Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Response

Effects of the Pacific Coast Salmon Plan Fisheries on the Sacramento River Winter-run Chinook salmon Evolutionarily Significant Unit

NMFS Consultation Number: WCR-2017-8012

Action Agency: National Marine Fisheries Service (NMFS)

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*)	Endangered	Yes	No	No	No

Fishery Management Plan That Describes EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	No	No
Pacific Fishery Management Council's Coastal Pelagic Species	No	No
Pacific Coast Groundfish	No	No
U.S. West Coast Fisheries for Highly Migratory Species	No	No

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By: ______________________________

FOR Barry A. Thom
Regional Administrator
West Coast Region

Date: 3/30/2018

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Acronyms and Abbreviations

7DADM	Seven-day Average Daily Maximums
AC	Autocorrelation
BA	Biological Assessment
BCSSRP	Battle Creek Salmon and Steelhead Restoration Project
BO	Biological Opinion
BOR	Bureau of Reclamation
CCC	California Coastal Chinook
CCE	California Current Ecosystem
CCIEA	California Current Integrated Ecosystem Assessment
CI	confidence interval
CNFH	Coleman National Fish Hatchery
CFR	Code of Federal Regulations
CO	Central Oregon (ocean management zone)
CPS	coastal and pelagic species
CR	control rule
CRR	cohort replacement rate
CV	California Central Valley
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWT	coded-wire tag (or tagged)
DAT	Daily average temperature
DPS	distinct population segment
DQA	Data Quality Act
EEZ	exclusive economic zone
EFH	essential fish habitat
ER	exploitation rate
ESA	Endangered Species Act
ESU	evolutionary significant unit
FB	Fort Bragg (ocean management zone)
FMP	Fishery Management Plan (for Pacific Coast Salmon)
FR	Federal Register
FWCA	Fish and Wildlife Coordination Act
GSI	Genetic Stock Identification
ISAB	Independent Science Advisory Board
IMR	incidental mortality rate
ITS	Incidental Take Statement
JPI	juvenile production index
KC	California KMZ (ocean management zone)
KMZ	Klamath Management Zone
KO	Oregon KMZ (ocean management zone)
KRFC	Klamath River Fall Chinook
LCR	Lower Columbia River
LSNFH	Livingston Stone National Fish Hatchery
MMPA	Marine Mammal Protection Act
MO	Monterey (ocean management zone) (includes South of Sur)

MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSE	management strategy evaluation
NEPA	National Environmental Protection Act
NMFS	National Marine Fisheries Service
NO	Northern Oregon (ocean management zone)
NOAA	National Oceanic and Atmospheric Administration
ONI	Ocean Nino Index
PBF	physical or biological feature
PCE	primary constituent element
PDO	Pacific Decadal Oscillation
PFMC	Pacific Fisheries Management Council
PK	perfect knowledge
PM	Performance Measures
PRD	Protected Resources Division
RBDD	Red Bluff Diversion Dam
RM	River Mile
RPA	Reasonable and Prudent Alternatives
SF	San Francisco (ocean management zone)
SFA	Sustainable Fisheries Act
SFD	Sustainable Fisheries Division
SRFC	Sacramento River Fall Chinook
SRWC	Sacramento River Winter Chinook
SRWCW	Sacramento River Winter Chinook Workgroup
SS	South of Sur (included in the Monterey ocean management zone)
STT	Salmon Technical Team
SWFSC	Southwest Fisheries Science Center
SWP	State Water Project
VSP	Viable Salmonid Population
VP	Variable Productivity
WCR	West Coast Region

1. INTRODUCTION

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402. The opinion documents consultation on the action proposed by NMFS, Sustainable Fisheries Division (SFD), West Coast Region (WCR).

We also completed an essential fish habitat (EFH) consultation on the Proposed Action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600. We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Public Consultation Tracking System https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts. A complete record of this consultation is on file at the SFD, WCR, NMFS.

1.2 Consultation History

Fisheries in the Exclusive Economic Zone (EEZ) are managed by NMFS under authority of the MSA. NMFS is responsible for authorizing ocean salmon fisheries in the EEZ, through its SFD. NMFS also reviews the effects of those fisheries on ESA-listed species for which it has jurisdiction. For the purposes of consultations on Federal fishery management activities under the ESA, NMFS serves as both the action and consulting agency.

Under the MSA, for fisheries in the EEZ off the U.S. west coast, the Pacific Fishery Management Council (PFMC) develops fishery management plans (FMPs) and regulations for NMFS' approval and implementation. Commercial and recreational ocean salmon fisheries in the EEZ off the coasts of Washington, Oregon, and California, are managed under the PFMC's Pacific Coast Salmon Fishery Management Plan (FMP) (PFMC 2016). As needed, the PFMC recommends amendments to the FMP for NMFS' approval and implementation, to address new information or issues in the salmon fisheries. Also, consistent with the FMP, the PFMC develops annual salmon management regulations for the upcoming fishing season. These regulations implement the FMP and take into account annual estimates of abundance for each salmon stock and stock status information. NMFS approves the PFMC's recommendations for amendments to the FMP and the annual salmon regulations if it finds them to be consistent with the MSA and other applicable law, including the ESA.

Twenty-eight (28) salmon evolutionarily significant units (ESUs) and steelhead distinct population segments (DPSs) are listed as threatened or endangered under the ESA on the west coast of the United States (Table 1-1). Beginning in 1991, NMFS considered the effects on ESA-listed salmon species resulting from implementation of the PFMC's Salmon FMP and issued biological opinions based on the regulations implemented each year rather than the FMP itself. In a biological opinion dated March 8, 1996, NMFS considered the impacts on all salmon species then listed under the ESA resulting from implementation of the Salmon FMP. Subsequent biological opinions beginning in 1997 considered the effects of fisheries managed under the FMP (PFMC fisheries) on the growing catalogue of listed species. Those opinions determined either that the fisheries would have no effect, were not likely to adversely affect, would jeopardize, or were not likely to jeopardize the species, and made necessary determinations related to designated critical habitat. NMFS has reinitiated consultation when new information became available on the status of the species or the impacts of the PFMC fisheries on the species, or when new species were listed. The biological opinions that considered the effects on listed salmonids and that are still in affect are shown in Table 1-2.

Other non-salmonid species that occur in the EEZ off the west coast have also been listed under the ESA in recent years, including Southern Resident killer whales (*Orcinis orca*), the southern DPS of North American green sturgeon (*Acipenser medirostris*), Stellar sea lions (*Eumetopias jubatus*), and Pacific eulachon (*Thaleichthys pacificus)*. NMFS has consulted on the effects of the Salmon FMP on these species and designated critical habitats as well (Table 1-2).

NMFS has reviewed each of these opinions and determined that the Proposed Action being considered here related to modification of the current harvest control rule for winter-run Chinook salmon is not likely to have any effects on the species considered in those opinions, other than Sacramento River winter-run Chinook salmon, that have not already been considered in those opinions. Thus NMFS concluded that this action does not trigger the reinitiation of consultation for those species.

NMFS has designated critical habitat for all ESA-listed salmon ESUs in the spawning and rearing habitats found in the fresh water portion of salmonid life history. To date, NMFS has designated no critical habitat for any salmonid in the marine environment. The ocean salmon fishery does not occur within the boundaries of any designated critical habitat for any ESA-listed salmon, including winter-run, and does not impact that habitat either directly or indirectly. Therefore, this opinion does not consider critical habitat for salmon. NMFS continues to review the most up-to-date information for the purpose of determining whether to reinitiate consultation for all ESA-listed salmon ESUs.

Table 1-1. Status and critical habitat designations for ESA listed salmonids (Listing status: 'T' means listed as threatened under the ESA; 'E' means listed as endangered).

Species	**Listing Status, Federal Register Notice**	**Critical Habitat Designated**
Chinook salmon (*Oncorhynchus tshawytscha*)		
Sacramento River winter-run	E: 70 FR 37160 6/28/05	58 FR 33212 06/16/93
Snake River fall-run	T: 70 FR 37160 6/28/05	58 FR 68543 12/28/93
Snake River spring/summer-run	T: 70 FR 37160 6/28/05	64 FR 57399 10/25/99
Puget Sound	T: 70 FR 37160 6/28/05	70 FR 52630 09/02/05
Lower Columbia River	T: 70 FR 37160 6/28/05	70 FR 52630 09/02/05
Upper Willamette River	T: 70 FR 37160 6/28/05	70 FR 52630 09/02/05
Upper Columbia River spring-run	E: 70 FR 37160 6/28/05	70 FR 52630 09/02/05
Central Valley spring-run	T: 70 FR 37160 6/28/05	70 FR 52630 09/02/05
California Coastal	T: 70 FR 37160 6/28/05	70 FR 52630 09/02/05
Chum salmon (*O. keta*)		
Hood Canal Summer-run	T: 70 FR 37160 6/28/05	70 FR 52630 09/02/05
Columbia River	T: 70 FR 37160 6/28/05	70 FR 52630 09/02/05
Coho Salmon (*O. kisutch*)		
Central California Coast	E: 70 FR 37160 6/28/05	64 FR 24049 05/05/99
S. Oregon/N. California Coasts	T: 70 FR 37160 6/28/05	64 FR 24049 05/05/99
Lower Columbia River	T: 70 FR 37160 6/28/05	81 FR 9251 02/24/16
Oregon Coast	T: 76 FR 35755 6/20/11	73 FR 7816 02/11/08
Sockeye Salmon (*O. nerka*)		
Snake River	E: 70 FR 37160 6/28/05	58 FR 68543 12/28/93
Ozette Lake	T: 70 FR 37160 6/28/05	70 FR 52630 09/02/05
Steelhead (*O. mykiss*)		
Southern California	E: 71 FR 834 1/05/06	70 FR 52630 09/02/05
South-Central California Coast	T: 71 FR 834 1/05/06	70 FR 52630 09/02/05
Central California Coast	T: 71 FR 834 1/05/06	70 FR 52630 09/02/05
Northern California	T: 71 FR 834 1/05/06	70 FR 52630 09/02/05
Upper Columbia River	T: 71 FR 834 1/05/06	70 FR 52630 09/02/05
Snake River Basin	T: 71 FR 834 1/05/06	70 FR 52630 09/02/05
Lower Columbia River	T: 71 FR 834 1/05/06	70 FR 52630 09/02/05
California Central Valley	T: 71 FR 834 1/05/06	70 FR 52630 09/02/05
Upper Willamette River	T: 71 FR 834 1/05/06	70 FR 52630 09/02/05
Middle Columbia River	T: 71 FR 834 1/05/06	70 FR 52630 09/02/05
Puget Sound Steelhead	T: 72 FR 26722 5/11/07	81 FR 9251 02/24/16

Table 1-2. NMFS ESA determinations regarding ESUs and DPSs affected by PFMC Fisheries and the duration of the 4(d) Limit determination or biological opinion (BO) (Only those determinations currently in effect are included).

Date (Decision type)	Duration	Citation	Species Considered
Salmonid Species			
March 8, 1996 (BO)	until reinitiated	(NMFS 1996)	Snake River spring/summer and fall Chinook, and sockeye salmon
April 28, 1999 (BO)	until reinitiated	(NMFS 1999a)	S. Oregon/N. California Coasts coho Central California Coast coho Oregon Coast coho
April 28, 2000 (BO)	until reinitiated	(NMFS 2000)	Central Valley Spring-run Chinook California Coastal Chinook salmon
September 14, 2001 (BO, 4(d) Limit)	until withdrawn	(NMFS 2001b)	Hood Canal summer-run chum
April 30, 2001 (BO)	until reinitiated	(NMFS 2001a)	Upper Willamette River Chinook Columbia River chum Ozette Lake sockeye Upper Columbia River spring-run Chinook Ten listed steelhead DPSs
June 13, 2005 (BO)	until reinitiated	(NMFS 2005c)	California Coastal Chinook salmon
April 29, 2004 (BO)	until reinitiated	(NMFS 2004b)	Puget Sound Chinook salmon
April 26, 2012 (BO)	until reinitiated	(NMFS 2012a)	Lower Columbia River Chinook salmon
April 30, 2012 (BO)	until reinitiated	(NMFS 2012b)	Sacramento River winter-run Chinook salmon
April 9, 2015 (BO)	Until reinitiated	(NMFS 2015a)	Lower Columbia River coho
Non Salmonid Species			
April 30, 2007 (BO)	until reinitiated	(NMFS 2007)	North American Green Sturgeon
December 22, 2008 (BO)	until December 2018	(NMFS 2008b)	Western DPS Steller Sea Lion
May 5, 2009 (BO)	until reinitiated	(NMFS 2009b)	Southern Resident Killer Whales
April 30, 2010 (BO)	until reinitiated	(NMFS 2010b)	Pacific Eulachon

Critical habitat of all ESA-listed salmon ESUs has been designated in the spawning and rearing habitats found in the fresh water portion of salmonid life history. To date, no critical habitat for any salmonid has been designated by NMFS in the marine environment. The ocean salmon fishery does not occur within the boundaries of any designated critical habitat for any ESA-listed salmon, including winter-run, and does not impact that habitat either directly or indirectly. Therefore, critical habitat for salmon will not be considered in this opinion. NMFS continues to review the most up-to-date information in determining whether to reinitiate consultation for all ESA-listed salmon ESUs.

The Sacramento River winter-run Chinook salmon (herein referred to as “winter-run”) ESU is one of the ESUs listed as endangered. Several regulatory actions have been taken to reduce the incidental take of this ESU in the ocean salmon fishery, as well as in designated critical fresh water habitat through the regulation of numerous fishery and non-fishery activities. The FMP requires that NMFS provide consultation standards for each ESA-listed species, which specify levels of take that are not likely to jeopardize the continued existence of the species. NMFS advises the PFMC of these standards in its annual guidance prior to the start of the annual preseason planning process (typically the beginning of March). The guidance provided by NMFS in this letter is derived from and consistent with the associated biological opinion for each species, and where appropriate takes into account information about annual abundance for each listed species. The FMP requires the PFMC to set management recommendations that meet or exceed NMFS consultation standards that are thus consistent with the associated species-specific biological opinions.

The Salmon FMP and its regulations[1] define the fishing year for the salmon fishery as May 1 through April 31 of the following year. This is the period for which annual regulations are developed and apply. Descriptions of open fishing periods and locations for the annual ocean salmon fishery are published at the conclusion of each year’s April PFMC meeting (*e.g.,* Preseason Report III, Analysis of Council Adopted Management Measures for 2017 Ocean Salmon Fisheries; PFMC 2017a). The fishing periods, locations and other regulations may be modified in-season in response to changes in catch and fishing effort, or weather conditions in order to assure achievement of the management objectives and consideration for safety concerns.

NMFS first listed the winter-run ESU under the ESA as threatened in November 1990 and then reclassified it as endangered in 1994. There have been five biological opinions issued for the ocean salmon fishery’s effects on winter-run (NMFS 1991, 1996/1997,[2] 2002, 2004b and most recently in 2010/2012b[3]. In the early 1990s, harvest impacts of the ocean salmon fishery had not been quantified but life history information suggested that the fishery impacts were relatively low. Harvest was, therefore, not identified as a primary factor of the species’ population decline at the time. Initial action involved shortening the recreational fishery south of Point Arena by two weeks on each end to allow more opportunity for maturing fish to exit the ocean. In the years following the ESA listing of winter-run Chinook salmon, more information on the impacts of the ocean fisheries on the ESU became available, and it was recognized that the fisheries may play a greater role in the viability of the ESU than previously thought. In 1996 and 1997, NMFS issued a biological opinion and amendment that determined that contemporary harvest management of the ocean fisheries jeopardized winter-run and, the reasonable and prudent alternative included fishery restrictions that NMFS implemented to protect the ESU (NMFS 1997).

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[1] Found at 50 CFR part 660, subpart H.

[2] Because the logic and outcomes of the two opinions were closely related, they are discussed jointly with particular focus on the 1997 opinion.

[3] In 2012 NMFS revised the RPA related to the 2010 biological opinion.

By 2001 it was apparent that abundance and productivity of winter-run were much improved from the levels recorded in the early/mid 1990s. The Proposed Action considered in the 2002 opinion was authorization of ocean salmon fisheries consistent with the FMP, but absent any specific management objectives for winter-run. Similar to the 1996/1997 opinion and amendment, the 2002 opinion concluded that the Proposed Action was likely to jeopardize the continued existence of winter run and thus offered, as a reasonable and prudent alternative (RPA), a set of protective measures intended to reduce the incidental take of winter-run and avoid the likelihood of jeopardizing the continued existence of this ESU. The RPA was implemented as an FMP conservation objective. The Proposed Action for the 2004 consultation on the fisheries included additional protective measures for winter-run. The 2004 consultation resulted in a no jeopardy determination.

In the fall of 2008, NMFS SFD began informal discussions with NMFS Protected Resources Division (PRD) with the intent to reinitiate consultation in response to the scheduled expiration of the 2004 Opinion on April 30, 2010. The Proposed Action for this consultation, similar to the 2004 Proposed Action, included management measures specifically intended to address impacts to Sacramento River winter Chinook (SRWC) salmon. NMFS PRD, SFD, and the Southwest Fisheries Science Center (SWFSC) agreed that the following information on winter-run would be necessary for the consultation:

- spatial and temporal ocean distribution data
- the spawner reduction rate
- the age-specific ocean fishery impact rate

To get this information, between August and November 2009, the SWFSC gathered and analyzed recovered coded wire tag (CWT) data of winter-run from the calendar years 2000 to 2007. A draft biological assessment (BA), including the SWFSC's preliminary findings, was provided by SFD in mid-December, and the finalized analyses and supplemental document were provided to PRD in early January 2010.

The 2010 opinion for ocean fisheries (NMFS 2010a) concluded that ocean fisheries were likely to jeopardize the continued existence of winter-run owing to a lack of measures and tools to constrain or reduce fishery impacts when this population's status is poor. NMFS developed an interim RPA for management of ocean harvest for 2010 and 2011 which included an increase in size limits and partial fishery closures to comply with the ESA while a more explicit management framework was developed.

In 2012, NMFS issued the final RPA which established a framework for managing winter-run impacts in the ocean salmon fishery that consisted of two components. The first component specified minimum size limits and seasonal windows for commercial and recreational fisheries in the area south of Point Arena Table 1-3. The second component was an abundance-based control rule that determined a year specific impact rated limit for winter-run that varies depending on the status of the winter-run population.

Table 1-3. Fishing Season and Size Restrictions for Ocean Chinook Salmon Fisheries, South of Point Arena, California.

Fishery	Location	Shall open no earlier than	Shall close no later than	Minimum size limit (total length[1]) shall be
Recreational	Between Point Arena and Pigeon Point	1st Saturday in April	2nd Sunday in November	20 inches
	Between Pigeon Point and the U.S./Mexico border	1st Saturday in April	1st Sunday in October	
Commercial	Between Point Arena and the U.S./Mexico border†	May 1	September 30†	26 inches
	†Exception: Between Point Reyes and Point San Pedro, there may be an October commercial fishery conducted Monday through Friday, but shall end no later than October 15.			

[1] Total length of salmon means the shortest distance between the tip of the snout or jaw (whichever extends furthest while the mouth is closed) and the tip of the longest lobe of the tail, without resort to any force or mutilation of the salmon other than fanning or swinging the tail (50 CFR 660.402).

The harvest control rule included in the 2012 RPA was based on the three-year geometric mean of escapement. The allowed impact rate was determined based on this mean escapement value. An impact rate of 20% was allowed when escapement values were between 4,000 and 5,000. Between 4,000 and 500 spawners, the allowable impact rate declines linearly from 20% to 10%. If the three-year geometric mean of escapement is over 5,000, then there is no controlling impact rate specified. However, the time and area limits would still apply and these result in an expected impact rate of 20%. When escapement values were below 500, no impact to SRWC was allowed, thus the salmon fisheries south of Point Arena would close.

An escapement of 500 is used as a breakpoint under the 2012 RPA (below which there is no fishing) and also under the Proposed Action (see section 1.3 Proposed Action below). The value was derived from a set of criteria used for assessing extinction risk (Lindley et al. 2007). One of the criteria relates to population size. For census data (e.g. spawning escapement) the range from 250 – 2,500 is used to indicate moderate risk of extinction. 500 is a value from the lower end of the range that is used for management to indicate an area below which there is increasing risk.

The 2012 RPA was used to set an upper limit on the impact rate for winter-run, however, in recent years additional measures were taken to reduce the impacts beyond that required by the RPA because of information related to the low abundance of juveniles, and other indicators of low abundance and adverse environmental conditions. The recent California drought has stressed the entire Sacramento River ecosystem; and consequently, fishery regulations needed to be more responsive to current conditions than a backward-looking three-year geometric mean concept would allow. Extended drought conditions beginning in 2012 and lasting until 2017 in the Sacramento River basin have increased concern on the status of winter-run. Record low egg to fry survival at Red Bluff Diversion Dam (RBDD) was documented at 5.9% in 2014 (Poytress

2016) and egg to fry survival in 2015 was even lower at approximately 4% due to lack of adequate cold-water flows from Shasta Dam (NMFS 2016).

In response to the recent low juvenile survival rates and anticipated reduction in adult returns for those brood years, and to address concerns that the zero impact rule at a 500 mean adult abundance was overly conservative, the PFMC in November 2015 formed the Ad Hoc Sacramento River Winter Chinook Workgroup (SRWCW, Workgroup). The Workgroup was tasked with exploring an alternative harvest policy for winter-run that would help address significant annual changes in abundance and explore *de minimis* levels of fishing that could avoid complete salmon fisheries closure without significantly increasing the risk of extinction. The Workgroup focused on three major areas; 1) develop methods for forecasting SRWC abundance, 2) develop a suite of potential control rules for the PFMC consideration, and 3) evaluate the performance of these control rules with regard to conservation benefits and fishery costs using a Management Strategy Evaluation (MSE) approach. At its September 2016 meeting, the PFMC reviewed the proposed forecasting methodology, and approved a draft range of nine alternative control rules for analysis.

During its September 2017 PFMC meeting, the PFMC provided preliminary recommendations on the winter-run harvest policy. The PFMC adopted for public review four alternative control rules, one of which was a new control rule not previously considered. This new control rule (CR10) was a blending of two existing alternative control rules. The PFMC also directed the Workgroup to use the median of the forecast distribution, rather than the mode, in all calculations for control rule analyses. The specific control rules that moved forward for public review were CR4, CR5, CR7 and CR10 (Ad Hoc SRWC Workgroup. 2017a).

The PFMC reviewed input from the public and results from Workgroup's analysis of the four alternatives at its November 2017 meeting. The Workgroup recommended CR10 to the Council. The PFMC adopted the Workgroup's recommendation regarding use of CR10 for winter run at its November 2017 meeting, and transmitted those recommendations to NMFS for consideration on December 6, 2017 (PFMC 2017b). In this Opinion, NMFS considers the PFMC's recommendation to adopt a new management framework for winter-run Chinook that included reliance on CR10 for potential implementation for ocean fisheries beginning in 2018.

1.3 Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). Federal action means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910). NMFS is currently considering approval of a management framework that includes the new harvest control rule recommended by the PFMC for managing ocean fisheries that impact winter-run Chinook salmon (PFMC 2017b). The management framework continues to include the size and season restrictions from the 2010/2012 RPA (Table 1-3). NMFS is the action agency and the consulting agency for the Proposed Action considered under the Pacific Coast Salmon FMP.

The proposed harvest control rule, referred to as control rule 10 in the development process (CR10), differs from the existing control rule both in terms of the methodology for determining the applicable impact rate, and in the impact rates allowed at different projected escapement levels. CR10 uses a forecast of winter-run age-3[4] escapement in the absence of fisheries (F^{3yo}) to determine the allowable impact rate (O'Farrell et al. 2016). The allowable impact rate for each fishing season is determined based on the annual median of the F^{3yo}. If the F^{3yo} is above 3,000, a maximum impact rate of 20% is allowed. If the median F^{3yo} is under 3,000, but above 500 the impact rate declines from 20% to 10% based on the median F^{3yo}. If the F^{3yo} is below 500, the impact rate has a steeper decline from 10% until it reaches zero as the F^{3yo} approaches zero (Figure 1-1). The previous management framework for winter-run regarding minimum size limits and seasonal windows south of Point Arena for both the commercial and recreational fisheries will continue to remain in effect at all times regardless of abundance estimates or impact rate limit (Table 1-3).

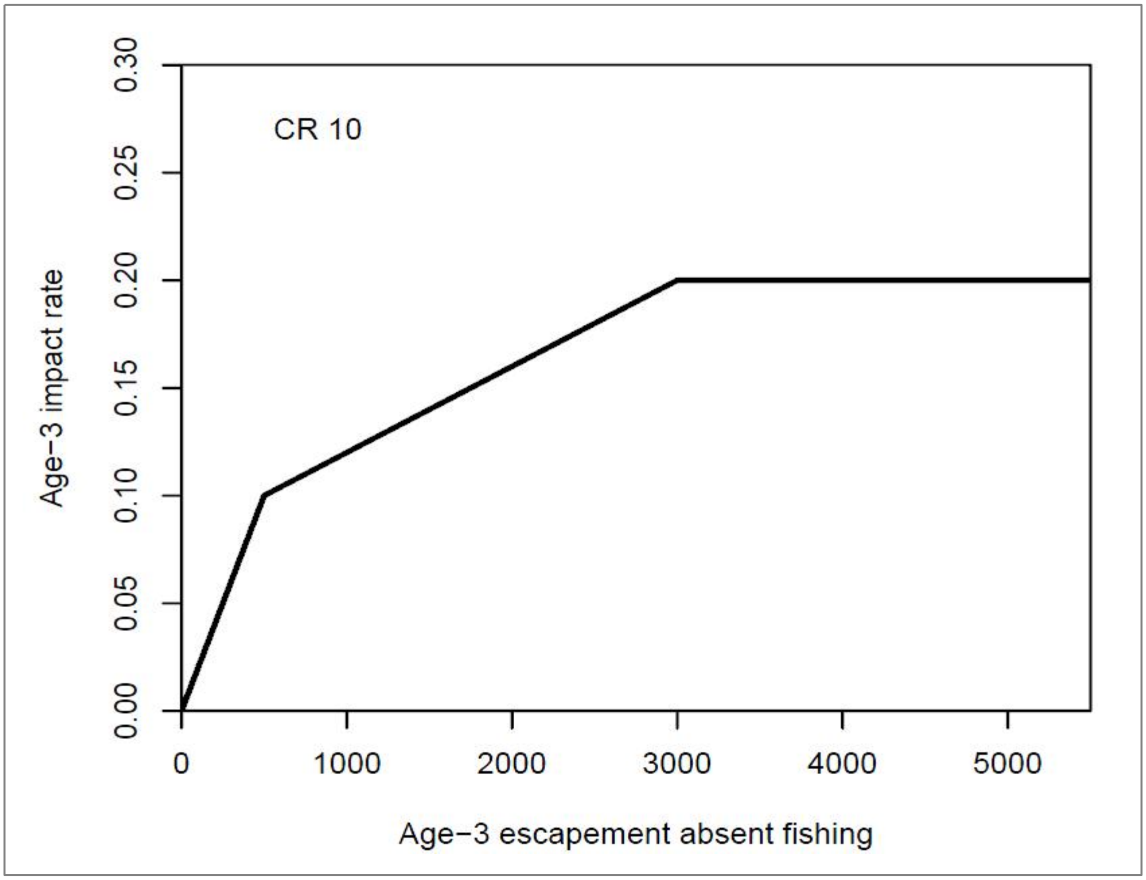

Figure 1-1. The proposed harvest control rule (CR10) for management of ocean fisheries that affect Winter-run Chinook salmon (Ad Hoc SRWC Workgroup, 2017b).

CR10 addresses concerns with the retrospective approach to determining the applicable impact rate used in the existing control rule. Instead of using a three-year geometric mean of escapement to determine the allowable impact rate, a juvenile abundance forecast is used to estimate the F^{3yo} (O'Farrell et al. 2016) The F^{3yo} can change dramatically each year due to fluctuations in

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[4] Age-3 fish refers to an adult salmon that was born three years prior.

freshwater survival allowing for better estimates of the status of winter-run Chinook salmon that can be used to determine harvest levels that are responsive. The new control rule also differs from the existing control rule in the inclusion of *de minimus* fishing when populations are near zero (Ad Hoc SRWC Workgroup 2017b). The existing control rule would result in closure of the recreational and commercial fisheries south of Point Arena if the three-year geometric mean of winter-run spawners fell under 500. Additionally, the proposed control rule maintains a 20% maximum impact rate once F^{3yo} is over 3,000 whereas the existing control rule maintained a 20% impact rate between 4,000 and 5,000 and relied on the specified time area restrictions when escapement was above 5,000. As explored in Section 2.5, Effects of the Action, analysis was conducted to assess the effect on the winter-run population and on the fishery under the various harvest control rules under a range of environmental conditions.

Further, the PFMC recommended a five-year review of the performance of the new control rule once implemented to ensure the projected results and key presumptions remain intact. The PFMC did not recommend an expiration date for the control rule, but rather proposed that would remain in place unless a performance review indicates that revisiting the rule is warranted.

“Interrelated actions” are those that are part of a larger action and depend on the larger action for their justification. “Interdependent actions” are those that have no independent utility apart from the action under consideration (50 CFR 402.02). No such actions were identified as part of this consultation.

2. ENDANGERED SPECIES ACT: BIOLOGICAL AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, Federal agencies must ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency’s actions would affect listed species and their critical habitat. If incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures and terms and conditions to minimize such impacts.

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and/or an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of “to jeopardize the continued existence of” a listed species, which is “to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species” (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This biological opinion relies on the definition of "destruction or adverse modification," which “means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features” (81 FR 7214).

The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ‘‘destruction or adverse modification’’ analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

We use the following approach to determine whether a Proposed Action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- *Identify the rangewide status of the species and critical habitat expected to be adversely affected by the Proposed Action.* Section 2.2 describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. For listed salmon and steelhead, NMFS has developed specific guidance for analyzing the status of the listed species’ component populations in a “viable salmonid populations” paper (VSP; McElhany et al. 2000). The VSP approach considers the abundance, productivity, spatial structure, and diversity of each population as part of the overall review of a species’ status. For listed salmon and steelhead, the VSP criteria therefore encompass the species’ “reproduction, numbers, or distribution” (50 CFR 402.02). In describing the rangewide status of listed species, we rely on viability assessments and criteria in technical recovery team documents and recovery plans, and other information where available, that describe how VSP criteria are applied to specific populations, major population groups, and species. We determine the rangewide status of critical habitat by examining the condition of its physical or biological features (also called “primary constituent elements” or PCEs in some designations) which were identified when the critical habitat was designated.

- *Describe the environmental baseline in the action area.* The environmental baseline (Section 2.4) includes the past and present impacts of Federal, state, or private actions and other human activities in the action area (Section 2.3). It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process.

- *Analyze the effects of the Proposed Action on both species and their habitat using an “exposure-response-risk” approach.* In this step (Section 2.5), NMFS considers how the Proposed Action would affect the species’ reproduction, numbers, and distribution or, in the case of salmon and steelhead, their VSP and other relevant characteristics. NMFS also evaluates the Proposed Action’s effects on critical habitat features.

- *Describe any cumulative effects in the action area.* Cumulative effects (Section 2.6), as defined in our implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities,that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the Proposed Action are not considered because they require separate section 7 consultation.

- *Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the Proposed Action poses to species and critical habitat.* (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the Proposed Action poses to species and critical habitat. (Section 2.7).

- *Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.* These conclusions (Section 2.8) flow from the logic and rationale presented in the Integration and Synthesis section (2.7).

If necessary, suggest a RPA to the Proposed Action. If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, we must identify a RPA to the action in Section 2.9. The RPA must not be likely to jeopardize the continued existence of listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the Proposed Action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans (NMFS 2014a), status reviews (NMFS 2011, 2016), and listing decisions (described in Section 2.2.1.) This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. There is no critical habitat designated in the action area for winter-run therefore we do not consider effects on critical habitat for this Proposed Action.

2.2.1 Sacramento winter-run Chinook Salmon – Evolutionarily Significant Unit

In order to describe a species' status, it is first necessary to define what "species" means in this context. In addition to defining "species" as including an entire taxonomic species or subspecies of animals or plants, the ESA also recognizes listing units that are a subset of the species as a whole. The ESA allows a distinct population segment (DPS) of a species to be listed as threatened or endangered. Winter-run Chinook salmon constitute an ESU, which is a salmon DPS of the taxonomic species *Oncorhynchus tshawytscha* and as such is considered a "species" under the ESA. In addition, an artificial propagation program at the Livingston Stone National Fish Hatchery (LSNFH) produces winter-run Chinook salmon that are considered to be part of this ESU (70 FR 37160; June 28, 2005). Documents describing the listing status, critical habitat, and protective regulations are summarized here and in Table 1-1 above.

- First listed as threatened (54 FR 32085; August 4, 1989), reclassified as endangered (59 FR 440; January 4, 1994)
- Reaffirmed as endangered (70 FR 37160; June 28, 2005)
- Designated critical habitat (58 FR 33212; June 16, 1993)

The Federally listed ESU of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) occurs in the action area and may be affected by the Proposed Action.

The winter-run ESU currently consists of only one population, which is confined to the upper Sacramento River (spawning below Shasta and Keswick dams) in California's Central Valley. Most components of the winter-run Chinook salmon life history (e.g., spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River. All historical spawning and rearing habitats have been blocked since the construction of Shasta Dam in 1943. Remaining spawning and rearing areas are completely dependent on cold water releases from Shasta Dam in order to sustain the remnant population (54 FR 32085; August 4, 1989).

2.2.2 Life History

2.2.2.1 Adult Migration and Spawning

Winter-run exhibit characteristics of both stream- and ocean-type races (Healey 1991). Winter-run adults tend to enter freshwater while still immature and travel far upriver and delay spawning for weeks or months upon arrival at their spawning grounds (stream-type) (Healey 1991). However, juvenile winter-run migrate to sea during their first year (ocean-type) using abrupt increases in riverine flows as a cue to migrate toward the Sacramento - San Joaquin Delta (del Rosario et al. 2013). Adults first enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate up the Sacramento River, past the Red Bluff Diversion Dam (RBDD) from mid-December through early August (NMFS 1997). The majority of the run passes RBDD from January through May, with the peak passage occurring in mid-March (Hallock and Fisher 1985). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type (Table 2-2) (Yoshiyama et al. 1998, Moyle 2002).

Spawning occurs primarily from mid-May to mid-August Table 2-2, with the peak activity occurring in June and July in the upper Sacramento River reach (50 miles) between Keswick Dam and RBDD (Vogel and Marine 1991). Winter-run Chinook salmon deposit and fertilize eggs in gravel beds known as redds, which are excavated by the female who then dies following spawning. Average fecundity was 5,192 eggs per female for the 2006 to 2013 returns to LSNFH, which is similar to other Chinook salmon runs (e.g., 5,401 average for Pacific Northwest (Quinn 2005). Chinook salmon spawning requirements for depth and velocities are broad, and the upper preferred water temperature was estimated to be between 55 and 57 degrees Fahrenheit (°F) (13 to 14 degrees Celsius [°C]) (Snider et al. 2001). The majority of winter-run adults return to spawning grounds after three years.

2.2.2.2 Egg Incubation/Fry Emergence

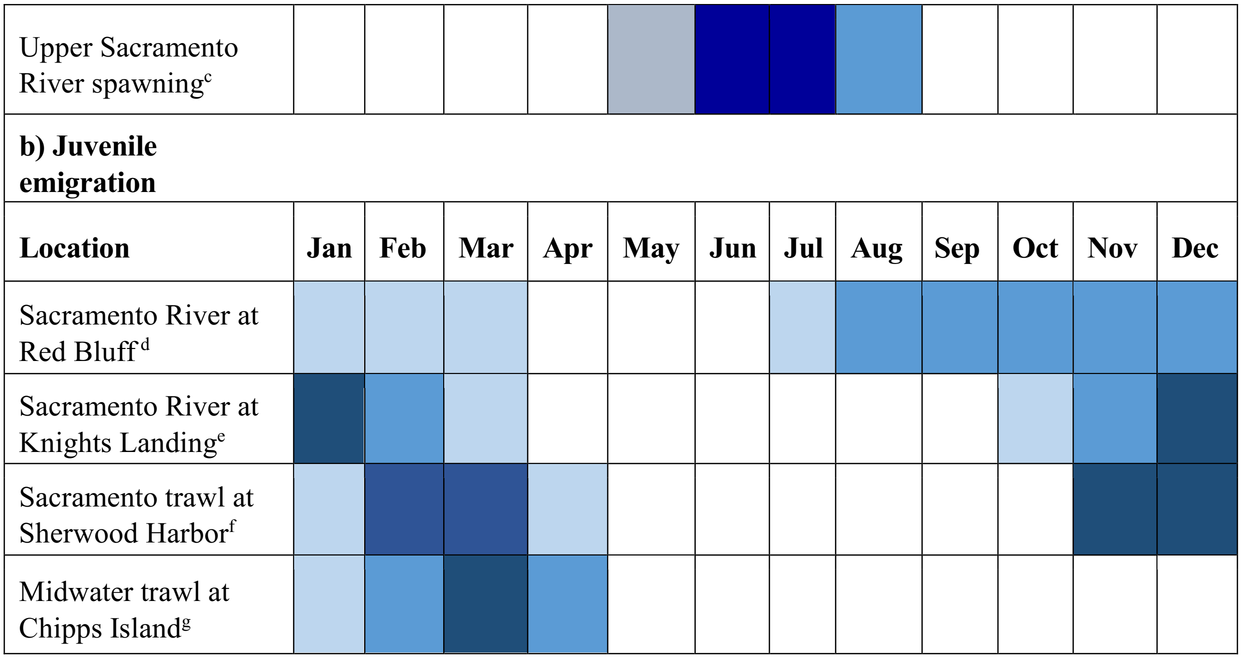
Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel percolation, poor water quality, and unsuitable temperatures. The length of development for Chinook salmon embryos is dependent on the ambient water temperature surrounding the egg pocket in the redd. Colder water necessitates longer development times as metabolic processes are slowed. Within the appropriate water temperature range for embryo incubation, embryos hatch in 40 to 60 days, and the alevins (yolk-sac fry) remain in the gravel for an additional four to six weeks before emerging from the gravel. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. Recent management of temperatures needed for successful winter-run spawning and incubation were based on laboratory studies indicating a 56°F average daily upper threshold. However, the ability of laboratory studies to predict and capture temperature associated mortality in the field environment have been reviewed and were shown to significantly underestimate field estimated thermal mortality by 3°C (Martin et al. 2016). This has resulted in new temperature management strategies in the upper Sacramento River to preserve suitable spawning and incubation temperatures for listed Chinook salmon in the Central Valley. The new protocol is a seven-day average of daily maximums (7DADM) at 55°F, or a surrogate of 53°F Daily Average Temperature (DAT) (NMFS 2017a). If these new temperature thresholds are met and maintained, the catastrophic temperature related mortality documented in 2014 and 2015 (94% - 96%) that occurred in large part due to exceedance of the previous 56°F standard will be avoided.

2.2.2.3 Juvenile Rearing and Outmigration

Juvenile winter-run have been found to exhibit variability in their life history dependent on emergence timing and growth rates (Beckman et al. 2007). Following spawning, egg incubation, and fry emergence from the gravel, juveniles begin to emigrate in the fall. Some juvenile winter-run migrate to sea after only four to seven months of river life, while others hold and rear upstream and spend nine to ten months in freshwater. Emigration of juvenile winter-run fry and pre-smolts past RBDD (River Mile (RM) 242) may begin as early as mid -July, but typically peaks at the end of September (Table 2-1), and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997).

Table 2-1. The Temporal Occurrence of Adult (a) and Juvenile (b) Sacramento River Winter-run Chinook Salmon in the Mainstem Sacramento River.

Winter-run relative abundance	■ High				▨ Medium				░ Low			
a) Adults freshwater												
Location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Sacramento River basin[a,b]	▨	▨	▨	▨	▨	▨	▨				▨	▨



Upper Sacramento River spawning[c]					▨	█	█	▒				
b) Juvenile emigration												
Location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Sacramento River at Red Bluff[d]	░	░	░				░	▒	▒	▒	▒	▒
Sacramento River at Knights Landing[e]	▓	▒	░							░	▒	▓
Sacramento trawl at Sherwood Harbor[f]	░	▓	▓	░							▓	▓
Midwater trawl at Chipps Island[g]	░	▒	▓	▒								

Sources: [a] (Yoshiyama et al. 1998); (Moyle 2002); [b](Myers et al. 1998) ; [c] (Williams 2006) ; [d] (Martin et al. 2001); [e] Knights Landing Rotary Screw Trap Data, CDFW (1999-2011); [f, g] Delta Juvenile Fish Monitoring Program, USFWS (1995–2015).

2.2.2.4 Estuarine/Delta Rearing

Juvenile winter-run emigration into the Delta and estuary occurs primarily from November through April based on data collected from trawls in the Sacramento River at Sherwood Harbor, RM 57 (Table 2-1). The timing of emigration may vary somewhat due to changes in river flows, Shasta Dam operations, and water year type, but has been correlated with the first storm event when flows exceed 14,000 cubic feet per second (cfs) at Knights Landing, RM 90 (Table 2-1),which triggers abrupt emigration towards the Delta (del Rosario et al. 2013). The average residence time in the Delta for juvenile winter-run is approximately three months based on median seasonal catch between Knights Landing and Chipps Island. (Table 2-1). In general, the earlier juvenile winter-run enter the Delta, the longer they stay and rear. Peak departure at Chipps Island (Table 2-1) regularly occurs in March (del Rosario et al. 2013). The Delta serves as an important rearing and transition zone for juvenile winter-run as they feed and physiologically adapt to marine waters during the smoltification process (change from freshwater to saltwater). The majority of juvenile winter-run in the Delta are 104 to 128 millimeters (mm) long based on U.S. Fish and Wildlife (USFWS) Delta Juvenile Fish Monitoring Program trawl data (1995 to 2012) and are from five to ten months old by the time they depart the Delta (Fisher 1994, Myers et al. 1998).

2.2.2.5 Ocean Rearing

Winter-run smolts enter the Pacific Ocean mainly in early spring (February to April) and grow rapidly on a diet of small fishes, crustaceans, and squid. Salmon runs that migrate to sea at a larger size tend to have higher marine survival rates (Quinn 2005). The diet composition of Chinook salmon from California consists of anchovy, rockfish, herring, and other invertebrates, in order of preference (Healey 1991). Most Chinook salmon from the Central Valley move northward off the Pacific coast of Oregon and Washington, where herring make up the majority of their diet. However, upon entering the ocean, winter-run tend to stay near the California coast and distribute from Point Arena southward to Monterey Bay. The region south of Point Reyes and east of the Farallon Islands appears to be a retention zone where juvenile Chinook salmon and salmon prey aggregate during their initial time at sea (Wing et al. 1998, MacFarlane 2010). Winter-run typically rear in freshwater for 5-10 months and exhibit a peak emigration period in March (del Rosario et al. 2013). The earlier entrance into the marine environment during February and March as smolts makes winter-run unique from other Chinook species in the Central Valley (CV). If feeding conditions are good, growth will be high and starvation or the effects of size-dependent predation may be lower (Cowan et al. 1996, Tucker et al. 2016). Thus, the conditions at the time of ocean entry and near the point of ocean entry are likely to be especially important in determining the survival of juvenile Chinook salmon (Lindley et al. 2009, Wells et al. 2016). Winter-run have high metabolic rates, feed heavily, and grow fast compared to other fishes in their range. They can double their length and increase their weight more than ten-fold in the first summer at sea (Quinn 2005). Mortality is typically highest in the first summer at sea, but can depend on ocean conditions (Wells et al. 2016). A growing body of evidence suggests that early marine growth and survival rates are strongly linked and furthermore, early marine survival appears to be highly correlated with total marine survival (Wells et al. 2016). Winter-run abundance has been correlated with ocean conditions such as periods of strong up-welling, cooler temperatures, and El Niño events (Lindley et al. 2009).

Winter-run spend approximately one to two years rearing in the ocean before returning to the Sacramento River as two to three year-old adults. Winter-run are somewhat unique in that the overwhelming majority of fish (>85%) return at age 3 as indicated by the CWT recoveries from the spawning grounds (CWT recoveries would represent only the hatchery population) (However, during the last two years (2016, 2017), two year olds have made up 60% and 40% of the adult returns (D. Killam pers comm). This has been due to the recurrent drought and increased mortality rates experienced by the juveniles three years prior. Very few winter-run reach age four. Once they reach age three, they are large enough to become vulnerable to commercial and sport fisheries.

Information on salmon abundance and distribution once they leave fresh water is based upon CWT recoveries and more recently by genetic sampling from ocean fisheries. For over 30 years, the marine distribution and relative abundance of specific stocks, including ESA-listed ESUs, has been estimated using a representative CWT hatchery stock (or stocks) to serve as proxies for the natural and hatchery-origin fish within ESUs. One important assumption of this approach is that hatchery and natural stock components are assumed to be similar in their life histories and ocean migration patterns. The recent genetic sampling studies discussed below have helped to confirm that ocean distribution is similar for hatchery and wild origin winter run.

Information from winter-run CWT recoveries suggest that winter-run tend to remain in southern waters rarely showing up in the salmon fishery north of Point Arena, CA. Several recent studies have confirmed the spatial residency of winter run in marine waters. Age 3 winter-run were found to be mostly (72%) south of Point Arena based on estimated historical contacts per unit effort in the month of June (Satterthwaite et al. 2013). Actual recoveries of winter-run fish north of Point Arena are quite rare (O'Farrell et al. 2012). Although Satterthwaite et al. (2013) suggested contacts of winter-run did occur north of Fort Bragg, it is likely a caveat of the model expanding on contacts per unit even though there was no representation of winter-run in the sampled portion of the retained harvest, highlighting the difficulty of estimating the probability or frequency of rare events (Satterthwaite et al 2013). Until recently, CWT data provided the only information that is available on parameters such as distribution, survival, and exploitation. Recent studies have used genetic stock identification (GSI) to determine origin and relative abundance of sampled fish which may include non-hatchery fish as well as untagged hatchery fish. Over 10,000 fin clip samples from 1998 to 2002 that had been previously preserved from dock side samples were genotyped to help address uncertainty on wild fish versus hatchery fish distribution in marine waters. Fish identified as winter-run were never sampled north of Fort Bragg and were rarely sampled north of Point Reyes (Satterthwaite et al 2015). Another recent study using catch effort data and GSI examined over 9,000 fin samples obtained during 2010. Winter-run were only detected in the San Francisco management area in June and were most abundant in the Monterey management area (Figure 2-10 in August and September (Bellinger et al. 2015)). This is consistent with earlier studies based on CWT recoveries of winter-run distributions in marine waters (O'Farrell et al. 2012, Satterthwaite et al. 2013).

Understanding winter-run ocean distribution is beneficial for conservation and resource management strategies. Salmon fishery management is spatially stratified to enable effective weak stock management (O'Farrell et al 2015). In the case of winter-run, since a very high proportion of the winter-run catch and coded wire tag recoveries have occurred south of Point Arena, CA specific measures have been implemented where winter-run are known to be present to reduce fisheries impact. The San Francisco management area is delineated between Point Arena south to Pigeon Point and the area south of Pigeon Point delineates the Monterey fishery management area (Figure 2-6). These two management areas have size and seasonal restrictions placed on the commercial and recreational ocean fisheries to reduce impacts to winter-run.

2.2.3 Climate Change and Other Ecosystem Effects

One factor affecting the rangewide status of the winter-run Chinook salmon ESU, and aquatic habitat at large is climate change. This section describes climate change and other ecosystem effects on winter-run.

Given the increasing certainty that climate change is occurring and is accelerating (Battin et al. 2007), NMFS anticipates salmonid habitats will be affected and this in turn is likely to affect the distribution and productivity of salmon populations in the region (Beechie et al. 2006, Lindley et al. 2007). Climate and hydrology models project significant reductions in both total snow pack and low-elevation snow pack in the Pacific Northwest over the next 50 years (Mote and Salathé 2010), these changes will shrink the extent of the snowmelt-dominated habitat available to salmon. Such changes may restrict our ability to conserve diverse salmon and steelhead life histories and make recovery targets for these salmon populations more difficult to achieve.

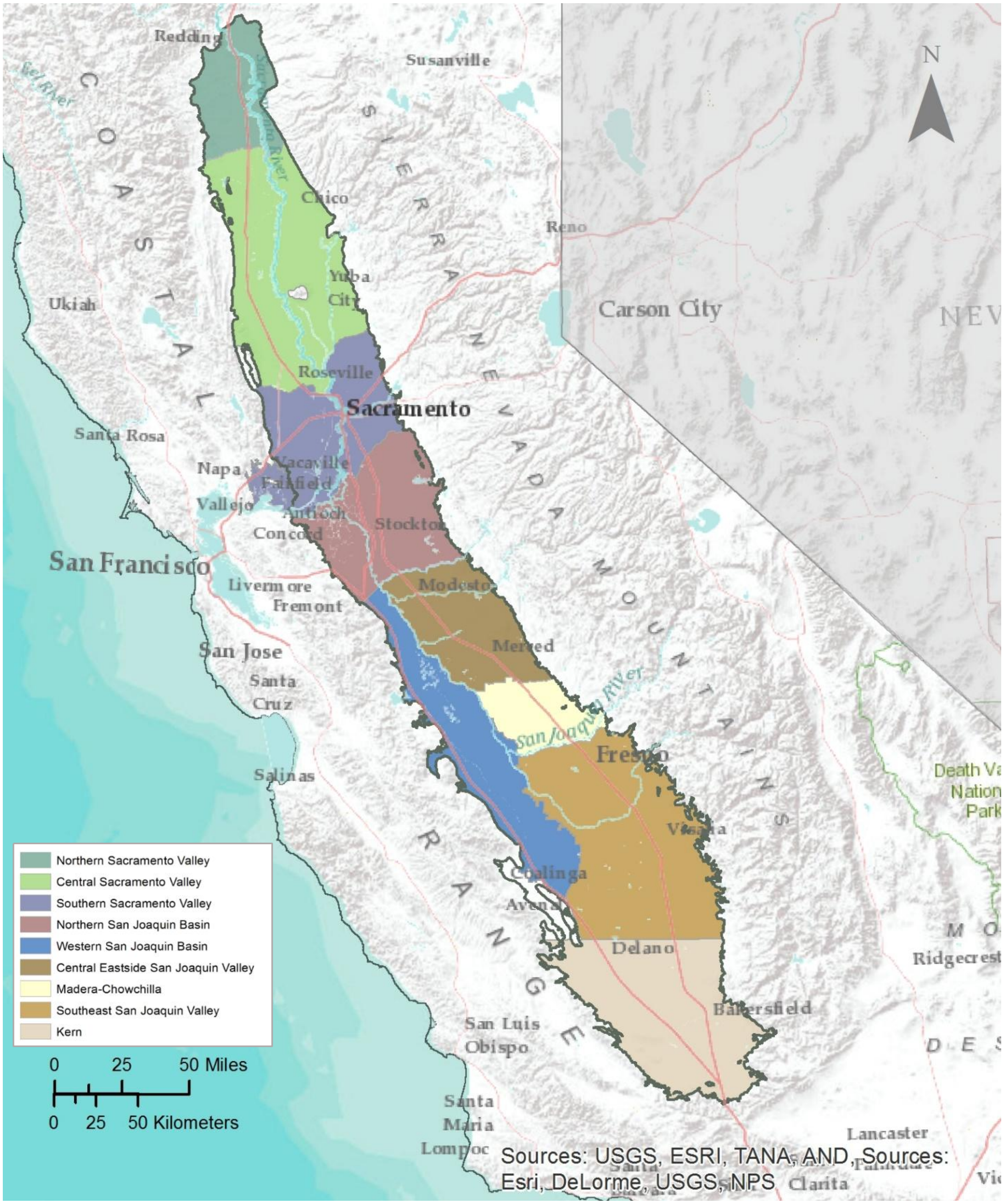
Climate change is a major factor affecting the range-wide status of the threatened and endangered anadromous fish in the Central Valley of California (CV) (Figure 2-1). Lindley et al. (2007) summarized several studies (Hayhoe et al. 2004; Dettinger et al. 2004; Dettinger 2005; VanRheenen et al. 2004; Knowles and Cayan 2002) on how anthropogenic climate change is expected to alter the CV and based on these studies, described the possible effects to anadromous salmonids. Climate models for the CV are broadly consistent in that temperatures in the future will warm significantly, total precipitation may decline, the variation in precipitation may substantially increase (i.e., more frequent flood flows and critically dry years), and snowfall will decline significantly (Lindley et al. 2007, BOR 2014).

Warming is already affecting CV Chinook salmon. Because the runs are restricted to low elevations as a result of impassable rim dams, if climate warms by 9°F (5°C), it is questionable whether any CV Chinook salmon populations can persist (Williams 2006). Based on an analysis of an ensemble of climate models and emission scenarios and a reference temperature from 1951 to 1980, the most plausible projection for warming over Northern California is 4.5°F (2.5°C) by 2050 and 9°F (5°C) by 2100, with a modest decrease in precipitation (Dettinger 2005). Chinook salmon in the CV are at the southern limit of their range, and warming will shorten the period in which the low elevation habitats used by naturally producing Chinook salmon are thermally acceptable.

Climate change has negative implications for designated critical habitats in the Pacific Northwest and California (CIG 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007, Lindley et al. 2007). Average annual Northwest air temperatures have increased by approximately 1ºC since 1900, or about 50% more than the global average over the same period (ISAB 2007). According to the Independent Scientific Advisory Board (ISAB), these effects pose the following impacts over the next 40 years:

- Warmer air temperatures will result in diminished snowpacks and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, these watersheds will see their runoff diminished earlier in the season, resulting in lower stream-flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Coast. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species (ISAB 2007).



Sources: USGS, ESRI, TANA, AND, Sources: Esri, DeLorme, USGS, NPS

Figure 2-1. Map of Central Valley of California. The Central Valley is 40 to 60 miles wide and extends approximately 450 miles from Redding in the north to Bakersfield in the southern end.

For Sacramento River winter-run Chinook salmon, the embryonic and larval life stages that are most vulnerable to warmer water temperatures occur during the summer, so this run is particularly at risk from climate warming. The only remaining population of winter-run Chinook salmon relies on the cold-water pool in Shasta Reservoir, which buffers the effects of warm temperatures in most years. The exception occurs during drought years, which are predicted to occur more often with climate change (Yates et al. 2008). The long-term projection of how the two main diverters on the Sacramento River, Central Valley Project (CVP) and the State Water Project (SWP), will operate incorporates the effects of potential climate change in three possible forms: less total precipitation; a shift to more precipitation in the form of rain rather than snow; or earlier spring snow melt (BOR 2008). Additionally, air temperature appears to be increasing at a greater rate than what was previously analyzed (Lindley 2008; Beechie et al. 2012; Dimacali 2013). These factors will compromise the quantity and/or quality of winter-run Chinook salmon habitat available downstream of Keswick Dam. It is imperative for additional populations of winter-run Chinook salmon to be re-established into historical habitat in Battle Creek and above Shasta Dam for long-term viability of the ESU (NMFS 2017c). NWFSC (2015) recently reported that climate conditions affecting salmonids were not optimistic; recent and unfavorable environmental trends are expected to continue.

In summary, observed and predicted climate change effects in freshwater habitat are generally detrimental to all of the Chinook salmon species in the Central Valley and Pacific Northwest, so unless offset by improvements in other factors, the status of the species and critical habitat is likely to decline over time. The climate change projections referenced above cover the period between the present and approximately 2100. While there is uncertainty associated with projections, which increase over time, the direction of change is relatively certain (McClure et al. 2013).

Once salmon leave fresh water they are subject to a highly variable and dynamic ocean environment that is also subject to climatic impacts. There is evidence that salmon abundance is linked to variation in climate effects on the marine environment. It is widely understood that variations in marine survival of salmon correspond with periods of cold and warm ocean conditions, with cold regimes being generally favorable for salmon survival and warm ones unfavorable (Fiechter et al. 2015, Behrenfeld et al. 2006, Wells et al. 2006). Both short term, Ocean Nino Index (ONI), and longer term climate variability, Pacific Decadal Oscillation (PDO), appear to play a part in salmon survival and abundance. An evaluation of conditions in the California Current since the late 1970s reveals a generally warm, unproductive regime that persisted until the late 1990s. This regime has been followed by a period of high variability that began with colder, more productive conditions lasting from 1999 to 2002. In general, salmon populations increased substantially during this period. However, this brief cold cycle was immediately succeeded by a 4-year period of predominantly warm ocean conditions beginning in late 2002, which appeared to have negatively impacted salmon populations in the California Current (Peterson et al. 2006). 2006 through 2013 had generally favorable PDO and ONI rankings with the exception of 2010 and conditions have been intermediate or unfavorable since 2013 (https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/g-forecast.cfm).

Evidence suggests these regime shifts generally follow a linear pattern beginning with the amount and timing of nutrients provided by upwelling and passing “up” the food chain from plankton to forage fish and eventually, salmon. There are also indications that these same regime shifts affect the migration patterns of larger animals that prey on salmon (*e.g.*, Pacific hake, sea birds) resulting in a "top-down" effect as well (Peterson et al. 2006). Fishing records indicate that in the past, these shifts in temperature and consequent salmon abundance, appear to last several decades (Mantua et al. 1997). However, the long term viability of salmon cannot be dependent on periods of good ocean conditions alone, and the relative importance of good ocean conditions is difficult to quantify (McClure et al. 2003) and it is quite possible that the climate patterns observed in the 20th century may not repeat in the 21st century due to long term climate change (Mantua and Francis 2004; IPCC 2001).

Salmon are migratory fish living in a dynamic environment related to the climate at different spatial and temporal scales. Large-scale events and conditions such as El Niño or Pacific Decadal Oscillation phase shifts can affect the entirety of the California Current ecosystem. However, when salmon first enter the ocean they may be most strongly affected by local and mesoscale features, with greater sensitivity to larger scale features and conditions as they age and migrate (Wells et al. 2012). The timing of the onset of upwelling is critical for juvenile salmon that migrate to sea in the spring. If upwelling and the pelagic food web it supports is well developed when young salmon enter the sea, they can grow rapidly and tend to survive well. If spring upwelling is not well-developed, or its onset is delayed, growth and survival may be poor[5] (Wells et al. 2008a; Lindley et al. 2009). Other factors including coastal sea surface temperature and sea level height (representative of the strength of the California current and southern transport) values are also related to improved ocean productivity (Wells and Mohr 2008).

Wells et al. (2008a) developed a multivariate environmental index that can be used to assess ocean productivity on a finer scale for the central California region. This index has also tracked the Northern Oscillation Index, which can be used to understand ocean conditions in the North Pacific Ocean in general. The divergence of these two indices in 2005 and 2006 provided evidence that ocean conditions were worse off the California coast than they were in the broader North Pacific region. The Wells et al. (2008a) index incorporates 13 oceanographic variables and indices and has correlated well with the productivity of zooplankton, juvenile shortbelly rockfish (*Sebastes jordani*), and common murre (*Uria aalge*) production along the California coast (MacFarlane et al. 2008). In addition to its use as an indicator of ocean productivity in general, the index may also relate to salmon dynamics due to their heavy reliance on krill and rockfish as prey items during early and later life stages (Wells et al. 2012).

NOAA provides the PFMC with a yearly update on the state of the California Current Ecosystem (CCE), as derived from environmental, biological and socio-economic indicators. NOAA's California Current Integrated Ecosystem Assessment (CCIEA) team is responsible for this report and the latest update can be found here: https://www.integratedecosystemassessment.noaa.gov/Assets/iea/california/Report/pdf/2017-iea-main-report.pdf.

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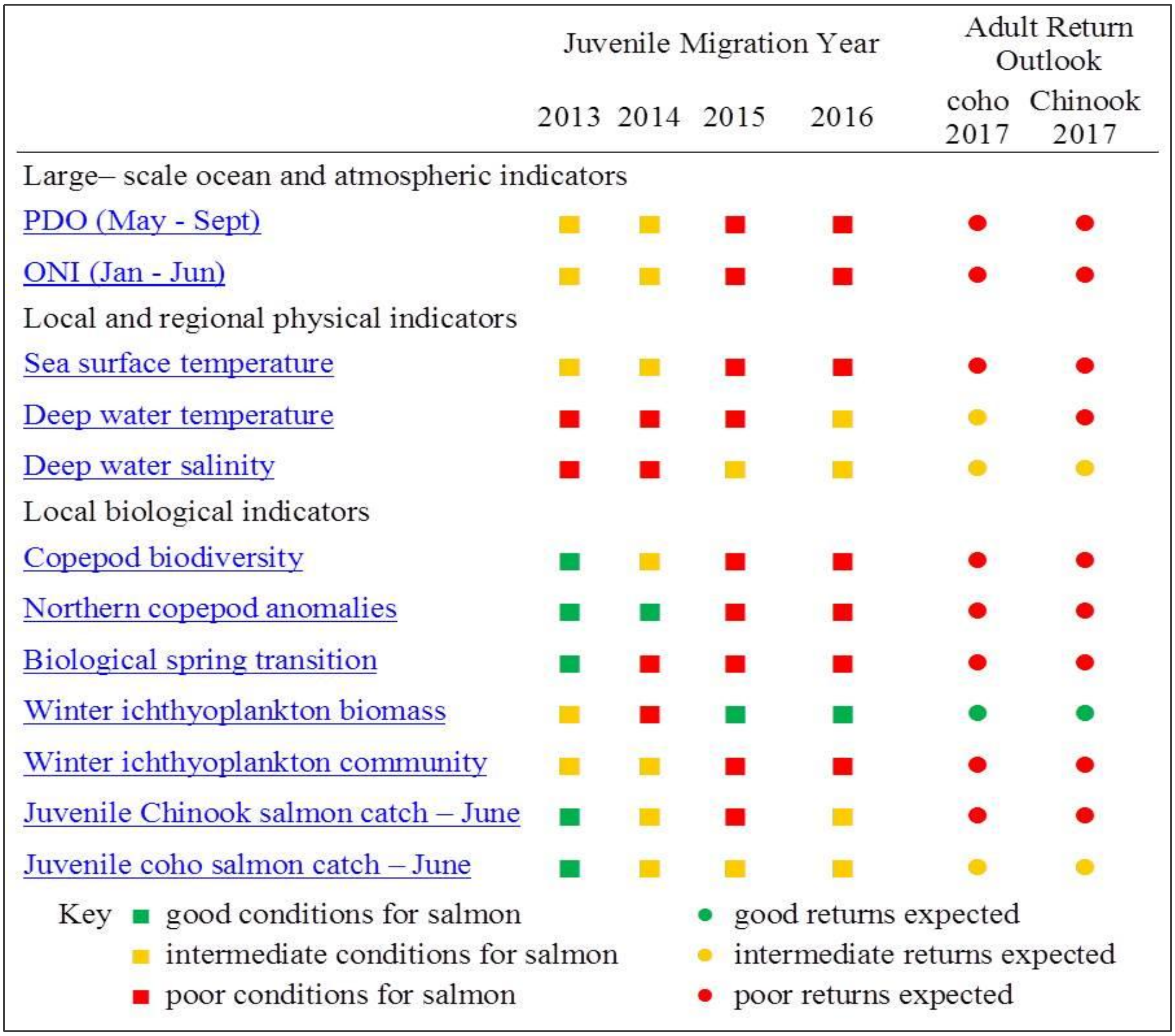
[5] More detailed information on how upwelling and other ecological conditions factor into productivity can be found in Lindley et al. 2009 and Wells et al. 2008b.

The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and local scale, provides an indication of the role they play in salmon survival in the ocean. The Northwest Fisheries Science Center produces annual forecasts of ocean productivity based on several indicators to predict Chinook salmon and coho returns for adults exposed to the Northern California Current (Figure 2-2).



	Juvenile Migration Year				Adult Return Outlook	
	2013	2014	2015	2016	coho 2017	Chinook 2017
Large– scale ocean and atmospheric indicators						
PDO (May - Sept)	🟨	🟨	🟥	🟥	🔴	🔴
ONI (Jan - Jun)	🟨	🟨	🟥	🟥	🔴	🔴
Local and regional physical indicators						
Sea surface temperature	🟨	🟨	🟥	🟥	🔴	🔴
Deep water temperature	🟥	🟥	🟥	🟨	🟡	🔴
Deep water salinity	🟥	🟥	🟨	🟨	🟡	🟡
Local biological indicators						
Copepod biodiversity	🟩	🟨	🟥	🟥	🔴	🔴
Northern copepod anomalies	🟩	🟩	🟥	🟥	🔴	🔴
Biological spring transition	🟩	🟥	🟥	🟥	🔴	🔴
Winter ichthyoplankton biomass	🟨	🟥	🟩	🟩	🟢	🟢
Winter ichthyoplankton community	🟨	🟨	🟥	🟥	🔴	🔴
Juvenile Chinook salmon catch – June	🟩	🟨	🟥	🟨	🔴	🔴
Juvenile coho salmon catch – June	🟩	🟨	🟨	🟨	🟡	🟡

Key 🟩 good conditions for salmon 🟢 good returns expected
🟨 intermediate conditions for salmon 🟡 intermediate returns expected
🟥 poor conditions for salmon 🔴 poor returns expected

Figure 2-2. Ocean ecosystem indicators of the Northern California Current. Colored squares indicate positive (green), neutral (yellow), or negative (red) conditions for salmon entering the ocean each year. In the two columns to the far right, colored dots indicate the forecast of adult returns based on ocean conditions in 2016 (coho salmon) and 2015 (Chinook salmon). (https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/g-forecast.cfm)

Variation in fish populations along the Pacific Coast may reflect broad-scale shifts in natural limiting conditions, such as predator abundances and food resources in ocean rearing areas. NMFS has noted that predation by marine mammals has increased as marine mammal numbers, especially harbor seals (*Phoca vitulina*) and California sea lions (*Zalophus californianus*) increase on the Pacific Coast (Myers et al. 1998; Jeffries et al. 2003; Pitcher et al. 2007; DFO 2010; Jeffries 2011, Chasco et al. 2017). In addition to predation by marine mammals, Fresh (1997) reported that 33 fish species and 13 bird species are predators of juvenile and adult salmon, particularly during freshwater rearing and migration stages. Ecosystem effects will be altered by climate change as it relates to migration changes in these predators.

To summarize, conditions winter-run experience when they first enter the ocean can be highly variable. The first few weeks are a critical time for juvenile salmon growth and survival. Variation in fish populations may reflect broad-scale shifts in predator abundances and food resources in ocean rearing areas. Several indices are either available or being researched to help predict what conditions any cohort may encounter. This could become a valuable tool in the future for forecasting winter-run adult returns.

2.2.4 Description of Viable Salmonid Population Parameters

For Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: spatial structure, diversity, abundance, and productivity (McElhany et al. 2000). These “viable salmonid population” (VSP) criteria therefore encompass the species’ “reproduction, numbers, or distribution” as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population’s capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout a species’ entire life cycle, and these characteristics, in turn, are influenced by habitat and other environmental conditions.

2.2.4.1 Abundance

“Abundance” generally refers to the number of naturally-produced adults (i.e., the progeny of naturally-spawning parents) in the natural environment (e.g., on spawning grounds).

Historically, winter-run Chinook salmon population estimates were as high as 120,000 fish in the 1960s, but declined to less than 200 fish by the 1990s (NMFS 2014a). In recent years, since carcass surveys began in 2001, the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively (Figure 2-3, Table 2-2) However, between 2007 and 2016 the population has shown a precipitous decline, averaging 2,909 during this period, with a low of 827 adults in 2011 (Table 2-2). The five-year status review on winter-run found that the point estimate for the 10-year trend in run size is negative (-0.15), suggesting a 15% per year decline in the population. The slope is marginally not different than ‘0’, yet it is clear that the population has been steadily declining rather than increasing over the past decade (NMFS 2016). This recent declining trend is likely due to a combination of factors such as poor ocean productivity (Lindley et al. 2009); drought conditions from 2007 to 2009 and again in 2016 to 2017 and extreme drought conditions in 2012 to 2015 (as defined by the U.S. Drought Monitor (droughtmonitor.unl.edu) causing low in river survival (NMFS 2016). In 2016, the adult spawning population was 1,546 and the preliminary estimate for 2017 is 1,123 adults, well below the average from 2007 to 2016 (CDFW 2017).

The winter-run adult returns in 2017 were low (estimated 1,123) due to the impact of drought on juveniles from brood year 2014 (Figure 2-3). It is anticipated that 2018 adult returns will also be low due to the high mortality experienced in the earliest life-stages for the brood year of 2015.

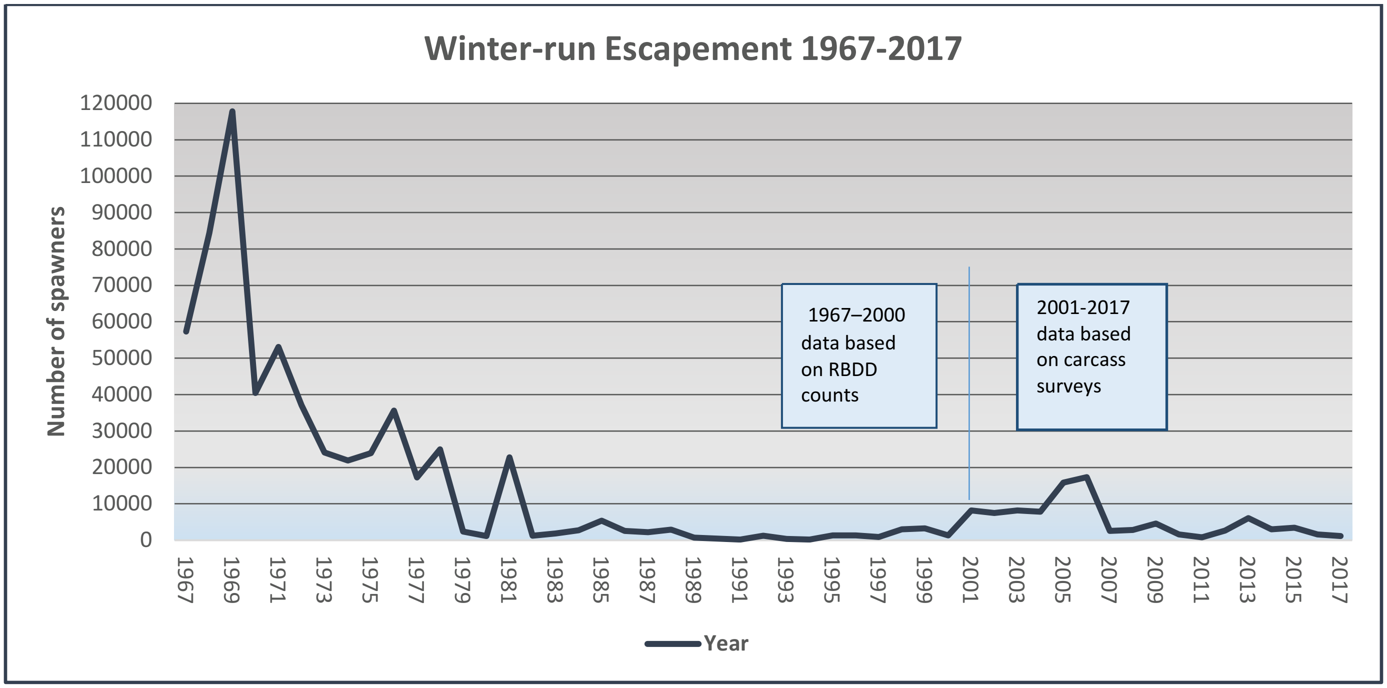


Figure 2-3. Winter-run Chinook Salmon Escapement 1967-2017 (CDFW 2017).

2.2.4.2 Productivity

"Productivity," as applied to viability factors, refers to the entire life cycle or portions of a life cycle; i.e., the number of progeny or naturally-spawning adults produced per parent. When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining. McElhany et al. (2000) use the terms "population growth rate" and "productivity" interchangeably when referring to production over the entire life cycle. They also refer to "trend in abundance," which is the manifestation of long-term population growth rate.

Winter-run ESU productivity was mostly positive from 1995 to 2006, and adult escapement and juvenile production had been trending upward until 2007 when productivity became negative (Table 2-2) with declining escapement estimates. The long-term trend for the ESU remains negative because productivity is subject to impacts from environmental and artificial conditions such as blockage to traditional spawning grounds and dependence on cold water pool at Shasta that is compromised due to droughts and anticipated climate change effects. The population growth rate based on cohort replacement rate (CRR) for the period 2007 to 2012 indicated a reduction in productivity (Table 2-2) meaning that the winter-run Chinook salmon population was not replacing itself. From 2013 to 2015, winter-run Chinook salmon experienced a positive CRR, possibly due to favorable in-river conditions in 2011 and 2012 (wet and below normal water year types, respectively), which increased juvenile survival to the ocean. However, the most recent escapement data in 2016 and 2017 show a negative CRR (0.25 and 0.37) likely due to low juvenile survival in freshwater. Table 2-2 shows the winter-run population trend using CRR derived from adult escapement, including hatchery fish from 1989 to 2017.

Table 2-2. Winter-run spawning escapement estimates from RBDD counts (1986 to 2000) and carcass surveys (2001 to 2017), and corresponding cohort replacement rates for the years since 1986 (CDFW 2017).

Year	Spawning Escapement[a]	3-Year Moving Average of Escapement	Cohort Replacement Rate[b]	3-Year Moving Average of Cohort Replacement Rate
1986	2,596	-	-	-
1987	2,185	-	-	-
1988	2,878	2,553	-	-
1989	696	1,920	0.27	-
1990	430	1,335	0.20	-
1991	211	446	0.07	0.18
1992	1,240	627	1.78	0.68
1993	387	613	0.90	0.92
1994	186	604	0.88	1.19
1995	1,297	623	1.05	0.94
1996	1,337	940	3.45	1.79
1997	880	1,171	4.73	3.08
1998	2,992	1,736	2.31	3.50
1999	3,288	2,387	2.46	3.17
2000	1,352	2,544	1.54	2.10
2001	8,224	4,288	2.75	2.25
2002	7,441	5,672	2.26	2.18
2003	8,218	7,961	6.08	3.70
2004	7,869	7,843	0.96	3.10
2005	15,839	10,642	2.13	3.05
2006	17,296	13,668	2.10	1.73
2007	2,541	11,892	0.32	1.52
2008	2,830	7,556	0.18	0.87
(2009)	4,537	3,303	0.26	0.25
(2010)	1,596	2,988	0.63	0.36
(2011)	827	2,320	0.29	0.39
(2012)	2,671	1,698	0.59	0.50
(2013)	6,084	3,194	3.81	1.56
(2014)	3,015	3,923	3.65	2.68
(2015)	3,440	4,180	1.29	2.92

Year	Spawning Escapement[a]	3-Year Moving Average of Escapement	Cohort Replacement Rate[b]	3-Year Moving Average of Cohort Replacement Rate
(2016)	1,546	2,667	0.25	1.73
(2017)[c]	1,123	2,036	0.37	0.64
median	**2,569**	**2,549**	**1.05**	**1.73**

*Data for years in parentheses are preliminary.

[a] GrandTab (http://www.dfg.ca.gov/fish/Resources/Chinook/CValleyAssessment.asp) Escapement estimates were based on RBDD counts until 2001. Starting in 2001, escapement estimates were based on carcass surveys.

[b] The majority of winter-run spawners are three years old. Therefore, NMFS calculated the CRR using the escapement estimates of a given year, divided by the escapement estimates three years prior.

[c] Preliminary estimate (PFMC 2017a).

Productivity, as measured by the number of juveniles passing RBDD rotary screw traps or juvenile production index JPI), has declined dramatically in recent years from a high of 8.9 million in 2005 to 440,951 in 2015 (Figure 2-4). In general, juvenile winter-run Chinook salmon productivity is lower than other Chinook salmon runs in the Central Valley and in the Pacific Northwest (Michel 2010). In addition to lower juvenile productivity, hatchery influence is increasing in both adult returns to the spawning grounds and in supplementation of the juvenile population as is discussed below and in Section 2.4.4.4 (Diversity).

Although impacts from hatchery fish (i.e., reduced fitness, smaller adult body size, lower predator avoidance behavior) are often cited as having deleterious impacts on natural in-river populations (Matala et al. 2012), the winter-run Chinook salmon conservation program at LSNFH is strictly controlled by the USFWS to reduce such impacts (NMFS 2014b, NMFS 2017c). All adults entered into the broodstock program are genetically sampled and wild returns are given preference. Additionally, hatchery juvenile are released upstream primarily in January after the majority of naturally spawned fry have moved towards the Sacramento-San Joaquin Delta. The average annual hatchery production at LSNFH is approximately 173,344 per year (2002 to 2012 average release total, D. Killam pers. comm.) compared to the estimated natural production juvenile outmigration that passes RBDD, which is 3.7 million per year based on the 2002 to 2012 average (Poytress et al. 2014). Therefore, hatchery production typically represented approximately four to five percent of the total in-river juvenile production. However, hatchery production has increased dramatically in recent years to offset high mortalities in the naturally spawning population. 2014 was the third year of a drought that increased water temperatures in the upper Sacramento River, and egg-to-fry survival to the RBDD was only 5.9% (Poytress 2016). Due to the lower than average survival in 2014, hatchery production from LSNFH was tripled to offset the impact of the drought (Figure 2-5) (CVP and SWP Drought Contingency Plan 2014).In 2015, egg-to-fry survival was the lowest on record (approximately four percent) due to the inability to release cold water from Shasta Dam in the fourth year of a drought (NMFS 2016). Hatchery production was increased again to 420,000 juveniles released (Figure 2-5).

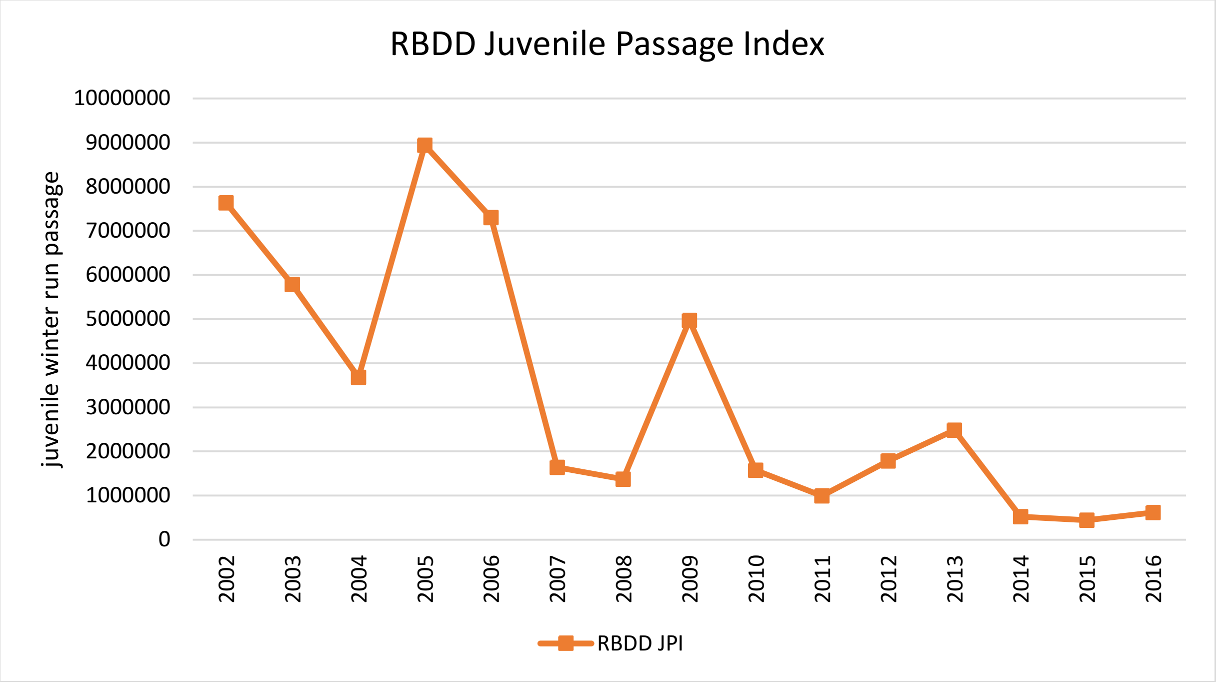


Figure 2-4. Historical winter run juvenile passage as estimated at RBDD rotary screw traps (2002-2016) (https://www.fws.gov/redbluff/MSJM%20Reports/RST/rbdd_jsmp_annual.html).

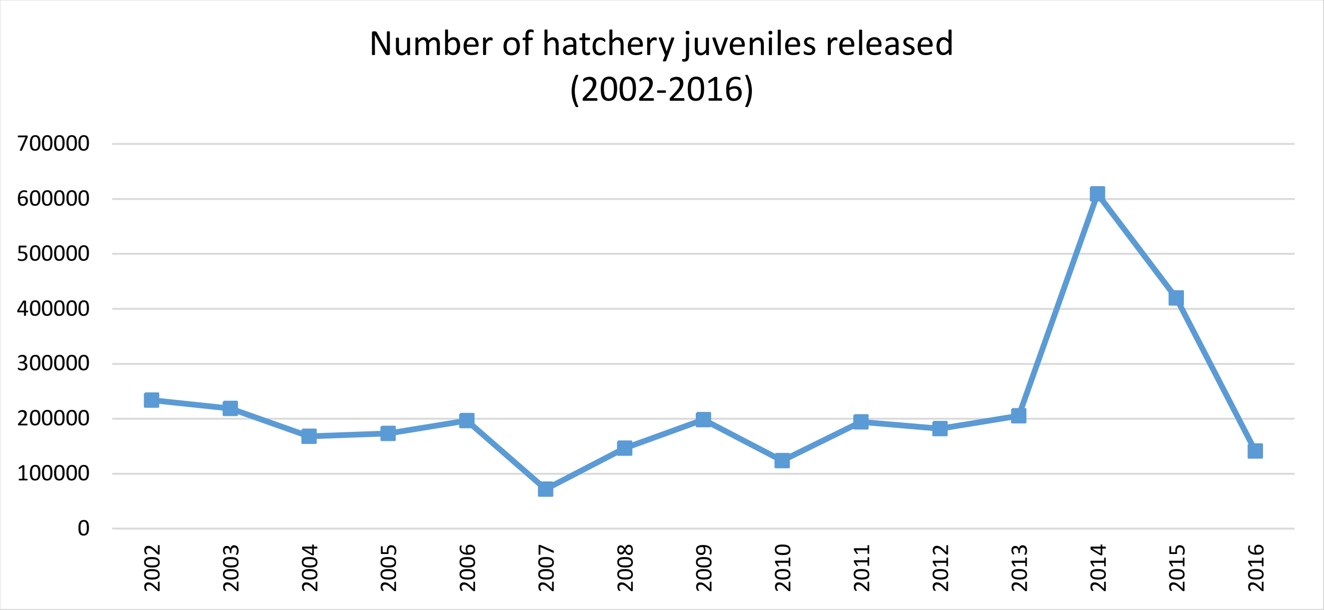


Figure 2-5. Historical winter-run juvenile in-river hatchery releases (D. Killam pers. comm.)

2.2.4.3 Spatial Structure

“Spatial structure” refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population’s spatial structure depends fundamentally on habitat quality and spatial configuration and the dynamics and dispersal characteristics of individuals in the population. Important considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as metapopulations (McElhany et al. 2000).

The construction of Shasta Dam in 1943 blocked access to historical spawning grounds where spring fed streams provided cold water throughout the summer allowing for spawning, egg incubation, and rearing during the mid-summer period (Slater 1963, Yoshiyama et al. 1998). Approximately 299 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to winter-run with the exception of Battle Creek (Figure 2-6), which has its own impediments to upstream migration including a number of small hydroelectric dams situated upstream of the Coleman National Fish Hatchery (CNFH) weir. (Moyle et al. 1989; NMFS 1997). Most components of the winter-run life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River (NMFS 2014a).

The greatest risk factor for winter-run Chinook salmon lies within its spatial structure (NMFS 2011). The spatial structure of winter-run resembles that of a panmictic population, where there are no subpopulations, and every mature male is equally likely to mate with every other mature female. The four historical independent populations of winter-run have been reduced to one population, resulting in a significant reduction in their spatial diversity. An ESU comprised of one population is not viable because it is unlikely to be able to adapt to significant environmental changes. A single catastrophe (*e.g.*, volcanic eruption of Lassen Peak, prolonged drought which depletes the cold-water pool at Lake Shasta, or some related failure to manage cold water storage, spill of toxic materials, or a disease outbreak) could extirpate the entire winter-run ESU, if its effects persisted for 3 or more years. The overwhelming majority of winter-run return to spawn in 3 years (in the same place), so a single catastrophe with effects that persist for at least 3 years would affect all of the winter-run cohorts.

The remnant and remaining population which cannot access 95% of their historical spawning habitat must therefore be artificially maintained in the Sacramento River by the following means:

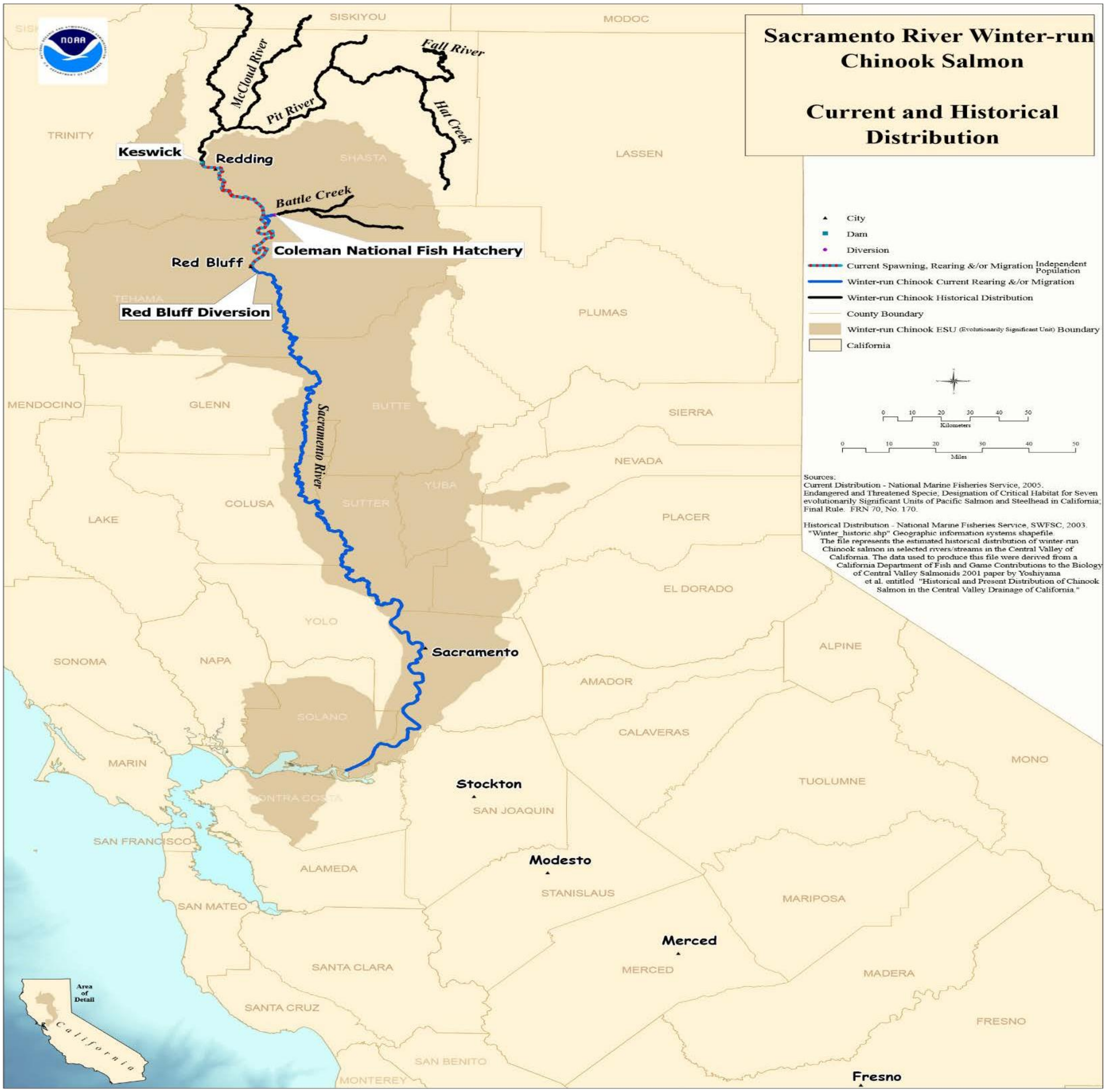
1. Spawning gravel augmentation
2. Hatchery supplementation
3. Regulation of the finite cold-water pool behind Shasta Dam to reduce water temperatures

Winter-run require cold water temperatures in the summer that simulate their historical upper basin habitat, and they are more likely to be exposed to the impacts of drought in a lower basin environment.

Battle Creek is currently the most feasible opportunity for the ESU to expand its spatial structure. Hydrological development eliminated approximately 48 miles of potential habitat in Battle Creek. The Battle Creek Salmon and Steelhead Restoration Project (BCSSRP) will eventually remove five dams on Battle Creek, install fish screens and ladders on three dams, and end the diversion of water from the North Fork to the South Fork and provide the conditions necessary for a successful reintroduction program. When the program is completed, a total of 42 miles of mainstem habitat and six miles of tributary habitat will be opened up to anadromous salmonids and will allow for successful reintroduction of the SR winter-run Chinook salmon ESU. The BCSSRP began in 2010 with the removal of Wildcat Diversion Dam and it is nearing its final implementation phase with completion expected by 2020. A report on the current status of the BCSSRP is available at http://www.battle-creek.net/docs/gbcwwg/GBCWWG_MTG_Sept_2017_RestorationProject%20Update.pdf. The BCSSRP is coupled with a plan to reintroduce winter-run Chinook into Battle Creek. The plan seeks to produce a self-sustaining, locally-adapted winter-run population in North Fork Battle Creek. Reintroduction of winter-run into the North Fork Battle Creek is part of a larger strategy in the NMFS Recovery Plan to restore some of the spatial structure of the ESU by reintroducing populations to habitats from which they have been extirpated. The reintroduction plan is also now complete (ICF Intl. 2016) and available at https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=129504&inline. 2017 will be the first year that fish from the Captive Broodstock Program will be mature and ready to spawn thus completing the life cycle within the Captive Broodstock Program. In 2018, 200,000 juveniles from the captive broodstock program were released into newly restored habitat in Battle Creek. This first reintroduction actually occurred ahead of schedule. The juveniles were available in 2018 because they were not needed to meet the hatchery production goals at the LSNFH.

The Central Valley Salmon and Steelhead Recovery Plan includes criteria for recovering the winter-run Chinook salmon ESU, including re-establishing a population into historical habitats upstream of Shasta Dam (NMFS 2014a). Additionally, NMFS (2009a) included a requirement for a pilot fish passage program above Shasta Dam. Studies are progressing on this requirement and BOR released a draft pilot implementation plan for Shasta Dam Fish Passage Evaluation in December of 2016 (BOR 2016). Both the Shasta Dam passage program and the Battle Creek reintroduction efforts are important steps needed towards the recovery goal of establishing three winter-run populations at low risk of extinction (NMFS 2016).

The recent drought related events have stressed the ESU over consecutive years and resulted in increased reliance on hatchery juvenile releases to try to compensate for high in-river mortalities. Since there is no immediate solution to restore additional spawning grounds to this ESU, NMFS concludes that winter-run are at a high risk of extinction based on spatial structure.



Sacramento River Winter-run Chinook Salmon

Current and Historical Distribution

Sources:
Current Distribution - National Marine Fisheries Service, 2005. Endangered and Threatened Specie; Designation of Critical Habitat for Seven evolutionarily Significant Units of Pacific Salmon and Steelhead in California; Final Rule. FRN 70, No. 170.

Historical Distribution - National Marine Fisheries Service, SWFSC, 2003. "Winter_historic.shp" Geographic information systems shapefile. The file represents the estimated historical distribution of winter-run Chinook salmon in selected rivers/streams in the Central Valley of California. The data used to produce this file were derived from a California Department of Fish and Game Contributions to the Biology of Central Valley Salmonids 2001 paper by Yoshiyama et al. entitled "Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California."

Figure 2-6. Current and Historical Sacramento River Winter-run Chinook Salmon Distribution.

2.2.4.4 Diversity

"Diversity" refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation at single genes to complex life history traits (McElhany et al. 2000).

Diversity, both genetic and behavioral, is critical to success in a changing environment. Salmonids express variation in a suite of traits, such as fecundity, run timing, spawn timing, juvenile behavior, age at maturity as well as physiology and molecular genetic characteristics. The more diverse these traits (or the more these traits are not restricted), the more adaptable a population is, and the more likely that individuals, and therefore the species, would survive and reproduce in the face of environmental variation (McElhany et al. 2000). However, when this diversity is reduced due to loss of entire life history strategies or to loss of habitat used by fish exhibiting variation in life history traits, the species is in all probability less able to survive and reproduce given environmental variation.

The current winter-run Chinook salmon population is the result of the introgression of several stocks (e.g., spring-run and fall-run Chinook salmon) that occurred when Shasta Dam blocked access to the upper watershed. A second genetic bottleneck occurred with the construction of Keswick Dam, which blocked access and did not allow spatial separation of the different runs (Good et al. 2005). Lindley et al. (2007) recommended reclassifying the winter-run Chinook salmon population extinction risk from low to moderate if the proportion of hatchery-origin fish from the LSNFH exceeded 15% due to the impacts of hatchery fish over multiple generations of spawners. Since 2005, the percentage of hatchery winter-run Chinook salmon recovered in the Sacramento River has been above 15% in six years including the last four consecutive years: 2005, 2012, 2014, 2015, 2016 and 2017 (Figure 2-7). The average over the last 12 years (about four generations) is 21%, with the most recent generation (2015-2017) at 46% hatchery influence. This is in part due to enhanced reliance on hatchery juvenile releases to supplement the catastrophic mortality that occurred during 2014 and 2015. It is expected that the hatchery influence will decline as stricter temperature requirements are implemented in the upper Sacramento River to better protect early life stages (NMFS 2017c). The 85% hatchery influence that occurred in 2017 was an anomaly and although the hatchery influence has seen a steady increase in recent years and will continue through 2018, it is expected that 2019 returns will resemble more traditional hatchery influence. However, as discussed in Section 2.2.3, climate change is exerting a negative effect on critical freshwater habitat particularly for winter-run that spawn in the summer and are blocked from traditional spawning grounds fed by cold-water springs. This may mean that hatchery influence remains higher than desired and in-river mortality continues to be problematic in dry years.

Concern over genetic introgression within the winter-run Chinook salmon population led to a conservation program at LSNFH that encompasses best management practices, including:

1. Genetic confirmation of each adult prior to spawning
2. A limited number of spawners based on the effective population size
3. Prioritize use of only natural-origin spawners. In recent years hatchery adult spawners have been accepted as broodstock due to drought contingency measures (NMFS 2017c)

Figure 2-7 shows the percentage of hatchery-origin winter-run Chinook salmon naturally spawning in the Sacramento River from 1998 to 2016.

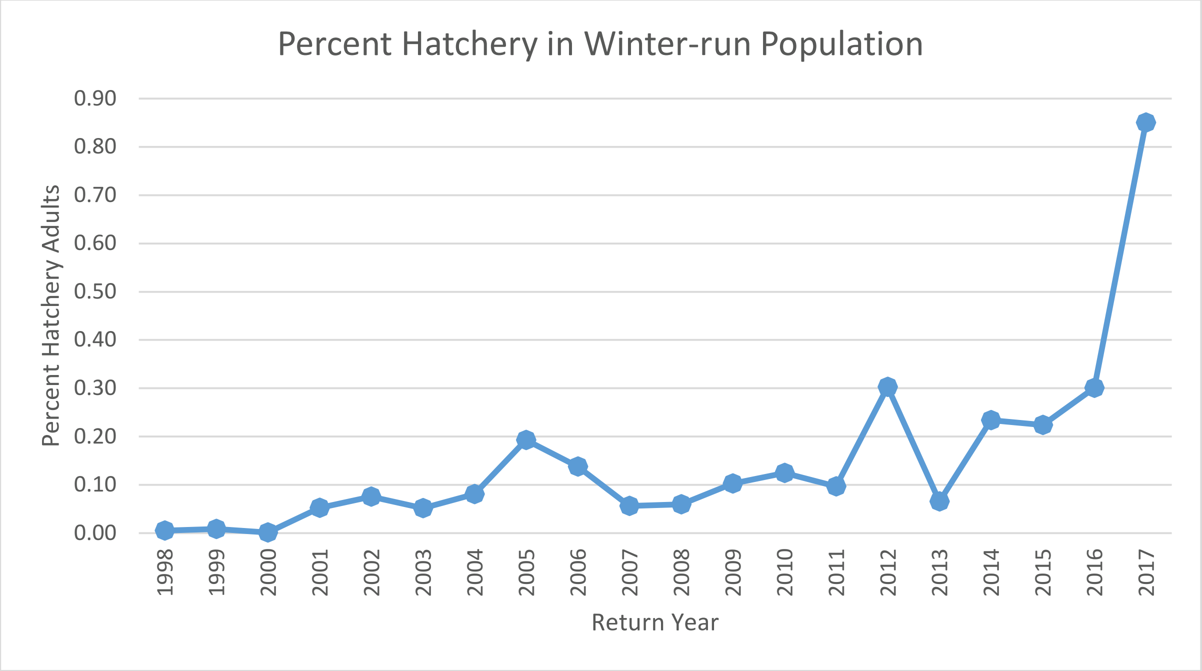


Figure 2-7. Percent of Hatchery Adults in Winter-run Spawning Population.

Measures are also in place to minimize the impact juvenile hatchery releases may have in-river on naturally spawned winter-run juveniles. Winter-run hatchery pre-smolts are released at the tail end of the outmigration period in order to reduce effects on the natural production. Although there is variation in survival during freshwater migrations it is likely that the relative exposure to various threats or environmental conditions are similar once fish enter the marine environment. In addition to increases in the percent of hatchery influence on returning spawners, the number of hatchery juveniles released in river has increased greatly in recent years. This has been in response to extreme drought conditions and ineffective cold-water pool management for brood years 2014 and 2015 resulting in very high mortality from egg to fry. Until very recently, the numbers of juvenile hatchery fish released in river was a very small percentage of the total juvenile winter-run passage past RBDD as measured in total JPI (Figure 2-8). Up until 2014, the in river hatchery releases could potentially have made up 2% to 20% of total passage at RBDD. However, in 2014, there were 609,311 juvenile hatchery smolts released in river (D. Killam pers. comm.) and only 523,872 (301,197 - 746,546 (90% CI)) juvenile winter run were estimated to pass RBDD. This does not suggest that all the winter-run passing RBDD in 2014 were hatchery releases, it was observed the majority of the winter-run were fry-sized fish passing before the larger hatchery smolts were released (Poytress 2016). It does indicate however that the potential of hatchery releases to make up the majority of the juvenile population exists for the first time since the hatchery program began. Similarly, in 2015, 420,006 juvenile hatchery fish were released while estimated passage at RBDD was 440,951 (288,911 – 592,992 (90% CI)). Therefore, the supplementation of hatchery fish in 2014 and 2015 had a much greater influence on the genetic pool of juvenile population then in previous years. This weakens the life history traits the winter-run population as a whole could utilize as the winter-run hatchery fish are "ocean ready" when they are released and presumed to migrate quickly. Additionally, the increased hatchery releases could attract predators to areas where the naturally spawned winter-run are still residing. En masse hatchery salmon smolt releases may cause displacement of rearing naturally produced juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature out-migration (Pearsons et al. 1994). In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance and when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility. This is the environment that occurs for winter-run upstream particularly in dry years when there is limited rainfall and there is less turbidity entering the rivers and streams.

Ideally, the hatchery program will continue to supplement the natural population of winter-run under the best management practices outlined above. The catastrophic mortality experienced by the natural population in 2014 and 2015 led to the urgent need to supplement the winter-run population using hatchery juveniles spawned from genetically confirmed winter-run. Without this conservation hatchery in place, very few adults would have returned to spawn in 2017 as evidenced by 85% of the ~1,100 spawners being of hatchery-origin (Figure 2-7).

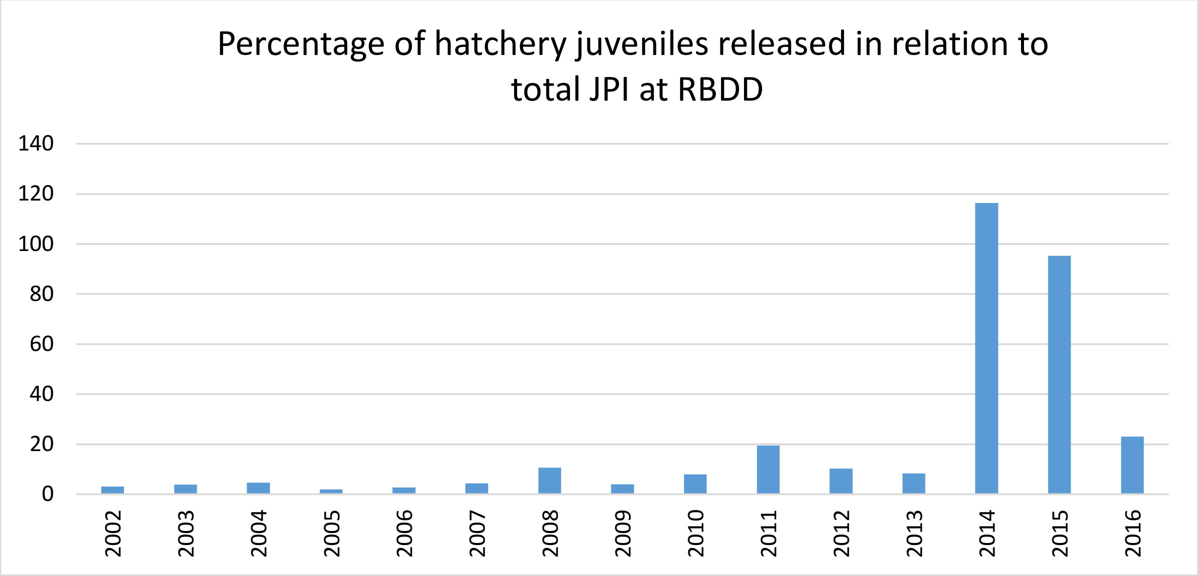


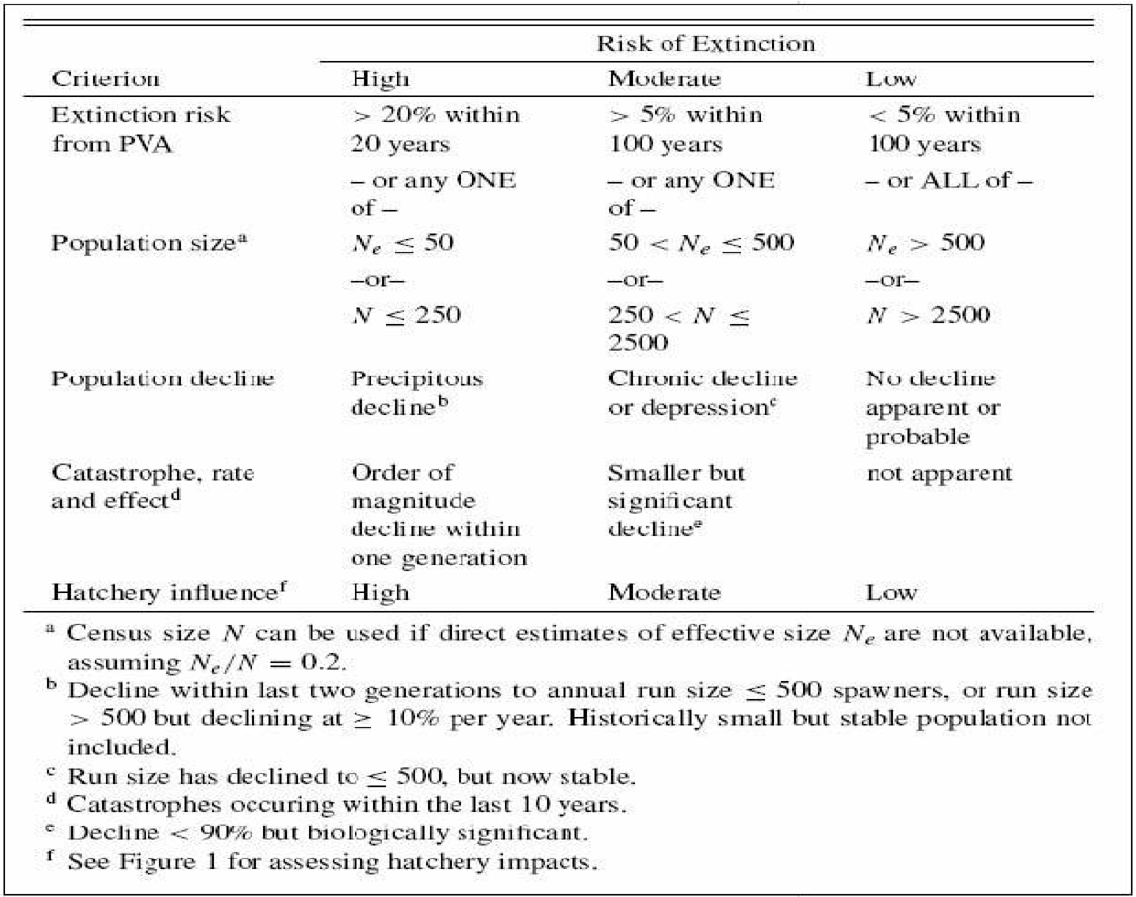
Figure 2-8. The number of hatchery winter-run juveniles released in river as a percent of total JPI estimated at RBDD (if more hatchery juveniles were released than were sampled at RBDD, hatchery juveniles would exceed 100% in the chart).

Another aspect of diversity that may be significant for winter-run is related to the age structure for this run where most fish return at age 3. There is evidence to suggest that age of maturity is at least a partially heritable trait for many fish, including Pacific salmonids, and activities such as fishing that result in consistent selective pressure can induce changes on a population scale (Ricker 1981; Law 2000; Hard et al. 2008). Winter-run does not express a great deal of diversity in this life history trait, as about 90% of returning fish are age 3 (although recently ~half the adult returns were 2 year olds, see Section 2.2.3.6). A more varied age structure, especially at the age of maturity, would provide more adaptive ability for this stock to respond to changing environmental conditions.

2.2.4.5 Summary of ESU Viability

There are several criteria for assessing the level of risk of extinction for the winter-run Chinook salmon ESU (Figure 2-9). Because there is still only one population that spawns below Keswick Dam, the winter-run Chinook salmon ESU is at a high risk of extinction in the long term (NMFS 2016). Recent trends for the mainstem Sacramento River winter-run population in those criteria are as follows:

1. Continued low abundance (Figure 2-3)
2. A negative growth rate over 6 years (2006 to 2012), which is two complete generations (Table 2-2)
3. A significant rate of decline since 2006 (Figure 2-4)
4. Increased hatchery influence on the population (Figure 2-7)
5. Catastrophic mortality due to extended drought causing very low egg to fry survival in 2014 (5.9%) and 2015 (~4%) with subsequent low adult returns and negative CRR in 2017 and anticipated in 2018.



Criterion	Risk of Extinction		
	High	Moderate	Low
Extinction risk from PVA	> 20% within 20 years – or any ONE of –	> 5% within 100 years – or any ONE of –	< 5% within 100 years – or ALL of –
Population size[a]	$N_e \le 50$ –or– $N \le 250$	$50 < N_e \le 500$ –or– $250 < N \le 2500$	$N_e > 500$ –or– $N > 2500$
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophe, rate and effect[d]	Order of magnitude decline within one generation	Smaller but significant decline[e]	not apparent
Hatchery influence[f]	High	Moderate	Low

[a] Census size N can be used if direct estimates of effective size N_e are not available, assuming $N_e/N = 0.2$.

[b] Decline within last two generations to annual run size ≤ 500 spawners, or run size > 500 but declining at $\ge$ 10% per year. Historically small but stable population not included.

[c] Run size has declined to ≤ 500, but now stable.

[d] Catastrophes occuring within the last 10 years.

[e] Decline < 90% but biologically significant.

[f] See Figure 1 for assessing hatchery impacts.

Figure 2-9. Criteria for assessing the level of risk of extinction for populations of Pacific salmonids (reproduced from Lindley et al. (2007)).

The most recent 5-year status review (NMFS 2016) on the winter-run ESU concluded that the sole mainstem Sacramento River population has increased from a low risk to a moderate risk of extinction. To summarize, the extinction risk for the winter-run ESU is high due to one remaining population located on the Sacramento River that is outside of its historical spawning distribution and dependent on artificially maintained habitat that is vulnerable to droughts and other catastrophes. Additionally, this mainstem Sacramento population has increased from a low risk to a moderate risk of extinction since 2005, and several listing factors have contributed to the recent decline, including hatchery influence exceeding 15% for several generations as well as reduced survival during drought and poor ocean conditions (NMFS 2016). Large-scale fish passage and habitat restoration actions are necessary for improving the winter-run Chinook salmon ESU viability (NMFS 2016).

Lindley et al. (2007) states that the winter-run ESU fails the “representation and redundancy rule” because it has only one population, and that population spawns outside of the eco-region in which it evolved. In order to satisfy the “representation and redundancy rule,” at least two populations of winter-run would have to be re-established in the basalt- and porous-lava region of its origin. An ESU represented by only one spawning population at moderate risk of extinction is at a high risk of extinction over an extended period of time (Lindley et al. 2007). There is only one population of winter run, and it depends on cold-water releases from Shasta Dam which makes them vulnerable to a prolonged drought (NMFS 2016). Based on the above descriptions of the population viability parameters, NMFS believes that the winter-run ESU is currently not viable and is at high risk of extinction as a single population representing the entire ESU in an apparent state of decline.

Although the current status of winter-run is poor and declining, remedial actions have been taken or are in the planning stages to improve the status of this ESU in the long run. A recovery plan for winter-run was completed in 2014 and it outlines the key stressors and recovery actions recommended. Some progress that has been made includes planning documents completed for Battle Creek reintroduction and planning documents in progress for Shasta Reintroduction. There has also been reinitiation of the Shasta RPA on water temperatures since there were two recent years of catastrophic mortality (>90%) due to failure to allocate enough cold water to maintain compliance with the 2009 Shasta RPA on the winter-run spawning ground. Two important remedies arose from this:1) a study indicated that the current temperature management schedule was not adequate to protect the earliest life-stages (Martin et al. 2016) and 2) the BOR and NMFS reinitiated a Shasta temperature management plan to better protect winter-run by using more conservative temperatures based on the best available science (NMFS 2017a).

Additional actions taken include improving passage at RBDD with the removal of the gates in 2012 as well as planning of restoration of 17,000 to 20,000 acres of floodplain habitat in the lower Sacramento, both are RPA actions of the 2009 NMFS Biological Opinion (NMFS 2009b). There are also efforts to restore habitat through California EcoRestore initiative introduced in 2015 and through the Central Valley Project Improvement Act (CVPIA). There has also been remedies to install weirs in areas known to falsely attract winter-run and other listed salmon to keep them from entering into the Colusa basin where it is believed ~300 winter-run adult spawners perished. These collective actions should help to remediate stressors that have been responsible for winter-run declines and help to restore the winter-run population.

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

In developing its annual recommendations for ocean salmon fisheries, the PFMC analyzes management options for fisheries occurring in the EEZ off the states of Washington, Oregon and California (*i.e.*, west coast EEZ). This analysis includes assumptions regarding the levels of harvest in state marine, estuarine, and freshwater areas, which are regulated under authority of the states and Federally recognized tribes with fishing rights. Due to the mixed stock nature of the fishery, the scope of the west coast EEZ that is open to salmon fishing and the length of time the areas are open in any one year depends on salmon stock abundances in excess of the conservation objectives and the spatial distribution of constraining stocks. NMFS establishes fishery management measures for ocean salmon fisheries occurring in the west coast EEZ based on the PFMC recommendations.

For the purposes of this Opinion, the action area is the U.S. west coast EEZ (which is directly affected by the management of ocean salmon fisheries by the PFMC and NMFS) and the marine waters, other than internal, of the states of Washington, Oregon, and California (which may be indirectly affected by management of ocean salmon fisheries by the PFMC and NMFS) (Figure 2-10). As described below, the ocean distribution of winter-run Chinook is primarily to the south of Point Arena, California. The analysis of the proposed action therefore focuses on the portion of the EEZ that is south of Point Arena.

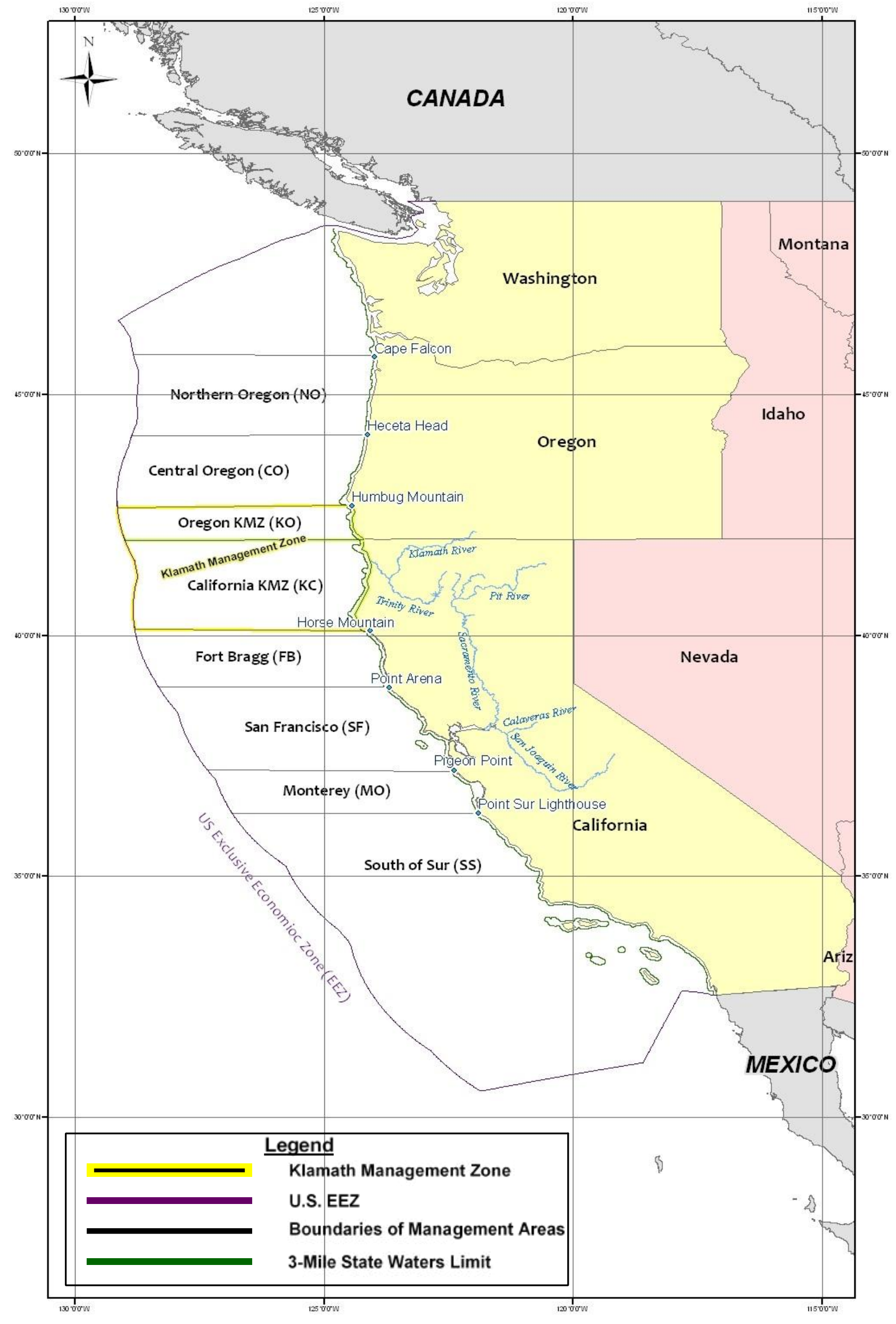


Figure 2-10. Map of the action area, including identification of Salmon FMP management areas.

2.4 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

The following environmental baseline section refers to the historical and current effects under the environmental baseline. However, by definition, the proposed action is not part of the environmental baseline, therefore no effects on winter-run from future PFMC salmon fisheries are assumed or implied in the baseline.

The discussion of activities under the environmental baseline that affect the winter-run ESU focuses on salmon and groundfish fisheries in the action area. We are not aware of other activities in the action area that affect the winter-run ESU.

2.4.1 Harvest Actions

2.4.1.1 Bycatch in Groundfish Fishery (Whiting and Bottom Trawl)

Salmon, particularly Chinook, are caught in the bottom trawl and whiting components of the groundfish fishery off the coasts of Washington, Oregon, and California. NMFS has conducted several section 7 consultations since early salmon ESA listings to determine effects of the fishery on ESA listed salmon. In each of the consultations, NMFS has determined that the incidental take of salmon in the fishery would not likely jeopardize the continued existence of the ESUs under consideration. The 1999 groundfish FMP opinion included an incidental take statement that permits the bycatch of 11,000 Chinook salmon in the whiting fishery (primarily a mid-water trawl) and 9,000 Chinook salmon in the bottom trawl component of the groundfish fishery (NMFS 1999b). Consultation on the groundfish fishery was reinitiated in 2006 as a result of data that indicated that the incidental take statement for Chinook salmon had been exceeded in some fashion in 3 out of 4 years between 2002 and 2005 (NMFS 2006). Ultimately, the supplemental biological opinion concluded that the fishery was not likely to jeopardize those ESUs and that the incidental take statement in place remained adequate for the groundfish fishery going forward. The groundfish trawl fishery operates in areas offshore most of the U.S. west coast, with the exception of southern California, but the amount of salmon bycatch associated with California Central Valley ESUs is not believed to be high. An earlier study of salmon bycatch in the whiting fishery estimated about 3% of the salmon were Central Valley fall-run, and no evidence of Sacramento winter-run was detected (Moran et al. 2009), although this finding was based on data from only one year. Based on additional information available from CWT recoveries, it seems likely that the bycatch of winter-run north of Point Arena would be minimal. There is little or no groundfish fishing south of Point Arena. NMFS recently completed a new consultation that considers new information related to the effects of the groundfish fishery on listed salmonids. Available information from 2008-2015 indicates take of Sacramento winter run would be negligible (Table 2-3) (NMFS 2017b).

Table 2-3. Average 2008-2015 (range) contribution by Chinook ESU to the at-sea and shoreside whiting fisheries used to assess stock composition of Chinook bycatch in this opinion.

Salmon ESU	% contribution to the catch	
	At-sea	Shorebased
Puget Sound Chinook salmon	7.0%	1.1%
Upper Columbia River Spring Chinook salmon	0.2%	0.0%
Upper Willamette River Chinook salmon	0.2%	0.0%
Lower Columbia River Chinook salmon	5.9%	4.1%
Snake River spring/summer Chinook salmon	0.2%	0.0%
Snake River fall Chinook salmon	1.5%	1.5%
California Coastal Chinook salmon	4.0%	2.5%
Sacramento winter-run Chinook salmon	0.0%	0.0%
Central Valley spring-run Chinook salmon	0.0%	0.0%

2.4.1.2 Bycatch in Coastal Pelagic Species Fisheries

Other fisheries that are known to incidentally take salmon as bycatch in the action area, Chinook salmon in particular, involve fisheries that target coastal pelagic species (CPS) such as sardines and squid. Typically, these fisheries involve a purse seine operation or some similar round haul net that is designed to surround and capture large aggregations of these species. The portion of the sardine fishery off the California coast where winter-run are likely to be encountered (south of Point Arena) has not been associated with much salmon bycatch (one salmon has been observed by dockside samplers in over 20 years of sampling (NMFS 2010a)). While other CPS fisheries, such as those targeting squid off California, might also be sources of salmon bycatch there is very little data available about salmon bycatch in these fisheries.

2.4.1.3 Salmon Ocean Fishery

Since 1977, salmon fisheries in the action area have been managed under the salmon FMP. PFMC fisheries have been a major source of mortality for Chinook salmon off the coast of California with nearly one million fish being harvested per year during the late 1980s (Table 2-4). It is unknown exactly what fraction of these fish were winter-run, but over that same period winter-run returns were reduced from historical levels as discussed in the Status Section (Section 2.2).

Table 2-4. Annual landings in California of Chinook salmon caught in the ocean salmon fishery.

Year (s)	Commercial	Recreational	Total
1976-1980[1]	618,637	92,422	711,059
1981-1985[1]	484,587	109,097	593,684
1986-1990[1]	795,767	166,396	962,163
1991-1995[1]	349,159	170,296	519,455
1996-2000[1]	368,001	157,742	525,743

2001-2005[1]	383,921	147,974	531,895
2006	69,728	96,292	166,020
2007	114,141	47,704	161,845
2008	-	6	6
2009	-	672	672
2010	15,088	14,809	29,897
2011	70,028	49,822	119,850
2012	215,585	123,926	339,511
2013	297,627	116,074	413,701
2014	168,283	74,840	243,123
2015	110,507	37,480	147,987
2016[2]	55,051	37,680	92,731

[1] average landing for those years.
[2] preliminary

After winter-run were listed under the ESA, the fishery was modified to reduce its effect on winter-run. Assessments of historical fishing impacts on winter run have been made previously, although the data and methods used may not be as reliable as those used in the modern analysis. A recent study that hindcasted historical fishing mortality rates for winter-run estimated that between the years 1978 through 2012, the impact rates were highest from the mid-1980's through the mid- 1990's ranging as high as 50 to 70% (O'Farrell et al. 2015). It was also evident from the study that recreational fisheries had the larger impact on winter-run starting in the mid-80's whereas the impact rate from commercial fisheries has declined steadily over the time series. These hindcasts generally captured the variation in the winter-run impact rates that could be estimated directly from coded-wire tag data by using cohort reconstruction methods (post 2000). Additionally, a comparison of the impact-rate hindcasts for winter-run were highly correlated to the Sacramento River fall Chinook (SRFC) harvest rates, south of Point Arena, where both populations have been subjected to the same fisheries. This correlation for the years in which the SRFC harvest rate is estimable from coded-wire tag data helps support the hindcasting methods used in the study. Since 2000, the impact rates have been reduced and generally range around 20% with the exception of 2008 and 2009 when the commercial and recreational fisheries were closed (Figure 2-11). The Effects Analysis below will describe the effects of the fishery on winter-run under the proposed harvest control rule.

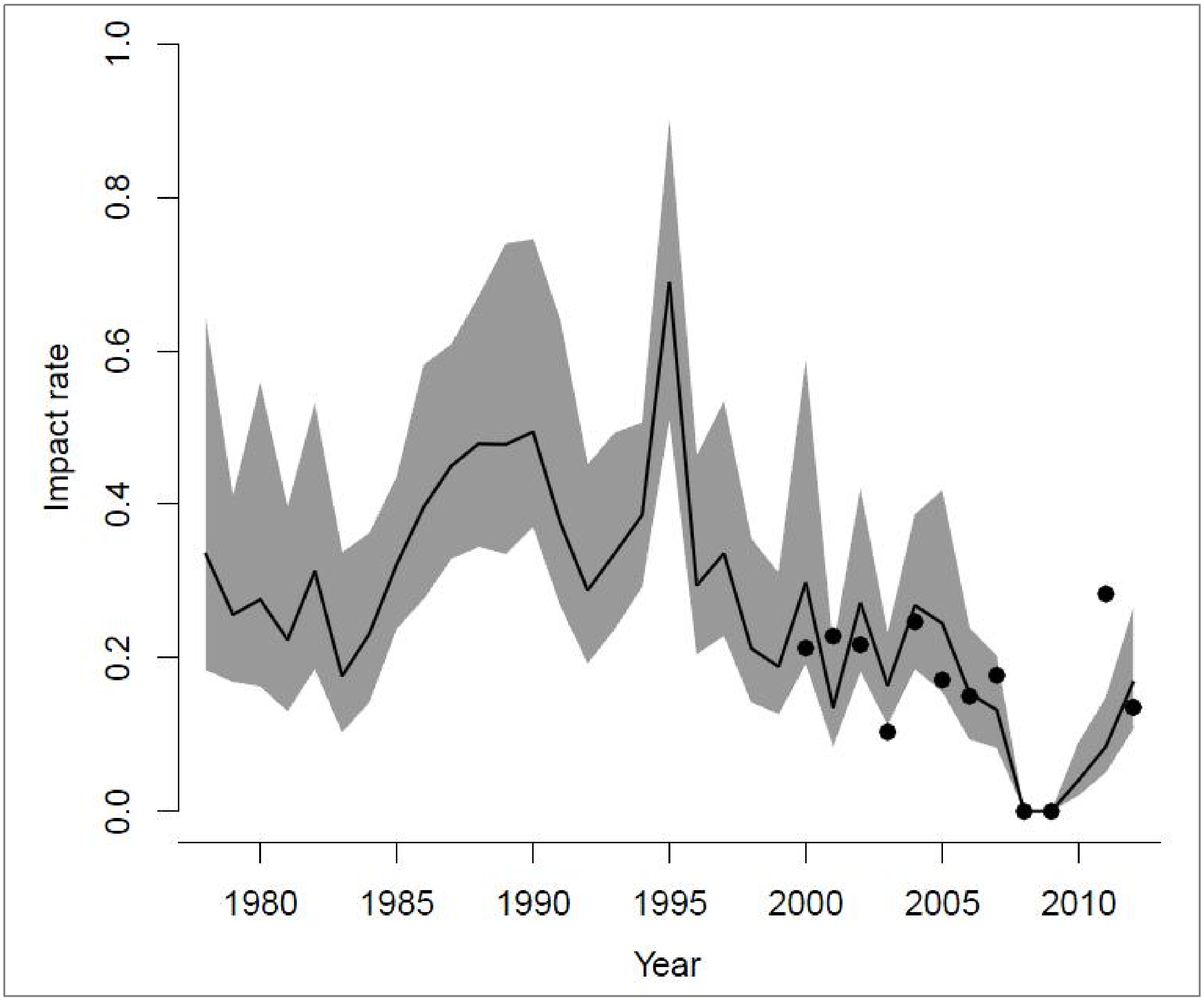


Figure 2-11. Time series of hindcast impact rates for the years 1978–2012 for Sacramento River winter Chinook salmon (Oncorhynchus tshawytscha) south of Point Arena, California. The black line represents the median, and the shaded area indicates the 0.68 percentile interval of the bootstrap distribution (O'Farrell et al. 2015). The dots indicate estimates of the impact rate derived with cohort reconstruction methods.

CWT recoveries from salmon landed in the ocean fishery indicate that winter-run CWTs are recovered predominantly from San Francisco (SF) and the Monterey (MO)(includes the South of Sur (SS) management area that extends to the U.S./Mexico border) in both the commercial and recreational ocean salmon fisheries for age 3 and age 4 fish (Figure 2-12).

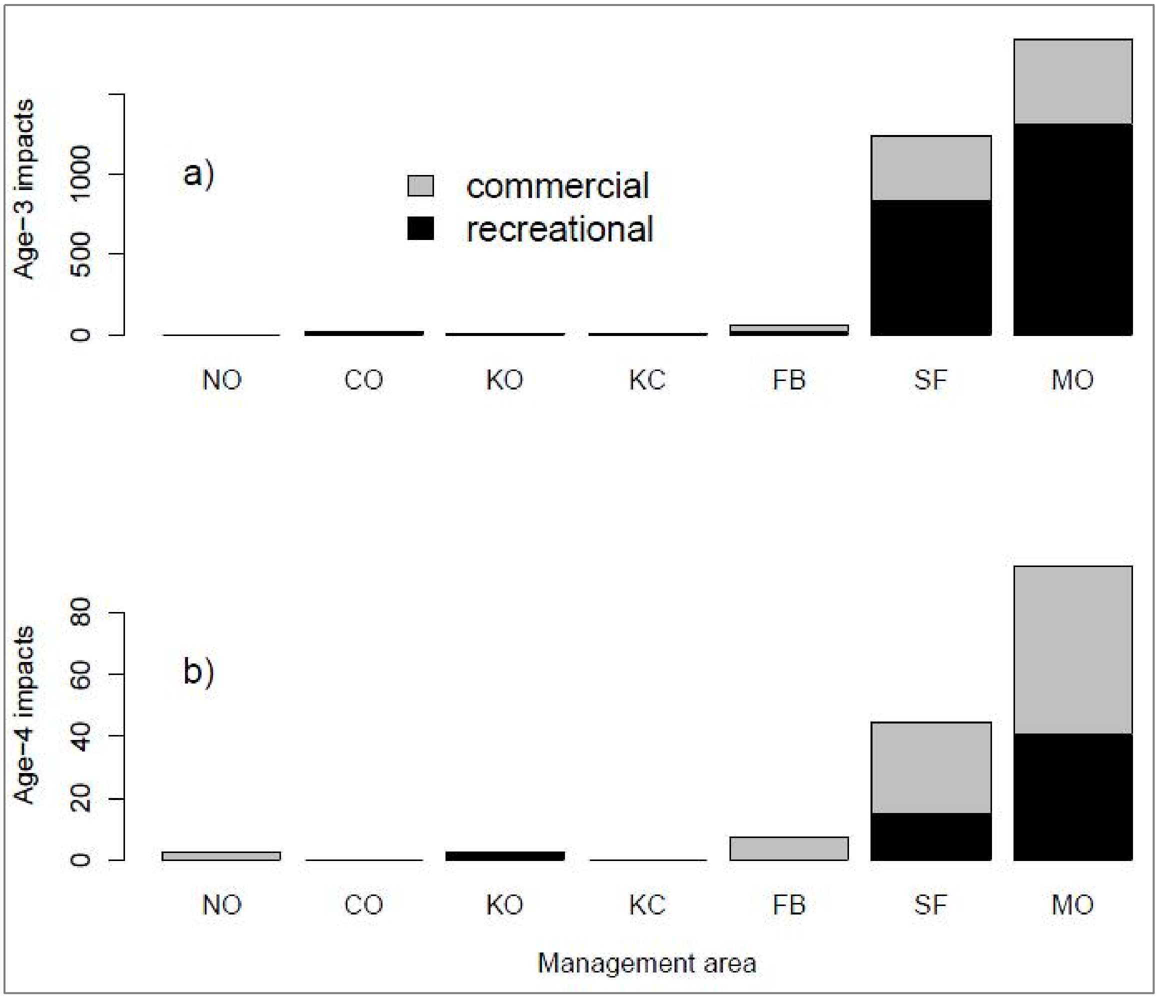


Figure 2-12. Ocean fishery impacts for hatchery-origin (a) age-3 and (b) age-4 Sacramento River winter Chinook salmon estimated by ocean fishery management area. Total impacts by area are the sum of impacts over calendar years 2000–2015 (Management area abbreviations are defined in Figure 10).

Winter-run impact rates for 2004 and 2005 stand out as having the highest impacts though coinciding with large winter-run returns for the calendar years associated with those impacts (2005 and 2006) (Figure 2-3). The least impacts logically occurred when the fisheries were closed in 2008 and 2009 (Figure 2-13). It is also evident that recreational fishing takes a larger toll on winter-run three year olds and commercial fishing takes a larger toll on winter-run four year olds. This is in part due to the ability of recreational fisheries to harvest the smaller size three year olds (20 inch size limit) whereas most three year old winter-run would not meet minimum size requirements under commercial fishing (26 or 27 inch size limit depending on time and area) until the fall (Figure 2-14).

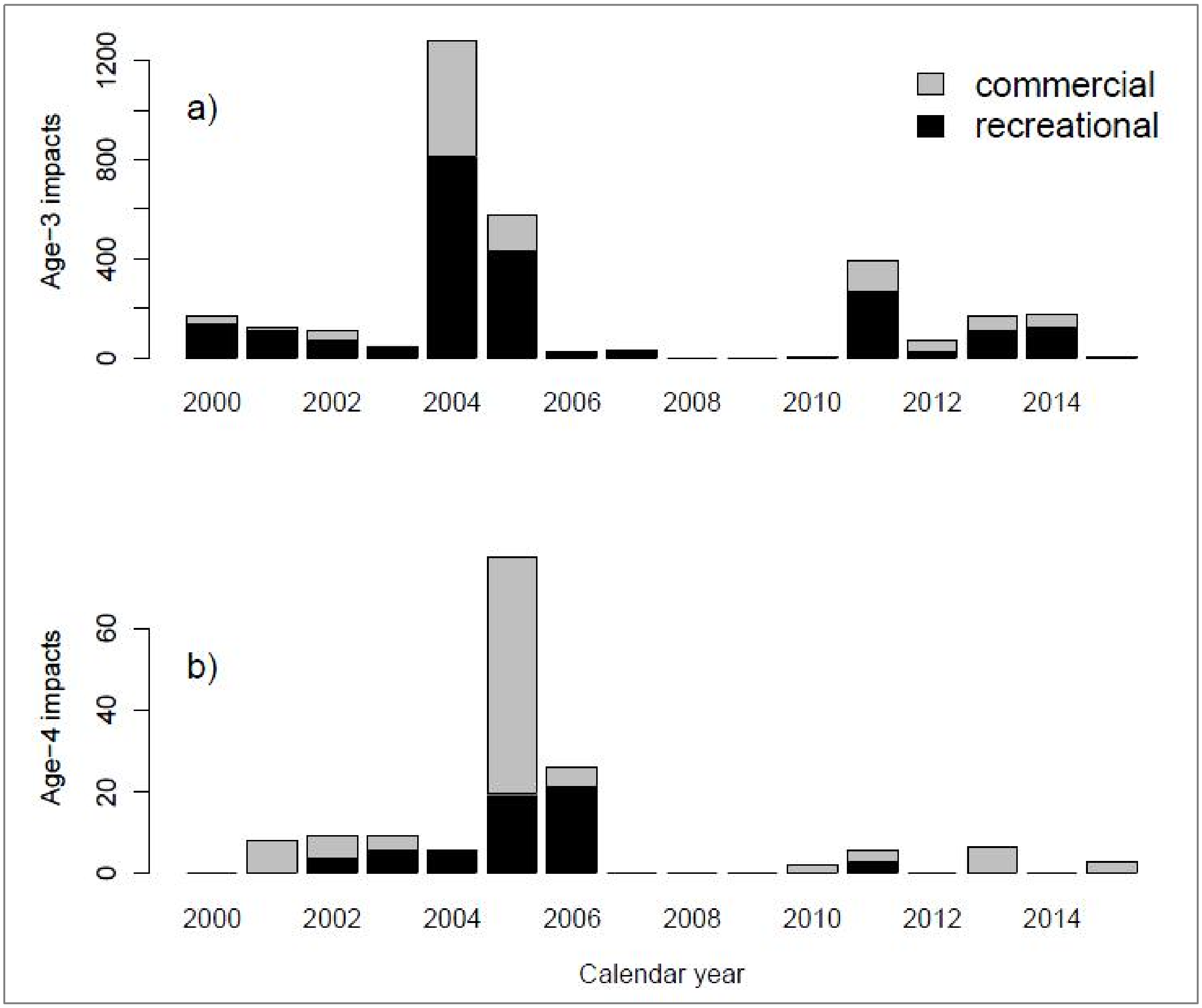


Figure 2-13. Ocean fishery impacts for hatchery-origin (a) age-3 and (b) age-4 Sacramento River winter Chinook estimated by calendar year. Total impacts by year are the sum of impacts over all ocean fishery management areas.

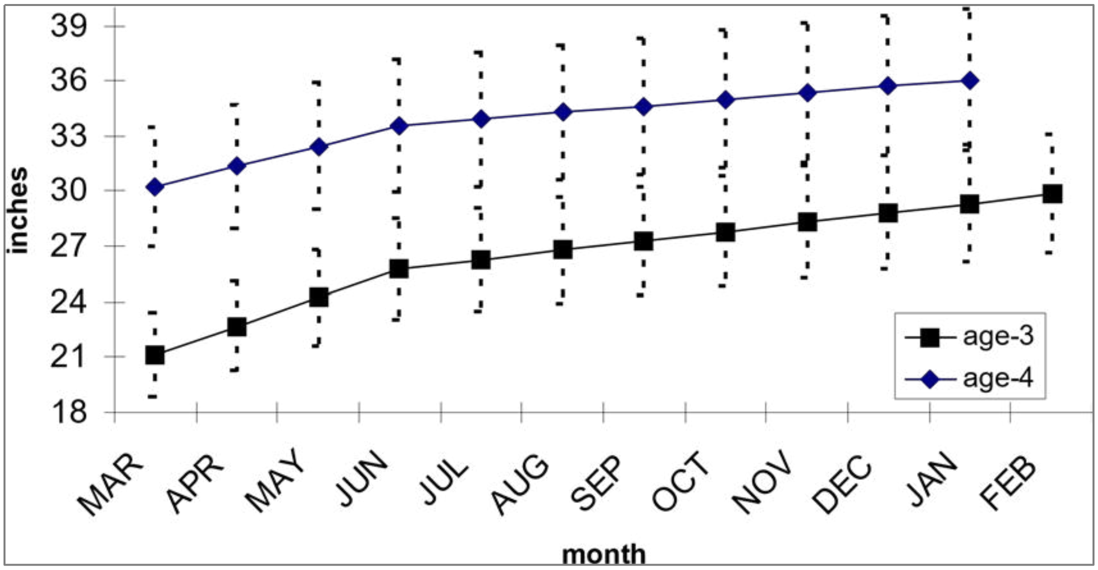


Figure 2-14. Average size at age of winter-run with one standard deviation (confidence interval of about 70%) (CDFG 1989; O'Farrell et al. 2010).

The temporal pattern of Chinook salmon harvest in the recreational fisheries is illustrated in Figure 2-15 and Figure 2-16. In the recreational fishery, most harvest impacts occurred in April and July. In 2004, season restrictions were put in place during February and March to allow more escapement of winter-run adults. Overall, the trend in months with the greatest catch has remained consistent since the new season restrictions were put in place.

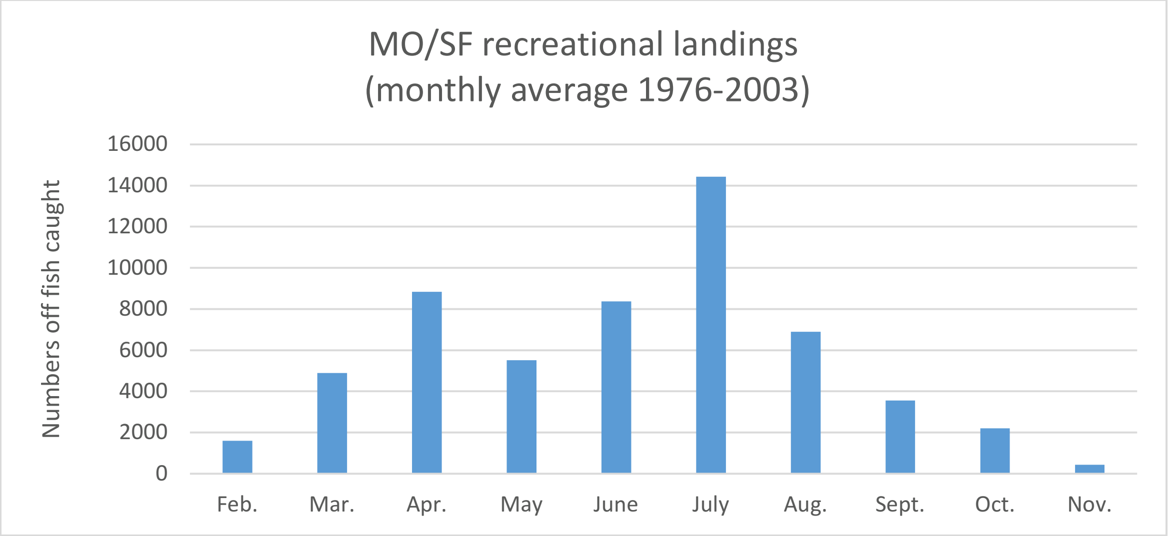
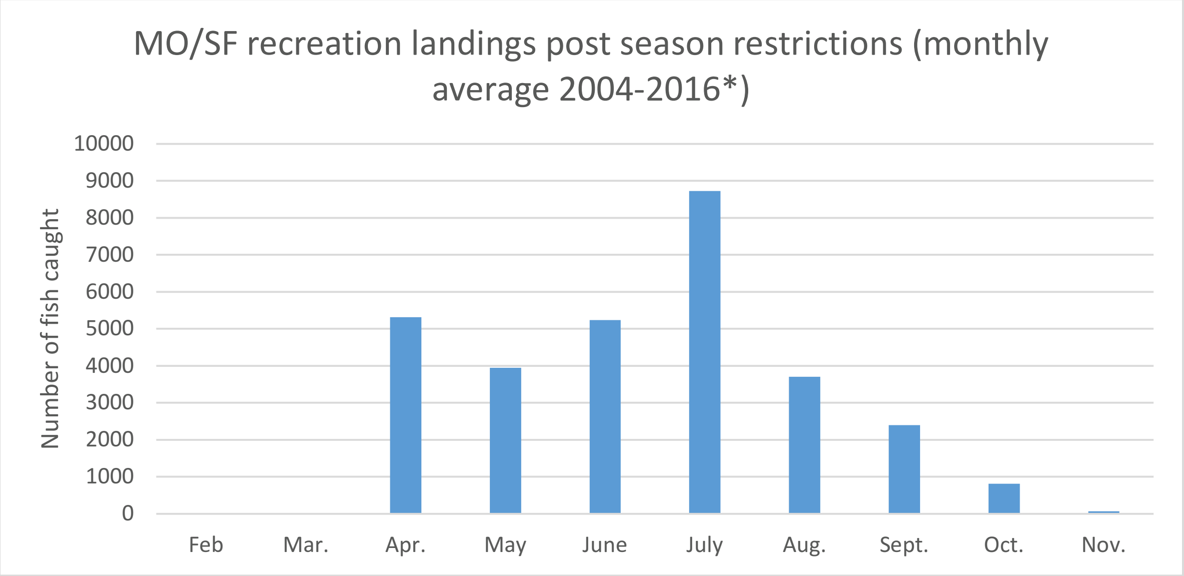


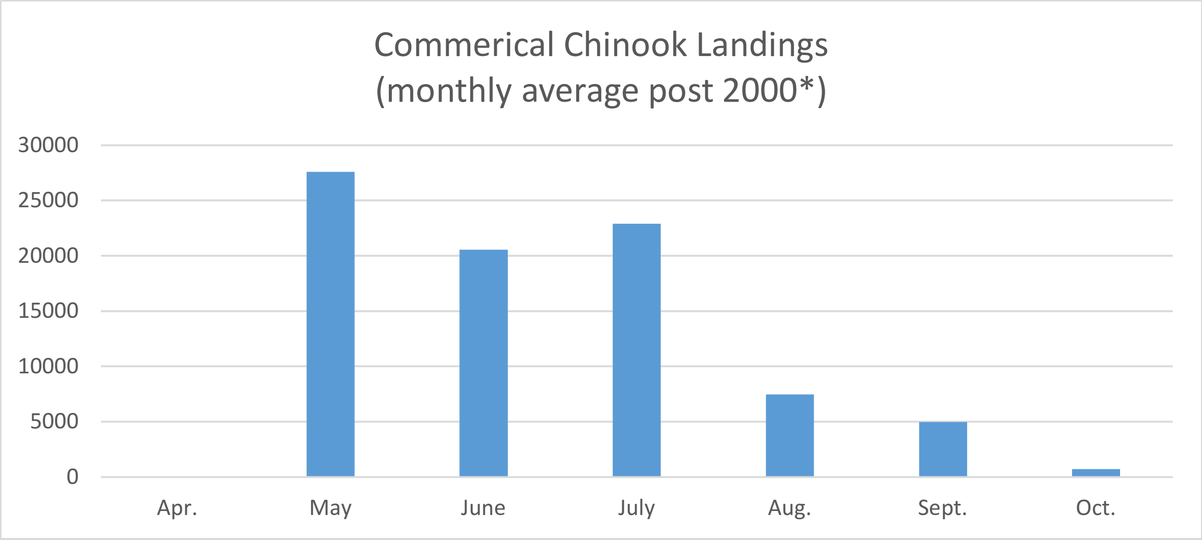
Figure 2-15. Recreational average landings of Chinook salmon by month prior to season restrictions in the San Francisco and Monterey management zones.
From: *http://www.pcouncil.org/wp-content/uploads/2017/04/2017_App_A_Hist_Catch_and_Effort.xlsx* *(table A-5)*



*Years 2008/2009 were omitted from average as the fisheries were closed

Figure 2-16. Recreational average landings of Chinook salmon by month in the San Francisco and Monterey management zones.
From: *http://www.pcouncil.org/wp-content/uploads/2017/04/2017_App_A_Hist_Catch_and_Effort.xlsx (table A-5).*

Commercial harvest of Chinook salmon south of the San Francisco management area has not occurred prior to April since 2000 (Figure 2-17). Most of the harvest impacts in the commercial fishery occurred from May through July in the San Francisco and Monterey management areas.



** Years 2008/2009 were omitted from average as the fisheries were closed*

Figure 2-17. Commercial average landing of Chinook salmon by month in the San Francisco and Monterey Management zones.
From: http://www.pcouncil.org/wp-content/uploads/2017/04/2017_App_A_Hist_Catch_and_Effort.xlsx *(Table A-3).*

Under the current winter-run harvest control rule, allowable impact rates have remained under 20% and averaged 16.1% between 2012 and 2017 (Table 2-5). Post season assessment of actual impact realized is available for three of those years (2012-2014) and indicates compliance in one of the years although the exceedance in 2014 was small. From 2015-2017 the impact rates were set below the maximum allowed to provide additional protection in response to drought conditions, poor juvenile survival, and adverse ocean conditions that were apparent at the time. Each year assessments are made after data is collected and adjustments are considered to help better predict and manage for the allowable impact rate in the future.

Table 2-5. Maximum allowable and post season estimated impact rate on winter-run under the current harvest control rule*. Impact rates were reduced below the allowable limit from 2015-2017 and are shown in parenthesis.

Year	**Maximum Allowable Impact Rate**	**Post Season Estimated Impact Rate**
2012	13.7	12.6
2013	12.9	18.8
2014	15.4	15.8
2015	19.0 (17.5)	n/a
2016	19.9 (12.8)	n/a
2017	15.8 (12.2)	n/a

*n/a not available- insufficient or incomplete cohort data

In considering the pattern of fishing, it is important to understand how the interplay of fishery management given FMP conservation objectives for target stocks (Sacramento River Fall Chinook (SRFC) and Klamath River Fall Chinook (KRFC) in the southern areas) and consultation standards for ESA-listed stocks (primarily winter-run and California Coastal Chinook (CCC)) has worked to shape to the fishery in the southern areas in recent years. The history for quite a while now has been:

- the recreational fishery south of Pt. Arena has been constrained primarily by the winter-run consultation standards (except for 2008 and 2009.
- the commercial fishery south of Pt. Arena has been frequently constrained by the KRFC conservation objective and harvest control rule that sets minimum natural-area spawner levels and maximum exploitation rates on an annual basis.
- the commercial fishery is occasionally constrained by the CCC standard, which calls for no greater than 16% age-4 ocean harvest rate on KRFC (has happened a few years since 2003).
- almost all recreational and commercial fishing was closed in 2008 and 2009 because of the poor returns of SRFC.

All of these objectives and measures collectively combine to minimize the effort and potential impacts to all stocks, including winter-run.

In its most recent 5-year status review NMFS considered the effects of harvest and actions that have been taken to reduce harvest and concluded that it is highly unlikely that overutilization has been a key factor limiting winter-run Chinook (NMFS 2016).

2.5 Effects of the Action

Under the ESA, “effects of the action” means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

Salmon fisheries may affect winter-run Chinook salmon in several ways that have bearing on the likelihood of continued survival and recovery of the species. Immediate mortality occurs from the capture, by hook or net, and subsequent retention of individual fish - those direct effects are considered explicitly in the following subsection of this opinion.

In addition, other effects occur when fish that are caught and released alive to comply with non-retention requirements that may be related to species or size limits are injured or subsequently die. Non-retention regulations are also sometimes used in mark-selective fisheries that target marked hatchery-origin fish for retention while requiring the release of unmarked fish. These effects are accounted for in the review of fishery management actions, as catch-and-release mortalities primarily result from implementation of management regulations designed to reduce mortalities to listed natural-origin fish through live release.

The catch-and-release mortality rate varies for different gear types, different species, and different fishing conditions, and those values are often not well known. Catch-and-release mortality rates have been estimated from available data and applied by the PFMC Salmon Technical Team (STT) and co-managers in the calculation of impacts to listed fish evaluated in this consultation. The SST applies a 14% incidental mortality rate (IMR) to the recreational fisheries on Chinook salmon captured north of Point Arena (PFMC 2008) and the STT applies a release mortality rate for recreational fisheries to Chinook salmon south of Point Arena that varies from year to year and is based on the incidence of "mooching" a fishing technique that involves drifting bait (as opposed to trolling) (PFMC 2008). For commercial ocean troll fisheries, the IMR is 26% for Chinook salmon (PFMC 2008).

The STT also applies an IMR to Chinook salmon that encounter the gear but drop off the gear before they can be handled by the fishermen. This is because they escape the hook, break the line, or otherwise fall off the gear. Also, some fish are depredated by other animals while they are being retrieved from the gear by fishermen. Most notably in California, this commonly involves pinniped species such as California sea lions (*Zalophus californianus*) and harbor seals (*Phoca vitulina)* (STT 1994; STT 2000; Hanan 2004; Weise and Harvey 2005). This drop off or 'other' mortality is estimated as five percent of total encounters for commercial troll and recreational gear (PFMC 2008). Estimates of catch-and-release mortality are combined with landed catch estimates when reporting the expected total mortality, and so are also specifically accounted for in this opinion.

The action is defined in Section 1.3. In simple terms, the proposed action is the management of PFMC salmon fisheries using a management framework that includes the size and area limits listed in Table 1-3 and the harvest control rule for winter-run shown in Figure 1.1 starting in 2018.

This analysis takes into account the effects on winter-run of harvest that occurs in state marine area fisheries as well as fisheries in the EEZ. The harvest that occurs in these state marine area fisheries are specifically included in the overall assessment of the impacts of PFMC salmon fisheries that are reported as part of the overall impact in the PFMC's preseason and postseason reporting documents and relied on for assessing impacts in this consultation.

As described in Section 2.2.2.5, all winter-run hatchery fish are fin-clipped and have CWTs. Reconstruction of CWT data has indicated that the winter-run hatchery fish are distributed primarily south of Point Arena and recent GSI sampling confirms this is also true for naturally spawned winter-run. The confirmation that naturally spawned winter-run are spatially distributed similarly to the CWT hatchery fish in the ocean, provides evidence that hatchery winter-run are a good surrogate for understanding winter-run spatial distribution and the location restrictions in place are effective for both (Satterthwaite et al 2015, Bellinger et al 2015, O'Farrell et al 2012). The size limits and fishing time and location restrictions that will continue to apply to fisheries south of Point Arena were included in the 2010/2012 RPA and were intended to limit fishery impacts to winter-run to 20%.

As discussed previously, the PFMC recommended that NMFS approve the use of CR10, in conjunction with the size, time and location limits described above, to limit fishery impacts on winter-run in 2018 and beyond. CR10 provides for a gradual reduction in impact if winter-run forecast of escapement declines below the most recent 10 year escapement mean of ~3,000 and an option of *de-minimis* fishing if escapement falls below 500 spawners (Figure 2-18c). The PFMC's SRWC Workgroup used a Management Strategy Evaluation (MSE) to test harvest strategies to meet management objectives while balancing trade-offs amid competing management objectives. Initially, the Workgroup evaluated nine harvest control rules covering a broad range of effects including the existing control rule (CR8) and bounded by control rules representing no harvest (minimal impact) and a control rule set at a constant 34% impact rate that approximates historical harvest levels (maximum impact) as determined from hindcasts (O'Farrell and Satterthwaite, 2015). The Workgroup produced a report titled "Evaluation of Alternative Sacramento River Winter Chinook Salmon Control Rules: Updated Management Strategy Evaluation Analysis," which includes a description of the control rules and analysis of the tradeoffs between conservation and fishery related outcomes and is wholly incorporated into this Opinion (AD Hoc SRWC Workgroup 2017a). Key parts of this analysis are discussed below.

In this Effects Analysis, we focus in particular on the effects of CR10 on the winter-run population and how it compares to the effects of the existing control rule (CR8) and to the no harvest control rule (CR1) (Figure 2-18 a,b,c) (AD Hoc SRWC Workgroup 2017a, AD Hoc SRWC Workgroup 2017b) as evaluated by the MSE. As CR8 is the existing control rule and is part of the 2012 RPA which NMFS previously determined to effectively reduce fishery impacts when winter-run abundance is projected to be low, comparing its effects with those of CR10 provides an informative contrast. Similarly, comparing the effects of CR10 to those of the no-fishing control rule provides a complete description of CR10's effects.

A distinguishing feature of CR10 compared to CR8 is that it uses estimates of juvenile abundance rather than the three-year geometric mean of prior escapements. CR10 was developed specifically to be more forward looking and to take advantage of available estimates of juvenile abundance and survival rates. The importance of this alternative approach was underscored in 2015 and 2016, in particular, when juvenile survival rates reached record lows. The analysis of the alternative discussed below takes the effects of these alternative approaches into account.

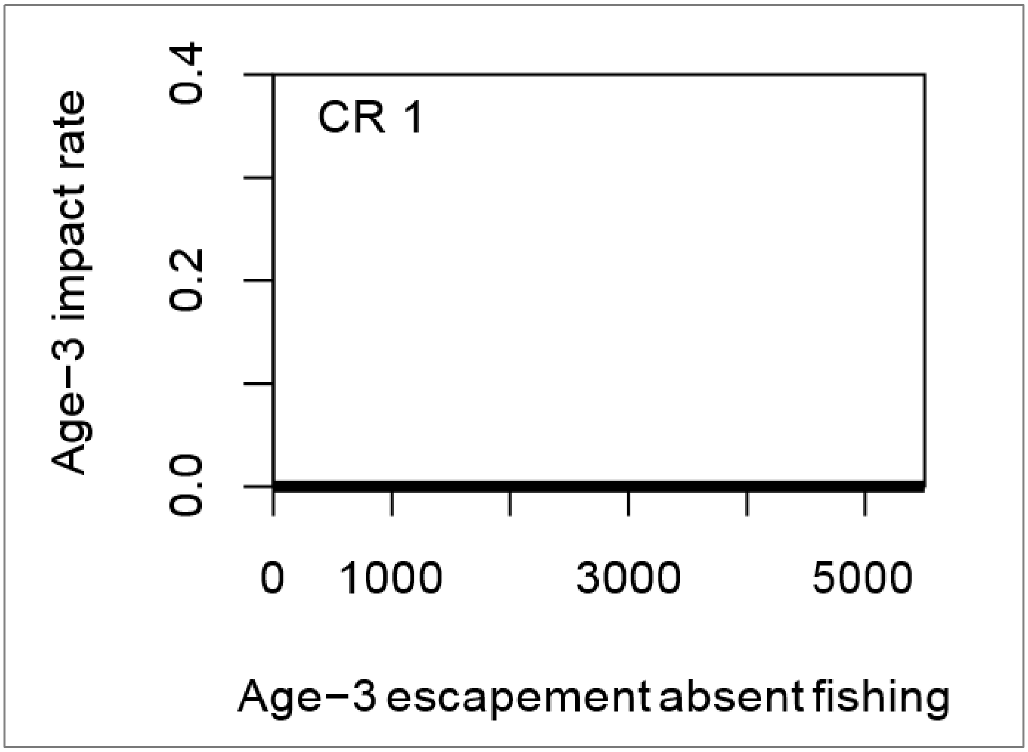


Figure 2-18a. CR1 – no harvest control rule (Ad Hoc SRWC Workgroup 2017a).

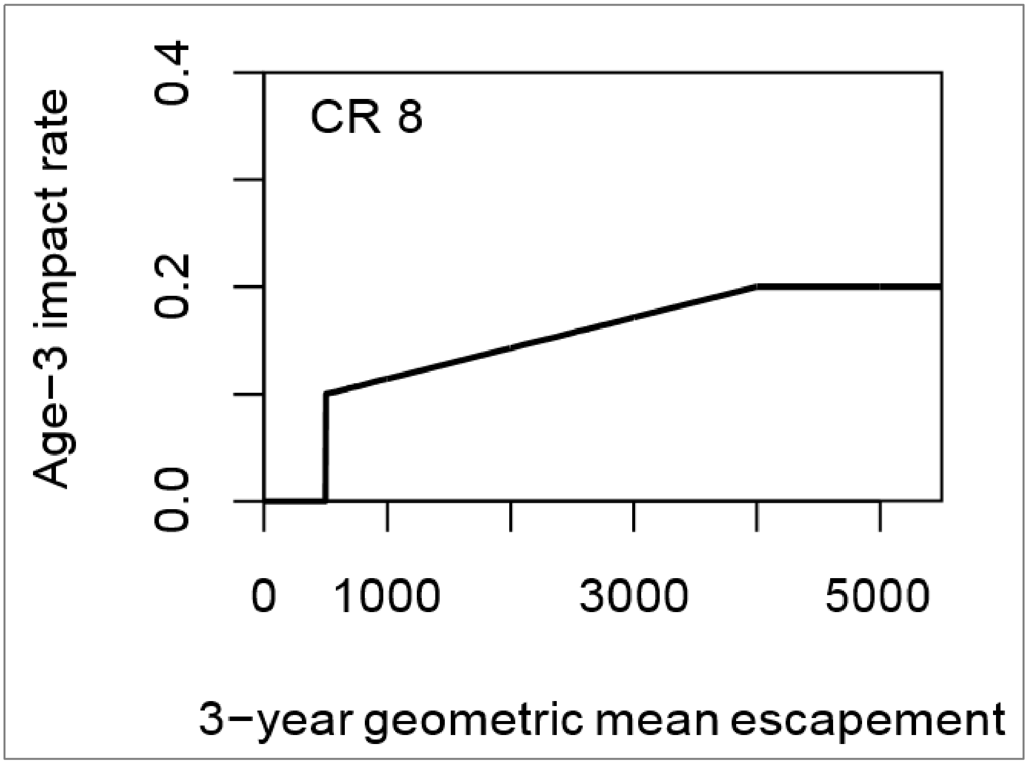


Figure 2-18b. CR 8 (existing control rule) (Ad Hoc SRWC Workgroup 2017a).

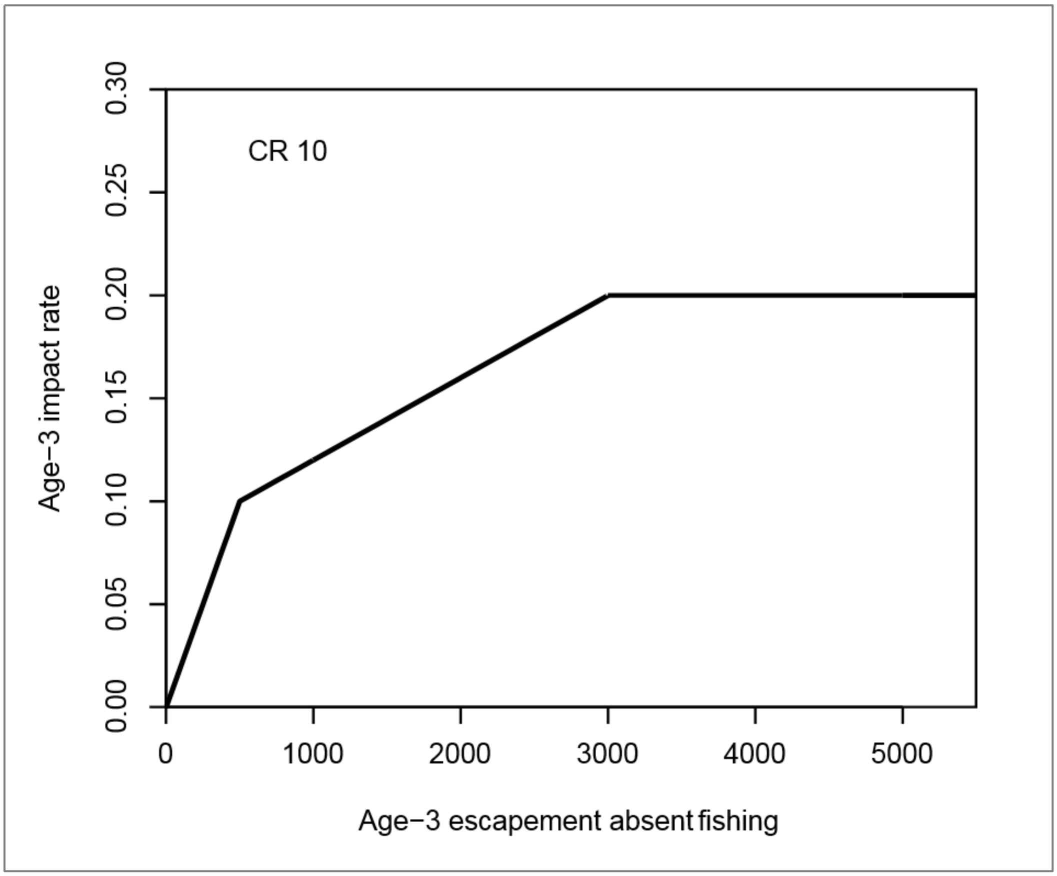


Figure 2-18c. CR10 – proposed harvest control rule (Ad Hoc SRWC Workgroup 2017b).

Figure 2-18. Harvest control rules evaluated by SRWC Workgroup a) no harvest (CR1), b) existing control rule (CR8), c) proposed control rule (CR10).

The performance of control rules with regard to effects on the SRWC population was evaluated based on the number of spawners and extinction risk criteria NMFS previously developed for Central Valley salmonids (Lindley et al. 2007). Four simulation scenarios were included in the MSE analysis, 1) the Base scenario, 2) the Autocorrelation (AC) scenario (temporal autocorrelation in the juvenile survival rate), 3) the Variable productivity (VP) scenario (temporal variability in the maximum egg-to-fry survival rate based on river temperature), and 4) the Perfect knowledge (PK) scenario (assumes that forecasts of the age-three escapement absent fishing are known without error). The scenarios were used to explore the sensitivity of model outcomes against a range of alternative assumptions. The key variables in the analysis were the egg-to-fry survival rates and juvenile survival rates (survival from the fry stage to the end of the first year in the ocean). The Base scenario, for example, assumed that the egg-to-survival rate was constant and there was no autocorrelation in the juvenile survival rate. Autocorrelation occurs when variables tend to be similar from one year to the next. For example, if juvenile survival is low in one year, it is more likely to also be low in the next year. The AC scenario was designed to examine the consequences of autocorrelation. It is clear that river temperature has a significant effect on egg-to-fry survival. Eggs and fry just do not survive well at higher temperatures. The VP scenario therefore examined the consequences depending on how river temperature might vary in the future. The PK scenario was also used to examine different assumption about the length and frequency of droughts and climate change. It is sometimes difficult to interpret the results of a complex model when several things are changing at one time. The PK scenario was designed to examine how the model behaves when we remove the uncertainty related to the forecast. The PK scenario therefore assumes the forecasts of escapement are known without error.

The MSE model, and parameter values used in the model, are described in O'Farrell (2017a) and previously in Winship et al. (2012, 2013). The MSE results presented in this report are the result of 20,000 simulations of 100 years in duration, performed for each control rule and simulation scenario.

2.5.1 Performance Measures

The following performance measures were used to evaluate the conservation benefits of the alternative control rules.

1. The mean and 95% intervals of spawner abundance in the final year of the 20,000 simulations ($t = 100$).

2. The proportion of simulations that resulted in a moderate or high risk of extinction for the population size criterion (Lindley et al. 2007). A moderate risk of extinction for this criterion results when the three-year sum of escapement (S) is less than or equal to 2,500, but greater than 250. A high risk of extinction for this criterion results when S is less than or equal to 250 fish.

3. The proportion of simulations that resulted in a moderate or high risk of extinction for the catastrophe criterion (Lindley et al. 2007). The catastrophe criterion ascribes extinction risk on the basis of generational changes in population size. A moderate risk of extinction occurs if there is at least one decline in population size between 50 and 90% over the last seven non-overlapping generations. A high risk of extinction occurs if there is at least one decline in population size greater than or equal to 90% over the last seven non-overlapping generations. See Winship et al. (2012) for details regarding how this criterion is defined.

4. The proportion of instances across all simulations in years $30 \le t \le 99$ where the control rule specified age-3 impact rate was greater than or equal to 0.20. We also calculate the proportion of instances in years $30 \le t \le 99$ that fell into allowable impact rate bins to evaluate the degree of the constraint to fisheries when the impact rate is reduced below the maximum level of 0.20.

5. The mean and 95% interval of the realized age-3 impact rate (the impact rate experienced by the population after accounting for implementation error and demographic stochasticity) in years $30 \le t \le 99$. The proportion of instances in years $30 \le t \le 99$, falling into impact rates bins was also calculated.

6. The minimum number of spawners for each control rule across all simulations in years $31 \leq t \leq 100$.

7. The conditional response to a spawner abundance less than or equal to a threshold level of 100 fish. The geometric mean of spawners was computed over the three years following an escapement at or below the threshold.

2.5.2 Results

Table 2-6 and Figure 2-19 (first row – spawners) show the results for performance measure 1: The mean and the 95% interval of the spawner abundance in the final year (after 100 years) for each of the 20,000 simulations.

Performance measure 1 tells us how many spawners we can expect to see at the end of the 100 year simulation period. CR1 (no harvest) has the greatest number of mean spawners when compared to CR8 and CR10, but there is little difference between CR8 and CR10. It is a common theme that CR1 has the greatest conservation benefit as it entails no ocean harvest. It is not surprising that mean spawner abundance is reduced when fisheries are implemented. Under performance measure 1, all control rules and scenarios evaluated have a mean spawner abundance projected to exceed the abundance related benchmark of 2,500 spawners (Table 2-6).

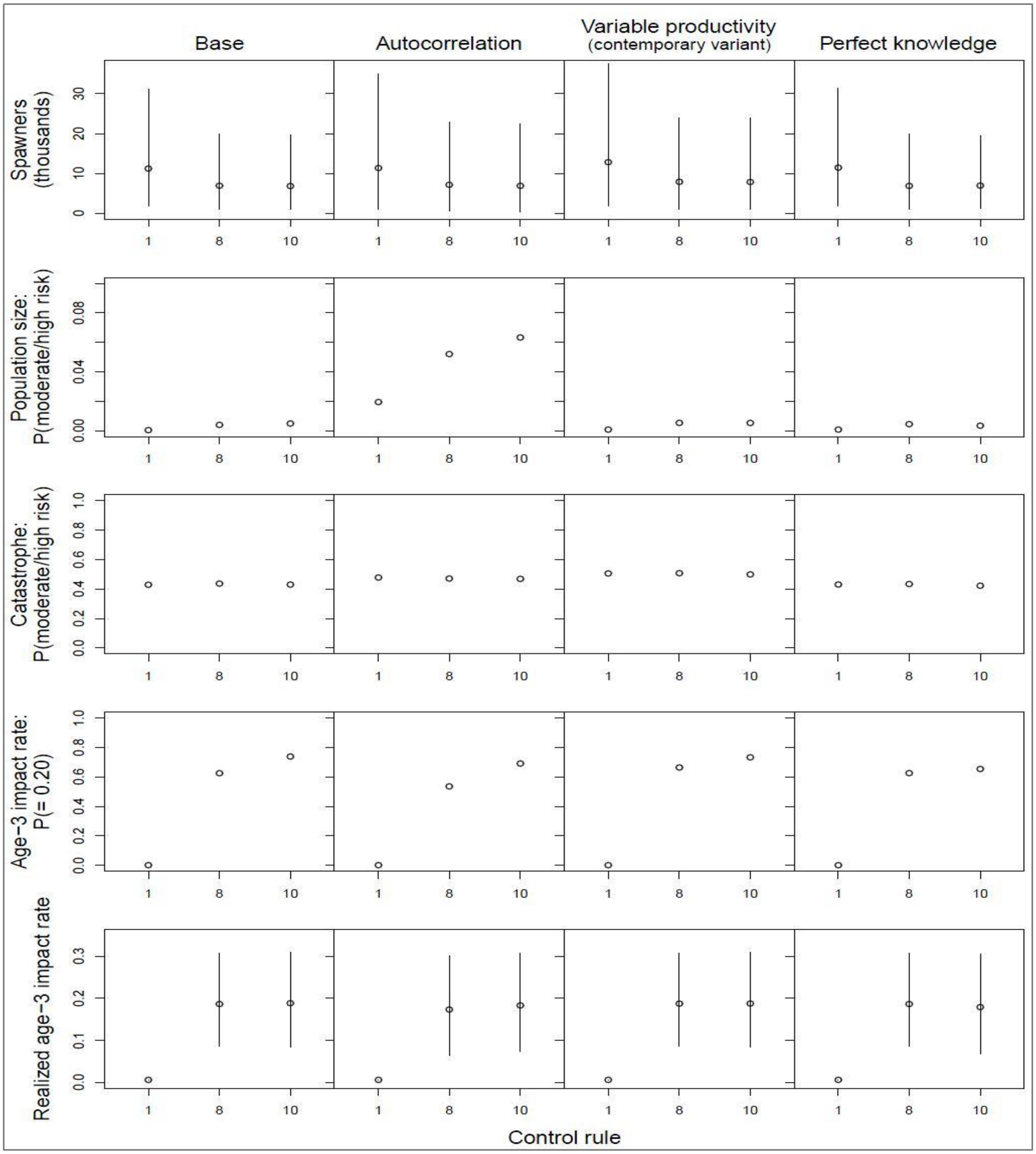


Figure 2-19. Performance measures evaluated for the three control rules and four scenarios. For "Spawners" and "Realized age-3 impact rate" the circles represent mean values and vertical lines denote the 95% intervals of the distribution. Circles for the other performance measures denote point estimates. The "Age-3 impact rate" performance measure denotes the allowable impact rate specified by the control rule. The "Realized age-3 impact rate" is the rate experienced by the population after accounting for implementation error.

Table 2-6. Mean spawner abundance across control rules and scenarios*.

Control Rule	**Base**	**AC**	**VP**	**PK**
1	11,241	11,369	12,847	11,459
8	6,935	7,186	7,910	6,912
10	6,852	6,925	7,881	6,963

**Scenario abbreviations include AC: Autocorrelation, VP: Variable productivity, and PK: Perfect knowledge.*

Table 2-7 and Figure 2-19 (second row – population size) show the results for performance measure 2: The proportion of simulations that resulted in a moderate or high risk of extinction for the population size criterion (Lindley et al. 2017).

Recall that a moderate risk of extinction occurs when the three-year sum of escapement (*S*) is less than or equal to 2,500, but greater than 250. A high risk of extinction occurs when *S* is less than or equal to 250 fish. CR1 had the lowest risk of extinction under all scenarios compared to CR8 and CR10. When comparing CR10 to CR8, results were very similar for the Base, VP, and PK scenarios with a low risk of extinction occurring over 99% of the time. There was some additional risk indicated under the AC scenario that assumed greater correlation in juvenile survival rates meaning, for example, that low survival in one year is more likely to be followed by low survival in the next. The proportion of simulations with a moderate risk of extinction was 1.9% for CR1 compared to 5.1% and 6.1% for CR8 and CR10, respectively. Overall, the majority of the simulations under all scenarios resulted in a low risk of extinction, meaning that the three-year sum of escapements rarely fell below 2,500 fish.

Table 2-7. Proportion of simulations resulting in high, moderate, and low risk of extinction for the populations size criterion across control rules and scenarios*.

CR	**Base**			**AC**			**VP**			**PK**		
	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	1.000	0.000	0.000	0.981	0.019	0.000	0.999	0.001	0.000	0.999	0.001	0.000
8	0.996	0.004	0.000	0.948	0.051	0.001	0.995	0.005	0.000	0.996	0.004	0.000
10	0.995	0.005	0.000	0.937	0.061	0.002	0.995	0.005	0.000	0.997	0.003	0.000

*Scenario abbreviations include AC: Autocorrelation, VP: Variable productivity, and PK: Perfect knowledge.

Table 2-8 and Figure 2-19 (third row – catastrophe) show the results for performance measure 3: The proportion of simulations that resulted in a moderate or high risk of extinction for the catastrophe criterion (Lindley et al. 2007).

Performance measure 3 analyzes generational changes in population size. It is looking to see if there are large changes in abundance (more than 50% or more than 90%) between non-overlapping generations. The proportion of simulations that resulted in a low risk of extinction were similar for all control rules under all scenarios. There was little difference in the risk metrics even when comparing CR1, the no fishing alternative, to CRs 8 and 10.

Table 2-8. Probability of high, moderate, and low risk of extinction for the catastrophe criterion across control rules and scenarios*.

CR	Base			AC			VP			PK		
	low	med	high	low	med	high	low	med	high	low	med	high
1	0.571	0.427	0.002	0.522	0.468	0.011	0.494	0.499	0.007	0.569	0.430	0.001
8	0.563	0.435	0.002	0.528	0.460	0.012	0.492	0.500	0.008	0.566	0.432	0.003
10	0.570	0.429	0.002	0.531	0.457	0.012	0.500	0.493	0.007	0.577	0.421	0.002

*Scenario abbreviations include AC: Autocorrelation, VP: Variable productivity, and PK: Perfect knowledge.

Table 2-9 and Figure 2-19 (fourth row – Age-3 impact rate) show the results of performance measure 4: The proportion of instances across all simulations in years 30≤t ≤99 where the control rule specified age-3 impact rate was greater than or equal to 0.20. Also shown is the proportion of instances in years 30≤t ≤99 when the impact rate is reduced below the maximum level of 0.20 and falls within specified bins.

To summarize the results for performance measure 4; under CR1, there is no salmon harvest allowed so the specified impact rate is always zero. The maximum allowable impact rate occurs more frequently under CR10 than CR8 and the complete closure of the salmon fishery due to winter-run population status does not occur under CR10. This is because *de minimus* fishing is allowed on target salmon stocks under CR10 whereas under CR8, if the three-year geometric mean of spawners were to fall below 500, the salmon fishery would be closed. In the AC scenario, 3% of the simulations indicated no allowable impact rate under CR8 (Table 2-9) compared to 0% of simulations under CR10.

The modeling simulations show that there is a small difference in harvest opportunities between CR8 and CR10 with CR10 allowing more potential harvest of target stocks.

Table 2-9. Proportion of simulations in which the allowable age-3 impact rate (i3) falls within the specified bins. Bins include i3=0, 0<i3≤0.10, 0.10<i3<0.20, and i3≥0.20*.

CR	Base				AC				VP				PK			
	0	0-0.1	0.1-0.2	≥0.2	0	0-0.1	0.1-0.2	≥0.2	0	0-0.1	0.1-0.2	≥0.2	0	0-0.1	0.1-0.2	≥0.2
1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
8	0.00	0.00	0.37	0.62	0.03	0.00	0.44	0.54	0.00	0.00	0.33	0.66	0.00	0.00	0.37	0.63
10	0.00	0.01	0.25	0.74	0.00	0.03	0.27	0.69	0.00	0.01	0.26	0.73	0.00	0.05	0.30	0.65

*Scenario abbreviations include AC: Autocorrelation, VP: Variable productivity, and PK: Perfect knowledge.

Figure 2-19 (fifth row – Realized age-3 impact rate) shows the result of performance measure 5: The mean and 95% interval of the realized age-3 impact rate in years 30≤t ≤99. The proportion of instances in years 30≤t ≤99, falling into impact rates bins was also calculated (Table 2-10).

The focus of performance measure 5, realized impact rates, account for uncertainty in the execution of preseason fishing plans. The MSE analysis simulated differences between the impact rates that are specified pre-season and post season estimates of what actually occurred. The realized impact rate may be higher or lower than the pre-season allowable impact rate. Since there is no salmon harvest under CR1 the realized age-3 impact rate is always 0 or close to it. In general, results for CR8 and CR10 were very similar for all scenarios. Under both CR8 and CR10, the realized impact rate fell within the bin of 0.1 to 0.2 with the greatest frequency (49%-51%). The realized impact rate of ≥ 0.20 occurred slightly more frequently under CR10 than CR8 for the AC scenario but occurred less frequently than CR8 under the PK scenario (Table 2-10).

Table 2-10. Proportion of simulations in which the realized age-3 impact rate (accounting only for implementation error) falls within the specified bins. Bins include i3=0, 0<i3≤0.10, 0.10<i3<0.20, and i3≥0.20.

CR	**Base**				**AC**				**VP**				**PK**			
	0	0-0.1	0.1-0.2	≥0.2	0	0-0.1	0.1-0.2	≥0.2	0	0-0.1	0.1-0.2	≥ 0.2	0	0-0.1	0.1-0.2	≥0.2
1	0	1.00	0.00	0.00	0	1.00	0.00	0.00	0	1.00	0.00	0.00	0	1.00	0.00	0.00
8	0	0.09	0.51	0.40	0	0.15	0.51	0.35	0	0.09	0.51	0.41	0	0.09	0.51	0.40
10	0	0.09	0.49	0.41	0	0.12	0.49	0.39	0	0.09	0.50	0.41	0	0.14	0.49	0.37

**Scenario abbreviations include AC: Autocorrelation, VP: Variable productivity, and PK: Perfect knowledge.*

Figure 2-20 shows the results of performance measure 6: The minimum number of spawners for each control rule across all simulations in years 31 ≤ *t* ≤ 100.

The results for performance measure 6 report the minimum number of spawners observed for each of the 20,000 simulations. The resulting distributions are shown in Figure 2-20. CR1 had the highest levels of minimum number of spawners under all scenarios. There was little difference in minimum spawners between CR8 and CR10 for the Base, AC and VP scenarios. Under the PK scenario, simulations under CR10 produced slightly higher values than under CR8.

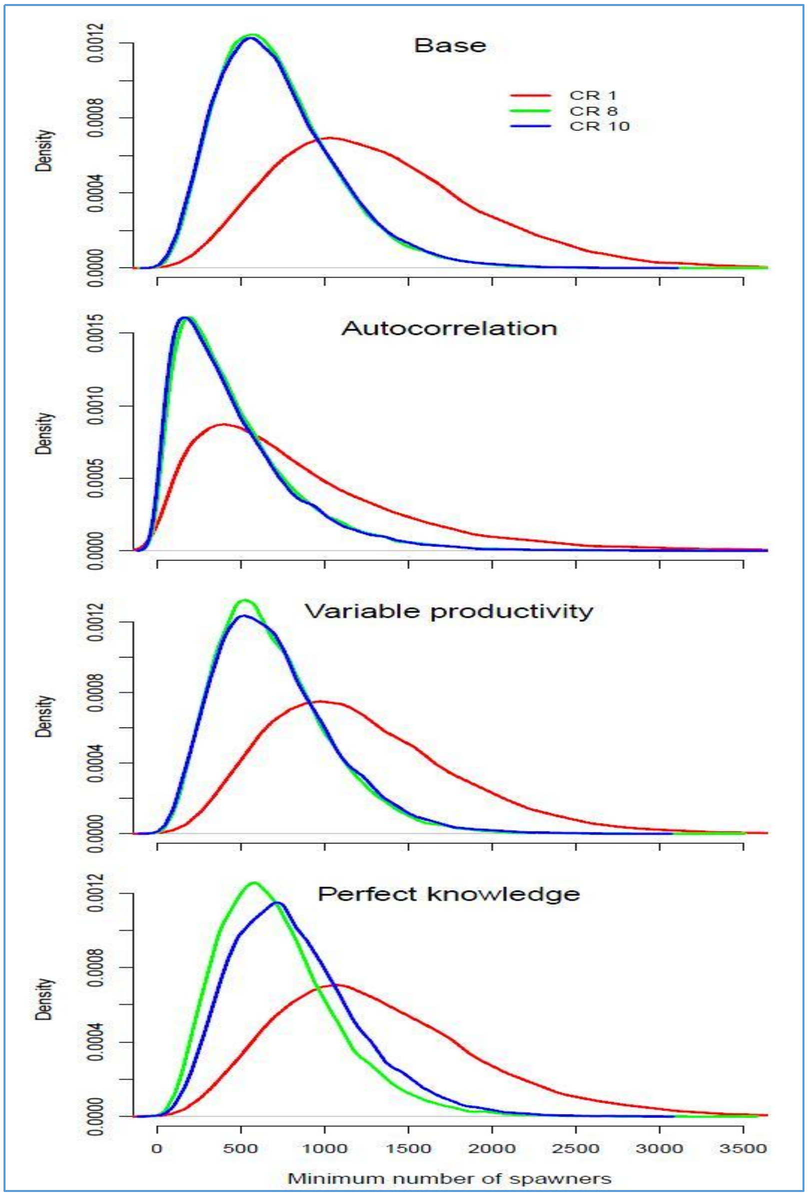


Figure 2-20. Distributions of the minimum number of spawners observed under each of the control rules and simulation scenarios.

Figure 2-21 shows results from performance measure 7: The conditional response to a spawner abundance less than or equal to a threshold level of 100 fish.

To evaluate performance measure 7, the geometric mean of spawners was computed over the three years following an escapement at or below the threshold. This analysis evaluated the ability for the population to rebound after a simulated escapement of ≤ 100 fish. The boxplots show the ranges of geometric mean of spawners. If the simulated number of spawners fell to 100 fish or less, the resulting geometric mean of spawners computed over the following three years tended to be greater than 100 fish (Figure 2-20). However, there was little contrast between the control rules in the geometric mean response to falling below the 100 fish threshold for a given scenario. The AC scenario shows a much higher occurrence of where the geometric mean of spawners falls below the 100 fish threshold. In this scenario, the assumption is that there is high correlation in the juvenile survival rates increasing the likelihood that low abundance years will be followed by more years of low abundance. Although low spawner events occur more often in the AC scenario, the relative difference between control rules is the same.

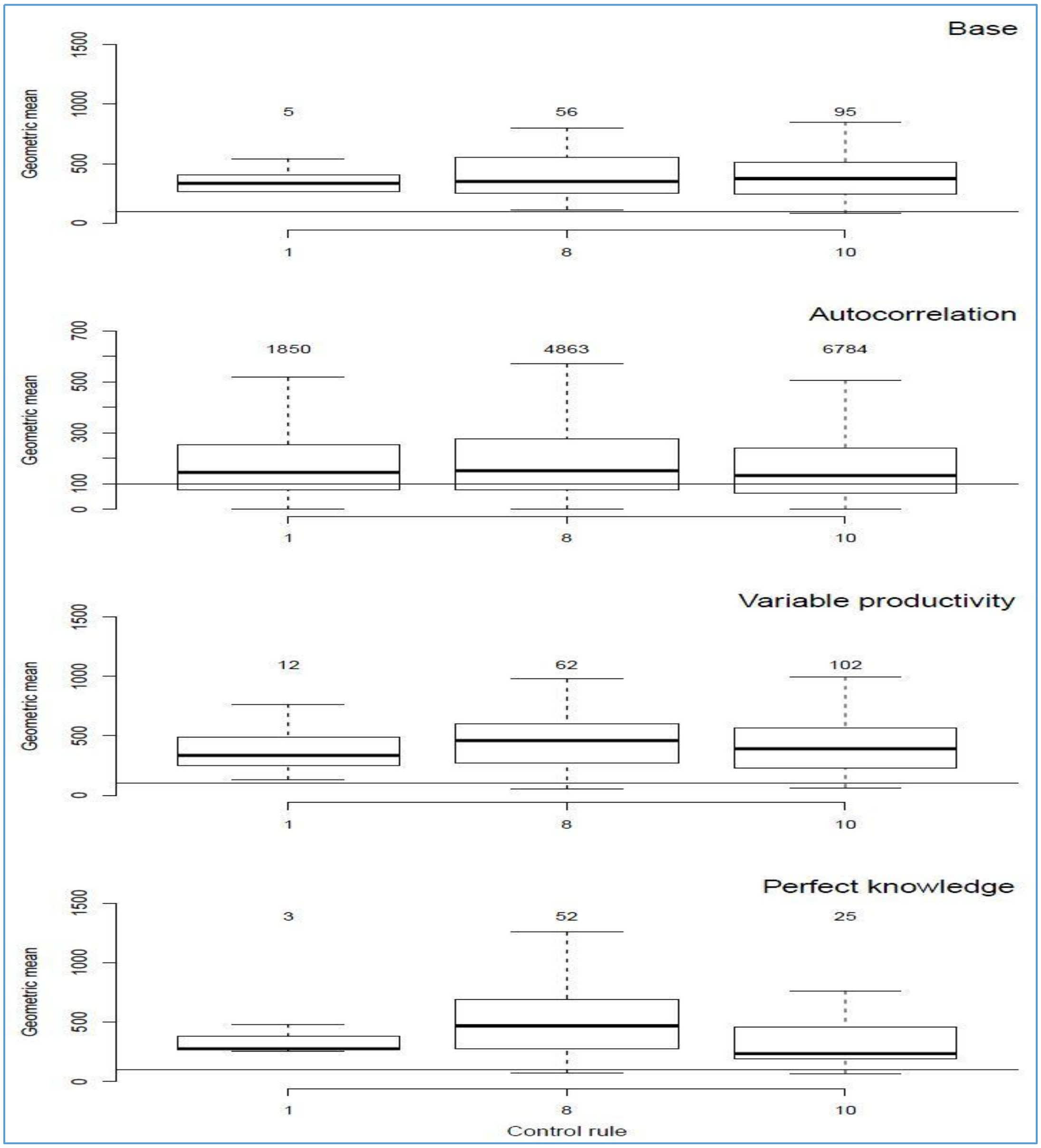


Figure 2-21. Boxplots summarizing the distribution of the geometric means of spawners computed over the three years following a simulated spawner level of ≤100 fish. Numbers above the boxplots denote the number of geometric means contributing to the boxplot (the number of instances when simulated escapement was ≤ 100 fish). Horizontal lines indicate the 100 fish threshold. Note differing y-axis scale for the Autocorrelation scenario.

Climate impacts were considered in the modeling evaluation of the control rule alternatives. The original "variable productivity" scenario assumed that the temperature covariate to the maximum egg-to-fry survival rate was the product of "normal" years that were punctuated by severe droughts. Severe droughts occurred, on average, every 28 years, and elevated river temperatures resulting from that drought lasted for a duration of two years. Elaborations were made on the variable productivity scenario by including (1) droughts of longer duration, (2) more frequent droughts, and (3) a climate change scenario where river temperatures were warmer in both drought and non-drought years (Figure 2-22). Control rules were evaluated under these new variable productivity scenarios with regard to extinction risk and the allowable age-3 impact rate.

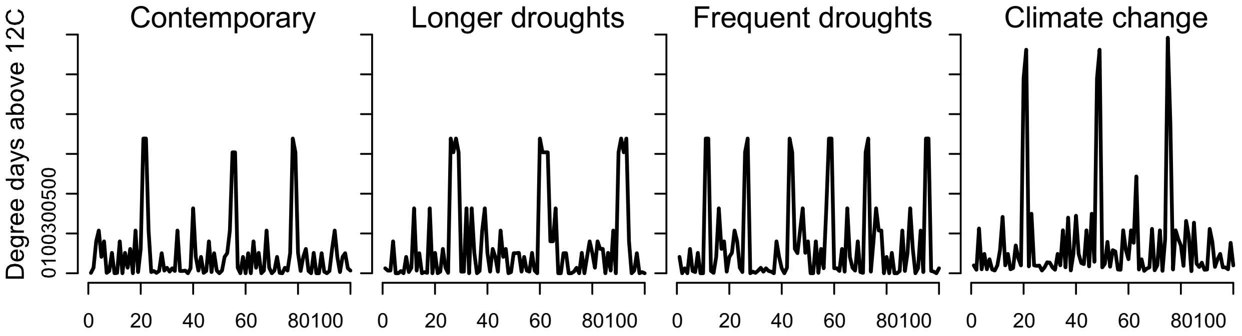


Figure 2-22. A single random example of the time series of the river temperature covariate to the maximum egg-to-fry survival rate parameter for the four variants of the Variable productivity scenario.

The MSE used measures of extinction risk to evaluate a range of increasingly pessimistic scenarios related to climate change and the frequency and intensity of drought events. There was little change in the risk metrics between control rules for the scenarios evaluated (Figure 2-23). The risk metrics were nearly always in the low category, were elevated to moderate in 0 to 2% of the scenarios, and never met the high risk criteria. Results for CR 8 and CR10 were virtually identical and just perceptibly different from CR1 with the proportion of simulations meeting the moderate risk threshold increasing from near 0 to 1% or 2% for CRs 8 and 10 (Figure 2-23).

The bottom panel of Figure 2-23 shows the proportion of the time allowable impact rates were in various bins. For example, under the contemporary scenario for CR10, the allowable impact rate was between 10% and 19.9% about 28% of the time (reading from the graph) and in the 0% to 9.9% range rarely as indicated by the height of the light blue bar. Implicitly this indicates that maximum allowable impact rate of 20% occurred more than 70% of the time. The maximum allowable impact rate occurred at least half the time for CR8 and CR10 under the all climate scenarios (bottom panel of Figure 2-23). Under the contemporary climate scenario, the proportion of time the maximum allowable impact was allowed exceeded 65% for CR8 and exceeded 70% for CR10. Similarly, for the other 3 climate scenarios the maximum allowable impact rate occurred more frequently under CR10. Instances when the allowable impact rate were less than 9.9% occurred infrequently (<2%). Less frequently (<1%) the allowable impact rate was zero under CR8. Differences between CR8 and CR10 were more pronounced in allowable impact rate than in extinction risk.

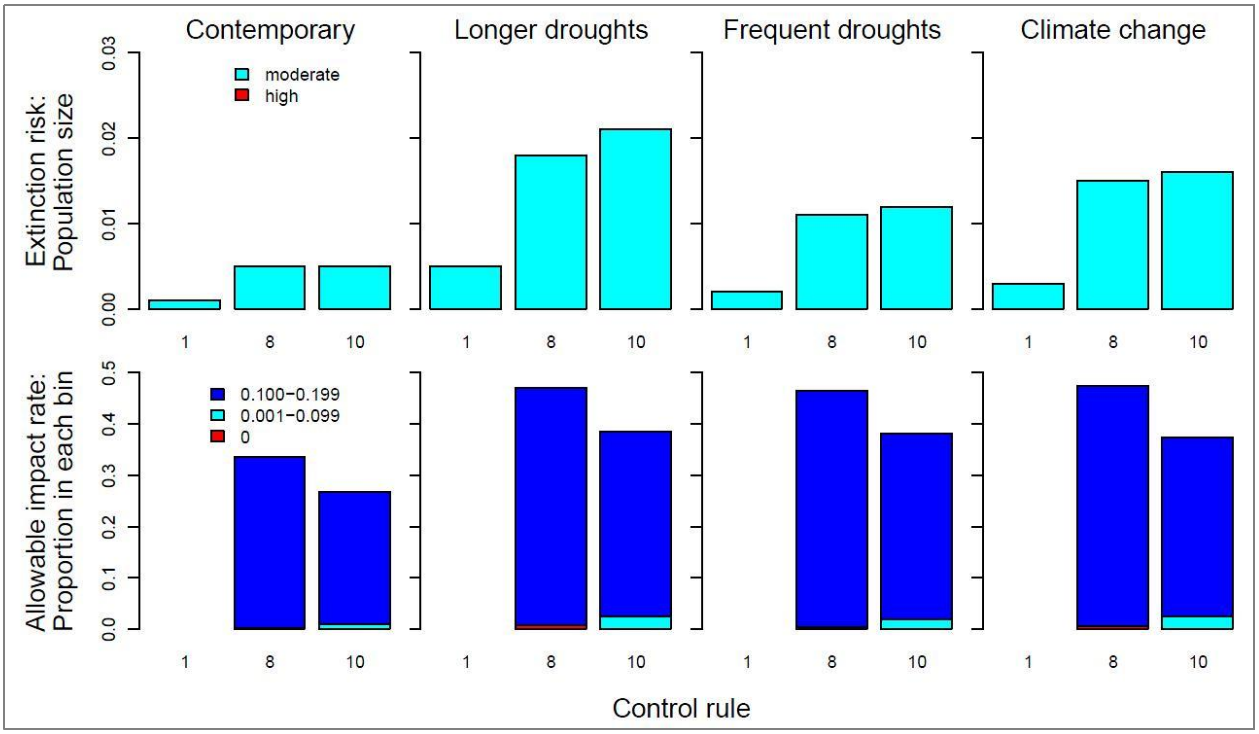


Figure 2-23. Proportion of simulations resulting in a moderate or high risk of extinction for the population size criterion (top panel) and allowable age-3 impact rates (bottom panel) for the four variants of the Variable productivity scenario (allowable impact rate exceeding 0.199 is implied in the figure).

2.6 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

Future tribal, state, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives and fishing permits. Activities in the action area are primarily those conducted under state, tribal or Federal government management. These actions may include changes in ocean policy and increases and decreases in the types of activities currently seen in the action area, including changes in the types of fishing activities, resource extraction, and designation of marine protected areas, any of which could impact listed species or their habitat. Government actions are subject to political, legislative and fiscal uncertainties. These realities, added to geographic scope of the action area which encompasses several government entities exercising various authorities, and the changing economies of the region, make any analysis of cumulative effects difficult and, frankly, speculative. Although state, tribal and local governments have developed plans and initiatives to benefit listed fish, they must be applied and sustained in a comprehensive way before NMFS can consider them "reasonably foreseeable" in its analysis of cumulative effects.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species. Since there is no critical habitat in the action area, it was not discussed further in this opinion.

The status of the winter-run ESU was described in Section 2.2 and is summarized here. Winter-run have been classified as endangered since 1994 when the adult return totaled 186. For a time thereafter the abundance of winter-run Chinook salmon trended upwards to reach a peak of over 17,000 spawners in 2006. Since 2006 the population has generally declined with the exception of strong cohort returns in 2013 and 2014 (Table 2-2). Ocean conditions negatively impacted winter-run in 2005 and 2006 and were identified as the key factor in low Chinook salmon adult returns to the Central Valley in 2007 and 2008 (Lindley et al. 2009). Brood years 2014 and 2015 experienced catastrophic mortality in the early life-stages (>90%) attributed to lack of cold water from the Shasta Dam pool leading to lethal temperatures for the early life-stages (Poytress 2016). For comparison, the egg to fry survival rate has averaged 27% over the 15 years prior to the extreme mortality levels experienced in 2014 and 2015 (NMFS 2015b). The recent five year status review of winter-run Chinook salmon (NMFS 2016) concluded that the 10-year trend in run size was negative suggesting a 15% per year decline in the population. The percent decline is significant but did not exceed the catastrophic decline criteria (>90% decline in one generation or annual run size < 500 spawners; Lindley et al. 2007).

The declining trend observed in recent years is also reflected by measures of productivity including the measures of the cohort replacement rate shown in Table 2-2. Productivity, as measured by the number of juveniles passing RBDD rotary screw traps or juvenile production index [JPI]), has declined in recent years from a high of 8.9 million in 2005 to 440,951 in 2015

(Table 2-4). In general, juvenile winter-run Chinook salmon productivity is lower than other Chinook salmon runs in the Central Valley and in the Pacific Northwest (Michel 2010).

The greatest risk factor for winter-run Chinook salmon lies within its spatial structure (NMFS 2011, NMFS 2014). The construction of Shasta Dam in 1943 blocked access to historical spawning grounds where spring fed streams provided cold water throughout the summer allowing for spawning, egg incubation, and rearing during the mid-summer period (Slater 1963, Yoshiyama et al. 1998). Approximately 299 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to winter-run with the exception of Battle Creek (Table 2-6), which has its own impediments to upstream migration including a number of small hydroelectric dams situated upstream of the Coleman National Fish Hatchery (CNFH) weir (Moyle et al. 1989; NMFS 1997). Most components of the winter-run life history (*e.g.*, spawning, incubation, freshwater rearing) have been reduced substantially by the habitat blockage in the upper Sacramento River (NMFS 2014a). As a consequence, the remaining population is, for the time being, dependent on interventions designed to mitigate specific risks including spawning gravel augmentation, hatchery supplementation, and the regulation of the finite cold-water pool behind Shasta Dam to reduce water temperatures.

A key aspect of the overall recovery plan is restoration of habitat and reintroduction of winter-run Chinook salmon in Battle Creek and above Shasta Dam. The Battle Creek Salmon and Steelhead Restoration Project began in 2010 with the removal of Wildcat Diversion Dam and it is nearing its final implementation phase with completion expected by 2020. The associated reintroduction plan is now also complete (ICF Intl. 2016) with the first releases of juvenile winter-run Chinook salmon into Battle Creek occurring in the spring of 2018.

The Central Valley Salmon and Steelhead Recovery Plan includes criteria for recovering the winter-run Chinook salmon ESU, including re-establishing a population into historical habitats upstream of Shasta Dam (NMFS 2014a). Additionally, NMFS (2009a) included a requirement for a pilot fish passage program above Shasta Dam. Studies are progressing on this requirement and BOR released a draft pilot implementation plan for Shasta Dam Fish Passage Evaluation in December of 2016 (BOR 2016). Both the Shasta Dam passage program and the Battle Creek reintroduction efforts are important steps required to meet the recovery goal of establishing three winter-run populations at low risk of extinction (NMFS 2016).

“Diversity” refers to the distribution of traits within and among populations. Diversity, both genetic and behavioral, is critical to the success of a population in a changing environment. The diversity of the current winter-run Chinook salmon population is reduced because of the introgression of several stocks (e.g., spring-run and fall-run Chinook salmon) that occurred when Shasta Dam blocked access to the upper watershed. As a consequence, the species is almost certainly less able to adapt in response to environmental variation.

Among the actions taken to mitigate the many risks to winter-run Chinook salmon was the development of a Conservation Hatchery Program and more recently a Captive Broodstock Program. The two hatchery programs provide essential safety nets that serve as backups in the event of catastrophic loss of the natural populations and resources for reintroduction and recovery purposes.

Concerns related to genetic introgression within the winter-run Chinook population led to development of the Conservation Hatchery Program at LSNFH beginning in 1998. The Program was implemented using best management practices to minimize the impact to naturally spawning winter-run Chinook salmon. For example, the Program prioritized the use of natural-origin adults for broodstock and limited the size of the hatchery program so that the relative abundance of hatchery and natural origin adults remained low. Some of the safeguards related to the relative size of the Conservation Hatchery Program were changed beginning in 2014. This was an emergency response to extreme drought conditions and ineffective cold-water pool management for brood years 2014 and 2015. In 2014, hatchery production from LSNFH was tripled to offset the impact of the drought (Figure 2-5). In 2015, hatchery production was increased again to 420,000 juveniles released (Figure 2-5). Although these changes in the Hatchery Program were designed to mitigate real and immediate risks and the prospect that the population would otherwise decline precipitously to critically low levels, they also had consequences. Because of the increase in relative abundance of hatchery fish in recent years, NMFS (2016) concluded that risk related to the genetic integrity of the population had increased from low in the previous status review to moderate.

In 2015, in response to concerns related to the ongoing drought, the management agencies also agreed to reinitiate a Captive Broodstock Program for winter-run Chinook salmon. The goals of the Captive Broodstock Program are to provide a genetic reserve for winter-run Chinook salmon to offset the risk of a catastrophic decline in abundance, and a resource for efforts to reintroduce winter-run Chinook salmon upstream of Shasta Dam and into restored habitats in Battle Creek. 2017 will be the first year that fish from the Captive Broodstock Program will be mature and ready to spawn thus completing the life cycle of the Captive Broodstock Program. In 2018 200,000 juveniles from the captive broodstock program were released into newly restored habitat in Battle Creek. This first reintroduction actually occurred ahead of schedule. The juveniles were available because they were not needed to meet the hatchery production goals at the LSNFH.

One additional factor affecting the rangewide status of the Sacramento River winter-run Chinook salmon ESU is climate change. NWFSC (2015) recently reported that climate conditions affecting salmonids were a substantive concern and that recent and unfavorable environmental trends are expected to continue. For Sacramento River winter-run Chinook salmon, the embryonic and larval life stages that are most vulnerable to warmer water temperatures occur during the summer, so the population is particularly at risk from climate related warming. The only remaining population of winter-run Chinook salmon relies on the cold-water pool in Shasta Reservoir, which buffers the effects of warm temperatures in most years. The exception occurs during drought years, which are predicted to occur more often with climate change (Yates et al. 2008). The long-term projection of how the two main diverters on the Sacramento River, Central Valley Project (CVP) and the State Water Project (SWP), will operate incorporates the effects of potential climate change in three possible forms: less total precipitation; a shift to more precipitation in the form of rain rather than snow; or earlier spring snow melt (Reclamation 2008). Additionally, air temperature appears to be increasing at a greater rate than what was previously analyzed (Lindley 2008; Beechie et al. 2012; Dimacali 2013). These factors may compromise the quantity and/or quality of winter-run Chinook salmon habitat available downstream of Keswick Dam. It is therefore imperative that additional populations of winter-run

Chinook salmon be re-established into historical habitat in Battle Creek and above Shasta Dam for long-term viability of the ESU (NMFS 2017c).

Past harvest of winter-run Chinook salmon in ocean fisheries is considered as part of the environmental baseline. The ocean harvest impact rates on winter-run have been reduced from previous highs that ranged from 20% to 70% beginning in 1978 to 20% or less since the early 2000's (Figure 2-11). The 2010 biological opinion on ocean fisheries concluded that those fisheries were likely to jeopardize the continued existence of winter-run largely because fishery management was not responsive to low abundance of winter-run. Thus, the 2012 RPA required an abundance-based management approach, which has been implemented since the issuance of that RPA. Since the current RPA and control rule was implemented in 2012, the allowable impact rates have ranged from 12.9% to 19.9%, averaging 16.1% (Figure 2-5). Annual landings of Chinook salmon caught in California have been reduced from previous highs that routinely exceeded 500,000 Chinook salmon per year to an average of less than 156,000 Chinook salmon since 2006 (Figure 2-4). These reductions were due partly to ocean harvest regulations that have been implemented to limit incidental take on winter-run Chinook salmon and partly to management regulations that limit harvest on other non-ESA listed Chinook salmon stocks. Conservation constraints for Central Valley fall Chinook salmon and Klamath River fall Chinook salmon lead to closures of the salmon fishery off of California in 2008 and 2009 and a near closure in 2010. Currently, ocean salmon fisheries are managed for winter-run Chinook salmon using a specified set of size and season restrictions coupled with an abundance-based management framework designed to provide more opportunity when the status of winter-run Chinook salmon is good, and constrain fisheries when the status of winter-run population is poor (NMFS 2012a).

In its most recent 5-year status review, NMFS considered the effects of harvest and actions that have been taken to reduce harvest and concluded that it is highly unlikely that overutilization has been a key factor limiting winter-run Chinook salmon (NMFS 2016).

The proposed action being considered is the implementation of the new harvest control (CR10) to replace the current harvest control rule (CR8) (Figure 2-18b-c) while maintaining the previous size and season restrictions that have been in place (Table 1-3). CR10, like CR8, would modify fisheries in response to winter-run abundance. However, under CR10 the allowable impact rate on winter-run would be based on measures of juvenile production rather than escapement. The juvenile production indicator is considered an improvement over the current method that depends on the three year geometric mean of escapement because it is more responsive to real time indicators of abundance. This will allow CR10 to respond to sudden annual changes in the population, such as those resulting from the extreme mortality for winter-run in the early life stages during 2014 and 2015.

The MSE analysis conducted by the Workgroup provides information on the effects of the proposed action on survival, recovery, and harvest opportunity. As discussed in the Effects section, this analysis relied on several performance measures. PMs 2 and 3 provide different indicators of extinction risk. PM 6 provides estimates of the minimum number of spawners likely to occur in the future. PM 7 considers how the population will respond when abundance falls below a threshold of 100 spawners. All four of these PMs provide information related to the effects of the proposed action on survival. PM 1 estimates spawner abundance in the final year of the simulation and is therefore an indicator related to recovery – how many spawners can we expected to see in the future. Although the MSE analysis considered all ten control rules, we focused in the Effects analysis on a comparison of CR1, the no fishing alternative, CR8, representing the current management framework, and CR10 representing the proposed action. As indicated in the effects section, there is relatively little difference between CRs 8 and 10. So here we focus on how the proposed action compares to the no fishing alternative.

The PMs were evaluated using four different scenarios (Base, Autocorrelation, Variable Productivity, and Perfect Knowledge) to help bracket the range of uncertainty related to future conditions. The analysis also explored four permutations of the Variable Productivity scenario that reflect different assumptions related to drought and climate change. As is generally the case with these types of models, they are better used to compare relative differences between alternatives or scenarios rather than the absolute values of estimates for things like spawner abundance or extinction risk. Nonetheless, the analysis used here represents the best available information.

PM 1 estimates the mean spawner abundance at the end of 100 years for 20,000 simulations. As expected, spawner abundance is reduced when fisheries are implemented under CR10 compared to CR1, no fishing. But the mean number of spawners under CR10 for all scenarios is in the range of 6,800 to 7,800 fish (Table 2-6) compared to the 2,500 spawner abundance criteria associated with low risk (Table 2-9).

PM 2 estimates the proportion of simulations resulting in high, moderate, or low risk of extinction. The relative differences in extinction risk between CR1 and CR10 are very small, generally just a fraction of one percent (Table 2-7). There are modest changes in extinction risk under the AC scenario of 3 or 4%, but even here the extinction risk is in the low category in 94% of all simulations.

PM 3 estimates the probability of high, moderate, and low risk of meeting the catastrophic risk criterion. PM 3 measures the probability of the population falling by more than 50% (moderate risk) or 90% (high risk) between generations. The moderate risk criterion was met on the order of 45% of the time, but the relative differences between control rules and scenarios are just barely perceptible (Table 2-8) indicating that there was very little difference between the fishing and no fishing alternatives.

PM 6 reports the minimum number of spawners that occur over 20,000 100 year-long simulations for each control rule and scenario. PM 6 reports on how low the population goes how often during the simulations. The results are shown as graphical distributions (Figure 2-21). The minimum number of spawners is reduced under CR10 compared to the no fishing alternative (the curve peaks are moved to the left), but with the exception of the AC scenario the mode of the distributions are still on the order of 500 fish and therefore well above the abundance criterion of 250 spawners associated with high risk. The distribution of spawners for CR1 and CR10 are shifted to the left under the AC scenario, but the relative differences seen between the control rules are still about the same in all scenarios.

PM 7 shows how the population will respond under the various control rules when spawner abundance falls below 100 spawners by estimating the geometric mean of spawners in the three years following the low escapement event. Once again there is very little contrast between CR 1 and CR10 across the scenarios. With the exception of the AC scenario, the occurrence of low spawner events (less than 100) is rare, as reflected by the number above the box plots. The AC scenario shows a much higher occurrence of events where the geometric mean of spawners falls below the 100 fish threshold. In this scenario, the assumption is that there is high correlation in the juvenile survival rates increasing the likelihood that low abundance years will be followed by more years of low abundance. Although the number of low spawner events is higher, the relative difference between control rules is the same.

Finally, the MSE used measures of extinction risk (PM 2) to evaluate a range of more pessimistic scenarios related to climate change and the frequency and intensity of drought events. There was little change in the risk metrics between CR1 and CR10 for the scenarios evaluated (Figure 2-23). Estimates of extinction risks were nearly always in the low category, were elevated to moderate in 0 to 2% of the scenarios, and never met the high risk criteria. Results for CR10 were just perceptibly different from CR1 with the proportion of simulations meeting the moderate risk threshold increased from near 0 to 1% or 2% for CR10 depending on the drought scenario.

The modeling analysis contributes to our understanding of the effects of the action on survival and recovery. PMs 2, 3, 6, and 7 in particular provide various measures related to survival. PMs 2 and 3 provide measures of the relative change in extinction risk by comparing the proposed action and no fishing alternatives. PM 6 reports on the minimum number of spawners expected across all simulations. PR7 reports on how the population will respond on those occasions when spawner abundance does fall below a low threshold of 100 spawners. In all cases, the relative differences between the proposed action and no fishing alternative are small. PM 1 provides estimates of the mean number of spawners at the end of the 100 year simulations. The projected spawner abundance is reduced under to the proposed action compared to the no fishing alternative, but remains well above the spawner abundance criterion of 2,500 associated with low risk. The modeling analysis therefore supports the conclusion that the proposed action will not appreciably reduce the likelihood of survival or recovery. This is consistent with NMFS' recent conclusion that it is highly unlikely that harvest has been a key factor limiting winter-run Chinook salmon (NMFS 2016).

2.8 Conclusion

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of Sacramento River Winter-run Chinook salmon. Critical habitat has been designated, but does not include areas in the marine environment in the action area; therefore, none was analyzed.

2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. “Harm” is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA, and the proposed action may incidentally take individuals of a listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. It also states that reasonable and prudent measures, and terms and conditions to implement the measures, be provided that are necessary to minimize such impacts.

The measures described below are non-discretionary and must be undertaken by NMFS so that they become binding conditions of any permit issued to an applicant, as appropriate, for the exemption in section 7(o)(2) to apply. NMFS has a continuing duty to regulate the activity covered by this incidental take statement. If NMFS fails to implement the terms and conditions, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, NMFS must document the progress of the action and its impact on the species as specified in the incidental take statement (50CFR § 402.14(i)(3)).

2.9.1 Amount of Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur. The proposed action of authorizing ocean salmon fisheries pursuant to the Pacific Coast Salmon Fishery Management Plan, in conjunction with additional protective measures designed to protect Sacramento River winter-run Chinook salmon, is likely to result in incidental take of this ESA listed endangered ESU. Through this action, NMFS is instituting a new harvest management framework for winter-run Chinook salmon. As described in section 1 the management framework has two parts. The first part of the management framework consists of a set of season and size restrictions for ocean salmon fisheries south of Point Arena, CA (Table 1-3). These are permanent and implemented every year. The second part of the framework is a new abundance based harvest control rule that is shown in Figure 1-1 and fully described in Section 1.3, Proposed Action. The expected level of take is specified as an allowable impact rate. The impact rate will vary from year-to-year, but is determined each year using the control rule. Fisheries are then planned preseason and managed consistent with the annual impact limit. Management error is such that it is reasonable to expect that postseason estimates of the impact rate will be both above and below the preseason limit. The MSE analysis accounted for management error that is inherent in fishery management. However, we expect that the deviations will be unbiased and on average consistent with the specified preseason limits. If the post season estimates of the impact rate exceeds the preseason limits in two out of three years by more than five percentage points, the consultation shall be reinitiated.

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to Sacramento River winter-run Chinook salmon.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

NMFS believes the following reasonable and prudent measures, as implemented by the terms and conditions, are necessary and appropriate to minimize impacts to Sacramento River winter run Chinook as a result of incidental take in the ocean salmon fishery. The measures described below are non-discretionary and must be undertaken for the exemption in section 7(o)(2) to apply. If NMFS fails to adhere to the terms and conditions of the incidental take statement, the protective coverage of section 7(o)(2) may lapse. Thus, the following reasonable and prudent measures must be implemented in order to authorize the ocean salmon fishery under the Pacific Salmon FMP in a manner which may result in the incidental take of winter-run.

1. In-season management actions taken during the course of the fisheries must be consistent with the harvest objectives and other management measures established in accordance with the salmon FMP that were subject to review with this biological opinion.

2. Incidental harvest impacts of Sacramento River winter Chinook shall be monitored on an annual basis using the best available measures. Although NMFS is the Federal agency responsible for ensuring that this reasonable and prudent measure is carried out, it is the states, tribes, PFMC, and U.S. Fish and Wildlife Service (USFWS) that conduct monitoring and reporting of catch and other data necessary to complete the analyses of impacts.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and NMFS or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). NMFS or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement reasonable and prudent measure 1:

   NMFS, in cooperation with the affected states and tribes, the PFMC, as appropriate, to ensure preseason and in-season management actions taken during the course of the fisheries are consistent with the objectives of the management framework and the take specified in the Incidental Take Statement of this biological opinion.

2. The following terms and conditions implement reasonable and prudent measure 2:

2A. NMFS, in cooperation with the affected states and tribes, the PFMC, and USFWS, as appropriate, must support efforts to ensure that the catch and effort and the implementation of other management measures under the Pacific Coast Salmon FMP is monitored at levels that are at least comparable to those used in recent years. Catch monitoring programs must be stratified by gear, time, and management area.

2B. NMFS, in cooperation with the affected states and tribes, the PFMC, and USFWS, as appropriate, must support efforts to ensure that surveys of spawning populations are conducted at a level sufficient to provide reliable estimates of spawning abundance that are made available prior to the preseason salmon management process each season.

2C. NMFS, in cooperation with the affected states and tribes, the PFMC, and USFWS, as appropriate, must support efforts to ensure that fisheries are sampled for stock composition, including the collection of coded-wire-tags (CWTs) in all fisheries. Additionally, collection of CWTs from spawning surveys must be conducted at a level sufficient to provide the data needed to complete estimates of impacts to ESA-listed salmon ESUs. To that end, NMFS must assess current CWT collection programs and evaluate plans to improve or address deficient efforts in the future.

2D. NMFS, in cooperation with the affected states and tribes, the PFMC, and USFWS, as appropriate, must ensure that post-season estimates of age-3 ocean impact rates and updates of spawner reduction rate estimates are conducted on an annual basis, as cohort reconstructions are completed.

2E. NMFS, in cooperation with the affected states and tribes, the PFMC, and USFWS, as appropriate, must monitor and assess the effectiveness of this management framework over time. This should include an annual review of the methods and models used to set the impact rate for winter-run Chinook. In addition, after the first five years of implementation and no less than every five years thereafter, NMFS shall conduct a review of the management framework for consistency with outcomes and expectations described in the reports of the Workgroup and in the MSE analysis.

2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

Necessary measures are specified as reasonable and prudent measures and terms and conditions. No additional discretionary measures are proposed.

2.11 Reinitiation of Consultation

This concludes formal consultation for NMFS' implementation of the PFMC's Pacific Coast Salmon FMP beginning May 1, 2018 and extending for the foreseeable future.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

3.1 Essential Fish Habitat Affected by the Project

For this EFH consultation, the proposed action and action area are described in detail above in Section 1.3, Proposed Action. Briefly, the proposed action is NMFS' promulgation of ocean fishing regulations within the EEZ of the Pacific Ocean (Figure 2-10). The action area is the EEZ, which is directly affected by the Federal action, and the coastal and inland marine waters of the states of Washington, Oregon and California. The estuarine and offshore marine waters are designated EFH for various life stages of Pacific Coast salmon, Pacific Coast groundfish, coastal pelagic species, and highly migratory species managed by the PFMC.

Pursuant to the MSA, the PFMC has designated EFH for five coastal pelagic species (PFMC 2011a), over 80 species of groundfish (PFMC 2014a), 13 highly migratory species (PFMC 2011b), and three species of Federally-managed Pacific salmon: Chinook salmon (*O. tshawytscha*); coho salmon (*O. kisutch*); and Puget Sound pink salmon (*O. gorbuscha*) (PFMC 2014b). The PFMC does not manage the fisheries for chum salmon (*O. keta*) or steelhead (*O. mykiss*). Therefore, EFH has not been designated for these species.

EFH for coastal pelagic species includes all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10℃ to 26℃. A more detailed description and identification of EFH for coastal pelagic species is found in Amendment 8 to the Coastal Pelagic Species Fishery Management Plan (PFMC 2011a).

EFH for groundfish includes all waters, substrates and associated biological communities from the mean higher highwater line, or the upriver extent of saltwater intrusion in river mouths, seaward to the 3500 m depth contour plus specified areas of interest such as seamounts. A more detailed description and identification of EFH for groundfish is found in the Appendix B of Amendment 10 to the Pacific Coast Groundfish Management Plan (PFMC 2014a).

EFH for highly migratory species range from vertical habitat within the upper ocean water column form the surface to depths generally not exceeding 200 m to vertical habitat within the mid-depth ocean water column, from depths between 200 and 1000 m. These range from coastal waters primarily over the continental shelf; generally over bottom depths equal to or less than 183 m to the open sea, beyond continental and insular shelves. A more detailed description and identification of EFH for highly migratory species in Appendix F of the Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species (PFMC 2011b).

Marine EFH for Chinook, coho and Puget Sound pink salmon in Washington, Oregon, and California includes all estuarine, nearshore and marine waters within the western boundary of the EEZ, 200 miles offshore. Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable man-made barriers, and longstanding, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years). A more detailed description and identification of EFH for salmon is found in Appendix A to Amendment 18 to the Pacific Coast Salmon Plan (PFMC 2014b). Assessment of potential adverse effects to these species' EFH from the proposed action is based, in part, on this information.

The harvest-related activity of the proposed action considered in this consultation involves boats using hook-and-line gear. The use of hook-and-line gear affects the water column rather than estuarine and near shore substrate or deeper water, offshore habitats.

3.2 Adverse Effects on Essential Fish Habitat

The PFMC assessed the effects of fishing on salmon EFH, mostly in freshwater, and provided recommended conservation measures in Appendix A to Amendment 18 of the Pacific Coast Salmon Plan (PFMC 2014b). The PFMC identified five types of impact on EFH: 1) gear effects; 2) harvest of prey species by commercial fisheries; 3) removal of salmon carcasses; 4) redd or juvenile fish disturbance; and 5) fishing vessel operation on habitat.

Harvest related activities described in this opinion for intercepted salmon are accounted for explicitly in the ESA analyses regarding harvest related mortality. Changes to overall salmon fishing activities have decreased over the last decade, as described in this opinion in Section 2.4.1. Therefore any gear related effects have also been reduced over this time frame. Derelict gear effects occur in fishing activities managed under all four Pacific Coast FMPs, as well as recreational and commercial fishing activities not managed by the PFMC. However, the action considered in this opinion does not include commercial trawl nets, gillnets, long lines, purse seines, crab and lobster pots or recreational pots. These types of gear losses are those most commonly associated as having an effect on EFH. Hook-and-line gear is not placed into this category, and so long as the action continues to authorize fisheries using hook-and-line regulations, gear effects will not be present on EFH.

Prey species can be considered a component of EFH (NMFS 2010b). However, the action considered in this opinion is promulgation of fisheries targeting adult salmon, which are not considered prey for any of the remaining species managed under the other three Pacific coast FMPs. Furthermore, the salmon fisheries considered in this opinion have not documented interception of prey species for the adult species managed under the other three FMPs either.

The PFMC addresses the third type of possible EFH impact, the removal of salmon carcasses, by continuing to manage for maximum sustainable spawner escapement and implementation of management measures to prevent overfishing. The use of proper spawner escapement levels ensures PFMC Fisheries are returning a consistent level of marine-derived nutrients back to freshwater areas.

Fishing vessel operation will occur in the EEZ as a result of the action. Vessels can adversely affect EFH by affecting physical or chemical mechanisms. Physical effects can include physical contact with spawning gravel and redds (freshwater streams) and propeller wash in eelgrass beds (estuaries). However, the bounds of the action area are outside the bounds of freshwater EFH. Derelict, sunk, or abandoned vessels can cause physical damage to essentially any bottom habitat the vessel comes into contact with (PFMC 2011c). Vessels operate in the EEZ as a result of implementing fisheries governed by any of the four FMPs, and for other non-fishing related activities. All of these operations provide potential for physical damage to any bottom habitat.

As discussed above the use of hook-and-line gear in the fisheries promulgated through the action in Section 1.3 of this opinion does not contribute to a decline in the values of estuarine and near shore substrate or deeper water, offshore habitats through gear effects. As adult salmon are not known prey species to the other species in the remaining three FMPs, prey removal is also not considered to have a discernable impact on EFH. Additionally, the bounds of the action area are outside the bounds of freshwater EFH, therefore redd or juvenile fish disturbance will not result from the action in this opinion. Fishing vessel operation as a result of the action may result in physical damage to marine EFH. Based on Pacific Coast Fisheries Information Network (PacFIN) data, a total of 1,145 vessels participated in the West Coast commercial salmon fishery in 2014. This is 4% more than participated in 2013 (1,098), 12% greater than the number participating in 2012 (1,021), and 36% more vessels than participated in 2011 (842). The preliminary number of vessel-based ocean salmon recreational angler trips taken on the West Coast in 2014 was 354,500, an increase of 15% over 2013, and 22% above the 2012 level, but 41% below the 1979-1990 annual average of 599,700 (PFMC 2015). These vessels, both commercial and recreational, also fish for Chinook salmon, therefore the number solely attributable to the action considered in this opinion are unknown. However, based on the gear type used and these total operating vessel estimates the effect on essential habitat features of the affected species from the action discussed in this biological opinion will be minimal, certainly not enough to contribute to a decline in the values of the habitat.

It is NMFS' opinion that current PFMC actions address EFH protection, and no discernible adverse effects on EFH for species managed under the Coastal Pelagic Species Fishery Management Plan (PFMC 2011a), the Pacific Coast Groundfish Management Plan (PFMC 2014a), the Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species (PFMC 2011b), and the Pacific Coast Salmon Plan (PFMC 2014b) will result from the proposed action considered in this biological opinion.

3.3 Essential Fish Habitat Conservation Recommendations

Pursuant to Section 305(b)(4)(A) of the MSA, NMFS is required to provide EFH conservation recommendations to Federal agencies regarding actions which may adversely affect EFH. However, because NMFS concludes that sufficient measures addressing possible EFH impact, as described in Section 3.2 of this opinion, have been made and adopted for the PFMC Fisheries and the proposed fisheries will not adversely affect the EFH, no additional conservation recommendations beyond those identified and already adopted are needed.

3.4 Statutory Response Requirement

Because there are no conservation recommendations, there are no statutory response requirements.

3.5 Supplemental Consultation

The NMFS must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

4. FISH AND WILDLIFE COORDINATION ACT

The purpose of the Fish and Wildlife Coordination Act (FWCA) is to ensure that wildlife conservation receives equal consideration, and is coordinated with other aspects of water resources development (16 USC 661). The FWCA establishes a consultation requirement for Federal agencies that undertake any action to modify any stream or other body of water for any purpose, including navigation and drainage (16 USC 662(a)), regarding the impacts of their actions on fish and wildlife, and measures to mitigate those impacts. Consistent with this consultation requirement, NMFS provides recommendations and comments to Federal action agencies for the purpose of conserving fish and wildlife resources, and providing equal consideration for these resources. NMFS' recommendations are provided to conserve wildlife resources by preventing loss of and damage to such resources. The FWCA allows the opportunity to provide recommendations for the conservation of all species and habitats within NMFS' authority, not just those currently managed under the ESA and MSA.
Because the proposed action does not modify any stream or other body of water for any purpose, no recommendations apply here and there are no statutory response requirements. This concludes the FWCA portion of this consultation.

5. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

5.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are NMFS and PFMC. Other interested users could include the CDFW, and the USFWS is consistent with their roles as fishery managers for the affected ESU and with NMFS' obligations under Secretarial Order 3206 (Department of Interior Order 3206, American Indian Tribal Rights, Federal-Tribal Trust Responsibilities and the Endangered Species Act). Individual copies of this opinion were provided to the PFMC, CDFW, and USFWS. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

5.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

5.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

6. REFERENCES

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