns raised about the certainty in fishery adjustments, provide a representative range of years, and include the range of observed abundances in the earlier period except for 1990 when the abundance was much higher. Therefore, using the 1994-2008 data period for the analysis would provide greater certainty in the results with no loss in information critical to the assessment.

Table FRAM-1. Description of composition and computation of escapement and exploitation rates by management unit for the FRAM Validation scenario.

Validation Runs

Stock	Escapement: Origins of Other Stock Information	Escapement: Computation	Exploit. Rate (ER) Computation	Comments
Nooksack Earlies (n)	ppn nat of tot: A&P tables?	Tot Esc *ppn nat	Tot (M&UM) ER	
Skagit Springs (n)	ppn nat of UM: pre-season	UM Esc * ppn nat of UM	UM ER	
White River Springs		UM Esc	UM ER	UM esc same as total and includes UM hatchery; no marked esc
Dungeness Springs	ppn Dung of JDF: Run Rec.; ppn marked hat & nat: pre-season	UM JDF Esc * ppn Dung of UM + M JDF Esc * ppn Dung of M	Tot (M&UM) ER	Tot same as UM; no marked
Skagit S/F	ppn nat of UM, ppn nat of M: pre-season	UM Esc * ppn nat of UM + M Esc * ppn nat of M	Tot (M&UM) ER	Includes wild broodstock; no marked esc, because ppn nat of M is zero, but mrkd contribute to ER comp
Stillaguamish (n)	ppn nat of UM: pre-season	UM Esc * ppn nat of UM	UM ER	
Snohomish (n)	ppn nat of UM: pre-season; Sky nat of Sno nat: pre-season	UM Esc * ppn nat of UM	UM Sky ER	
Lake Wa. (Cedar R.) (n)	ppn nat South Tribs: ; ppn nat Lk WA of UM SPS: RR & pre-season (ppn UM nat)	UM SPS ESC * ppn nat LK WA of UM SPS* ppn nat South Tribs	UM Lk WA ER	
Green	ppn nat Green of UM SPS: RR & pre-season (ppn UM nat)	UM SPS ESC * ppn nat Green of UM SPS	UM Green R ER	
Puyallup	ppn nat Puyallup of UM SPS: RR & pre-season (ppn UM nat)	UM SPS ESC * ppn nat Puyallup of UM SPS	UM Puyallup R ER	
Nisqually	ppn nat Nisqually of UM SPS: RR & pre-season (ppn UM nat)	UM SPS ESC * ppn nat Nisqually of UM SPS	UM Nisqually R ER	
Western Strait-Hoko		UM Esc + M Esc	Tot (M&UM) ER	Marked fish, which are included in the natural forecast, contribute to escapement and exploitation rate calculations
Elwha	ppn UM Elwha of UM Elwha/Dung: pre-season	UM JDF Esc * ppn UM Elwha of UM Elwha/Dung	Tot (M&UM) JDF	Ignores small amount of marked Elwha/Dung escapement, because TAMM assumes no marked fish
Mid-Hood Canal tribs. (n)	ppn UM 12B nat of UM HC: RR & pre-season	UM HC Esc * ppn UM 12B nat of UM HC	UM 12B nat ER	UM esc same as total, no marked escapement
Skokomish	ppn UM Skok nat of UM HC: RR & pre-season	UM HC ESC * ppn UM Skok nat of UM HC	UM Skok nat ER	UM esc same as total, no marked escapement

Key: UM = unmarked fish which could be wild or unmarked hatchery
M = marked hatchery fish, i.e., adipose fin clipped
ppn = proportion
nat = natural fish which include both hatchery and wild fish spawning in the wild
RR = run reconstruction which adds catch and escapements to calculate terminal run size
TAMM = Terminal Area Management Module used by FRAM to estimate catches and runsizes in freshwater and adjacent marine areas.

Table FRAM-2. Description of composition of thresholds and computation of exploitation rates by management unit in the proposed 2010 Puget Sound Chinook RMP. They are compared with the composition of escapements from the FRAM Validation scenario and revisions that have been made to the computation of escapement in FRAM beginning in 2010.

Management Unit	Population	RMP Thresholds LAT	RMP Thresholds UMT	Escapement FRAM Valid runs	Escapement 2010 and beyond	RMP Expl. Rate Computation	Comments
Nooksack Earlies (n)	NF Nooksack	NOR		NOR	NOR	Tot (M&UM) ER	Only DIT marked
	SF Nooksack	NOR			NOR		
Skagit Springs (n)	Suiattle	Natural	Natural	Unintentional NOR	NOR	UM ER	
	Upper Sauk	Natural	Natural		NOR		
	Upper Cascade	Natural	Natural		NOR		
White River Springs	White River early	Natural	Natural	H+W UM	H+W UM	UM ER	UM esc same as total and includes UM hatchery; no marked esc
Dungeness Springs	Dungeness	Natural	Natural	natural	natural	Tot (M&UM) ER	No marked fish
Skagit S/F	Upper Skagit	Natural	Natural	natural	natural	Tot (M&UM) ER	Includes wild broodstock; no marked esc, because ppn nat of M is zero, but mrkd contribute to ER comp
	Lower Skagit	Natural	Natural		natural		Includes wild broodstock; no marked esc, because ppn nat of M is zero, but mrkd contribute to ER comp
	Lower Sauk	Natural	Natural		natural		Includes wild broodstock; no marked esc, because ppn nat of M is zero, but mrkd contribute to ER comp
Stillaguamish (n)	NF Stillaguamish	NOR	NOR	natural	NOR	UM ER	Only PST marked
	SF Stillaguamish	NOR	NOR		NOR		
Snohomish (n)	Skykomish	NOR	NOR	natural	NOR	UM Sky ER	
	Snoqualmie	NOR	NOR		NOR		
Lake Wa.	Cedar River	Natural	Natural	natural	natural	UM Lk WA ER	
	Sammamish						
Green	Green	Natural	Natural	natural	natural	UM Green R ER	
Puyallup	Puyallup	Natural	Natural	natural	NOR	UM Puyallup R ER	
Nisqually	Nisqually			natural	natural	UM Nisqually R ER	
Elwha	Elwha	Natural	Natural	natural	natural	Tot (M&UM) JDF.	
Mid-Hood Canal tribs. (n)	Mid Hood Canal	Natural	Natural	natural	natural	UM 12B nat ER	
Skokomish	Skokomish	Natural	Natural	natural	natural	UM Skok nat ER	

Viability Risk Assessment Procedure

NMFS analyzes the effects of harvest actions on populations using quantitative analyses where possible and more qualitative considerations where necessary. The Viable Risk Assessment Procedure (VRAP) is an example of a quantitative risk assessment method that was developed by NMFS and applied primarily for analyzing harvest impacts on Puget Sound (and Lower Columbia River tule Chinook.) VRAP provides estimates of population-specific exploitation rates (called Rebuilding Exploitation Rates or RERs) that are designed to be consistent with ESA-related survival and recovery requirements. Proposed fisheries are then evaluated, in part, by comparing the RERs to rates that can be anticipated as a result of the proposed harvest plan. Where impacts of the proposed plan are less than or equal to the RERs, NMFS considers the harvest plan to present a low risk to that population (the context and basis of NMFS' conclusions related to RERs is discussed in more detail below). The results of this comparison, together with more qualitative considerations for populations where RERs cannot be calculated, are then used in making the jeopardy determination for the ESU as a whole. A brief summary of VRAP and how it is used to estimate an RER is provided below. For a more detailed explanation see NMFS (2000) and NMFS (2004).

The Viable Risk Assessment Procedure:

- quantifies the risk to survival and recovery of individual populations compared with a zero harvest scenario;
- accounts for total fishing mortality throughout the migratory range of the ESU;
- explicitly incorporates management, data, and environmental uncertainty; and
- isolates the effect of harvest from mortality that occurs in the habitat and hatchery sectors.

The result of applying the VRAP to an individual population is an RER which is the highest allowable ("ceiling") exploitation rate that satisfies specified risk criteria related to survival and recovery. Calculation of RERs depend on the selection of two abundance-related reference points (referred to as critical and rebuilding escapement thresholds (CET and RET[4])), and two risk criteria that define the probability that a population will fall below the CET and exceed the RET. Considerations for selecting the risk criteria and thresholds are discussed briefly here and in more detail in NMFS 2000.

The selection of risk criteria for analytical purposes is essentially a policy decision. For jeopardy determinations, the standard is to not "…reduce appreciably the likelihood of survival and recovery …" (50 CFR 402.2). In this context, NMFS used guidance from earlier biological opinions to guide the selection of risk criteria for VRAP. NMFS' 1995 biological opinion on the operation of the Columbia River hydropower system (NMFS 1995) considered the biological requirements for Snake River spring/summer Chinook to be met if there was a high likelihood,

[4] Also referred to in previous opinions as the Upper Escapement Threshold.

relative to the historic likelihood, that a majority of populations were above lower threshold levels[5] and a moderate to high likelihood that a majority of populations would achieve their recovery levels in a specified amount of time. High likelihood was considered to be a 70% or greater probability, and a moderate-to-high likelihood was considered to be a 50% or greater probability (NMFS 1995). The Cumulative Risk Initiative (CRI) has used a standard of 5% probability of absolute extinction in evaluating the risks of management actions to Columbia River ESUs. The different standards of risk, i.e., 50% vs. 5%, were based primarily on the thresholds that the standard was measured against. The CRI threshold is one of absolute extinction, i.e., 1 spawning adult in a brood cycle. The Biological Requirements Work Group (BRWG 1994) threshold is based on a point of potential population destabilization, i.e., 150-300 adult spawners, but well above what would be considered extinction. In fact, several of the populations considered by the BRWG had fallen below their thresholds at some point and rebounded, or persisted at lower levels. Since the consequences to a species of the CRI threshold are much greater than the consequences of the BRWG thresholds, the CRI standard of risk should be much higher (5%). Scientists commonly define high likelihood to be ≥95%. For example, tests of significance typically set the acceptable probability of making a Type I error at 5%. The basis of the VRAP critical threshold is more similar to the BRWG lower threshold in that it represents a point of potential population destabilization. However, given the uncertainties in the data, especially when projected over a long period of time, and the different risk to populations represented by the two thresholds, we chose a conservative approach both for falling below the critical threshold, i.e., 5%, and exceeding the recovery threshold, i.e., 80%.

The risk criteria were chosen within the context of the jeopardy standard. They measure the effect of the proposed action against the baseline condition, and require that the proposed action not result in a significant negative effect on the status of the species over the conditions that already exist. We determined that the risk criteria consistent with the jeopardy standard would be that: (1) the percentage of escapements below the critical threshold differs no more than 5% from that under baseline conditions; *and* (2) the viable threshold must be met 80% of the time, *or* the percentage of escapements less than the viable threshold differs no more than 10% from that under baseline conditions. Said another way, these criteria seek to identify an exploitation rate that will not appreciably increase the number of times a population will fall below the critical threshold and also not appreciably reduce the prospects of achieving recovery. For example, if under baseline conditions, the population never fell below the critical threshold, escapements must meet or exceed the critical threshold 95% of the time under the proposed harvest regime.

As described above, VRAP uses critical escapement and rebuilding escapement thresholds as benchmarks for calculating the RERs. Both thresholds represent natural-origin spawners. The CET represents a boundary below which uncertainties about population dynamics increase

5 The Biological Requirements Work Group defined these as levels below which uncertainties about processes or population enumerations are likely to become significant, and below which qualitative changes in processes are likely to occur (BRWG 1994). They accounted for genetic risk, and some sources of demographic and environmental risk.

substantially. In cases where sufficient stock-specific information is available, we can use the population dynamics relationship to define this point. Otherwise, we use alternative population-specific data, or general literature-based guidance. NMFS has provided some guidance on the range of critical thresholds in its document, *Viable Salmonid Populations* (McElhaney et al. 2000). The VSP guidance suggests that effective population sizes of less than 500 to 5,000 per generation, or 125 to 1,250 per annual escapement, are at increased risk. For the Lower Columbia River tule analyses, we generally used CETs corresponding to the Willamette/Lower Columbia River TRT's quasi-extinction thresholds (QET): 50/year for four years for 'small' populations, 150/year for four years for medium populations, and 250/year for four years for large populations (McElhany et al. 2000).

The RET may represent a higher abundance level that would generally indicate recovery or a point beyond which ESA type protections are no longer required. The RET could also be an estimate of the spawners needed to achieve maximum sustainable yield or for maximum recruits, or some other designation. It is important to recognize, though, that the RET is not an escapement goal but rather a threshold level that is expected to be exceeded most of the time (≥ 80%). It should also be noted that, should the productivity and/or capacity conditions for the population improve, the RET should be changed to reflect the change in conditions.
There is often some confusion about the relationship between rebuilding escapement thresholds used in the VRAP analysis, and abundance related recovery goals. The RET are generally significantly less than recovery goals that are specified in recovery plans. VRAP seeks to analyze a population in its existing habitat given current conditions. As the productivity and capacity of the habitat improves, the VRAP analysis will be adjusted to reflect those changes. Thus the RET serves as a step in the progression to recovery, which will occur as the contributions from recovery action across all sectors are realized.

There are two phases to the VRAP process for determining an RER for a population. The first, or model fitting phase, involves using data from the target population itself, or a representative indicator population, to fit a spawner-recruit relationship representing the performance of the population over the time period analyzed. Population performance is modeled as:

$$R = f(S, \mathbf{e}),$$

where S is the number of fish spawning in a single return year, R is the number of adult equivalent recruits,[6] and e is a vector of environmental, density-independent indicators of annual survival.

Several data sets are necessary for this: a time series of natural spawning escapement, a time series of total recruitment by cohort, and time series for the environmental correlates of survival. In addition, one must assume a functional form for f , the spawner-recruit relationship. Given

[6] Equivalently, this could be termed "potential spawners" because it represents the number of fish that would return to spawn absent harvest-related mortality.

the data, one can numerically estimate the parameters of the assumed spawner-recruit relationship to complete the model fitting phase.

The data are fitted using three different models for the spawner recruit relationship: the Ricker (Ricker 1975), Beverton-Holt (Ricker 1975), and Hockey stick (Barrowman and Meyers 2000). The simple forms of these models can be augmented by the inclusion of environmental variables correlated with brood year survival. The VRAP is therefore flexible in that it facilitates comparison of results depending on assumptions between production functions and any of a wide range of possible environmental co-variates. Equations for the three models are as follows:

$R = (aSe^{-bS})(M^{c}e^{dF})$ [Ricker]

$R = (S/[bS + a])(M^{c}e^{dF})$ [Beverton-Holt]

$R = (\min[aS, b])(M^{c}e^{dF})$ [hockey stick]

In the above, M is the index of marine survival and F is the freshwater correlate.

The second, or projection phase, of the analysis involves using the fitted model in a Monte Carlo simulation to project the probability distribution of the near-term future performance of the population assuming that current conditions of productivity continue. Besides the fitted values of the parameters of the spawner-recruit relationships, one needs estimates of the probability distributions of the variables driving the population dynamics, including the process error (including first order autocorrelation) of the spawner-recruit relationship itself and each of the environmental correlates.[7] Also, since fishing-related mortality is modeled in the projection phase, one must estimate the distribution of the deviation of actual fishing-related mortality from the intended ceiling. This is termed "management error" and its distribution, as well as the others, is estimated from available recent data.

For each of a stepped series of exploitation rates the population is repeatedly projected for 25 years. From the simulation results we computed the fraction of years in all runs where the escapement is less than the critical escapement threshold and the fraction of runs for which the final year's escapement is greater than the rebuilding escapement threshold. Exploitation rates for which the first fraction is less than 5% and the second fraction is greater than 80% (or 10% from baseline) satisfies the identified risk criteria are thus used to define the population specific ceiling exploitation rates for harvest management.

Finally, the population-specific RERs must be made compatible with the exploitation rates generated from the FRAM model for use in fishery management planning. The VRAP and the

[7] Actual environmental conditions may vary from the modeled 25-year projections due to such things as climate change, restoration actions, development, etc. However, it is difficult to anticipate exactly how conditions might be different for a specific population which is the focus of the VRAP analysis. Incorporation of the observed uncertainty in each of the key parameters in the VRAP analysis, the use of high probabilities related to abundance thresholds and periodic revision of the RERs on a shorter time frame (e.g., 5-10 years) in the event that conditions have changes serve to mitigate this concern.

FRAM model were developed for different purposes and are therefore based on different data sources and use different approaches to estimate exploitation rates. The VRAP uses long-term population intensive data to derive a RER for a single population. The FRAM uses fishery intensive data to estimate the effects of southern U.S. West Coast fishing regimes across the management units (populations or groups of populations) present in those fisheries. Because the FRAM model is used for preseason planning and to manage fisheries, it is necessary to ensure that the RERs derived from VRAP are consistent with the management unit exploitation rates that we estimated by the FRAM model. To make them compatible, the RERs derived from VRAP are converted to FRAM-based RERs using linear or log-transform regressions between the exploitation rate estimates from the population specific data and post season exploitation rate estimates derived from FRAM.

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Comprehensive Management Plan for Puget Sound Chinook
Harvest Management Component

Appendix 2

Retrospective Analysis Model Runs by Puget Sound Chinook Management Unit

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Nooksack River

Total AEQ exploitation rates and escapements[1] for Nooksack River early Chinook from the Retrospective Analysis (LaVoy 2010).

	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
Fishing Year	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	30%	31%	24%	24%	24%	24%	17%	17%	6%	7%	7%	7%	82	82	85	51
1995	28%	30%	23%	23%	21%	23%	16%	16%	7%	7%	7%	7%	369	361	376	225
1996	22%	27%	20%	20%	14%	20%	13%	13%	8%	7%	7%	7%	303	294	306	184
1997	24%	29%	22%	22%	16%	22%	15%	15%	8%	7%	7%	7%	183	172	179	107
1998	23%	30%	23%	23%	19%	23%	16%	16%	5%	7%	7%	7%	109	101	105	63
1999	24%	27%	21%	21%	19%	20%	14%	14%	5%	7%	7%	7%	222	213	220	132
2000	25%	30%	23%	23%	20%	23%	16%	16%	5%	7%	7%	7%	386	366	383	230
2001	22%	29%	23%	23%	17%	22%	16%	16%	5%	7%	7%	7%	443	416	432	263
2002	19%	30%	24%	24%	17%	23%	17%	17%	2%	7%	7%	7%	452	407	423	254
2003	19%	31%	23%	23%	16%	24%	16%	16%	3%	7%	7%	7%	377	341	360	216
2004	20%	26%	20%	20%	16%	19%	13%	13%	4%	7%	7%	7%	394	368	386	232
2005	21%	28%	19%	19%	17%	21%	12%	12%	4%	7%	7%	7%	288	273	286	172
2006	16%	25%	17%	17%	11%	18%	10%	10%	5%	7%	7%	7%	595	558	589	354
2007	20%	26%	19%	19%	15%	20%	12%	12%	5%	7%	7%	7%	539	509	536	322
2008	14%	21%	15%	16%	11%	14%	8%	9%	3%	7%	7%	7%	304	292	301	180
1994-08 Average	22%	28%	21%	21%	17%	21%	14%	14%	5%	7%	7%	7%	336	317	331	199
% Change from validation (94-08 avg.)		28%	-4%	-4%												

[1] The escapements shown here include returns to both the North Fork and South Fork Nooksack populations.

AR016158

Skagit Summer/Fall

Total AEQ exploitation rates and escapements[2] for Skagit River Summer/Fall Chinook from the Retrospective Analysis (LaVoy 2010).

	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
Fishing Year	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	63%	59%	49%	49%	48%	53%	42%	42%	15%	6%	7%	7%	6357	6897	7254	4342
1995	63%	59%	50%	50%	36%	46%	34%	35%	27%	14%	15%	15%	6733	7682	8271	4945
1996	38%	48%	39%	39%	21%	41%	31%	31%	17%	7%	8%	8%	10836	10378	10903	6513
1997	50%	48%	41%	41%	27%	36%	28%	28%	23%	12%	13%	14%	4939	5447	5707	3407
1998	30%	30%	27%	28%	25%	25%	22%	22%	4%	5%	5%	6%	14658	14398	14914	8888
1999	39%	41%	32%	33%	30%	35%	26%	26%	8%	7%	7%	7%	4920	5109	5322	3156
2000	40%	42%	36%	36%	35%	38%	32%	32%	5%	4%	4%	5%	16998	16759	17519	10503
2001	32%	39%	32%	32%	25%	31%	25%	27%	8%	8%	7%	5%	13877	13142	14031	8481
2002	46%	53%	46%	46%	33%	42%	34%	34%	12%	11%	12%	12%	17971	17155	18054	10849
2003	46%	56%	47%	47%	38%	49%	40%	40%	8%	7%	7%	8%	10219	9366	10165	6041
2004	43%	40%	34%	34%	37%	35%	28%	28%	6%	5%	6%	6%	23500	24357	25617	15393
2005	50%	47%	39%	41%	40%	35%	28%	28%	10%	12%	11%	13%	20718	22046	23458	13698
2006	41%	42%	34%	34%	32%	35%	26%	26%	9%	8%	8%	8%	20994	22045	23061	13858
2007	58%	55%	49%	49%	45%	45%	40%	40%	13%	10%	10%	10%	11386	12818	13614	8228
2008	53%	57%	50%	49%	36%	43%	34%	32%	17%	15%	15%	17%	11502	11383	12388	7417
1994-08 Average	46%	48%	40%	41%	34%	39%	31%	31%	12%	9%	9%	9%	13041	13265	14019	8381
% Change from validation (94-08 avg.)		4%	-12%	-12%												

[2] The escapements shown here include returns to the Upper Skagit, Lower Skagit, and Lower Sauk River populations.

Skagit Spring

Total AEQ exploitation rates and escapements[3] for Skagit River Spring Chinook from the Retrospective Analysis (LaVoy 2010).

	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
Fishing Year	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	53%	33%	25%	29%	17%	22%	13%	13%	36%	11%	12%	16%	1043	1322	1392	793
1995	46%	29%	20%	21%	14%	21%	11%	11%	32%	8%	8%	10%	1290	1635	1720	1010
1996	44%	33%	24%	26%	7%	20%	11%	11%	36%	13%	14%	15%	1076	1228	1292	763
1997	45%	29%	20%	21%	9%	21%	12%	12%	36%	7%	8%	9%	1001	1268	1335	792
1998	28%	35%	26%	27%	7%	20%	10%	10%	21%	14%	16%	17%	1083	1078	1134	676
1999	23%	27%	17%	18%	10%	21%	10%	11%	14%	5%	7%	7%	362	357	374	222
2000	27%	32%	23%	24%	11%	21%	10%	10%	17%	11%	13%	13%	1192	1153	1218	724
2001	30%	37%	28%	24%	9%	20%	10%	11%	21%	17%	18%	13%	1309	1264	1338	828
2002	26%	33%	24%	24%	11%	21%	11%	11%	15%	12%	12%	13%	838	818	857	514
2003	23%	34%	23%	24%	10%	22%	11%	10%	13%	12%	13%	13%	950	881	946	566
2004	23%	27%	20%	21%	11%	18%	9%	9%	11%	9%	11%	12%	1678	1606	1709	1012
2005	26%	36%	23%	24%	13%	24%	11%	11%	13%	12%	13%	13%	2021	1955	2067	1228
2006	22%	30%	20%	20%	10%	21%	9%	10%	12%	9%	11%	11%	1742	1650	1752	1051
2007	23%	29%	20%	20%	12%	20%	10%	11%	10%	9%	9%	10%	1680	1627	1735	1038
2008	24%	31%	23%	24%	9%	16%	8%	6%	15%	15%	15%	18%	1231	1166	1244	742
1994-08 Average	31%	32%	22%	23%	11%	21%	11%	10%	20%	11%	12%	13%	1233	1267	1341	797
% Change from validation (94-08 avg.)		2%	-27%	-25%												

[3] The escapements shown here include returns to the Suiattle, Upper Sauk, and Upper Cascade River populations.

Stillaguamish Summer/Fall

Total AEQ exploitation rates and escapements[4] for Stillaguamish Summer/Fall Chinook from the Retrospective Analysis (LaVoy 2010).

	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
Fishing Year	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	37%	18%	15%	14%	14%	13%	9%	9%	23%	5%	5%	5%	954	1073	1086	652
1995	42%	24%	20%	20%	10%	12%	8%	8%	32%	12%	12%	12%	815	991	1007	600
1996	41%	23%	18%	19%	5%	12%	8%	8%	36%	11%	11%	11%	1243	1441	1461	876
1997	36%	23%	19%	19%	7%	14%	10%	10%	28%	9%	9%	10%	1150	1360	1377	823
1998	22%	24%	21%	22%	5%	11%	8%	8%	17%	13%	13%	14%	1534	1567	1586	949
1999	26%	23%	19%	20%	9%	15%	9%	9%	17%	8%	10%	11%	1090	1106	1119	668
2000	24%	23%	19%	20%	10%	12%	8%	9%	15%	11%	11%	11%	1646	1650	1673	1003
2001	25%	26%	23%	20%	9%	13%	10%	10%	16%	13%	13%	11%	1350	1350	1369	841
2002	22%	24%	20%	21%	11%	15%	12%	12%	11%	9%	9%	9%	1588	1602	1617	970
2003	21%	26%	21%	22%	10%	15%	11%	11%	11%	11%	10%	11%	977	953	972	582
2004	19%	18%	16%	16%	12%	12%	9%	9%	7%	6%	7%	7%	1505	1507	1529	917
2005	25%	24%	20%	20%	16%	15%	11%	10%	9%	10%	9%	9%	930	943	957	574
2006	16%	17%	13%	13%	8%	12%	7%	7%	8%	6%	6%	6%	1166	1164	1181	706
2007	27%	28%	22%	22%	10%	15%	9%	9%	17%	13%	13%	13%	618	620	632	378
2008	14%	17%	14%	14%	9%	10%	7%	7%	5%	7%	7%	8%	939	931	943	563
1994-08 Average	26%	23%	19%	19%	10%	13%	9%	9%	17%	10%	10%	10%	1167	1217	1234	740
% Change from validation (94-08 avg.)		-15%	-29%	-29%												

[4] The escapements shown here include returns to the both the North Fork and South Fork Stillaguamish River populations.

Snohomish Summer/Fall

Total AEQ exploitation rates and escapements[5] on Snohomish River Summer/Fall Chinook from the Retrospective Analysis (LaVoy 2010).

Fishing Year	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	52%	35%	27%	27%	21%	26%	17%	17%	31%	9%	10%	10%	3599	4091	4218	2523
1995	67%	49%	36%	35%	17%	34%	21%	21%	50%	15%	15%	15%	2826	3505	3834	2292
1996	49%	38%	29%	29%	10%	23%	14%	14%	40%	15%	15%	15%	4536	5503	5890	3530
1997	29%	17%	14%	14%	7%	12%	9%	9%	21%	5%	5%	6%	4293	5352	5510	3302
1998	27%	32%	26%	26%	7%	19%	12%	12%	19%	13%	14%	14%	6229	6362	6580	3955
1999	36%	39%	30%	30%	15%	28%	16%	16%	22%	11%	14%	14%	4015	4064	4186	2506
2000	28%	31%	25%	25%	11%	16%	10%	10%	17%	15%	15%	15%	6097	5884	6170	3701
2001	30%	36%	29%	29%	14%	21%	14%	14%	16%	15%	15%	15%	8130	7820	8291	4956
2002	30%	35%	29%	29%	13%	20%	14%	14%	17%	15%	15%	15%	7192	7024	7330	4401
2003	24%	32%	24%	25%	12%	21%	13%	13%	12%	12%	11%	12%	5331	5036	5325	3163
2004	26%	28%	22%	22%	16%	20%	12%	12%	10%	8%	10%	10%	10962	10673	11255	6753
2005	36%	41%	30%	31%	23%	26%	17%	17%	13%	15%	13%	15%	4682	4600	4866	2887
2006	34%	44%	33%	33%	18%	32%	18%	18%	16%	12%	15%	15%	8248	7775	8194	4916
2007	33%	36%	29%	29%	14%	21%	15%	15%	19%	15%	15%	15%	3773	3717	3880	2328
2008	21%	31%	24%	23%	11%	19%	11%	11%	10%	12%	13%	13%	8136	7654	8001	4841
1994-08 Average	35%	35%	27%	27%	14%	23%	14%	14%	21%	12%	13%	13%	5870	5937	6235	3737
% Change from validation (94-08 avg.)		0%	-22%	-22%												

[5] The escapements shown here include returns to the both the Skykomish and Snoqualmie River populations.

AR016162

Lake Washington

Total AEQ exploitation rates and escapements[6] for Lake Washington Chinook from the Retrospective Analysis (LaVoy 2010).

	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
Fishing Year	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	42%	22%	21%	20%	19%	15%	13%	14%	22%	7%	7%	7%	341	424	430	259
1995	30%	17%	15%	15%	12%	11%	9%	9%	18%	6%	6%	6%	628	749	760	456
1996	29%	23%	21%	21%	5%	10%	9%	9%	24%	13%	12%	12%	291	322	329	197
1997	29%	20%	18%	19%	9%	13%	11%	11%	21%	8%	7%	8%	211	246	251	150
1998	16%	22%	20%	21%	5%	12%	11%	11%	11%	10%	10%	10%	413	393	398	238
1999	16%	16%	15%	15%	8%	10%	9%	9%	8%	6%	6%	6%	234	236	237	142
2000	22%	22%	20%	20%	13%	13%	11%	11%	10%	9%	9%	9%	118	116	118	71
2001	22%	24%	22%	22%	11%	13%	11%	11%	12%	11%	11%	11%	623	613	623	376
2002	20%	23%	21%	21%	11%	14%	13%	13%	9%	9%	9%	8%	341	334	340	204
2003	28%	33%	30%	30%	17%	21%	18%	18%	12%	12%	12%	12%	526	505	521	310
2004	36%	33%	30%	27%	20%	18%	15%	15%	15%	15%	16%	13%	406	413	421	264
2005	50%	46%	41%	37%	33%	28%	23%	22%	17%	18%	19%	15%	382	398	392	259
2006	38%	39%	37%	37%	19%	22%	18%	18%	20%	18%	19%	19%	1066	1060	1072	646
2007	36%	36%	32%	32%	19%	20%	16%	16%	16%	16%	16%	16%	1627	1628	1663	1005
2008	38%	41%	37%	37%	21%	23%	18%	18%	17%	17%	18%	19%	946	918	941	562
1994-08 Average	30%	28%	25%	25%	15%	16%	14%	14%	15%	12%	12%	11%	544	557	566	343
% Change from validation (94-08 avg.)		-8%	-16%	-17%												

[6] The escapements shown here include returns to the both the Cedar and Sammamish River populations.

AR016163

Green River

Total AEQ exploitation rates and escapements for Duwamish-Green River Chinook from the Retrospective Analysis (LaVoy 2010).

	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
Fishing Year	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	66%	42%	41%	23%	19%	15%	13%	14%	47%	27%	28%	9%	3662	5826	5880	4625
1995	36%	22%	21%	21%	12%	11%	9%	9%	24%	12%	11%	12%	8361	10238	10396	6215
1996	40%	31%	29%	18%	5%	10%	9%	9%	35%	21%	21%	9%	6653	7824	7995	5556
1997	32%	24%	22%	22%	9%	13%	11%	11%	23%	11%	11%	11%	11387	13124	13337	7992
1998	28%	34%	33%	25%	5%	12%	11%	11%	23%	22%	22%	15%	9166	8614	8743	5833
1999	23%	22%	21%	22%	8%	10%	9%	9%	15%	12%	13%	13%	13135	13261	13366	8005
2000	39%	38%	37%	37%	13%	13%	11%	11%	26%	26%	26%	26%	10753	10592	10810	6426
2001	33%	35%	33%	33%	11%	13%	11%	11%	22%	22%	22%	22%	21903	21476	21892	13194
2002	46%	48%	47%	46%	11%	14%	13%	13%	34%	34%	34%	34%	12807	12390	12742	7668
2003	44%	48%	50%	36%	17%	21%	18%	18%	28%	27%	32%	18%	8437	8003	7680	5847
2004	51%	49%	47%	47%	20%	18%	15%	15%	31%	31%	32%	32%	13510	13806	14163	8485
2005	52%	44%	39%	40%	33%	28%	23%	22%	19%	16%	16%	18%	4197	4733	4674	2858
2006	48%	49%	47%	47%	19%	22%	18%	18%	29%	27%	29%	29%	10610	10543	10693	6442
2007	57%	58%	55%	39%	19%	20%	16%	16%	38%	38%	38%	23%	7049	7038	7303	5848
2008	59%	56%	54%	31%	21%	23%	18%	18%	38%	33%	36%	13%	5281	5812	5827	5302
1994-08 Average	44%	40%	38%	32%	15%	16%	14%	14%	29%	24%	25%	19%	9794	10219	10367	6686
% Change from validation (94-08 avg.)		-8%	-12%	-26%												

AR016164

White River

Total AEQ exploitation rates and escapements for White River Chinook from the Retrospective Analysis (LaVoy 2010).

Fishing Year	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	45%	13%	11%	11%	3%	5%	3%	3%	42%	7%	8%	8%	628	716	717	431
1995	36%	12%	11%	10%	2%	5%	3%	3%	34%	7%	7%	7%	864	1060	1062	637
1996	30%	12%	11%	11%	2%	4%	3%	3%	28%	8%	8%	8%	985	1181	1183	710
1997	23%	11%	9%	10%	1%	5%	4%	4%	22%	6%	5%	7%	1061	1189	1192	715
1998	22%	18%	18%	18%	2%	4%	3%	3%	20%	14%	14%	15%	509	524	524	313
1999	41%	18%	20%	20%	3%	11%	3%	4%	38%	7%	16%	16%	591	610	607	365
2000	13%	11%	10%	10%	3%	4%	3%	3%	10%	7%	7%	7%	1926	1948	1953	1170
2001	20%	19%	18%	18%	4%	5%	4%	3%	16%	14%	14%	15%	2343	2383	2386	1412
2002	14%	14%	12%	12%	2%	4%	3%	2%	12%	10%	9%	10%	988	1007	1009	604
2003	14%	15%	15%	15%	3%	4%	3%	3%	12%	12%	12%	12%	1771	1765	1766	1061
2004	24%	20%	20%	20%	4%	8%	4%	4%	20%	12%	16%	16%	1488	1536	1530	919
2005	13%	19%	13%	13%	1%	7%	1%	1%	12%	12%	12%	13%	1783	1779	1786	1069
2006	24%	18%	20%	20%	2%	6%	2%	2%	22%	12%	18%	18%	3097	3291	3143	1897
2007	12%	13%	12%	12%	1%	2%	1%	1%	11%	10%	10%	10%	5006	5046	5063	3031
2008	17%	17%	17%	18%	1%	2%	1%	1%	16%	14%	16%	17%	1816	1847	1816	1082
1994-08 Average	23%	15%	14%	15%	2%	5%	3%	3%	21%	10%	12%	12%	1657	1725	1716	1028
% Change from validation (94-08 avg.)		-34%	-38%	-37%												

AR016165

Puyallup River

Total AEQ exploitation rates and escapements for Puyallup River Chinook from the Retrospective Analysis (LaVoy 2010).

	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
Fishing Year	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	72%	50%	50%	50%	19%	15%	14%	14%	53%	34%	36%	36%	1707	2883	2852	1710
1995	67%	50%	50%	50%	12%	11%	9%	9%	55%	39%	40%	40%	2577	3977	3971	2383
1996	60%	50%	50%	50%	5%	10%	9%	9%	55%	40%	41%	41%	2503	3200	3176	1921
1997	57%	45%	44%	45%	9%	13%	11%	11%	48%	33%	33%	34%	1441	1891	1944	1136
1998	33%	38%	37%	38%	5%	12%	11%	11%	28%	26%	26%	27%	4819	4547	4623	2732
1999	50%	49%	48%	50%	8%	10%	9%	9%	42%	39%	40%	41%	1869	1898	1920	1121
2000	64%	50%	50%	50%	13%	13%	11%	11%	52%	37%	39%	39%	1050	1445	1445	869
2001	72%	50%	50%	50%	11%	13%	11%	11%	62%	37%	38%	39%	1830	3334	3344	2003
2002	69%	50%	50%	50%	11%	14%	13%	13%	57%	36%	37%	37%	1433	2310	2298	1384
2003	63%	50%	49%	50%	17%	21%	18%	18%	47%	29%	32%	32%	1366	1923	1918	1131
2004	72%	50%	50%	50%	20%	18%	15%	15%	52%	32%	35%	35%	890	1570	1547	925
2005	69%	50%	50%	50%	33%	28%	23%	22%	36%	22%	27%	28%	867	1370	1246	764
2006	48%	49%	46%	50%	19%	22%	18%	18%	29%	27%	28%	32%	1731	1721	1744	970
2007	50%	50%	47%	49%	19%	20%	16%	16%	30%	29%	30%	33%	2872	2901	2959	1673
2008	50%	49%	49%	50%	21%	23%	18%	18%	29%	26%	31%	32%	1874	1936	1852	1104
1994-08 Average	60%	48%	48%	49%	15%	16%	14%	14%	45%	32%	34%	35%	1922	2460	2456	1455
% Change from validation (94-08 avg.)		-19%	-20%	-19%												

AR016166

Nisqually River

Total AEQ exploitation rates and escapements for Nisqually River Chinook from the Retrospective Analysis (LaVoy 2010).

	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
Fishing Year	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	94%	58%	58%	58%	17%	17%	12%	12%	77%	41%	46%	45%	390	2622	2585	1554
1995	82%	58%	58%	58%	7%	9%	6%	6%	75%	49%	52%	51%	476	1136	1116	674
1996	82%	58%	58%	58%	4%	11%	8%	8%	78%	46%	50%	50%	367	883	882	527
1997	72%	58%	58%	58%	7%	15%	11%	11%	65%	42%	47%	47%	298	431	417	256
1998	78%	58%	58%	58%	4%	11%	8%	8%	74%	46%	50%	49%	453	859	851	515
1999	79%	58%	58%	58%	5%	8%	5%	6%	74%	50%	52%	52%	542	1070	1083	647
2000	67%	58%	58%	58%	11%	18%	12%	12%	56%	40%	46%	45%	1226	1510	1459	892
2001	73%	58%	58%	58%	8%	12%	9%	9%	65%	46%	48%	49%	838	1317	1316	747
2002	76%	58%	58%	58%	10%	16%	12%	12%	65%	42%	46%	46%	1261	2238	2194	1318
2003	83%	58%	58%	58%	16%	23%	18%	18%	67%	34%	40%	40%	546	1434	1384	829
2004	78%	58%	58%	58%	23%	25%	18%	18%	56%	33%	40%	40%	2572	4900	4711	2811
2005	71%	58%	58%	58%	26%	28%	19%	18%	46%	30%	39%	40%	1844	2795	2492	1529
2006	83%	58%	58%	58%	16%	24%	15%	15%	67%	34%	43%	43%	1500	3804	3619	2169
2007	79%	58%	58%	58%	19%	24%	17%	18%	60%	34%	40%	40%	1564	3257	3046	1817
2008	79%	58%	58%	58%	16%	21%	14%	14%	63%	37%	44%	43%	1795	3770	3544	2199
1994-08 Average	78%	58%	58%	58%	12%	18%	12%	12%	66%	40%	45%	45%	1045	2135	2047	1232
% Change from validation (94-08 avg.)		-26%	-26%	-26%												

Mid-Hood Canal

Total AEQ exploitation rates and escapements for Mid-Hood Canal Rivers Chinook from the Retrospective Analysis (LaVoy 2010).

	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
Fishing Year	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	64%	40%	38%	38%	25%	28%	25%	25%	39%	12%	13%	13%	238	265	266	159
1995	41%	24%	22%	23%	16%	15%	14%	14%	26%	9%	8%	9%	96	111	112	67
1996	35%	27%	24%	24%	8%	15%	14%	14%	27%	12%	10%	10%	20	21	21	13
1997	45%	29%	27%	27%	10%	18%	16%	15%	35%	12%	11%	12%	4	5	5	3
1998	19%	29%	29%	29%	6%	17%	16%	16%	14%	12%	13%	13%	222	200	200	121
1999	20%	19%	18%	19%	9%	13%	11%	11%	11%	6%	7%	7%	778	805	782	467
2000	24%	22%	21%	21%	14%	13%	12%	12%	10%	9%	9%	9%	405	406	408	245
2001	26%	28%	26%	24%	15%	17%	16%	15%	11%	11%	10%	9%	306	302	305	183
2002	24%	26%	25%	25%	16%	18%	17%	17%	8%	8%	8%	7%	95	94	94	57
2003	26%	29%	28%	28%	19%	22%	21%	21%	7%	7%	7%	7%	188	182	182	110
2004	33%	28%	27%	27%	23%	18%	16%	16%	10%	10%	11%	11%	125	129	130	78
2005	39%	33%	32%	33%	32%	25%	24%	24%	7%	8%	8%	8%	44	46	47	28
2006	23%	23%	22%	23%	15%	15%	15%	14%	8%	8%	8%	8%	30	30	30	18
2007	29%	29%	26%	26%	18%	18%	16%	16%	11%	11%	10%	10%	75	75	76	45
2008	24%	26%	25%	24%	16%	16%	14%	14%	8%	11%	11%	10%	267	268	270	160
1994-08 Average	32%	27%	26%	26%	16%	18%	17%	16%	16%	10%	9%	10%	193	196	195	117
% Change from validation (94-08 avg.)		-13%	-18%	-18%												

AR016168

Skokomish River

Total AEQ exploitation rates and escapements on Skokomish River Chinook from the Retrospective Analysis (LaVoy 2010).

Fishing Year	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	75%	43%	41%	41%	25%	27%	25%	25%	50%	16%	16%	17%	344	539	550	325
1995	41%	25%	23%	24%	16%	15%	14%	14%	26%	11%	9%	10%	1319	1526	1539	919
1996	35%	28%	26%	26%	8%	14%	14%	14%	27%	14%	12%	12%	849	879	891	534
1997	46%	31%	29%	30%	10%	17%	15%	15%	36%	14%	14%	15%	321	356	358	215
1998	20%	31%	31%	31%	6%	17%	16%	16%	14%	15%	15%	15%	971	874	875	527
1999	37%	31%	35%	34%	9%	12%	11%	11%	28%	18%	24%	22%	1498	2013	1508	932
2000	41%	39%	38%	24%	14%	12%	12%	12%	27%	26%	26%	13%	908	912	917	672
2001	55%	50%	50%	50%	15%	16%	16%	14%	41%	34%	34%	36%	1879	2125	2116	1252
2002	51%	50%	50%	50%	15%	18%	17%	17%	36%	32%	32%	32%	1500	1561	1553	933
2003	59%	50%	50%	50%	19%	21%	20%	20%	41%	28%	29%	30%	1112	1393	1374	825
2004	55%	50%	50%	50%	22%	17%	16%	16%	33%	32%	34%	34%	2448	2659	2640	1583
2005	58%	50%	50%	50%	31%	24%	24%	24%	27%	26%	26%	26%	2060	2398	2388	1444
2006	58%	50%	50%	50%	15%	15%	15%	14%	43%	35%	35%	35%	1249	1519	1503	908
2007	67%	45%	43%	29%	18%	18%	16%	16%	49%	27%	26%	13%	471	785	802	591
2008	62%	50%	50%	50%	16%	16%	14%	14%	46%	34%	36%	36%	1166	1605	1586	929
1994-08 Average	51%	42%	41%	39%	16%	17%	16%	16%	35%	24%	25%	23%	1206	1410	1373	839
% Change from validation (94-08 avg.)		-18%	-20%	-23%												

AR016169

Elwha River

Total AEQ exploitation rates and escapements for Elwha River Chinook from the Retrospective Analysis (LaVoy 2010).

	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
Fishing Year	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	60%	47%	44%	45%	45%	43%	39%	40%	15%	4%	4%	5%	1165	1302	1322	780
1995	42%	29%	25%	26%	30%	26%	22%	23%	12%	3%	3%	4%	1094	1203	1219	727
1996	49%	47%	41%	42%	31%	42%	36%	36%	18%	5%	5%	5%	1561	1556	1576	943
1997	40%	35%	31%	31%	26%	33%	29%	29%	13%	2%	2%	3%	2710	2817	2857	1708
1998	22%	23%	21%	21%	18%	21%	18%	18%	4%	3%	3%	3%	1851	1874	1896	1134
1999	23%	20%	17%	18%	20%	17%	15%	15%	3%	2%	3%	3%	1568	1584	1601	949
2000	18%	16%	15%	15%	16%	15%	13%	13%	2%	2%	2%	2%	1865	1896	1918	1148
2001	19%	22%	19%	19%	16%	19%	16%	17%	3%	3%	3%	2%	2132	2110	2136	1303
2002	31%	37%	33%	33%	26%	33%	28%	29%	5%	4%	4%	4%	2287	2239	2265	1357
2003	36%	41%	36%	37%	30%	35%	31%	31%	6%	6%	6%	6%	2187	2143	2179	1306
2004	34%	29%	27%	27%	31%	25%	23%	23%	4%	4%	4%	4%	3198	3249	3283	1967
2005	39%	33%	28%	29%	36%	30%	25%	25%	3%	3%	3%	3%	2470	2563	2593	1551
2006	32%	29%	24%	24%	29%	26%	21%	21%	3%	3%	3%	4%	1834	1882	1906	1141
2007	42%	40%	34%	35%	38%	36%	30%	30%	4%	4%	4%	5%	833	852	864	516
2008	30%	31%	28%	28%	27%	26%	23%	23%	4%	6%	6%	5%	1487	1522	1540	922
1994-08 Average	35%	32%	28%	29%	28%	28%	25%	25%	7%	4%	4%	4%	1883	1919	1944	1163
% Change from validation (94-08 avg.)		-7%	-18%	-17%												

Dungeness River

Total AEQ exploitation rates and escapements for Dungeness River Chinook from the Retrospective Analysis (LaVoy 2010).

	Total Exploitation Rate				Northern Exploitation Rate				Southern Exploitation Rate				Escapement			
Fishing Year	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction	FRAM Validation	High North	2010 RMP Likely	40% reduction
1994	59%	46%	42%	43%	45%	43%	39%	40%	14%	3%	3%	2%	70	78	80	48
1995	42%	29%	25%	26%	30%	26%	22%	23%	12%	3%	3%	3%	156	172	174	104
1996	49%	47%	41%	41%	31%	42%	36%	36%	18%	5%	5%	5%	183	183	185	111
1997	42%	38%	34%	34%	26%	32%	28%	28%	16%	6%	6%	6%	62	64	65	39
1998	22%	24%	22%	22%	18%	21%	18%	18%	5%	3%	3%	4%	87	88	89	53
1999	22%	19%	16%	16%	20%	17%	15%	15%	2%	1%	1%	1%	73	74	75	45
2000	17%	16%	15%	15%	16%	15%	13%	13%	2%	1%	1%	1%	214	218	220	132
2001	19%	21%	19%	18%	16%	19%	16%	17%	3%	3%	3%	2%	445	440	446	272
2002	31%	37%	33%	33%	26%	33%	28%	29%	5%	4%	4%	4%	629	616	623	374
2003	36%	41%	36%	36%	30%	35%	31%	31%	5%	6%	6%	6%	628	615	625	375
2004	35%	30%	27%	28%	30%	25%	23%	23%	4%	4%	4%	5%	975	991	1002	599
2005	39%	33%	28%	28%	36%	30%	25%	25%	2%	3%	3%	3%	669	695	702	421
2006	32%	29%	24%	24%	29%	26%	21%	21%	3%	3%	3%	4%	1365	1401	1418	850
2007	42%	39%	34%	34%	37%	35%	30%	29%	5%	4%	4%	4%	321	327	333	198
2008	31%	32%	29%	29%	27%	26%	23%	23%	4%	6%	6%	6%	301	309	312	186
1994-08 Average	35%	32%	28%	28%	28%	28%	25%	25%	7%	4%	4%	4%	412	418	423	254
% Change from validation (94-08 avg.)		-7%	-18%	-18%												

AR016171

Literature Cited

LaVoy, Larrie. 2010. Excel spreadsheet with results of retrospective analysis: exploitation rates and escapements by management scenario, fishery, year and Puget Sound Chinook management unit. Final version. June 7.