U.S. Fish & Wildlife Service

Arcata Fish and Wildlife Office
Fish and Aquatic Habitat Program Overview 2016

Role of AFWO Fish & Aquatic Habitat Conservation Program

The U. S. Fish and Wildlife Service's Fish and Aquatic Habitat Conservation (FAC) 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) assisting with management of inter-jurisdictional fisheries and fish resources and aquatic habitats,
4) providing technical assistance to native American Tribes, and
5) maintaining a federal leadership role in scientifically-based management of national fishery resources.

Authority and directives supporting Service activities to protect and restore fishery resources and aquatic habitats is described in several acts, including the Fish and Wildlife Act of 1956, Fish and Wildlife Coordination Act, Fish and Wildlife Improvement Act of 1978, Federal Power Act, Anadromous Fish Conservation Act, and Endangered Species Act, and more locally, the Klamath River Basin Fishery Resources Restoration Act, Title 34 of the Central Valley Project Improvement Act, and the Trinity River Basin Fish and Wildlife Restoration Act, among others. The Service has been identified as being DOI's "principle fact-finding arm and scientific authority on fishery resource matters", with the role of our FAC Program specified in detail in its national strategic plan titled *Strategic Plan for the U.S. Fish and Wildlife Service Fish and Aquatic Conservation Program: FY2016-2020*.

AFWO Fish Program History

The U. S. Fish & Wildlife Service Arcata Fish and Wildlife Office (AFWO) was established over 30 years ago as a *Fisheries Assistance Office* to fulfill trust responsibilities to Native American peoples relating to restoration of depleted inter-jurisdictional salmon fisheries on the Klamath River. Specific roles of the Arcata Office's FAC Program have changed over the years, evolving from tribal net harvest management in the late 1970's and 1980's, to development of tribal fish program capabilities in the 80's and 90's, to more recently providing technical and scientific support to established Tribal Fisheries Programs, federal and state agency partners and Service managers. Today, the Program works to fulfill its tribal and public trust responsibilities by conducting a variety of fish population studies and aquatic habitat assessments deemed essential for managing inter-jurisdictional fisheries and guiding and assessing the effectiveness of large-scale fish and aquatic habitat restoration programs.

Trinity River Restoration Program

A primary focus of the Arcata Fish and Wildlife Office FAC Program continues to center on implementing the Trinity River Restoration Programs (TRRP). The goal of the TRRP is to restore anadromous fish populations in the Trinity River to pre-dam levels through implementation of a suite of flow management and instream restoration actions guided by an adaptive management science program. The Service is charged with implementing the TRRP for the Secretary of the Interior as a co-lead with the Bureau of Reclamation. The AFWO Field Supervisor represents the Service on the Trinity River Management Council (TMC) and directly supervises the TRRP's Science Coordinator. The Field Supervisor attends an average of six TMC on-site meetings, participates in 12 conference calls, and attends four to six Government to Government meetings each year. In addition to providing policy guidance to the TRRP through its co-lead role, the AFWO provides technical support through the development and implementation fish habitat and fish population studies, in collaboration with TRRP partners, to evaluate the effectiveness of restoration actions and provide feedback to the Program's adaptive management process. The AFWO currently funds the Science Program Coordinator and provides administrative support and serves as the Designated Federal Official for the Trinity Adaptive Management Working Group, a federally recognized FACA Committee.

Klamath River Fish Habitat Assessment Program

The Klamath River Fish Habitat Assessment Program, also known as the "Klamath River Flow Study," continues to provide the data, analytical tools, and models needed to help restore one of the most treasured salmon-producing regions in the United States—the Klamath Basin. Established by Congress in 2001, the program was initiated to provide a scientific "road map" to help guide the restoration of Klamath River salmon, steelhead, sturgeon, and lamprey and associated fisheries. Work conducted by the Arcata Office's Klamath Program is extensive and has been instrumental in developing the Hardy Phase II Flow Study, the discovery of population-level impacts of the juvenile fish health issue in the Basin, in furthering the understanding of the complex life cycle of *Ceratonova shasta* and its relation with environmental parameters and possible control measures, and in establishing and communicating the scientific foundation supporting the removal of Klamath River Dams, among others.

Established Long-Term Data Sets

The Arcata FAC Program has monitored escapement of adult Chinook Salmon spawning on the Klamath and Trinity rivers for over 20 years, establishing an expansive mainstem spawning dataset for the Basin. These data are used to develop and support flow management alternatives and are a driving parameter in modeling work that is used define the extent of fish diseases, manage flows, and guide restoration actions. These data also serve as the baseline for restored passage/dam removal conditions and strongly influence the methods that are being incorporated into the Klamath Basin Integrated Monitoring and Restoration Plan. AFWO staff have also conducted Coho Salmon spawning surveys on the mainstem Klamath River for several years. These observational data represent the only documented cases of mainstem spawning of Coho Salmon in the Basin, which is important with regard to flow management given the threatened status of SONCC Coho Salmon under the ESA. The Program has also monitored the abundance

and health of outmigrant juvenile salmon and steelhead on the Klamath and Trinity rivers for over 20 years, creating one of the longest existing datasets for juvenile salmon production in the Pacific Northwest. These data serve as the baseline for restored passage/dam removal conditions, with the methods also being incorporated into the Klamath Basin Integrated Monitoring and Restoration Plan.

Developing Decision Support Tools

The Arcata FAC Program continues to lead collaborative efforts in the Klamath Basin to guide and assess the effectiveness of large river restoration activities, with recent work relying on state-of-the-art, peer-reviewed methods that have been published in grey literature and professional journals. Through a collaboration between the Service, U.S. Geological Survey, and Texas State University, the Program continues to serve a lead role in developing Decision Support System tools such as SIAM (Klamath River System Impact Assessment Model), SALMOD (salmon production model), and most recently, the Stream Salmonid Simulator or S3 Model. The S3 Model is an integrated set of sub models that can be used to quantifiably predict and compare the effects of various management alternatives, such as pre- and post-dam removal, restored passage, pre- and post- physical habitat restoration, etc., on the production of juvenile Chinook Salmon. The S3 Model is currently being extended into the Trinity Basin and, as requested by NOAA Fisheries and BOR through newly established reimbursable agreements, is also being expanded to incorporate Coho Salmon.

Other AFWO FAC Roles

The Arcata FAC Program also maintains several other roles in the Klamath/Trinity Basin. Our office established the single most extensive water quality dataset for the Klamath Basin, which proved critical in the FERC re-licensing process for PacifiCorp's Klamath River dams, and in establishing the baseline that will be used to define methods and sites to incorporate into the Klamath Basin Integrated Monitoring and Restoration Plan. Staff from the Arcata FAC Program also continue to serve as the lead for the Service's Pacific Southwest Region for the CA component of the Pacific Lamprey Conservation Initiative and for the Pacific Marine and Estuarine Fish Habitat Partnership.

Integration of Klamath & Trinity Restoration Programs

Flow issues within the Klamath Basin are complex and are often driven by management decisions that are influenced by Reclamation's Klamath Basin Irrigation Project, PacifiCorp's operational flow releases to the Klamath River from Iron Gate Dam, the TRRP's flow schedule for Trinity River flow releases from Lewiston Dam, and by Reclamation's Central Valley Operations. A coordinated approach to managing and monitoring these interconnected sub basins is needed and therefore, it's essential that this connectivity be addressed by linking the Klamath Basin Integrated Monitoring and Restoration Plan with the Trinity River Integrated Assessment Plan. Success in implementing a single-basin approach will require integration between the Trinity River Restoration Program and Klamath water management, biological studies, hatchery operations, and harvest management.

FY16 - Year in Review

In FY16, the Service's Arcata Fish and Wildlife Office FAC Program, working in close collaboration with tribal and agency partners, contributed about 2.5 million dollars in support of monitoring and research studies and restoration projects needed for managing and guiding restoration of anadromous fish populations and aquatic habitats. The primary focus of activities conducted by the Arcata FAC Program continues to be in the Klamath Basin, including its participation in the TRRP. Activities supported by the Service's Arcata Office in FY16 are extensive and include:

- collection of adult salmon escapement and stock assessment data used by Pacific Fishery Management Council to develop harvest management recommendations and quotas,
- monitoring juvenile fish abundance, size, growth, and health,
- assessing the prevalence and distribution of fish diseases and associated intermediate host of parasites and their relation to management actions,
- monitoring and modeling water temperatures in the Klamath and Trinity rivers,
- 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,
- developing, validating and calibrating the S3 Chinook Salmon Production Model, which integrates data from virtually all of the studies conducted by the Program into a decision support tool for managers,
- conducting statistical analyses and model structure formulation in support of the development of the Klamath River S3 Coho Salmon Production Model,
- running predictive models such as S3 and the Klamath Basin Water Temperature Model to compare and contrast the effects of water management alternatives on aquatic resources,
- responding to requests for technical assistance regarding juvenile and adult fish health concerns, aquatic habitat availability and quality, and supplemental flow releases from Reclamation as directed under the Fish and Wildlife Coordination Act,
- providing technical assistance to Tribes in the Klamath/Trinity, Smith, Mad, Eel river basins, etc,
- developing and overseeing the implementation of the geographically-specific Pacific Lamprey Initiative Implementation Plans.

Featured 2016 Projects

Klamath River Juvenile Salmonid Production Monitoring: This study is a collaborative effort between the Service and the Karuk Tribe and results in weekly-stratified and annual abundance and variance estimates of outmigrant juvenile Chinook Salmon, and indices of abundance for Coho Salmon, Steelhead, and lamprey sp. in the Klamath River. Monitoring sites are used to document incidence of lethal fish diseases in the Klamath River to report to managers in real time. We also are extensively involved in the collection of samples to document prevalence of infection in the outmigrant population using QPCR analyses that we then incorporate into

various statistical analyses to evaluate potential relations between disease and environmental conditions and control measures.

***Trinity River Juvenile Salmonid Production Monitoring*:** Since 1988, the AFWO has conducted a juvenile salmonid monitoring program on the mainstem Klamath and Trinity rivers. Information collected on the Trinity River is used to estimate annual abundance indices and define outmigration timing of juvenile Chinook and Coho salmon, Steelhead, lamprey sp. and Green Sturgeon; to define wild stock salmonid production; and to provide a metric to assess the effectiveness of restoration efforts and management actions being conducted through the Trinity River Restoration Program.

Juvenile Salmonid Density Monitoring on the Mainstem Trinity River: Our staff worked collaboratively with the Yurok Tribal Fisheries Program and the Hoopa Valley Tribal Fisheries Department to monitor the density of juvenile salmonids using mainstem Trinity River aquatic habitats. The overall goal of this scientific study is to collect the data necessary to model the relationship between various habitat parameters and density of juvenile salmonids. In combination with the Trinity Juvenile Production study, model outputs generated by this study are then used to guide the design, type, and placement of river restoration structures and flow prescriptions through the TRRP's adaptive management process.

Klamath River Fall Chinook Salmon Spawning Escapement Survey

This collaborative annual project involves a partnership between the Service's Arcata and Yreka Field offices, Yurok Tribe, Karuk Tribe, Quartz Valley Tribe, and California Department of Fish and Wildlife, U. S. Forest Service, and NGO's to monitor the spawning distribution and estimate age composition and spawning escapement of Fall Chinook salmon within an 80-mile reach of the Klamath River. Data generated by this collaborative study are used by the Pacific Fishery Management Council to develop run-size forecasts, harvest strategies, and to set quotas for ocean commercial and sport fisheries and in-river sport, tribal commercial, and tribal subsistence fisheries. In-season updates and annual and multiyear trend analysis reports for this project are available from the Arcata Fish and Wildlife Office website at http://www.fws.gov/arcata/.

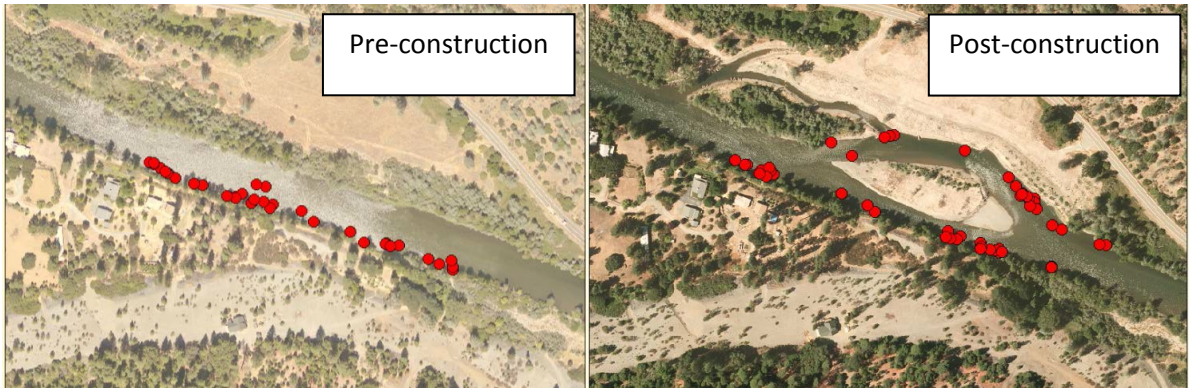
Chinook Salmon carcass on the banks of the Klamath River. (USFWS photo).

Spawning Chinook Salmon in the Mainstem Klamath River (USFWS photo).

Trinity River Fall Chinook Salmon Spawning Distribution

This project is being implemented through a unique partnership between the Service's Arcata Fish and Wildlife Office and the Bureau of Reclamation, Hoopa Valley Tribe, Yurok Tribe, U.S. Forest Service, and California Department of Fish and Wildlife. The objective of this multi-year study is to quantify changes in the distribution and abundance of spawning Chinook salmon within a 113-mile reach of the Trinity River, which is one metric used to define success of restoration actions of the Trinity River Restoration Program (TRRP). Data generated by this study are used by the TRRP through an adaptive management framework to inform and direct

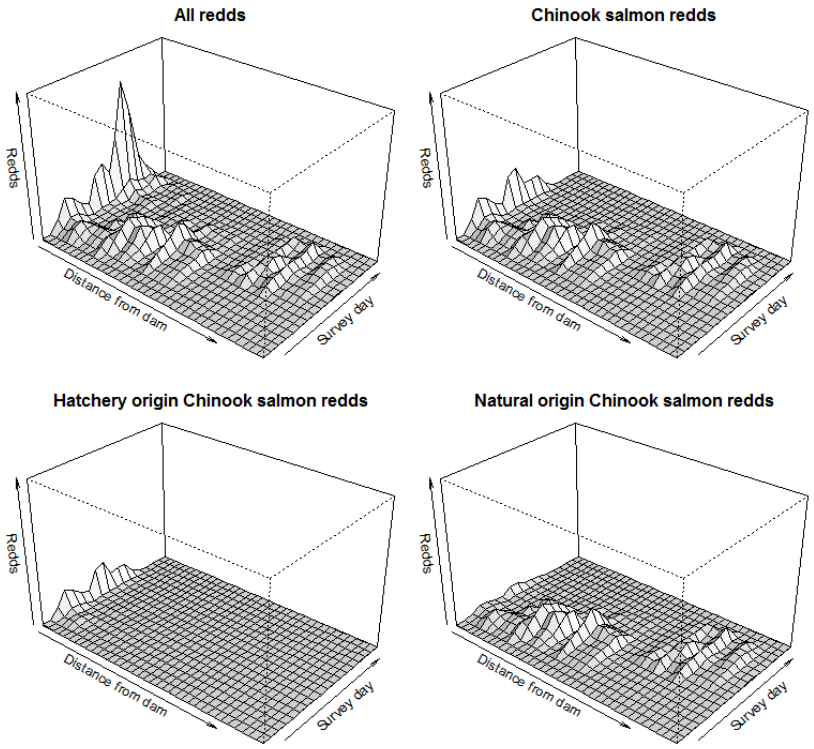
restoration actions aimed at altering the river's physical morphology, with a goal of increasing the availability of juvenile rearing habitat and ultimately, naturally-produced Chinook Salmon and other endemic fishes. River morphology is a major determinant in the suitability of habitat for spawning salmon and changes at the rehabilitation-site scale occur rapidly from construction projects or through channel response to high flow events and gravel injections. The localized use of spawning habitats likewise responds quickly to these morphological changes.



Distribution of salmon redds (spawning beds) before and after construction at the Wheel Gulch Fish Habitat Rehabilitation Site (USFWS graphic).

Spawning site selection by natural-origin salmon also influences the spatial distribution of rearing habitats populated by post-emergent fry. Newly emerged salmon fry experience higher survival if they emerge from redds that are adjacent to rearing habitats that are of sufficient quantity and quality, and these "survivors" are more likely to contribute to the spawning distribution of future adult returns.

Trinity River Hatchery is adjacent to Lewiston Dam where significant straying by hatchery fish into the river currently skews mainstem salmon spawning distribution. As TRRP management actions improve rearing conditions throughout the Trinity River corridor, it is expected that the spawning distribution of natural origin salmon will increase in relation to the influence exerted by straying hatchery fish. At the system scale (64 km of river from Lewiston Dam to North Fork Trinity River and beyond) the distribution of spawners should respond to broad scale changes in the distribution of rearing habitat over a period that spans multiple salmon generations. Annual and a multiyear trend analysis reports for this study are available from the Arcata Fish and Wildlife Office website at http://www.fws.gov/arcata/.



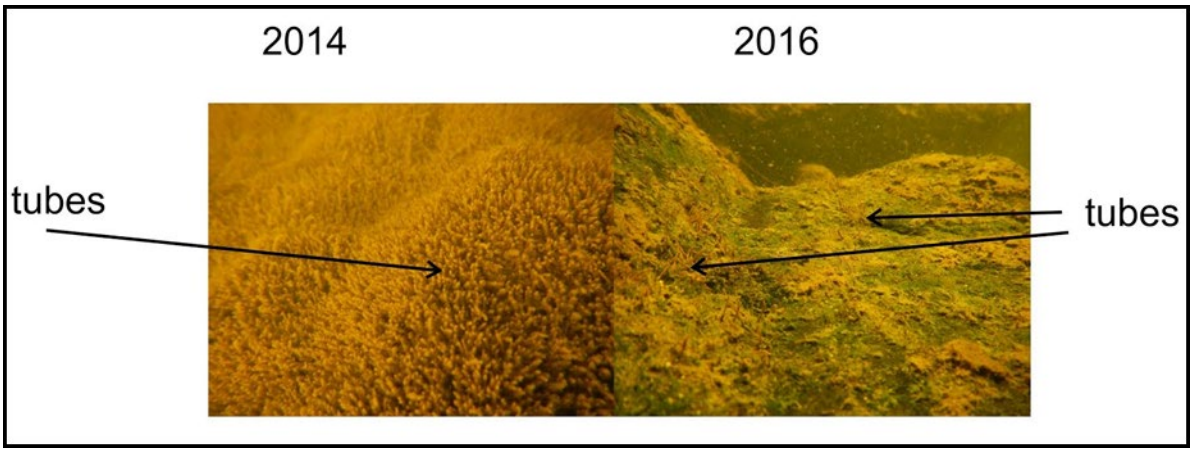
Three dimensional plots depicting differences in redd abundance as a function of distance from Lewiston Dam and time (USFWS graphic).

Trinity River Fish Habitat Evaluation: The Trinity Fish Habitat Evaluation study assessed the effectiveness of mechanical restoration and high flows in creating quality fish habitats. This study, conducted collaboratively with the Service's tribal partners, estimated the systemic fish habitat conditions within the 42-mile "restoration reach" and for individual restoration project sites. Information provided by this project was used to inform the Trinity River Restoration Program's site design planning, which relies on an adaptive management approach to achieve the goal of restoring Trinity River dependent fisheries. Habitat quantity and quality continues to be a key metric to determine success of TRRP restoration actions. Specific tasks include estimating fish habitat quantity and quality, large wood distribution and abundance, and substrate mapping. In FY16 this project resulted in one peer-reviewed publication and two peer-reviewed USFWS reports.

Klamath River Juvenile Chinook and Coho Salmon Fish Health Survey: Assisted the Service's CA-NV Fish Health Center with the collection and preservation of juvenile Chinook Salmon for determination of infection rates of the myxosporean parasites, *Ceratonova shasta* and *Parvicapsula minibicornis*, in the Klamath River Basin. In addition, we document the presence of external symptoms of infections and other clinical signs of disease in juvenile salmonids in real time, generating weekly updates that are provided to managers to help inform water

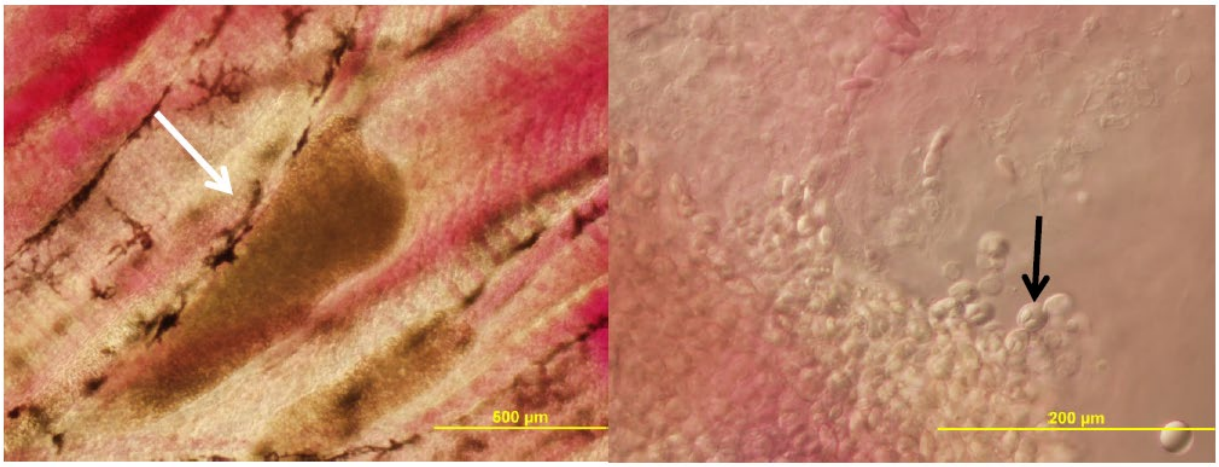
management decisions. Project is a collaborative effort between the Service's Arcata Office and CA-NV Fish Health Center, Yurok and Karuk tribes.

Development and Application of a 2-D hydraulic Model to Predict Polychaete Habitat Availability in the Klamath River: In FY16 we applied this peer-reviewed model to predict relative changes in polychaete habitat in relation to peak-discharge hydraulics, and evaluate those model predictions. Results of this modelling effort were included in a set of four technical memos summarizing the current state of the science and knowledge regarding the disease lifecycle of *C. shasta*, lead-authored by the AFWO Fisheries Program in response to a formal request for technical assistance by the Yurok and Karuk tribes.



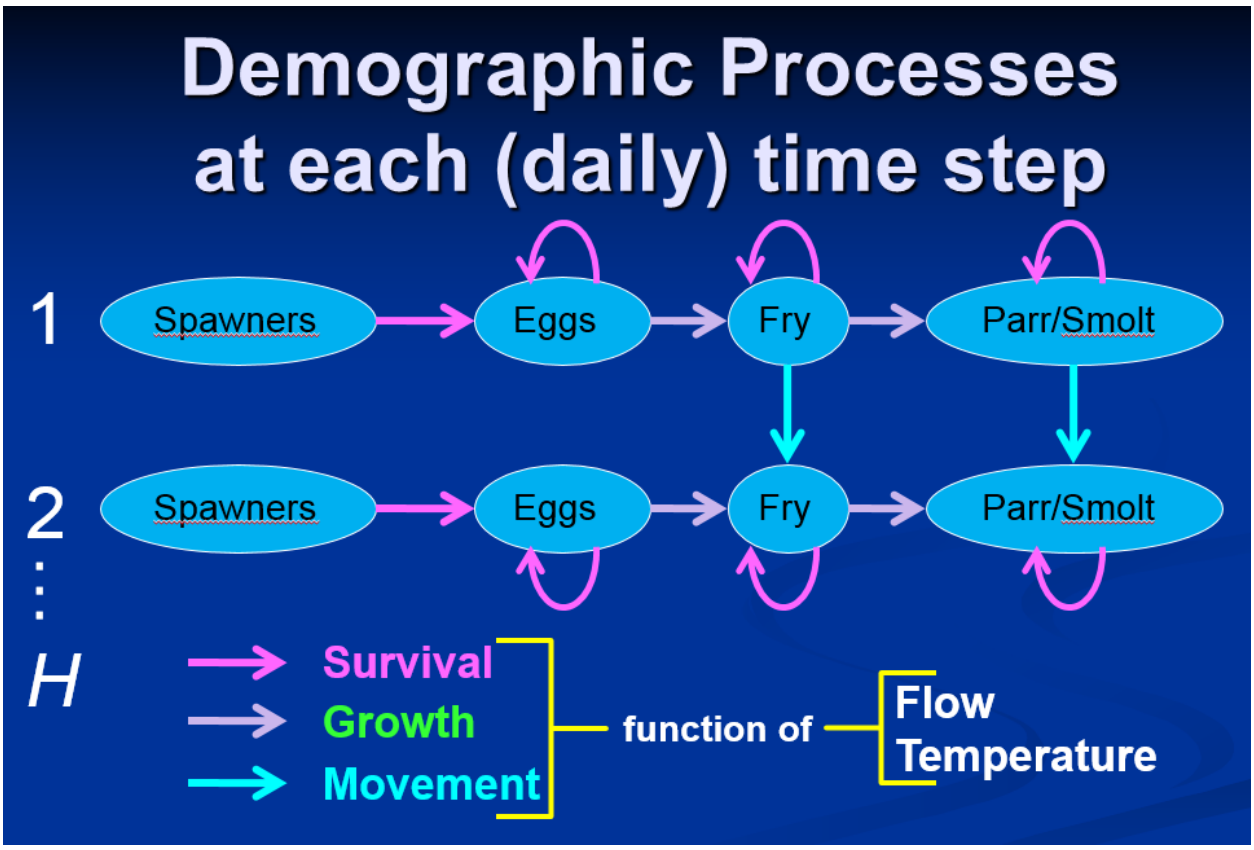
Split screen picture of an identical rock in the mainstem Klamath River taken in 2014 (left) and in 2016 (right) following the March 2016 peak release of 11,200 cfs from Iron Gate Dam.

Index of Infectivity - Ichthyophthirus multifiliis in Resident Fishes in the Klamath River: This project was initiated in 2015 to determine the prevalence of Ich infections in native and sentinel "non-game" fishes during late summer and early fall and to develop an "infectivity index" for the lower Klamath River at two sites directly before and during the adult fall-run Chinook Salmon up-river migration. Water samples were collected and processed at sentinel sites for Ich eDNA analysis. This study was a collaboration between the Service's CA–NV Fish Health Center and AFWO FAC Program, with AFWO staff providing logistical and field support that included transporting personnel lower river sentinel and fish collection sites via jet boat. Work conducted in FY16 consisted of finalizing a peer-reviewed technical report to document the results of the study, which was co-authored by AFWO staff and posted on the FFWO website.



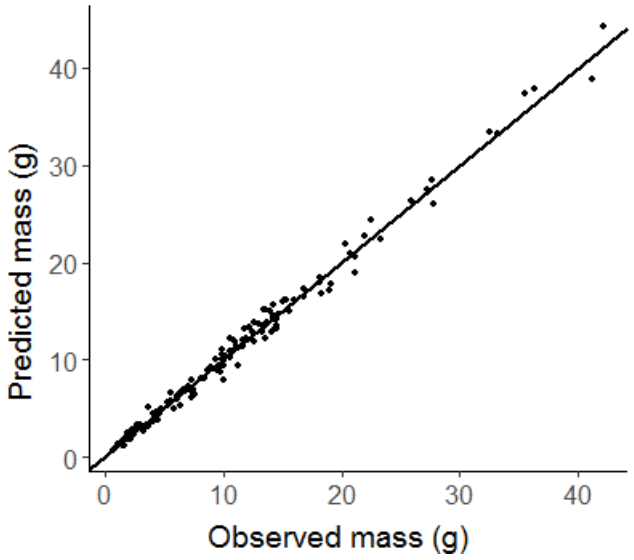
Gill cyst (white arrow), of presumptive Myxobolus sp. myxospores (black arrow), in Speckled Dace used for sentinel study. Low and high magnification of wet mount sample using phase microscopy.

Development of the Stream Salmonid Simulator – A Chinook Production Model for the Klamath Basin: The Service and USGS have worked collaboratively with input from basin partners to further develop the Stream Salmonid Simulator or "S3" Model. The S3 Model is an integrated set of sub models for predicting effects of water management alternatives on the juvenile Chinook Salmon production. This decision support tool is an integrated subset of models used to predict the effects of water management alternatives on movement, health, and production of juvenile Chinook Salmon. The model tracks causes of mortality (i.e., red scour, habitat limitations, disease, water quality, etc.) over time throughout the sub-adult life history of Chinook Salmon within the 223-mile section of the mainstem Klamath River spanning from Keno Dam in Oregon to its confluence with the Pacific Ocean in California. In 2016 the Klamath S3 Model was calibrated and validated to estimate production of juvenile Chinook Salmon.



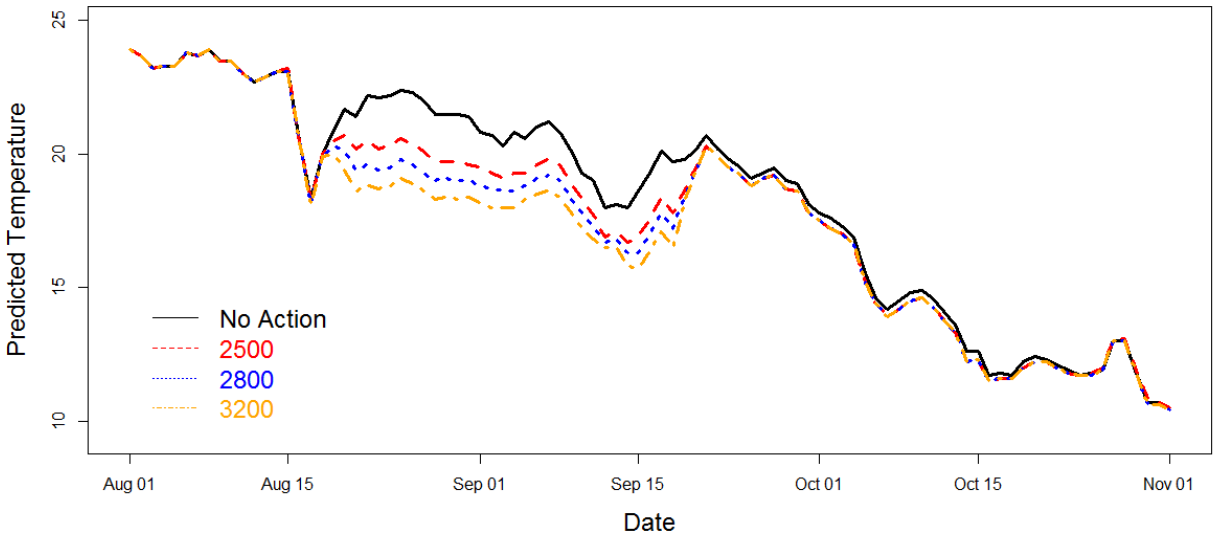
Demographic process of the Chinook Stream Salmonid Simulator (S3) Model at each time step (daily) within sequential mesohabitat units $_{1...H}$ in the Klamath River.

Development of the Stream Salmonid Simulator – A Coho Production Model for the Klamath River: The Service and USGS have also worked collaboratively with input from basin partners to initiate development of the Coho Salmon S3 Model. Structurally, many components of this model mirror their Chinook S3 counterparts; however, a large number of model changes are also necessary to accommodate variations in the life-history characteristics and interactions between the species. In 2016, development of the Coho Salmon S3 Model framework was completed, as well as many statistical analyses targeted to estimate demographics parameters essential to capture the species freshwater life-history. Additionally, a new growth submodel specific to Coho Salmon was developed and incorporated into the S3 model framework, which was published in the Canadian Journal of Fisheries and Aquatic Sciences.



Mass of juvenile Coho Salmon predicted by the ration-parameterized Ratkowsky growth model versus observed mass, depicted against a 1:1 reference line.

Predicting Water Temperatures in the Klamath River to Reduce Fish Disease Impacts 2016: Water temperature predictions generated by this study were included in a technical memorandum submitted to BOR in response to a formal request for technical assistance. Results of various model temperature simulations were used by BOR to support a management decision regarding the release of supplemental flows from Lewiston Dam on the Trinity River to reduce the risk of an adult fish kill on the lower Klamath River. Predictions were made using the Klamath RBM10 Water Temperature Model developed jointly by the USGS and the Service's Arcata Fish and Wildlife Office.



Predicted water temperatures in the lower Klamath River near Klamath CA used by Reclamation to inform management decisions on the release of fall augmented flows from Lewiston Dam to reduce the risk of an adult fish kill. No action refers to base operation flows from the dam without using the bypass facility whereas the three augmented flow release scenarios depict releases necessary to achieve discharge of 2,500, 2,800, and 3,200 cfs at the Klamath gage site using the bypass.

Development of an Integrated Fisheries Restoration & Monitoring Plan for the Klamath Basin: There has been a widely recognized need for a transparent, basin-wide, science-driven approach to fisheries management and fish habitat restoration in the Klamath Basin that integrates needs of listed suckers, Bull Trout, and Coho Salmon with those of tribal and public trust species such as spring and fall Chinook Salmon, Steelhead, Pacific Lamprey, and Green Sturgeon. The National Research Council made the following conclusion and recommendation in their 2008 report titled Hydrology, Ecology, and Fishes of the Klamath River Basin:

"A formal science plan for the Klamath River basin should support policy and decision-making"… and "*should prioritize data needs, identify key uncertainties, specify limits to management capabilities, conduct independent scientific review of research and management plans using that research, construct and oversee monitoring of the systems, and create hydrologic and ecological models."*

The Service and NMFS, with assistance of the Pacific States Marine Fisheries Commission, are working closely with Basin Partners in helping to guide the various components of the Integrated Fisheries Restoration & Monitoring Plan, including the design, prioritization, effectiveness monitoring, and adaptive management aspects of the overarching Plan. The goal of this effort is to facilitate restoring and sustaining natural fish production that provides for full participation in ocean and river harvest opportunities of various fish species throughout the Klamath Basin. The monitoring component of the Plan will also provide data necessary to inform harvest management, design fish habitat restoration actions, and support water management decisions in the basin. The Plan will also incorporate monitoring and restoration being developed in a "Anadromous Fish Reintroduction Plan", a separate effort being completed by the states of Oregon and California and the Klamath Tribes.