Klamath River Basin 2014 Report to Congress

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Completed off-channel winter rearing habitat for juvenile salmonids

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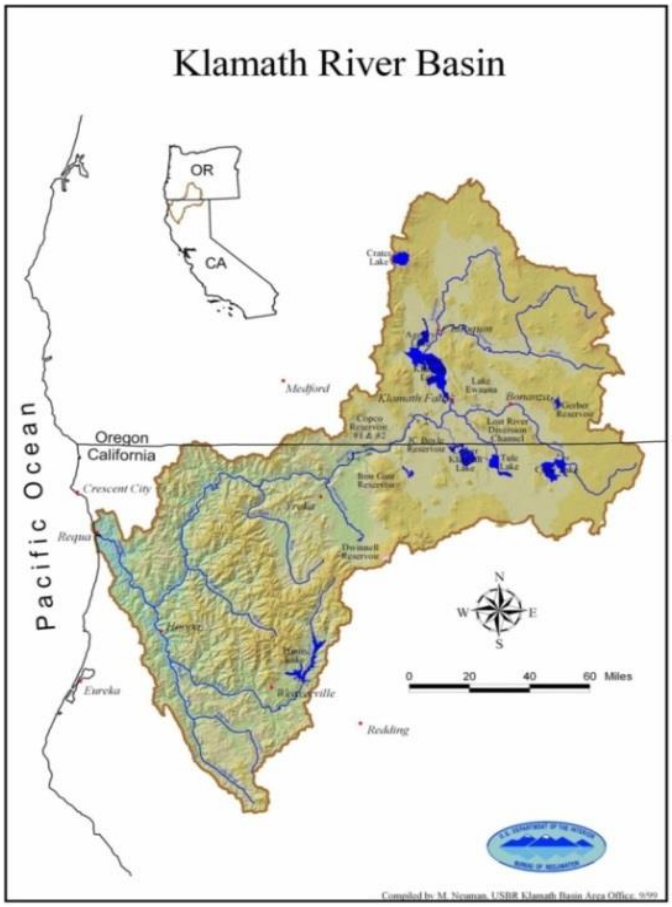
Executive Summary



The Klamath River Basin includes the Salmon, Scott, Shasta and Trinity Rivers

The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 required NOAA's National Marine Fisheries Service (NMFS) to develop a recovery plan for Klamath River coho salmon in 2007 and submit annual reports to Congress beginning in 2009. This document is the fifth annual Klamath River Basin Report to Congress. The report updates information presented in the 2012 annual report with information for the calendar years 2012 and 2013 and includes: (1) the actions taken under the recovery plan and other laws relating to recovery of Klamath River coho salmon (*Oncorhynchus kisutch*), and how those actions are specifically contributing to its recovery; (2) the progress made on the restoration of salmon spawning habitat, including water conditions as they relate to salmon health and recovery, with emphasis on the Klamath River and its tributaries below Iron Gate Dam; (3) the status of other Klamath River anadromous fish populations, particularly Chinook salmon; and (4) the actions taken by the Secretary of Commerce (Secretary) to address the calendar year 2003 National Research Council (NRC) recommendations regarding monitoring and research on Klamath River Basin salmon stocks.

Salmon troller, F/V Seamaid

The Klamath River Basin supports Chinook salmon, coho salmon, and steelhead populations, among other anadromous species (e.g., North American green sturgeon (*Acipenser medirostris*), and eulachon (*Thaleichthys pacificus*)). Historically, anadromous fish populations

supported important commercial, recreational, and tribal fisheries. However, many anadromous fish populations have declined substantially in abundance, and the restoration of these populations will require strong partnerships and collaboration between agencies and stakeholders throughout the basin. One of the target stocks of the ocean mixed-stock recreational and commercial salmon fisheries is the Klamath River fall Chinook salmon. Since the early 1990s, this stock has commonly restricted the ocean mixed-stock salmon fisheries off California and Oregon due to low abundance. However, Klamath River fall Chinook salmon have been relatively abundant in recent years and ocean salmon fisheries have been constrained by other salmon populations.

Of the anadromous salmonid fish occurring within the Klamath River Basin, only coho salmon are protected under both Federal and California Endangered Species Acts. Updated abundance data for Klamath River coho salmon stocks suggest that populations are not viable and some populations are at high risk of extinction (CDFW 2013). Although limited data are available on steelhead and spring Chinook salmon abundance in the Klamath River Basin, abundance data for these species suggest wild populations continue to be at low levels (CDFW 2013).

Several noteworthy restoration and recovery actions have been implemented since 2012. These projects were diverse and included developing water trusts, constructing off-channel rearing habitat, gravel augmentation, and dam removal. Off-channel ponds were also constructed by the Mid-Klamath Watershed Council and Karuk Tribe with funding from the U.S. Fish and Wildlife Service (USFWS) and PacifiCorp.

Introduction

The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (MSRA)[1] of 2006 was signed into law on January 12, 2007, amending the Magnuson-Stevens Fishery Conservation and Management Act (MSA)[2]. The MSRA required the NMFS to prepare a Klamath River Coho Salmon Recovery plan in 2007 and submit annual reports to Congress starting in 2009[3]. The draft recovery plan was completed in July 2007 (NMFS 2007) and the

Karuk Tribal Fisheries Program biologists conducting a seining survey. Photo: Shari Whitmore, NMFS

submission of annual reports began in 2009[4]. This document is the fifth annual Report to Congress and provides updated information on: (1) the actions taken under the recovery plan and other laws relating to recovery of Klamath River coho salmon, and how those actions are specifically contributing to its recovery; (2) the progress made on the restoration of salmon spawning habitat, including water conditions as they relate to salmon health and recovery, with emphasis on the Klamath River and its tributaries below Iron Gate Dam; (3) the status of other Klamath River anadromous fish populations, particularly Chinook salmon; and (4) the actions

[1] Public Law No. 109-479.
[2] Public Law No. 94-265.
[3] See MSRA Section 113(b).
[4] http://www.westcoast.fisheries.noaa.gov/klamath/salmon_management.html

taken by the Secretary to address the calendar year 2003 NRC recommendations regarding monitoring and research on Klamath River Basin salmon stocks.

Status of Klamath River Basin Anadromous Salmonid Species

The current distribution of all anadromous salmon and trout species in the Klamath River Basin is limited to spawning and rearing habitat below Lewiston Dam and Iron Gate Dam, which became operational in 1962. Historically, all three species, Chinook and coho salmon as well as steelhead, inhabited areas of the Klamath River Basin above Iron Gate Dam, though Chinook salmon and spring Chinook salmon in particular, likely migrated the furthest upstream (Hamilton et al. 2005).

Chinook Salmon

Populations of Klamath Basin Chinook salmon upstream of the Klamath-Trinity Rivers confluence are composed of the Upper Klamath and Trinity Rivers Chinook salmon Evolutionarily Significant Unit (ESU[5]). Populations downstream of the confluence are a component of the Southern Oregon / Northern California Coastal Chinook salmon ESU. Neither of these ESUs of Chinook salmon are listed under the Endangered Species Act (ESA). Chinook salmon continue to be the most abundant salmonid species present in the Klamath Basin and support important commercial, recreational, and tribal fisheries.

The abundance of fall Chinook salmon adult escapement to the Klamath River Basin has been highly variable across years. Exhibit 1 illustrates the estimated abundance of fall Chinook salmon returns to the Klamath Basin between 1981 and 2013, the number of Chinook salmon that spawned in natural areas and hatcheries, and the Chinook salmon harvests in tribal and river recreational fisheries. In 2013, sufficient adult fall Chinook salmon returned to spawn in natural

[5] For an explanation of this term, see NMFS' Policy on Applying the Definition of Species Under the ESA to Pacific Salmon (ESUs) (56 FR 58612; November 20, 1991).

areas to meet conservation objectives and be in compliance with annual catch limit requirements and the stock was neither overfished nor subjected to overfishing.

The limited data for Klamath River Basin spring Chinook salmon suggest that adult spawner abundance has been highly variable since 1980. Recent adult spawner abundance estimates have been lower than levels observed in the late 1980s and early 2000s. Dam construction eliminated a substantial amount of the historical spawning and rearing habitat for spring Chinook salmon. In addition, dam construction was partially responsible for the extirpation of at least seven spring Chinook salmon populations (Hamilton et al. 2005). Two spring Chinook salmon natural populations remain: (1) the Salmon River population; and (2) the South Fork Trinity River population. Exhibit 2 shows the estimated spring Chinook salmon returns (adults and jacks) to the Klamath River Basin from 1981 to 2013.

Spawning Chinook salmon in the mainstem Klamath River. Photo: USFWS

Exhibit 1: Estimated fall Chinook salmon returns (adult and jacks) to the Klamath River Basin (CDFW 2014).[6]

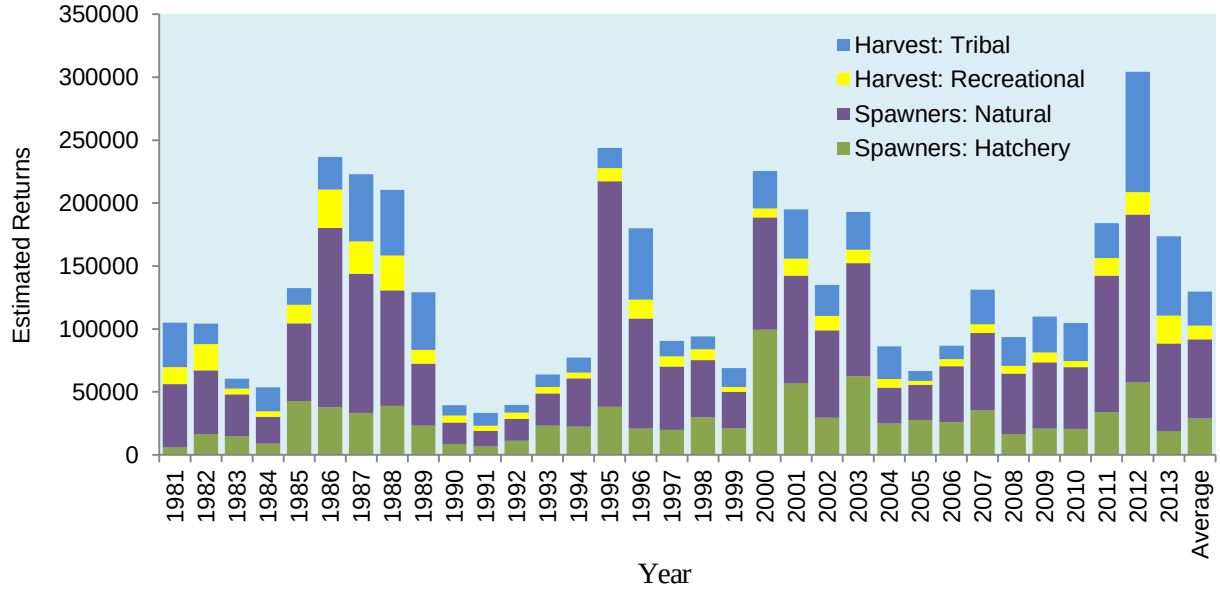
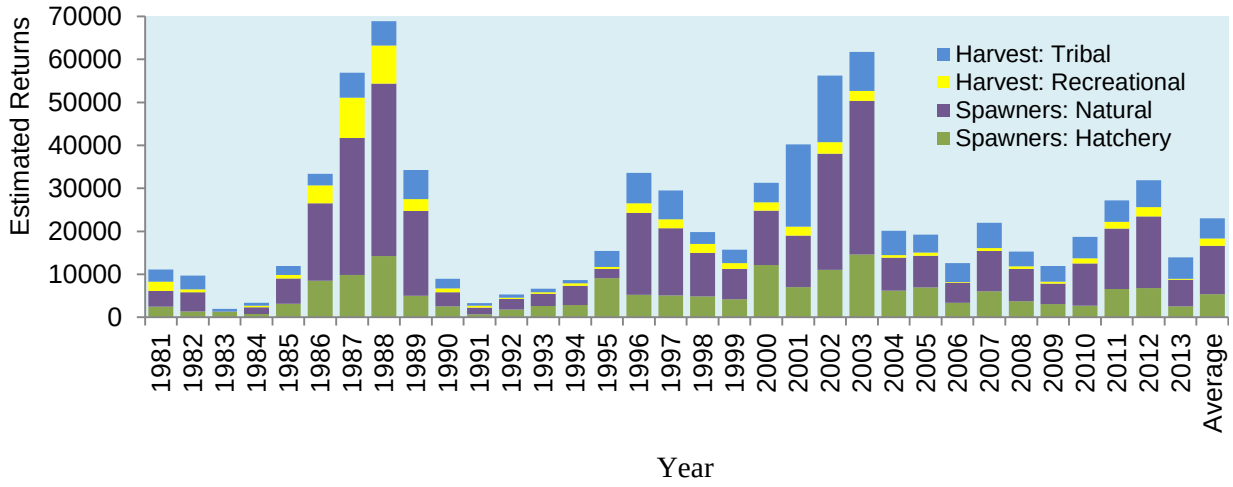


Exhibit 2: Estimated spring Chinook salmon returns (adults and jacks) to the Klamath River Basin (CDFW 2013).[7]



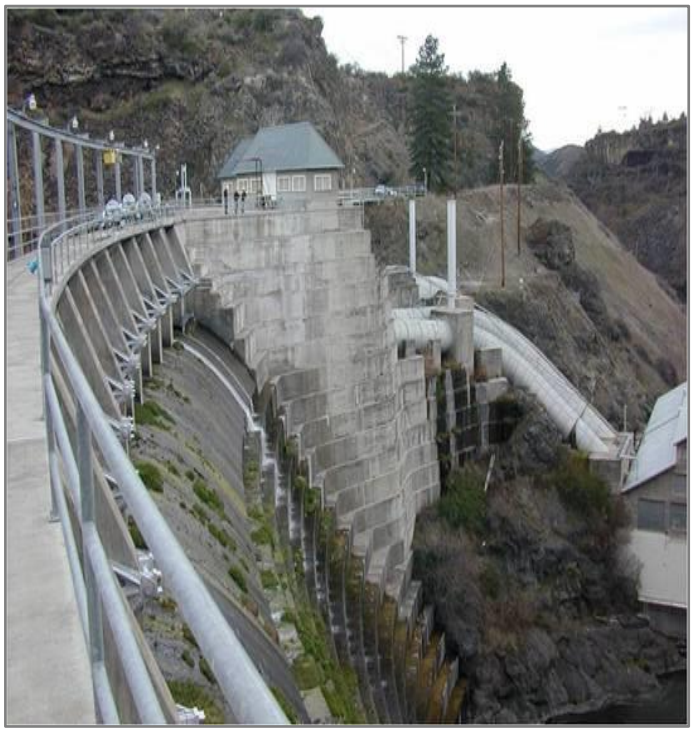
[6] Because these estimates are based on returns to the Klamath River Basin, estimates of Chinook salmon harvest in commercial and recreational ocean fisheries are not included. The estimate from 2002 does not account for a die off of ~ 33,000 fish (USFWS 2003).

[7] Because these estimates are based on return spawners, estimates of Chinook salmon harvest in commercial and recreational ocean fisheries are not included.

Coho Salmon

Coho salmon in the Klamath Basin are a component of the Southern Oregon/Northern California Coast (SONCC) coho salmon ESU, which was listed as threatened in 1997 under the ESA. All nine coho salmon populations within the Klamath basin (i.e., Upper, Middle, and Lower Klamath River populations, Upper and Lower Trinity River populations, Scott, Shasta and Salmon River populations, and the South Fork of the Trinity River population) have declined relative to historical levels. Dam construction, beginning with the California/Oregon Power Company's (COPCO) Copco 1 Dam in 1918 on the mainstem Klamath River and Trinity Dam in 1956 on the Trinity River, has substantially reduced the historical habitat of the two uppermost populations. Many of the Klamath River Basin's coho salmon populations are considered to be at high risk of extinction because they are below, or likely below, their depensation threshold (NMFS 2012). The depensation threshold refers to the number of fish (representing a population) under which recovery becomes unlikely due to a corresponding reduction in productivity (i.e., a degenerative feedback loop, or "downward spiral" likely to result in the population's extinction).

Estimates of returns derived from numerous sources for four of the nine populations are provided (Exhibits 3 and 4). The 4 populations described in Exhibits 3 and 4 have the most data available for NMFS to analyze. The Scott River population appears to have a stronger year class than the other two year classes, with the 2013 returns being the strongest observed over the period of record. Both the Shasta River and Bogus Creek spawner abundance remain at low levels, even with contributions from Iron Gate hatchery (IGH). Coho salmon populations in the Trinity Basin have been variable, but have been trending upwards over the past few years.



PacifiCorp's Copco 1 Dam. Photo: USFWS

Exhibit 3: Coho salmon abundance estimates for the Shasta River, Scott River, and Bogus Creek[8]

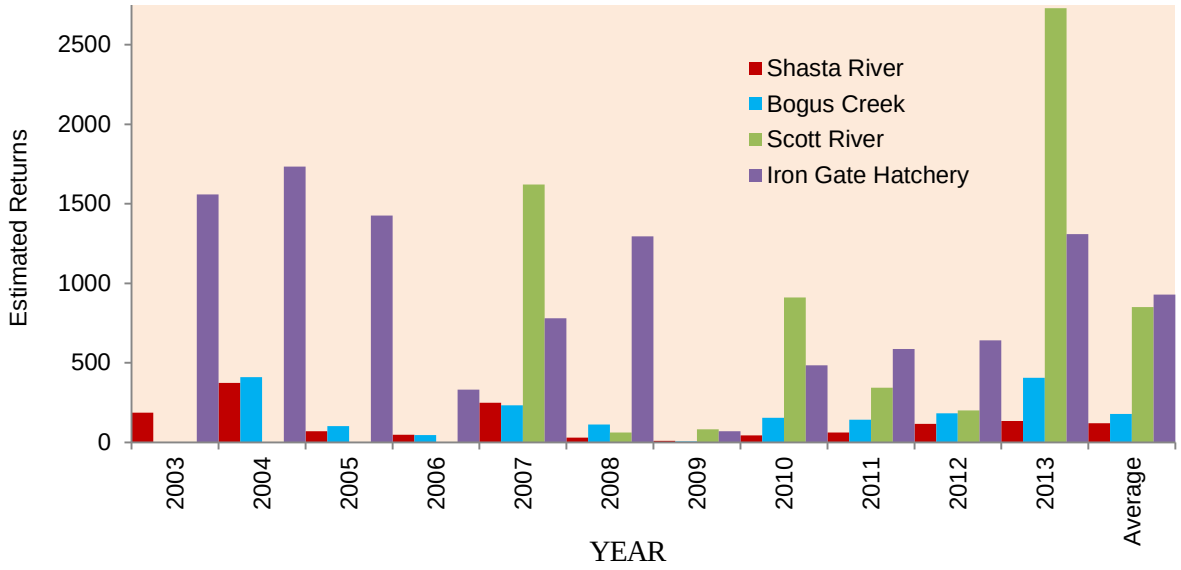
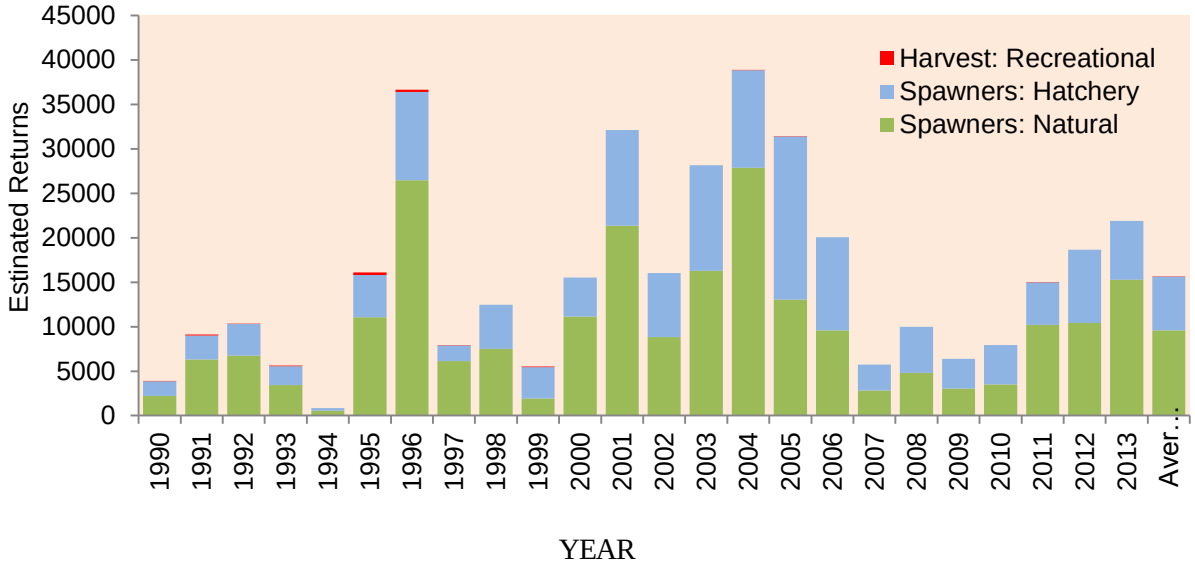


Exhibit 4: Coho salmon abundance estimates for the Trinity River (CDFW 2014b).

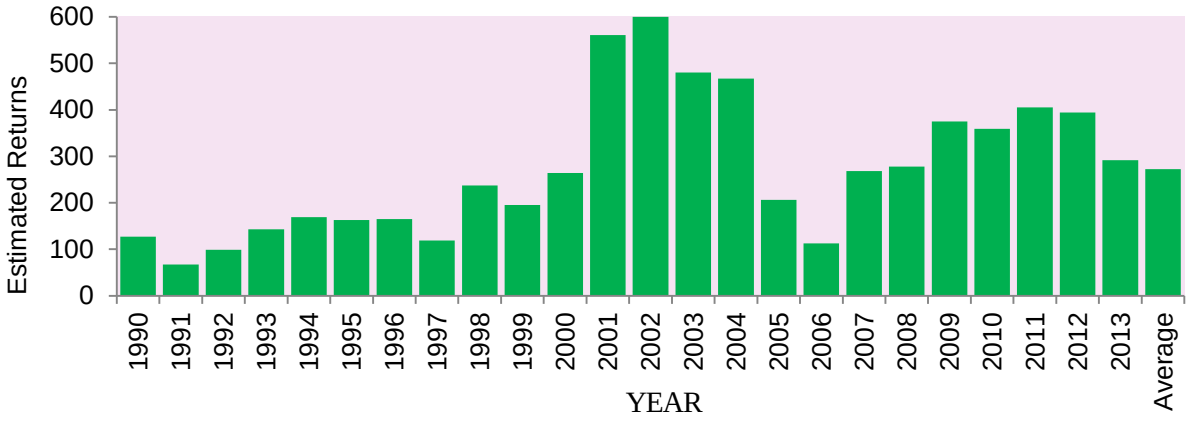


[8] CDFW, Northern Region, Yreka. Personal communication. April 4, 2014. Data obtained as part of the Klamath River Project (KRP), which funds video fish-counting facilities and cooperative spawning ground surveys. Bogus Creek and Scott River weir data are not available prior to 2004 and 2007, respectively.

Steelhead

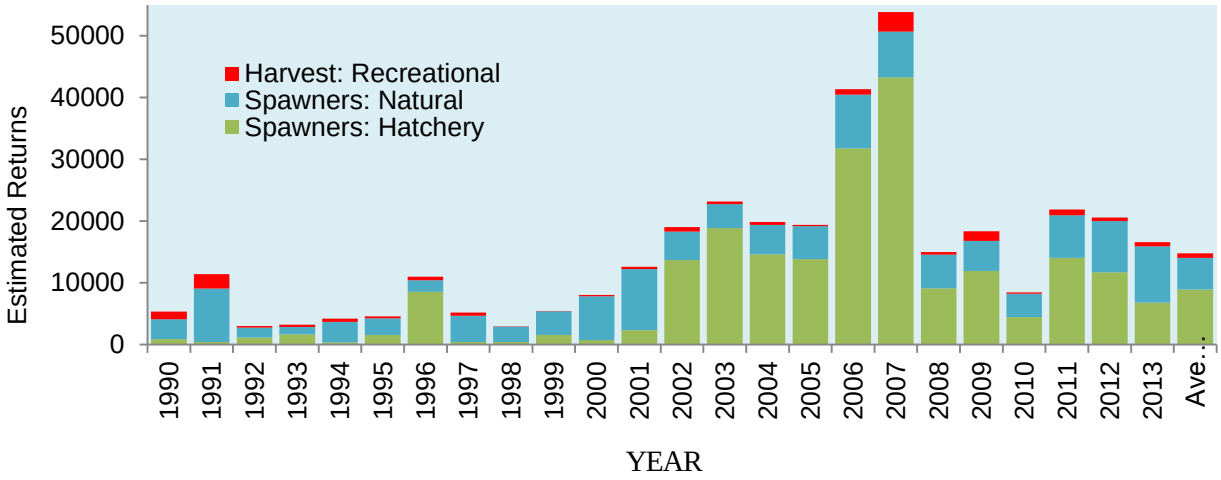
Steelhead populations in the Klamath Basin are part of the Klamath Mountains Province steelhead ESU. This ESU is not listed under the ESA. Steelhead in the Klamath River Basin are widely distributed and include winter, summer, and fall steelhead populations. However, dam construction has substantially reduced the overall habitat for steelhead in the Klamath Basin (Hamilton et al. 2005). Winter steelhead abundance is not well known because it is difficult to survey in the winter during periods of high flow, but it is thought to be stable. Summer steelhead are generally considered to be less viable than winter steelhead. Salmon River summer steelhead estimated abundance has been relatively consistent since 2000 (Exhibit 5). Returns of fall steelhead to the Trinity basin have also been consistent and typically above average since 2000 (Exhibit 6).

Exhibit 5: Estimated summer steelhead returns (adults and "half-pounders") in the Salmon River.[9]



[9] Data courtesy of Lyra Cressey of the Salmon River Restoration Council in 2014. The 2006 count is an estimate (wildfires prevented survey access to 35% of the Salmon River). "Half-pounder" data not available prior to 2000. A "half-pounder" is a steelhead that returns to fresh water after only two to four months of saltwater residence.

Exhibit 6: Estimated fall steelhead returns to the Trinity Basin (CDFW 2014).



Joint NMFS/USFWS Biological Opinion for the Klamath Project

NMFS issued a rare joint Biological Opinion (BO) with the USFWS on the effects of the U.S. Bureau of Reclamation's (Reclamation) Klamath Project operations in May 2013. This BO was the first attempt to reconcile, in a single document, the disparate needs of the threatened SONCC coho salmon ESU (listed by NMFS), endangered shortnose sucker (*Chasmistes brevirostris*) and Lost River sucker (*Deltistes luxatus*) (listed by USFWS), and the Klamath Project. The Klamath Project BO represented significant effort and collaboration between NMFS, USFWS, and Reclamation. The rationale for a joint BO was to ensure that all factors were considered for these species in a coordinated, comprehensive single regulatory document. NMFS, Reclamation and the USFWS collaborated with multiple stakeholders (e.g., PacifiCorp, local Tribes, and the agricultural community) to produce a novel, workable system that satisfies the needs of the ESA listed species and also provides Klamath Basin farmers within the Klamath Project service area with a greater level of certainty for water deliveries than in the past.

Klamath Hydroelectric Settlement Agreement and Klamath Basin Restoration Agreement

The Klamath Basin Restoration Agreement (KBRA) and the Klamath Hydroelectric Settlement Agreement (KHSA) were forged by Klamath Basin stakeholder groups including Basin irrigators, fishermen, tribes and conservation groups, a dam owner (PacifiCorp), counties and agencies within the states of California and Oregon, and Federal agencies. There are 45 Parties to the KHSA and 43 Parties to the KBRA. The KBRA is designed to create economic stability, provide reliable water supplies and energy, and restore important fisheries for all the Basin's diverse communities. The KHSA lays out the process for additional studies, environmental review, and a determination by the Secretary of the Interior regarding whether removal of four dams owned by PacifiCorp on the Klamath River: 1) will advance restoration of the salmonid fisheries of the Klamath Basin; and 2) is in the public interest, which includes but is not limited to consideration of potential impacts on affected local communities and tribes. As of 2013, implementation of a number of programs under these agreements has been delayed because certain proposed activities are not currently authorized under existing law and funding has not been available. Over 2012 and 2013, parties to these agreements have implemented the near-term actions described in more detail below.

Summary of Klamath Basin Restoration Agreement Activities

First Amendment to the KBRA - In 2012, all Parties to the KBRA signed the First Amendment to the KBRA, which extends the KBRA deadline for Federal authorizing legislation until December 31, 2014. In addition, amendments stipulate that the Secretary of the Interior and signatory Tribes must consent to any future decrease in funding under the KBRA for certain programs, which may affect the Tribes' bargained-for benefits under the agreement. Highlights of other amendments include:

- The addition of the Klamath Basin Power Alliance as a new Party to the KBRA.
- Clarification that Clear Lake, Gerber Reservoir and Lost River (above Harpold Dam) will not be required to provide water to wildlife refuges under the new refuge allocation in the KBRA.

- Clarification and updates on other KBRA provisions, such as:
    - **Funding:** Updates references to funding to accommodate reductions of initial KBRA cost estimates.
    - **Draft Drought Plan:** Plan completed and dates for future amendments updated.
    - **Habitat Conservation Plans:** Clarifies the applicable processes for these plans based on NMFS and USFWS policies. The KBRA provides a process to develop such plans under the Endangered Species Act to address potential impacts of Upper Klamath Basin activities to fish, including salmon that would return to the Upper Klamath Basin if Klamath River dams are removed.
    - **Emergencies:** Clarifies that the Bureau of Reclamation will continue to address emergencies that affect Klamath Reclamation Project facilities under existing authorities.
    - **Eligibility for Power Program:** Clarifies the eligibility of the KBRA program to provide low-cost power to pump water to irrigators and wildlife refuges, and return water to the Klamath River, to make it clear that power users can either own or lease the land and use individual or multiple pumps or meters.

The KBRA amendments do not affect the KHSA.

Restoration and Monitoring Plan Development - The Fishery Managers have agreed on an outline and approach to develop the Klamath Basin Fisheries Restoration and Monitoring Plan. However, only partial funding has been made available for the development of the Plan.

Summary of Klamath Hydroelectric Settlement Agreement Activities

In 2012, the Department of the Interior, in conjunction with the Department of Commerce (NMFS), prepared a final report summarizing two years of peer-reviewed scientific and technical studies as well as existing studies to help inform the Secretary of the Interior on the determination whether to remove four hydroelectric dams on the Klamath River per the KHSA. The comprehensive report, entitled Klamath Dam Removal Overview Report for the Secretary of the Interior: an Assessment of Science and Technical Information (Overview Report), and each

individual study conducted on the environmental and economic impacts of the potential dam removal, are available at www.KlamathRestoration.gov.

On April 4, 2013, the U.S. Department of the Interior released a Final Environmental Impact Statement (EIS) evaluating the potential removal of four privately owned hydroelectric facilities on the Klamath River. The Final EIS identifies the preferred alternative as full removal of all four facilities; the matter now awaits congressional action before the Secretary of the Interior may make a determination of whether the removal of the four facilities will advance restoration of the salmonid fisheries of the Klamath Basin and is in the public interest. The EIS was developed under the provisions of the KHSA and the National Environmental Policy Act, and it describes advantages and disadvantages to potential dam removal on the Klamath River. The EIS reveals that, over the next few decades, dam removal and the implementation of a related watershed-wide restoration program could significantly increase available habitat for salmon and other anadromous fish in the Klamath Basin, largely eliminate toxic algae blooms and other water quality problems currently produced in reservoirs and transported downstream, and largely eliminate elevated late summer/fall water temperatures in the river below the current reservoirs, which is important for salmon and other anadromous fish.

The interim measures to improve environmental conditions within the Klamath Hydroelectric Project to benefit aquatic habitat and listed species, improve water quality, and improve hatchery operations are being implemented as called for in the KHSA. In addition, on February 24, 2012, NMFS issued to PacifiCorp a permit for incidental take of coho salmon associated with implementation of PacifiCorp's Klamath Hydroelectric Project interim operations habitat conservation plan for coho salmon. The incidental take permit was issued pursuant to the ESA and as called for in the KHSA. The habitat conservation plan provides for implementation of a conservation strategy that includes turbine venting at Iron Gate Dam to enhance dissolved oxygen concentrations in surface waters downstream; measures to provide instream flow, flow variability, and flow ramping rates to benefit listed coho salmon downstream of Iron Gate Dam consistent with NMFS's biological opinion for Reclamation's Klamath Project; retrieving large woody debris trapped at or near the four dams on the Klamath River and placing it in mainstem or tributary waters downstream of Iron Gate Dam; habitat restoration projects designed to enhance the survival and recovery of listed coho salmon, funded through the coho enhancement

fund, and conducted by third parties; research studies on fish disease conditions and causal factors downstream, funded through the Klamath River fish disease research fund, and conducted by third parties; and funding and participation in Iron Gate Hatchery measures developed to support a hatchery and genetic management plan to maximize conservation benefits of the hatchery program to coho salmon.

Restoration and Recovery

The following sections highlight key recent restoration actions in the Klamath River Basin that were intended to advance the recovery of the SONCC coho salmon ESU.

Camp Creek Off-Channel Salmonid Rearing Habitat Project

Since 2012, NOAA's Restoration Center has provided $43,256 to fund this project which has created approximately 3,000 square feet of high quality off-channel thermal refuge and winter rearing habitat for juvenile salmonids on Camp Creek, a Klamath River tributary. The species benefited will be steelhead and ESA-listed coho salmon, although high densities of out-migrating juvenile Chinook salmon have been documented using similar habitats as thermal and high flow refuge during late spring and early summer months.

Hostler Creek Dam Removal Project

Juvenile coho salmon. Photo: John McMillan

This 2012 project used $110,000 provided by NOAA's Restoration Center. The Restoration Center partnered with the national non-profit conservation organization American Rivers to remove the man-made Hostler Creek fish barrier. This action restored the creek to its natural channel and gradient which has allowed volitional passage of juvenile and adult coho salmon, Chinook salmon, and steelhead over a range of flows. The project re-established access to 2 miles of fully functional stream habitat (i.e., channel and riparian habitats) upstream, and the thermal refuge that upstream habitat provides for anadromous fish.

Restoration of Lower Klamath River Fisheries and Riparian Habitats

In 2013, NOAA's Restoration Center funding continued for Lower Klamath River Restoration projects with $128,000 provided for improving fisheries and riparian habitats. Hunter Creek is located in the Lower Klamath River sub-basin in Northern California and an ongoing project will construct 48 engineered log jams along a one-mile reach of Hunter Creek. These engineered structures will increase habitat complexity, and provide excellent refugia for wild runs of coho salmon and Chinook salmon, steelhead, and coastal cutthroat trout, as well as Pacific and River lampreys. The project will also plant native trees and install willow baffles in these reaches to provide additional immediate and long term benefits to native fish. Project implementation began in the summer of 2014 and is scheduled to be completed in autumn of 2015.

Final SONCC Coho Salmon Recovery Plan

In 1997, NMFS determined that declining abundance and productivity, range reductions and diminished life history diversity warranted listing the SONCC coho salmon ESU (which includes naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California, as well as three artificial propagation programs that were added to the ESU in 2005) as a threatened species under the ESA. In September, 2014, NMFS released the Final Recovery Plan for SONCC Coho Salmon (Plan). The goal of the Final Plan is to recover the species to the point that it becomes naturally self-sustaining and no longer requires the protections afforded by the ESA, at which point it may be delisted under the ESA.

The Final Plan's recovery objectives describe the biological parameters of the species-level recovery goal using the concept of viable salmonid populations (VSP). The Final Plan identifies measurable biological levels for each of the four VSP parameters (i.e., abundance, productivity, spatial structure, and diversity) that would constitute "recovery" for each population. The Final Plan also establishes criteria at the ESU, diversity strata, and population scales to measure whether the recovery objectives are being met.

Recovery actions include removal of, or passage at, both large and small dams; ensuring sufficient water quantity and quality; restoring in-channel habitat and upslope ecological

function; and the creation and safeguarding of suitable estuarine nurseries. Other actions include managing fisheries, scientific data collection, decreasing the incidence of salmonid disease, reducing non-native predator species, and operating hatcheries consistent with recovery goals. The cost of achieving recovery and delisting of SONCC coho salmon by implementation of the Final Plan's actions is estimated at approximately $5.0 billion over 25+ years. It is important to note that the calculation of cost estimates does not imply funding availability (NMFS 2014). While this figure represents a considerable investment, the recovery of SONCC coho salmon will produce a wide array of economic, ecologic, and societal benefits. Many of the actions identified are designed to improve watershed-wide processes, which could result in benefits to many indigenous flora and fauna by restoring nominal ecosystem functions. Biological recovery goals, objectives and measurable criteria will provide a tangible mechanism to track recovery progress objectively.

Funding Updates

Federal and State agencies in the Klamath River Basin are continuing to commit funding and personnel resources toward restoration activities largely recommended in the 2007 Klamath River coho salmon recovery plan (NMFS 2007) (Exhibit 7).

Exhibit 7: Annual estimated funding of restoration and salmon and trout recovery activities in the Klamath River Basin by NOAA and other Federal and State agencies. *NB: Amounts depicted are in thousands of dollars.

Fiscal Year	NOAA			State of California		Other Federal Agencies			
	NMFS PCSRF [A]	NMFS	Restoration Center	Department of Fish and Wildlife FRGP [B]	Coastal Conservancy	US Fish and Wildlife Service	US Forest Service	Bureau of Reclamation	USDA Natural Resources Conservation Service
2012	$2,580	$2,539	$110	$100	$16	$2,790	$2,027	$13,053	$1,918
2013	$1,416	$1,300	$323	$316	$318	$5,000	$2,027	$13,401	$2,696
Total	$3,996	$3,839	$433	$416	$334	$7,790	$4,054	$26,454	$4,614

[A] Pacific Coastal Salmon Recovery Fund
[B] Fisheries Restoration Grant Program

Fisheries Management

Chinook Salmon

The Federal ocean salmon fishery off the coasts of California, Oregon, and Washington is managed under the Pacific Coast Salmon Fishery Management Plan (FMP) under the MSA. Pursuant to the MSA, the Pacific Fishery Management Council (PFMC) provides fisheries management recommendations to the Secretary through NMFS. The Secretary will implement the management measures into regulation if the PFMC recommendations are consistent with the MSA, ESA, and other applicable laws.

In December 2011, the Salmon FMP was amended (i.e., Amendment 16) to provide a new framework that complies with the MSA, as amended in 2007, and the National Standard 1 Guidelines, as revised in 2009, to prevent overfishing and attain optimum yield. Notably, Amendment 16 established new status determination criteria (SDC), annual catch limits, and accountability measures, as well as *de minimis* fishing provisions to allow for low levels of fishing impacts on stocks that are at low levels of abundance. Additionally, it updated the conservation objective for Klamath River fall Chinook salmon. Previously the conservation objective required at least 35,000 natural-area adult spawners. This was changed to a conservation objective reflecting the maximum sustainable yield escapement level of 40,700 natural-area adult spawners. Under the new SDC established by Amendment 16, Klamath River fall Chinook salmon are considered overfished when the 3-year geometric mean spawning escapement falls below 30,525 natural-area adult spawners (PFMC 2012).

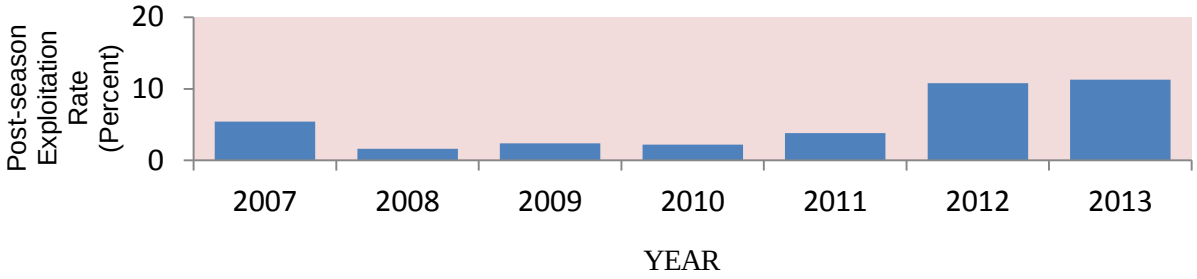
Overfishing occurs when the exploitation rate exceeds the maximum fishing mortality rate threshold of 71%. The stock is managed through the implementation of a new control rule specifying that the predicted exploitation rate cannot exceed 68%, which represents a 5% reduction from the maximum fishing mortality rate threshold to account for scientific uncertainty. The control rule also specifies further reductions in the annual exploitation rate as abundance forecasts decrease (PFMC 2012).

Under this new management framework, both the 2012 and 2013 abundance forecasts for Klamath River fall Chinook salmon were sufficiently large for the control rule to specify an allowable exploitation rate of 68%. The post-season estimates of the exploitation rate were within the limits described above with a 46% exploitation rate in 2012 and a 64% exploitation rate in 2013 (PFMC 2014b); therefore, Klamath River fall Chinook were not subject to overfishing. The post-season estimates of escapement were 118,047 natural-area adult spawners in 2012 and 59,627 natural-area adult spawners in 2013 (PFMC 2014a). The 3-year geometric mean spawning escapement (2011-2013) was 69,045, indicating that Klamath River fall Chinook were not overfished (PFMC 2014a).

Coho Salmon

The Klamath coho salmon stock is managed under the ESA as part of the SONCC coho salmon ESU. Fisheries targeting coho salmon and retention of coho salmon caught incidentally in Chinook-directed fisheries south of the Oregon/California border are prohibited. The incidental take limit in the commercial Chinook salmon fishery for this ESU is an ocean exploitation rate of no more than 13% on SONCC coho salmon, using the Rogue/Klamath hatchery stocks as an indicator (NMFS 1999). Post-season exploitation rates from the ocean fishery have been consistently below this limit since exploitation rates were first assessed in 2007 (Exhibit 8), in part because of the coho target and retention prohibition.

Exhibit 8: Ocean fishery post-season exploitation rates of the Rogue River/Klamath River coho salmon (PFMC, 2008, 2009, 2010, 2011, 2012a, 2013, 2014a).



Research and Monitoring

The following sections highlight key research and monitoring actions in the Klamath River Basin during this reporting period that were intended to advance the recovery of SONCC coho salmon.

NMFS SWFSC Research and Monitoring Activities

Research activities by the NMFS Southwest Fisheries Science Center (SWFSC) have recently expanded in the Klamath River Basin. Specific projects focused on gaining an understanding of environmental variation and fish response at spatial scales ranging from local to regional to inform management and conservation of ESA-listed coho salmon, and steelhead and Chinook salmon populations that contribute to tribal, commercial, and sport fisheries. In addition, the SWFSC is continuing its long history of providing ocean harvest management support for Klamath River fall Chinook salmon.

Klamath River Fall Chinook Salmon Stock and Fishery Assessment

The SWFSC Salmon Assessment Team leads efforts in conducting the annual stock assessment of Klamath River fall Chinook salmon. The data collected are used by NMFS in reporting the stock's status to Congress; and by the PFMC and the California Department of Fish and Wildlife (CDFW) to develop ocean commercial and recreational salmon fishery regulations off the coasts of California and Oregon, and river tribal and recreational fishery regulations in the Klamath River Basin. The assessments are used to determine the current status of Klamath River fall Chinook salmon and forecast stock abundance, fishery impacts, and spawning escapements in the coming year as a function of prospective fishery management measures. Surveys of spawning fish are conducted cooperatively by a variety of agencies (including CDFW, USFWS, Tribes, and U.S. Forest Service (USFS)) and local watershed groups, with funding provided by USFWS, CDFW, and others.

Genetic Population Structure and Stock Identification-Based Estimation of Klamath River Basin Salmonid Contribution in Ocean Fisheries

The SWFSC has several projects intended to provide a better understanding of Klamath/Trinity River Basin salmon and steelhead population structure. SWFSC staff are engaged in evaluations of population structure for coho salmon in the entire basin below Iron Gate and Lewiston dams,

having recently completed such evaluations for both Chinook salmon and for steelhead/rainbow trout above and below both dams. The Chinook salmon data were used to respond to an ESA petition for listing and also to enhance the coast-wide baseline dataset for Genetic Stock Identification (GSI). These projects were conducted in collaboration with Humboldt State University, CDFW, Oregon Department of Fish and Wildlife, and the Hoopa Valley and Yurok tribes. In addition, the SWFSC is evaluating the contribution of Klamath and Trinity River Chinook salmon stocks to ocean fisheries through GSI analysis of samples collected from commercial fisheries and associated with exact catch location data in a unique collaboration with the commercial salmon fleet.

Klamath River Temperature Modeling and Use of Thermal Refugia by Salmonids

Late summer and early fall water temperature regimes are critical to the persistence of salmon and steelhead populations in the Klamath River. Water temperatures critically influence fish physiology in numerous ways, and understanding water temperature dynamics is a prerequisite to assessing acute and chronic thermal impacts on salmonids. Currently, the temperature dynamics of the Klamath River mainstem are not well understood at the appropriate scales necessary for fisheries management decisions. The presence and duration of cold water refugia may be a key factor for salmonid survival, yet little is known about the spatio-temporal dynamics of these refugia. The SWFSC is furthering our understanding of these issues through a combination of a high-resolution stream temperature and fish mortality models of the Klamath River mainstem, and fish tracking studies to evaluate the associated spatial response of salmonids in and around selected thermal refugia. This model is driven by recently developed NASA satellite-derived climate data. The model will provide hindcasts and forecasts (including various climate change scenarios) of the Klamath River mainstem at sub-hourly intervals for every one kilometer of stream reach. These data will be used as inputs to spatially explicit fish energetic models in order to evaluate the temperature impacts on salmonids at sub-adult life stages. The SWFSC measured fine-scale spatio-temporal use of the thermal refugia and mainstem by salmonids through radio tracking of individual fish and found that fish move into the cold water habitat when temperatures reach critical thresholds above 23° C. The study also showed that fish are more likely to move into colder water when the mainstem temperature has higher daily variation.

Roles of Climate Variation, Habitat Restoration, Hatchery Practices, and Biocomplexity

Scientists at the SWFSC are developing a tool that will allow resource managers to predict how various management actions would contribute to improving the sustainability of California's Chinook salmon fishery. The tool will be a numerical multiple-population, spatially-explicit life-cycle model of Klamath River and California Central Valley Chinook salmon stocks incorporating harvest, growth, survival, maturation, and movement. The effects of management actions on salmon vital rates, production, and harvest in a varying environment are simulated by this model. The model is designed to allow resource managers to examine how changes in life-history diversity (run-timing, age of returning spawners, etc.) contribute to the resiliency of Chinook salmon populations and therefore fisheries. A critical aspect of the model is the nature of variation of survival in freshwater, the estuary, and the ocean. This approach uses models to describe fish survival based on data from coded-wire tag recoveries and time series of spawner escapement, relating the variation in survival to environmental conditions. The model results will allow resource managers the ability to track effects of various management scenarios on salmon production and resiliency.

Genetic Broodstock Management of Coho Salmon at Iron Gate Hatchery

Historically low returns of coho salmon to the upper Klamath River Basin, including to Iron Gate Hatchery, in the last decade raised concerns about genetic variability and inbreeding in this ESA-listed salmon stock. The SWFSC has been conducting a continual genetic analysis of coho salmon broodstock at Iron Gate Hatchery since 2006 to evaluate inbreeding and family structure in the hatchery-produced fish, as well as genetic differentiation from naturally spawned stocks. Since 2010, the SWFSC has provided in-season genetic broodstock management, in which coho salmon returning to Iron Gate Hatchery that are potential broodstock are rapidly characterized for genetic relatedness prior to spawning to identify and avoid potential inbred matings. This technique has significantly reduced inbreeding in Iron Gate Hatchery coho salmon. These data are also being used to inform a planned collaboration to supplement coho salmon populations in the Shasta River in habitat restored by supportive private landowners.

Application of Intergenerational Genetic Tagging of Chinook Salmon at Trinity River Hatchery

Since 2010, the SWFSC staff have collaborated with the Hoopa Valley Tribal Fisheries Department and Humboldt State University to conduct an evaluation of intergenerational genetic tagging at the Trinity River Hatchery (TRH) for both fall and spring Chinook salmon. This project involves taking tissue samples from all broodstock used in Chinook salmon production and then genotyping them with 96 single nucleotide polymorphism genetic markers developed by the SWFSC. These genotypes provide individual-specific tags for 100% of the hatchery production that can be recovered at any life stage from fish produced at the hatchery. These tags are currently being recovered in ocean fisheries and associated with exact catch location data in a unique collaboration with the commercial salmon fleet. These genetic tag recoveries will provide information about the differences in ocean migration patterns of the spring and fall Chinook salmon from the Trinity River and to evaluate contribution of Trinity River Hatchery fish to ocean fisheries. Future applications of this tagging program include estimation of the heritability of age at reproduction, and detailed analysis of the effects of hatchery practices on marine/post-release survival.

NMFS Technical Advice through Membership on Hatchery Coordination Teams

SWFSC staff are actively involved in improving management practices for the seven anadromous salmonid hatchery programs in the Klamath Basin through membership in the recently established hatchery coordination teams for Iron Gate and Trinity hatcheries. SWFSC staff have attended all meetings, and provided technical advice about how to best meet program goals and objectives, and participated in formulation of proposed management plans for the salmon and steelhead programs at these two facilities.

NMFS Cooperative Research Projects with Humboldt State University

The SWFSC along with NMFS California Coastal Office supports Darren Ward, a faculty member at Humboldt State University, to conduct research on regional issues; much of this research focuses on issues in the Klamath Basin. Those research projects include:

- Trinity River brown trout predation on juvenile salmon, a project being done in collaboration with the Hoopa Tribal Fisheries Department.
- Performance of juvenile coho salmon in constructed off-channel ponds in the Klamath River watershed. This project is being done in collaboration with the Mid-Klamath Watershed Council and Karuk Tribe.
- Migration timing and survival as a function of rearing location for juvenile coho salmon from the Shasta and Scott Rivers.
- Movement, survival, and growth of juvenile coho salmon in Klamath River tributaries (graduate student Shari Anderson, NOAA Advanced Study Program).
- Evaluating habitat-specific Chinook salmon production in the Shasta River.

Research of Off-Channel Habitat in the Mid-Klamath Watershed

A thesis project funded by NMFS explored the function of off-channel habitat in the mid-Klamath watershed and the role this habitat plays in juvenile coho salmon life history (Whitmore 2014). Three types of off-channel habitats were studied, including constructed ponds (restoration sites), non-natal tributaries, and beaver pond habitats. The project highlights the importance of off-channel habitat in the mid-Klamath by estimating large populations of non-natal rearing juvenile coho salmon at the sites. These types of off-channel habitats may act as a lifeline to fish displaced from natal streams (e.g., Shasta and Scott Rivers) where unsuitable rearing conditions such as elevated water temperatures exist.

Complex movement strategies were discovered as part of the project, including individual fish that occupied four or more different off channel habitats during their one year in freshwater. Also, a daily movement pattern was identified, showing that juvenile coho salmon often move between the mainstem Klamath River and their off-channel habitat during the night; even when the mainstem river reaches stressful temperatures (Whitmore 2014). New thesis projects studying these same sites are currently underway and will further our understanding of the importance of off-channel habitats and help improve the design of future restoration projects so that they may be most effective to the greatest number of fish.

USFWS Fisheries Research and Monitoring in the Klamath River Basin

Since 2010, the USFWS has been working collaboratively with Tribal and agency partners and supporting research and monitoring studies to inform management and restoration of anadromous fish populations and associated aquatic habitats in the Klamath River Basin, including participation in the Trinity River Restoration Program. In 2013, the USFWS Fisheries Program contributed more than 2.9 million dollars for research and monitoring studies and provided technical support needed for managing and guiding restoration of anadromous fish populations and associated aquatic habitats in the Klamath Basin.

Studies supported by the USFWS in the Klamath Basin in 2013 were extensive and included:

- Collection of adult salmon escapement and stock assessment data used by the PFMC to develop harvest management recommendations
- Monitoring juvenile fish abundance, size, growth, and health
- Assessing the prevalence and distribution of fish diseases and associated intermediate hosts
- Monitoring and modeling water temperatures in the Klamath and Trinity rivers
- Developing, validating and calibrating the S^3 (Stream Salmonid Simulator) Chinook Salmon production model
- Developing fish habitat/flow relationship models on both the Klamath and Trinity rivers to inform water management decisions, assess effectiveness of restoration actions, and guide the design of future restoration projects through an adaptive management process
- Co-hosting the 2013 Klamath Fish Health Conference with Oregon State University

The USFWS has also provided $45,000 in American Recovery and Reinvestment Act (ARRA) fund grants through the National Fish Passage Program (NFPP) to the Karuk Tribe, Mid-Klamath Watershed Council, and Salmon River Restoration Council to survey the lower reaches of tributary streams throughout the middle Klamath River and to remove more than eight fish passage barriers.

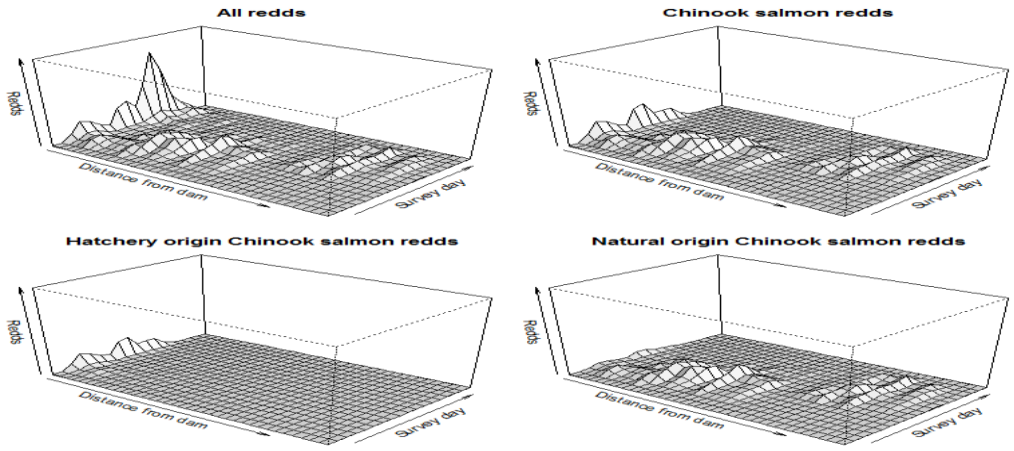
Klamath Basin Anadromous Fisheries Monitoring and Assessments

The USFWS Fisheries Program is responsible for: (1) facilitating the restoration of nationally significant fishery resources; (2) seeking and providing mitigation of fishery resources adversely impacted by Federal water development projects; (3) providing technical assistance with regard to management of inter-jurisdictional fisheries and fishery resources on Federal and Indian lands; and (4) maintaining a Federal leadership role in scientifically-based management of national fishery resources. Consistent with this direction, the USFWS has an established history of working collaboratively on salmon issues in the Klamath Basin, with its involvement dating back over 30 years ago with the creation of the Arcata Office to help fulfill the U.S. Government's trust responsibilities to Native American peoples to restore depleted inter-jurisdictional salmon resources. In addition, studies conducted and supported by the USFWS regarding adult escapement and stock assessment data have been used by the Klamath River Technical Team and the PFMC to develop harvest management recommendations.

Klamath and Trinity Rivers Fall Chinook Salmon Spawning Distribution and Escapement

This collaborative project involving the Arcata and Yreka Field offices of the USFWS, Native American Tribes, U.S. Forest Service, and CDFW monitors the spawning distribution and estimates age composition and spawning escapement of natural fall Chinook salmon within an 80-mile reach of the Klamath and 105-mile reach of the Trinity River. Data gathered by the study are used by the PFMC to develop run-size forecasts and harvest strategies, and to set quotas for Tribal, commercial, and sport fisheries. Data is also used by the Trinity River Restoration Program to evaluate the response of salmon spawning distribution to Program and/or TRH actions (Exhibit 9). Annual and multi-year trend analysis reports are available from the Arcata Fish and Wildlife Office website at http://www.fws.gov/arcata/.

Exhibit 9. Salmon Spawning Distribution in the Klamath and Trinity Rivers.



Klamath Basin Juvenile Salmonid Production Monitoring

The USFWS and Tribal, State, and Federal partners are continuing a multiyear study to assess annual estimates of juvenile abundance of Chinook and coho salmon, steelhead and lamprey in the Klamath and Trinity rivers. Fish trapping sites are also used to collect information on incidence of infectious fish diseases and their relation to environmental effects such as water temperature and flow. Information from this study has proved valuable in assessing potential effects of water management alternatives, habitat restoration efforts, and disease management.

Developing Decision Support Tools

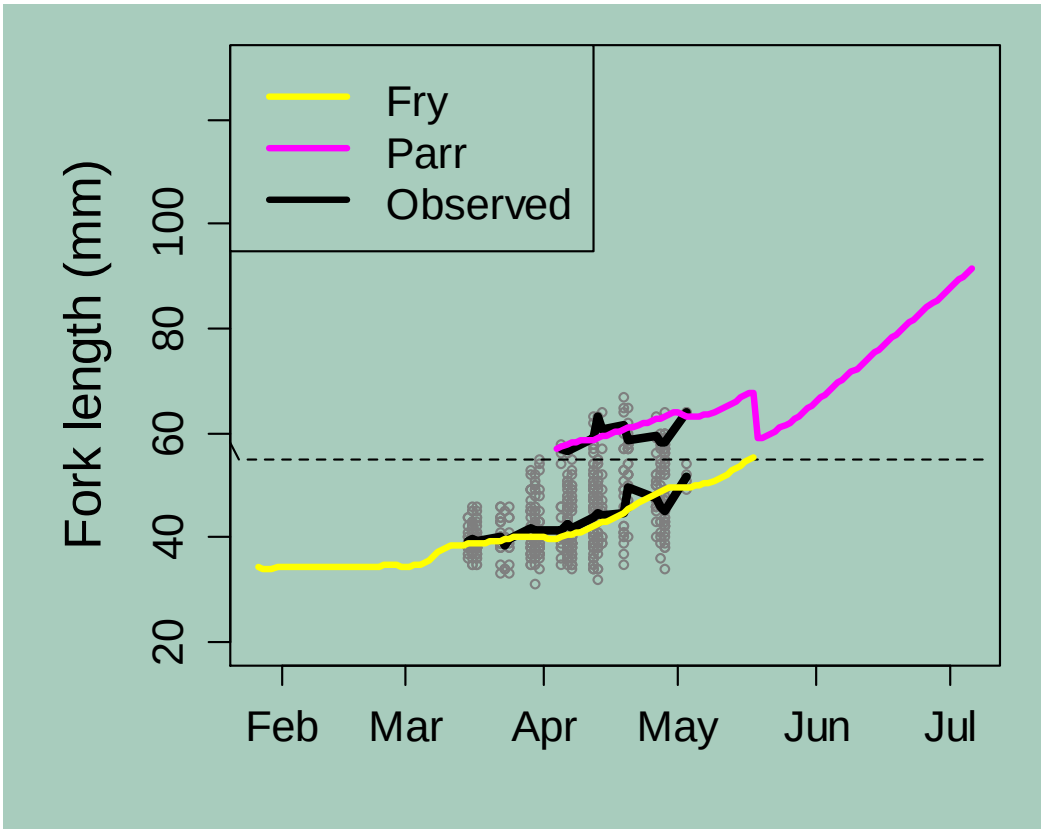
The USFWS and the U.S. Geological Survey are working collaboratively with input from NMFS and other Klamath Basin Partners to develop Decision Support Systems like the Klamath River System Impact Assessment Model (SIAM) and more recently, the Stream Salmonid Simulator (S^3) Model. The S^3 Model is an integrated set of sub-models that can be used to predict and compare the effects of water management alternatives on the production of juvenile Chinook salmon (Exhibit 10). The S^3 Model tracks causes of mortality throughout the sub-adult life history of Chinook Salmon (redd scour, habitat limitations, disease, etc.) over time within the 233-mile section of the mainstem Klamath River spanning from Keno Dam in Oregon to its confluence with the Pacific Ocean in California.

A critical component of the S^3 Model is its fish disease module, developed through an on-going partnership between the Services Arcata Office and California-Nevada Fish Health Center, the U.S. Geological Survey Columbia River Research Laboratory, and the Salmon Disease Lab at

Oregon State University. This disease sub-model simulates the prevalence of the fish parasite *C. shasta* and resulting mortality of juvenile salmon in relation to biological and physical factors experienced by juvenile salmon in the Klamath River. The model is currently being calibrated and validated to historical abundance estimates of juvenile Chinook salmon.

Due to needs and support from NMFS and the Bureau of Reclamation, the S^3 Model is now being extended into the Trinity Basin, with the addition of an ocean component and an upstream adult migration sub module. These improvements will transform S^3 into a full life cycle model that can be used to evaluate the effectiveness of channel rehabilitation projects, gravel injections, large wood augmentation, differing flow regimes, etc., by isolating ocean versus in-river influences on fish production.

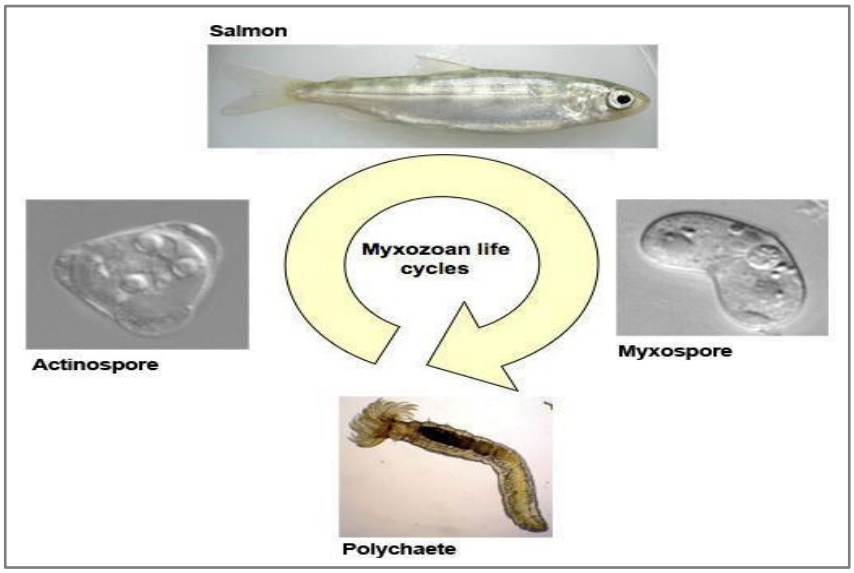
Exhibit 10: Example output from S^3 showing predicted size of juvenile Chinook salmon compared to observed size data collected at juvenile traps in the Klamath River. The dashed horizontal line at 55 mm Fork Length represents the breakpoint between fry and parr.



Myxozoan Disease Effects on Klamath Basin Salmonids

Drs. Scott Foott (USFWS, CA-Nevada Fish Health Center) and Jerri Bartholomew (Oregon State University) annually monitor for two myxozoan parasites, *Ceratonova (syn. Ceratomyxa) shasta* and *Parvicapsula minibicornis*, and their intermediate host, the polychaete worm, *Manyunkia speciosa*, associated with disease and mortality of Klamath River salmon. Monitoring indicates that parasite infections and disease have been lower recently (2010-2013) compared with previous years (2007-2009). In addition, Chinook salmon from different areas of the basin have varying parasite loads, with fewer parasites detected in fall from the Klamath than those in the Shasta or Trinity Rivers (Foott et al. 2013).

Exhibit 11. Life cycle of *Ceratonova shasta* (J. Bartholomew).



Dr. Bartholomew's laboratory has also developed a suite of models to study and understand the complex interactions involved in the life cycle of *C. shasta* with the goal of managing disease in Klamath River salmonids. Global climate models (developed by other researchers) provide temperature and water flow data. This data is used to predict polychaete host density (Exhibit 11). The predictions of polychaete host density, along with other variables, are then used to identify points in the life cycle that may be sensitive to management actions. For example, increasing winter flows could decrease polychaete populations through scouring, resulting in fewer parasites and less disease in the fish host. A separate model can be used to estimate disease in juvenile salmon and could inform projections of returning adults (Ray et al. 2014).

USFWS Role in Restoring Klamath Basin Anadromous Fish Populations

Klamath Basin Habitat Restoration and Fish Passage: Partners for Fish and Wildlife Program

The Partners for Fish and Wildlife (PFW) Program is the USFWS's primary habitat restoration program for private landowners in the Klamath Basin. The PFW Program contributed more than 1.8 million dollars through the Arcata and Yreka Fish and Wildlife field offices to support restoring habitat conditions and passage for anadromous fish species in the Klamath Basin in 2013, with an additional $300,000 provided by the USFWS's Fish Passage Program. Specific projects implemented by the PFW in the Basin in 2013 included:

- Parks Creek Fish Screen Upgrade
- Middle Klamath Large Woody Debris Placement
- Upper Parks Creek Riparian Fencing
- East Fork Scott River Off-Channel Habitat for Coho Phase II
- Horse Creek Off-Channel Coho Winter Rearing Habitat Project
- Titus Creek Off-Channel Coho Winter Rearing Habitat Project
- Panther Creek Off-Channel Habitat Restoration-Lower Klamath River Estuary
- Hunter Creek In-stream Complexity and Floodplain Project Phase III
- Lower Mynot Creek Off-Channel Wetland Habitat Enhancement

Two of these projects are highlighted below and they involve Federal resource agencies partnering with private landowners to facilitate habitat improvements. Promoting this type of "buy-in" from the public is essential to recovering listed Pacific salmonids to viable levels.

Panther Creek Off-Channel Habitat Restoration-Lower Klamath River Estuary Project

During 2013, the USFWS's PFW Program provided funding and technical assistance to a private landowner and the Yurok Tribe to expand and enhance off-channel wetland habitat along lower South Fork Panther Creek. Project objectives included deepening and augmenting 2 acres of off-channel wetlands, protecting and enhancing riparian vegetation with livestock exclusionary

fencing and native vegetation planting, and improving passage by replacing two undersized culverts with bridges. Project work occurred immediately adjacent to an earlier project funded in 2011 by the PFW program and the two projects became interconnected in 2013, totaling nearly 5 acres of off-channel wetland habitat in the Panther Creek drainage to the Lower Klamath River.

East Fork Scott River Off-Channel Habitat Restoration Project

Off channel habitats (e.g., alcoves, ponds, and groundwater channels) provide critical overwintering habitats for coho salmon throughout the range of the species, including in the Mid-Klamath Basin. These overwintering habitat types have been well demonstrated to be essential for coho salmon to complete the freshwater phase of their life cycle. Land use practices, however, have reduced the quality, quantity and availability of these habitats in the Scott River watershed and elsewhere in the Klamath Basin. In 2013, the Yreka Fish and Wildlife Field Office worked with a private landowner to expand and complete the enhancement and reconnection of 1.7 acres of off-channel habitat and the removal of a passage barrier. Juvenile coho salmon were documented using the habitat within hours of the habitat being connected to the river. The landowner has also reported adult coho salmon in the newly restored area. In addition to fish presence, water temperatures are more stable in the restored habitat than the main channel and several species of aquatic invertebrates now occupy this newly created habitat.

Summary

Habitat restoration and conservation, along with improved scientific knowledge of the threats to population viability, are furthering efforts to recover and restore anadromous salmonids in the Klamath River Basin. Continued commitment to these activities is imperative to restoring the River ecosystem and the communities that depend on it for their livelihood and cultural heritage. NMFS is committed to further strengthening conservation program partnerships for the recovery of salmonid populations within the Klamath River Basin. Future progress on these efforts will continue to be reported annually to Congress.

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