U.S. Fish & Wildlife Service

KLAMATH RIVER FISH HABITAT ASSESSMENT PROGRAM

Developing Innovative Solutions for Restoring the Klamath River

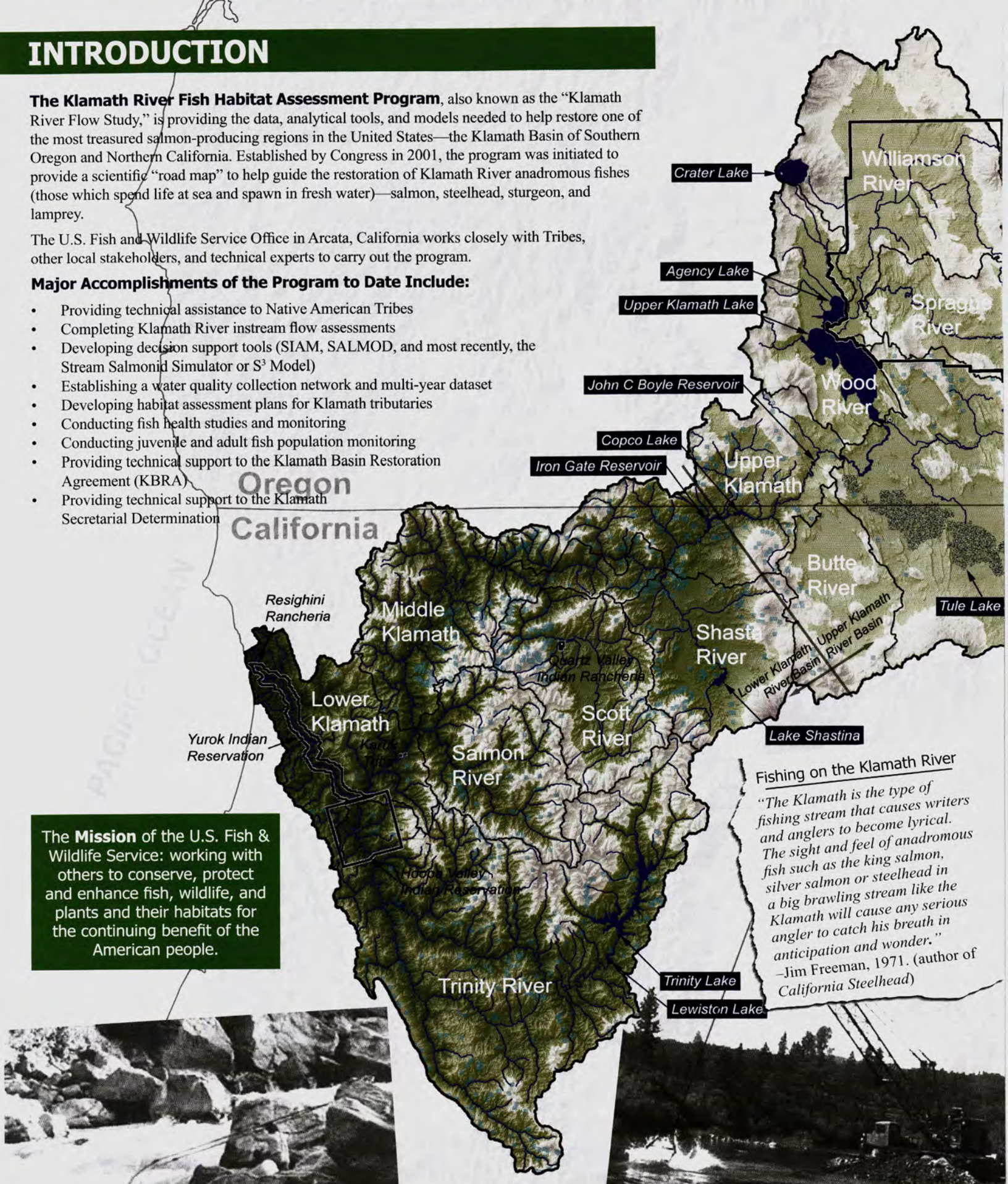
INTRODUCTION

The Klamath River Fish Habitat Assessment Program, also known as the "Klamath River Flow Study," is providing 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 of Southern Oregon and Northern California. Established by Congress in 2001, the program was initiated to provide a scientific "road map" to help guide the restoration of Klamath River anadromous fishes (those which spend life at sea and spawn in fresh water)—salmon, steelhead, sturgeon, and lamprey.

The U.S. Fish and Wildlife Service Office in Arcata, California works closely with Tribes, other local stakeholders, and technical experts to carry out the program.

Major Accomplishments of the Program to Date Include:

- Providing technical assistance to Native American Tribes
- Completing Klamath River instream flow assessments
- Developing decision support tools (SIAM, SALMOD, and most recently, the Stream Salmonid Simulator or S^3 Model)
- Establishing a water quality collection network and multi-year dataset
- Developing habitat assessment plans for Klamath tributaries
- Conducting fish health studies and monitoring
- Conducting juvenile and adult fish population monitoring
- Providing technical support to the Klamath Basin Restoration Agreement (KBRA)
- Providing technical support to the Klamath Secretarial Determination



The **Mission** of the U.S. Fish & Wildlife Service: working with others to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.

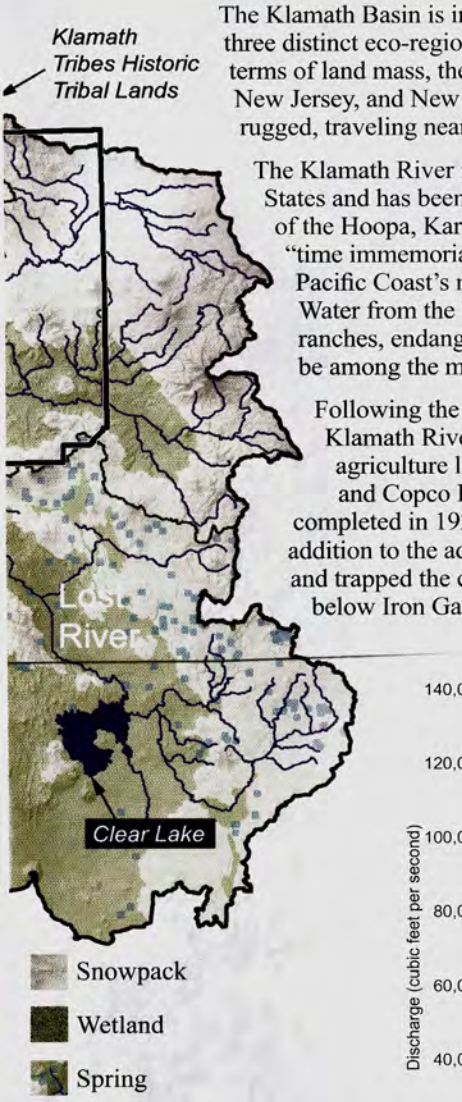
Fishing on the Klamath River

"The Klamath is the type of fishing stream that causes writers and anglers to become lyrical. The sight and feel of anadromous fish such as the king salmon, silver salmon or steelhead in a big brawling stream like the Klamath will cause any serious angler to catch his breath in anticipation and wonder."
–Jim Freeman, 1971. (author of *California Steelhead*)

Karuk fisherman at Ishi Pishi Falls using a traditional dip net (Karuk photo)

In-channel gravel mining, Trinity River 1950 (Trinity County Historical Society photo)

THE KLAMATH BASIN: A TREASURED LANDSCAPE



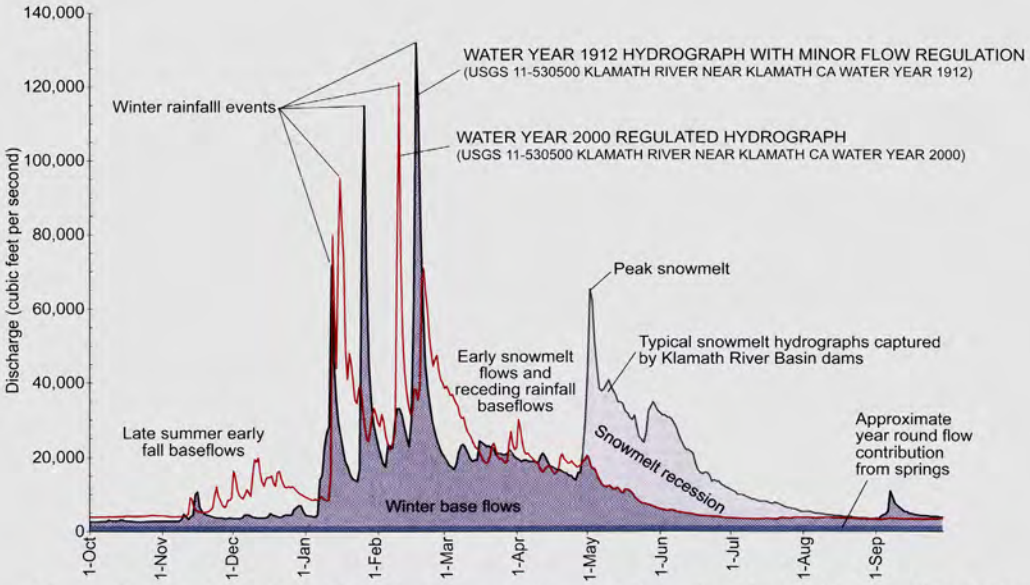
The Klamath Basin is impressive in both geographic and ecological diversity, encompassing three distinct eco-regions: the Cascades, the Klamath Mountains, and the Coast Range. In terms of land mass, the Klamath Basin is larger than many states, including Maryland, New Jersey, and New Hampshire. The course of the Klamath River is extensive and often rugged, traveling nearly 300 miles from its headwaters to the Pacific Ocean.

The Klamath River is host to the third largest run of salmon in the continental United States and has been a focal point of subsistence fisheries and traditional ceremonies of the Hoopa, Karuk, Klamath, Quartz Valley, Resighni, and Yurok tribes since "time immemorial." Salmon from the Klamath River also support one of the Pacific Coast's most economically important commercial and sport fisheries. Water from the Upper Klamath Basin is essential to meet the needs of family farms and ranches, endangered species of suckers and other resident fishes, and six national wildlife refuges considered to be among the most important migratory bird and waterfowl wetlands in the world.

Historic Salmon Runs

"In 1850 in this river during the running season, salmon were so plentiful, according to the reports of the early settlers, that in fording the stream it was with difficulty that they could induce their horses to make the attempt, on account of the river being alive with the finny tribe."
– Robert Deniston Hume (salmon cannery owner/hatchery operator), circa 1892.

Following the mid-1800s, large-scale gold mining and timber harvest greatly altered the beds and banks of the Klamath River and its tributaries, while vast wetlands of the Upper Basin were drained and converted into fertile agriculture lands. Six dams have been constructed on the mainstem of the Klamath River: Iron Gate, Copco I and Copco II, J.C. Boyle, Keno, and Link River. The first of four hydroelectric dams on the Klamath River was completed in 1921, blocking access to more than 400 miles of habitat for salmon, steelhead, and Pacific lamprey. In addition to the adverse physical, biological, and chemical effects from vastly varying the flow, these dams captured and trapped the cobbles and gravels that are essential to maintaining channel geomorphology and spawning habitats below Iron Gate Dam.

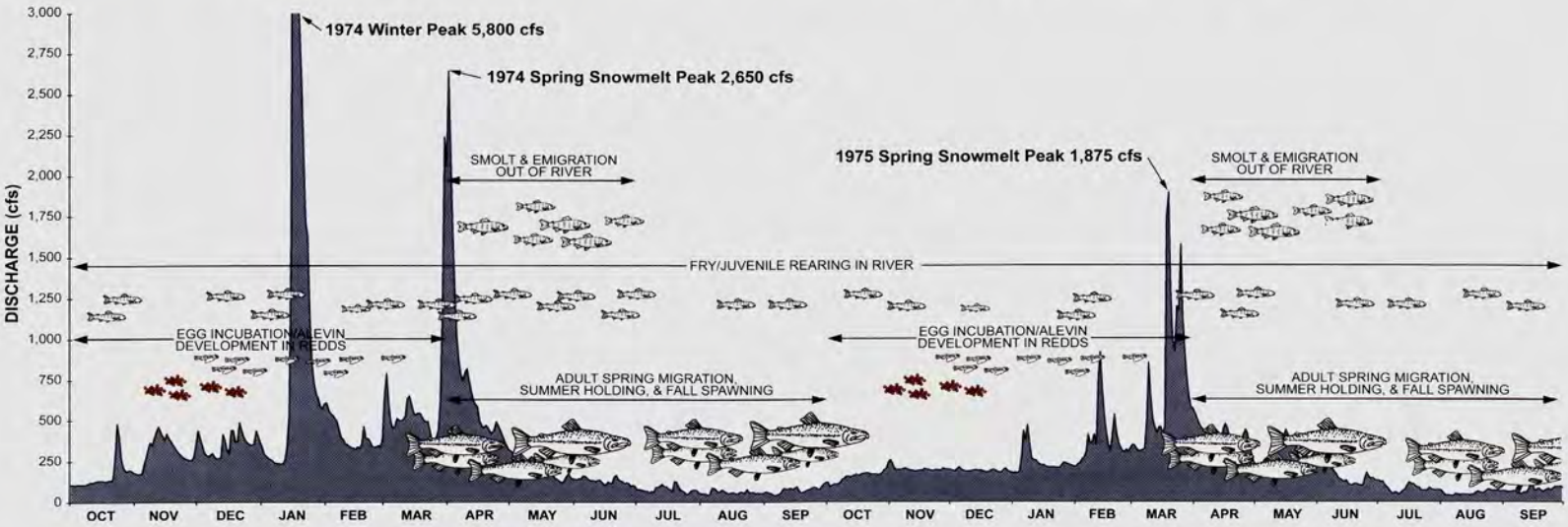


Unregulated and regulated flows for Klamath River at Klamath, CA (USGS gage 11-530500) showing the hydrograph components and the portion of the snowmelt hydrograph captured and diverted by dams.

Copco Dam, one of the four PacifiCorp dams being considered for removal (USFWS photo)

KLAMATH RIVER SALMON

Understanding the life history of Klamath salmon provides a better understanding of what it will take to restore the salmon fishery.



Relationship between the various hydrograph components and the different life stages of the spring-run Chinook salmon.

SPRING-RUN CHINOOK SALMON (or "springers") were once the dominant run of salmon in the Klamath River. Today, very few "springers" return to the Klamath Basin. Life history strategies of spring-run Chinook salmon were intimately tied to what scientists call the hydrograph, defined as the relationship between seasonal precipitation, snowmelt, and base flows. Historically, adult "springers" entered the Klamath River in April and May coinciding with the swollen mainstem river from the Cascade Range, Klamath Mountains, and Trinity Alps snow melt. This allowed them to access the cold, spring fed headwaters of the Upper Klamath Basin and avoid the warmer summer temperature conditions. This strategy also created both a geographic and seasonal separation between the spring and fall runs of Chinook salmon, helping to maximize their ability to saturate the available habitat with their offspring. A portion of the young "springers" (referred to as "fingerlings") would make the long journey to the ocean during that spring's snowmelt segment of the hydrograph. However, many offspring remained in the river throughout the summer months to feed and grow in the food-rich environment of the Klamath River, tributaries, and lakes. This helped prepare them for their long fall migration to the Klamath estuary. Other offspring continued to rear and migrate during the following spring as "yearlings." When these yearlings entered the ocean, their larger size gave them a higher likelihood of surviving the numerous predators of the marine environment and, ultimately, returning as adults to spawn and repeat the life cycle.

FALL-RUN CHINOOK SALMON make their way up the mainstem Klamath River and large tributaries in August and September, relying on fall base flows and rains to aid their successful upstream migration. Adult Chinook spawn in the suitable gravel of the Klamath River and tributaries from October through December and all adults die after they spawn. The eggs incubate in their gravel nests throughout the winter, with young "fry" emerging from the gravel in late winter through early spring. Upon emergence, these fry require quality rearing habitat to feed and avoid fast water and predation. The majority of the fall-run offspring migrate to the ocean during the first spring snowmelt season as fingerlings, with a small percentage migrating during the fall or the following spring as yearlings. Fall-run Chinook salmon are now the dominant run of salmon in the Klamath River. Historically, while the fall-run Chinook salmon were making their way up the Klamath River, the spring-run adults were already occupying the cool, deep pools of the upper watershed in preparation for spawning.

COHO SALMON runs have experienced a precipitous decline in the Klamath Basin and are presently listed as "threatened" under the federal (1997) and state (2002) Endangered Species Acts. Coho salmon migrate up the Klamath River during the late fall and early winter. Most of these fish will enter tributaries to spawn, though some will spawn in the mainstem Klamath River. Eggs incubate through the winter and the young emerge from the gravel in the spring, seeking quality habitat. Coho juveniles have numerous strategies for survival. Some remain in their natal spawning location while others travel long distances both upstream and downstream, even occupying different tributaries, before entering the ocean the following spring as yearlings. Either way, they face many obstacles in their quest for survival.

Spring Chinook salmon holding in the cool pools of the Salmon River (SRRP photo)

Northern pintail (USFWS photo)

Fall Chinook salmon migrate up Bogus Creek, 190 miles up the Klamath River (USFWS photo)

NOT JUST ABOUT SALMON

The Klamath Basin is host to a number of other fish and wildlife species, and there is an increasing effort to better understand these species as basin-wide restoration efforts take hold.

SUCKERS - Four species of suckers are native to the Klamath. The Klamath smallscale suckers are widely distributed throughout the river. Shortnose, Lost River, and largescale suckers were once so abundant that they were a major food source for Native Americans. Unfortunately, the abundance and distribution of two of the four species (the Lost River and shortnose) have declined in recent years and are presently listed as "endangered" under the federal and state Endangered Species Acts. These species have been around for thousands of years, surviving the geologic turmoil that shaped the region, including the eruption of Mt. Mazama (now Crater Lake). However, these fish are on the verge of extinction due to habitat loss, poor water quality, and low survival rates over the recent century. Biologists estimate that these populations have severely declined since 2000, with little recruitment of juveniles into the adult population since the late 1990s.

STURGEON - Green and white sturgeon are native to the Klamath Basin. Their large size, late-age to maturity, and affinity to deep pools make them vulnerable to harvest and habitat loss. A white sturgeon harvested in recent years measured at 10½ feet long and was estimated to be 82 years old. Green sturgeon is the dominant species of sturgeon in the Klamath River and sightings of white sturgeon are becoming increasingly rare. The Klamath and Sacramento rivers are the primary sturgeon producing streams in California, with harvest of sturgeon from the Klamath Basin restricted to tribal subsistence and ceremonial use.

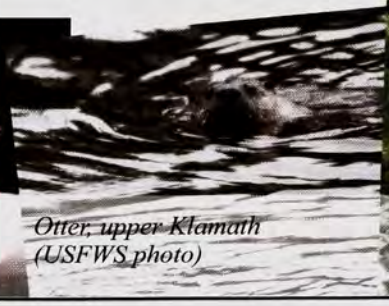
EULACHON & LAMPREY - Historically, eulachon and Pacific lamprey were two ecologically and culturally important species of the Klamath River. Today, eulachon (also known as "candlefish") have virtually disappeared from the Klamath and other nearby coastal drainages, with sightings being rare since 1988. Pacific lamprey experienced a noticeable decline as well, and is now considered a species of special concern.

STEELHEAD - Steelhead are the highest valued sport fish in the Klamath River, attracting anglers from all over the world. Adult steelhead can be found in the river year round, with distinct runs of spring/summer, fall, and winter fish. The largest run, fall steelhead, peaks in October and November following the fall Chinook salmon run. Klamath "half-pounders" are prized fish that typically flood into the Klamath River during the fall and return to the ocean the following spring. This life history strategy is unique to Northern California and Southern Oregon rivers. After emerging from the gravel, juvenile steelhead spend at least one year, often two, rearing in the tributaries and mainstem river. As they take their time migrating downstream to the estuary, they grow bigger and stronger before entering the Pacific Ocean. Yet, this extended freshwater residence also makes steelhead vulnerable to both habitat and environmental conditions, especially the summer run. Like spring Chinook, summer run steelhead adults enter the Klamath River in the spring and must survive in deep, cold water pools throughout the summer months. However, unlike salmon, not all steelhead die after spawning. Many adults return to the ocean and will spawn again another year.

COASTAL CUTTHROAT TROUT - The range of coastal cutthroat trout extends along the Pacific Coast from Prince William Sound in southwest Alaska to just south of the Eel River in Northern California. Coastal cutthroat exhibit diverse life history patterns and are relatively long lived. They can spawn numerous times, but like other species of cutthroat, coastal cutthroat can be vulnerable to overfishing and habitat change. Information on coastal cutthroat trout in the Klamath River is limited. Developing an understanding of their life history patterns, population dynamics, habitat needs, and genetic variability will be necessary for successful management.

WATERFOWL - Historically, the Klamath Basin was comprised of over 350,000 acres of naturally occurring seasonal and permanent wetland habitats and shallow freshwater lakes. These wetlands attracted millions of migratory birds along the Pacific flyway and the largest overwintering population of bald eagles in the lower 48 states. In 1908, President Roosevelt designated 81,000 acres of marsh and open water in Lower Klamath Lake as the first National Wildlife Refuge for waterfowl. Today, less than 25% of the historic wetlands remain, with the majority protected within the U.S. Fish and Wildlife Service's Klamath Basin Wildlife Refuge Complex. Ongoing restoration efforts continue to concentrate on reviving these important ecological features of the Upper Klamath Basin.

Juvenile green sturgeon, lower Klamath River (USFWS photo)



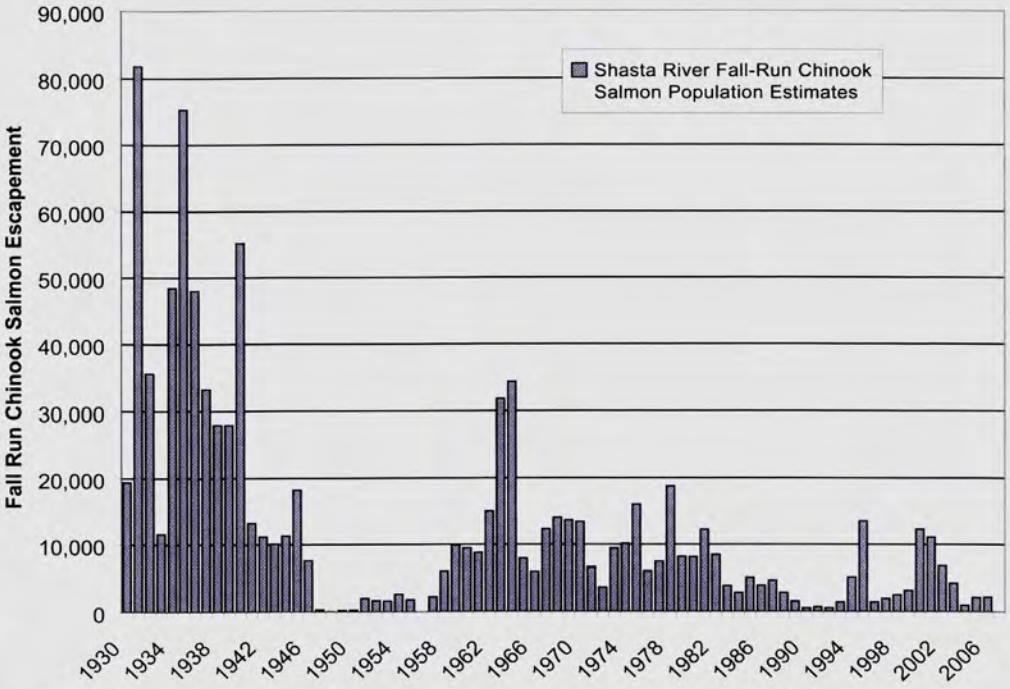
Otter, upper Klamath (USFWS photo)

Lost River Sucker (USFWS photo)

KEY KLAMATH RIVER TRIBUTARIES

Klamath Basin fish runs are not a product of the mainstem Klamath River alone. Tributaries make substantial contributions to the overall production of fish in the basin. However, population trends within these tributaries are also on the decline. Restoring salmon and steelhead productivity in key tributaries is fundamental to basin-wide population recovery.

THE SHASTA RIVER'S unique blend of geology, hydrology, and climate distinguishes it from other Klamath River tributaries. The Shasta Basin lies near the southern extent of the Cascade Range. The basin's many springs and snowmelt historically provided cold water inflows to the Shasta River. These habitats functioned as an oasis in the hot, dry summers to support highly productive salmon and steelhead populations. There is great potential for this unique stream to once again sustain significant salmon populations. Efforts by the local Resource Conservation District, landowners, and others clearly demonstrate the desire to bring this unique watershed into a sustainable balance.



Fall-run Chinook salmon population numbers measured near the mouth of the Shasta River.

THE SCOTT RIVER was originally named "Beaver River" by the Hudson Bay Company trappers who first entered the Scott Valley in the 1830s. Beavers were so abundant that one trapper claimed that "Beaver Valley" was "the richest place for beaver" he had ever seen. Salmon and steelhead were also abundant, with large runs of Chinook, steelhead, and coho salmon. Like the Shasta River, the Scott River has great potential to once again become a significant salmon and steelhead producer. On-the-ground efforts by the local Resource Conservation District, landowners, and others will help bring this watershed into balance.

Historic Runs in the Shasta River

The runs of king salmon into the river were probably very large, for even in 1931, when the Shasta was supposed to be in poor shape, there were 81,000 kings. This may be as great a number as has ever been known to enter a minor California stream. – JH Wales, 1951

THE SALMON RIVER is a large, free-flowing, undammed tributary in the Klamath Basin that has escaped major agricultural and urban development. Not surprisingly, spring-run and fall-run Chinook salmon, summer, fall and winter steelhead, coho, and green sturgeon persist in the Salmon River.

Collecting data on the Klamath River for a hydrodynamic model used to predict fish disease (USFWS photo)

Klamath River confluence with the Salmon River (USFWS photo)

THE TRINITY RIVER is the largest tributary of the Klamath. Runs of fall and spring Chinook populations in the Trinity have declined dramatically since the completion of the Shasta/Trinity Diversion Project. Trinity Dam's completion in 1964 eliminated passage into the Upper Trinity River and facilitated the transport of over 80% of Trinity River water to the Sacramento Valley. In 2000, additional water was secured for release back into the Trinity River with the signing of the Trinity River Record of Decision. In addition, the Trinity River Restoration Program was established to implement a stakeholder-driven approach to designing and constructing channel restoration projects, conducting physical and biological studies to monitor their effectiveness, and to adjust the approach to restoration based on a commitment to adaptive management.

ROLE OF THE MAINSTEM ESTUARY

The Klamath River estuary has remained mostly undeveloped over the years. The relatively intact nature of the estuary is unique among major rivers in the United States and is one of the main reasons why the Klamath River is considered to be restorable. Adult salmon and steelhead rely on estuaries as their staging grounds prior to beginning their long and difficult upstream spawning migrations. Estuaries are important for juveniles, providing a good place for foraging as they make the transition from freshwater to seawater. Gaining a better understanding of the specific roles of the Klamath estuary in the production of salmon and steelhead in the basin continues to be a high priority for the program. This knowledge will help managers preserve and potentially restore this essential habitat.

Lost River Suckers

Lost River suckers and their principal habitats have been subjected to just about every environmental insult possible, with no end in sight. The suckers are gone from Lower Klamath and Sheepy Lakes, uncommon in Upper Klamath and Tule Lakes, and common only in Clear Lake Reservoir.
Dr. Peter Moyle, 2002

A photomicrograph of a scale of one of these estuary salmon, measuring 184 millimeters, is presented to the left. Here a well-defined central nuclear region of more or less crowded circuli (R indicates the transition between time spent in the Klamath River and estuary) is to be distinguished from a broad outer area of widely spaced ones (assumed to represent time spent in the estuary). The structure of this scale is typical of every one of the larger estuary fish, the size of the nuclear area remaining fairly constant, while the area lying without or bordering the nuclear part varies in width about as the fish vary in size. There is no evidence that these fish have come in from the sea. On the contrary, it is certain that they are down-stream migrants, lately arrived in the estuary, where abundant food has contributed to very rapid growth.

JO Snyder, 1931.

Klamath River estuary as it enters the Pacific Ocean (USFWS photo)

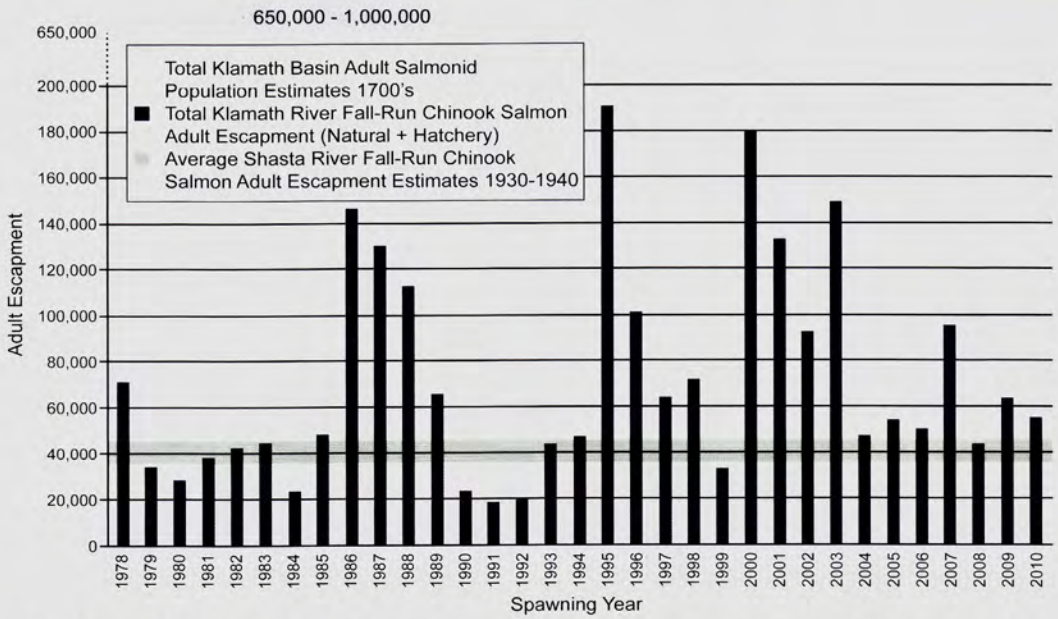
Historic town of Requa, located along the Klamath River esturary (Yurok photo)

QUALITY SCIENCE INFORMING MANAGEMENT DECISIONS

Quality science needs to be at the forefront in guiding the decisions of federal, state, local and tribal natural resource managers in the Klamath Basin. The collection of quality data is crucial to science and is well supported by the program. The most significant factors that limit growth, population size, diversity, and distribution of anadromous fish in the Klamath Basin have been identified. These are: water quality, water quantity, fish health, and fish habitat.

"...a more coherent, systematic, and comprehensive analysis of scientific and management needs for the basin should be conducted to identify the most important and urgent science needs to inform management decisions."

The National Research Council of the National Academies of Science, 2004.



Total Klamath River fall-run Chinook salmon adult count between 1978 and 2010 compared to historic Klamath and Shasta River Basin returns.

Limiting factors for anadromous fish identified by the Klamath River Habitat Assessment Program

Water Quality – excessively high water temperatures, nutrients, and low dissolved oxygen levels.	**Water Quantity** - effects on physical, chemical, and biological factors from alterations of the natural hydrograph (timing, magnitude, frequency, duration, and rate of change).
Fish Health - unnaturally high adult and juvenile fish mortalities.	**Fish Passage** - physical structures and chemical constraints such as temperature and dissolved oxygen.
Microhabitat - loss of depth, velocity, and cover availability due to alterations in stream flow.	**Riparian Vegetation (plants lining stream)** - lack of shade, cover, food production, and large wood recruitment.
Geomorphology - loss of the dynamic alluvial processes that form and maintain an ecologically functional river system.	**Hatcheries** - competition with natural fish.
Wetlands - loss of the distribution, quantity, quality, and diversity throughout the Klamath Basin.	**Groundwater** - effects on the streamflow hydrograph.
Lake and Reservoir Operations - influences on water quantity and quality for both the river and lake dependent species.	**Unscreened Diversions** - effects on anadromous and resident fish survival.
Fine Sediment and High Turbidity - effects on anadromous fish life stages and river function.	**Contaminants** - fertilizers, herbicides, insecticides, and others affect anadromous and resident fish reproduction and survival.
Coarse Sediment Supply - dams and diversions reduce or eliminate the supply of bed load material.	**Thermal Refugia** - understanding the influences of cool, clear water entering the Klamath River during adverse periods.
Anadromous Juvenile Production - understanding factors that limit or promote juvenile survival upon ocean entry.	**Non-Native Species** - competition with natives and the effect on production.

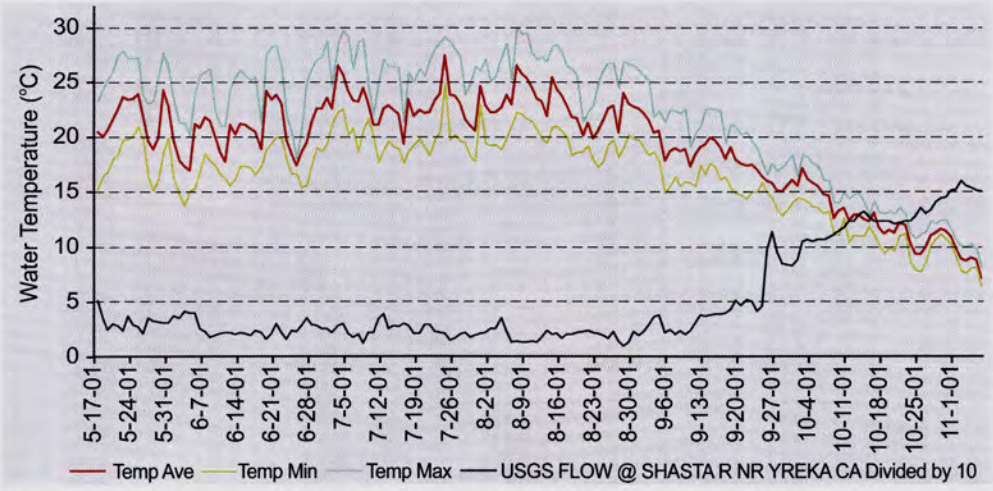
Juvenile Coho salmon (USFWS photo)

Traditional Hoopa Valley Tribal weir constructed for educational purposes. (USFWS photo)

WATER QUALITY

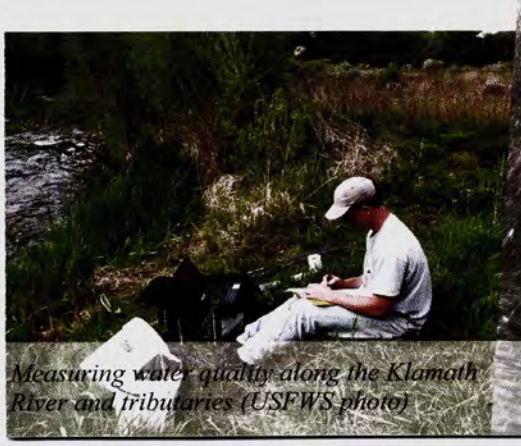
The program and its many partners identified water quality (temperature, dissolved oxygen, contaminants, and nutrients) as a significant bottleneck affecting successful salmon production. The mainstem Klamath River and several of its tributaries are listed under the Clean Water Act as "impaired." Natural occurrence of phosphorous from the volcanic geology of the Upper Basin and Shasta River combined with additional point and non-point sources of nutrients have resulted in eutrophic (nutrient-rich) conditions. The U.S. Fish and Wildlife Service, worked cooperatively with several Tribes, the U.S. Geological Survey, and national experts from the University of Texas and Humboldt State University to establish a water quality-monitoring network in the basin. This coordinated effort with standardized protocols, continues to collect water quality information from strategic locations throughout the Klamath Basin. The data collected determine the loading, timing, and trends in water quality. These data will establish the baseline condition for future comparisons following restoration activities and regulatory actions that focus on water quality improvements.

Filtered water samples (above left) and periphyton (bottom feeding algae or crustacean) samples (above right) help scientists understand the nutrient dynamics of the Klamath River (USFWS photos).



Shasta River daily average, minimum and maximum water temperature measured 0.5 miles upstream of the confluence with the Klamath River. Shasta River flow data are in cubic feet per second.

Restoration of salmon and steelhead populations, require instream flows that increase habitat quantity. However, it may be even more important to restore juvenile rearing habitat quality. This must be done by providing water temperatures that favor rapid growth and minimize exposure to disease.



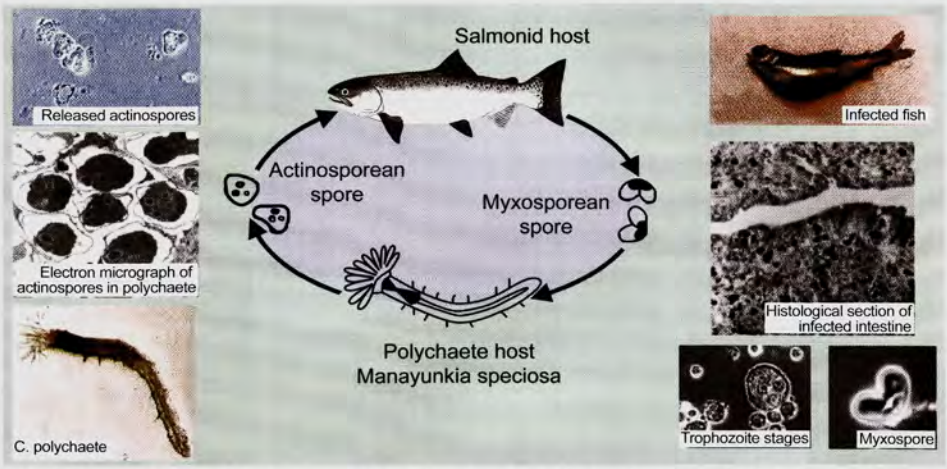
Measuring water quality along the Klamath River and tributaries (USFWS photo)

Biologists negotiate the snow during a fall-run Chinook salmon spawing survey (USFWS photo)

Chinook fry rescued from stranding (USFWS photo)

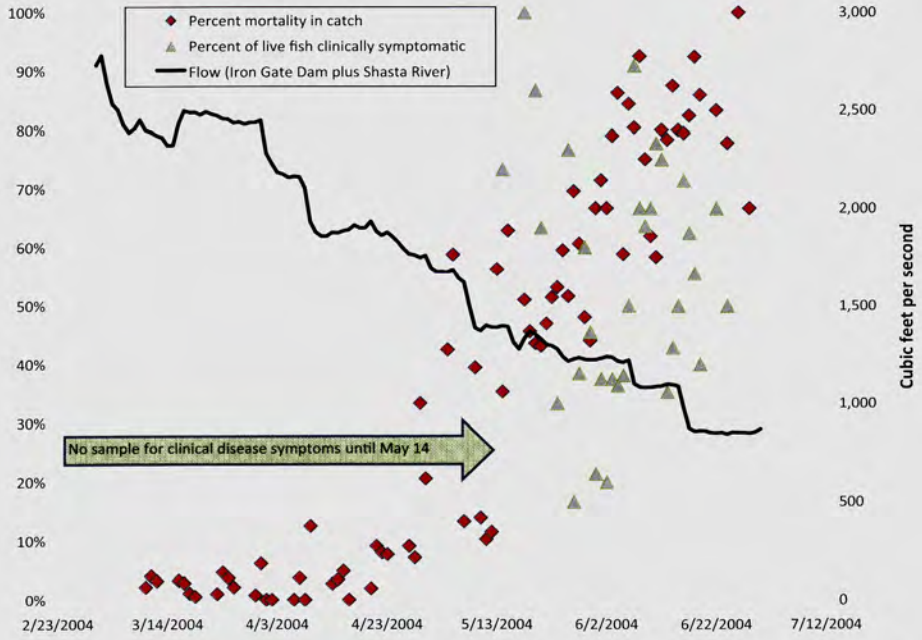
FISH HEALTH

Out of all the significant limiting factors, the program partners ranked fish health as the highest priority for studies within the anadromous reach (below Iron Gate Dam) of the Klamath River. The disease problem in juvenile salmon in the Klamath River centers mainly on a microscopic, myxozoan parasite called *Ceratomyxa shasta*. The parasite requires adult and juvenile salmonids and freshwater polychaete worms (*Manayunkia speciosa*), as intermediate hosts to complete the parasite's lifecycle. These polychaete worms live in a variety of habitats, but large colonies are most often associated with organically rich sand and silt deposits as well as dense beds of Cladophora, abundant green filamentous algae found in the Klamath River. The high concentrations of organic matter, nutrients, and prey items, paired with low, stable flow releases from Iron Gate Dam, make an ideal environment for successful polychaete worm production. Once the *C. shasta* myxospores infect polychaete worms, a large number of actinospores



*The life cycle of the disease organism **Ceratomyxa shasta** involves both salmonids and its intermediate host, the polychaete worm **Manayunkia speciosa**. (Figure from Stocking and Bartholomew, 2004).*

are produced and released into the water, causing high infection rates and disease in juvenile salmonids. Healthy, native fish have developed natural defenses against these endemic parasites. However, stressors from habitat induced pressure, poor water quality, elevated water temperatures, and the abnormally high spore concentrations greatly increase the likelihood of infection, disease, and subsequent mortality. Recent studies have determined that due to high infection rates from C. shasta, up to 45 percent of the juvenile salmon migrating down the mainstem Klamath River are unlikely to survive to adulthood. Ongoing and future studies are critical in order to understand the mechanisms that lead to the unnaturally high infection rates. This knowledge will help determine the necessary management actions to bring this parasite-host relationship back into balance.



Percent of the weekly frame-trap catch of Chinook salmon that were dead, percent of the remaining live Chinook examined that exhibited outward clinical signs of disease, and weekly average discharge at the Kinsman trap site (RM 146) on the Klamath River near the mouth of the Scott River in 2004.

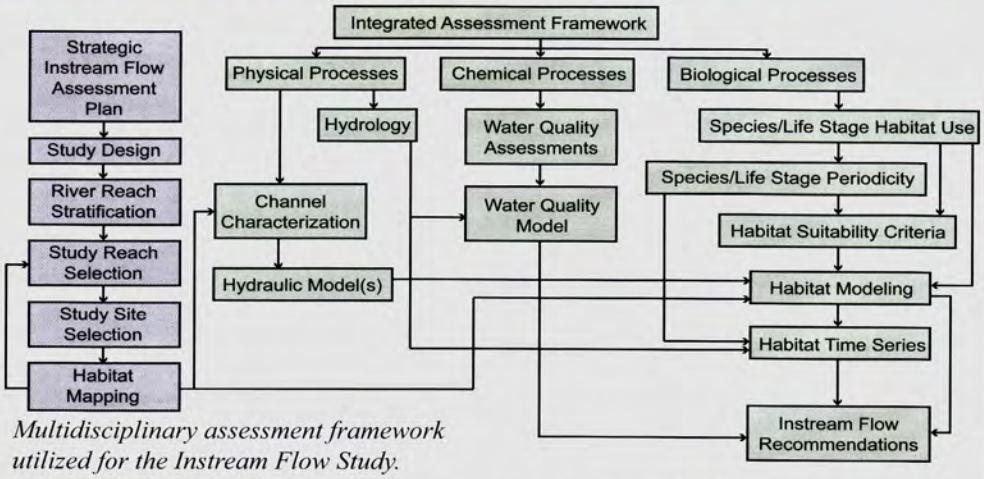
Chinook salmon gills infected by bacteria and parasites (USFWS photo)

Chinook salmon fry rescued from flow-related stranding event (USFWS photo)

September 2002 fish kill resulting from infections from pathogens (Yurok photo)

FUTURE NEEDS OF THE PROGRAM: SCIENCE INFORMING RESTORATION

The National Research Council emphasized the need for a strategic, basin-wide scientific framework to guide future monitoring, research, and recovery efforts in the Klamath Basin. Consistent with this direction, the program and its partners identified five main areas that warrant further study: **hydrology**, **water quality**, **microhabitat**, **geomorphology**, and **fisheries biology**. Within each of these disciplines, the program continues to support prioritized data collection, analysis of existing and newly acquired information, and development of predictive tools to inform management and direct restoration projects to address factors limiting fish production.

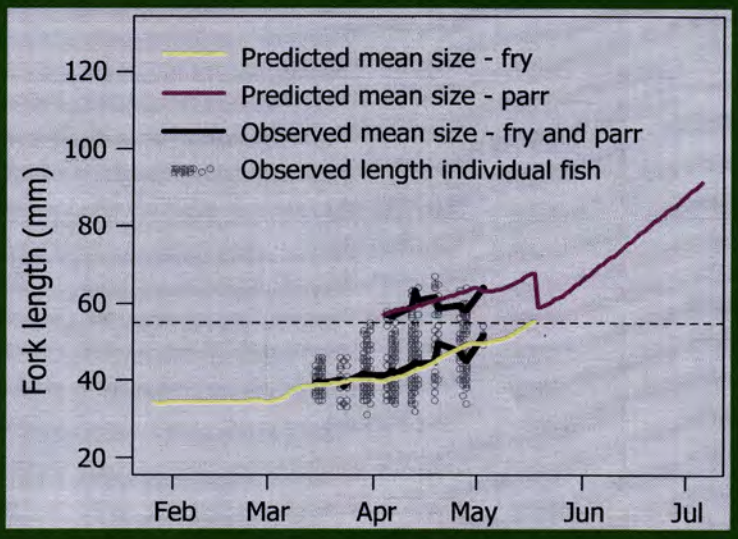


Multidisciplinary assessment framework utilized for the Instream Flow Study.

DEVELOPING PREDICTIVE CAPABILITIES

The National Research Council also recommended that Klamath Basin stakeholders work towards "connecting science and decision making" and employ conceptual and simulation models to support an adaptive management approach on a basin-wide scale. Consistent with this guidance, the Service and its partners continue to collect and assemble the biological, physical, and chemical data necessary to develop, populate, calibrate, and validate predictive models. These models rely on data collected over a range of conditions (wet years and dry years, different seasons, etc.) to help uncover relationships that can be used to predict the outcome of resource management decisions.

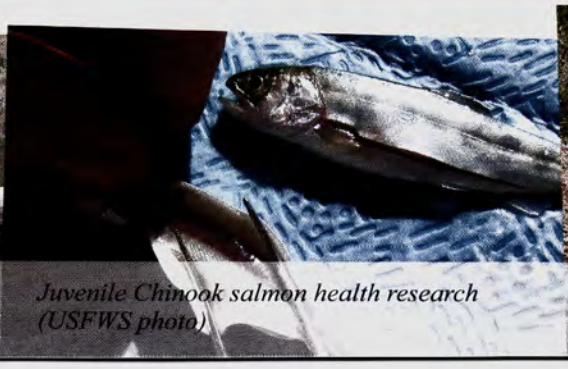
DECISION SUPPORT TOOLS The Service and the U.S. Geological Society have worked collaboratively with input from basin partners to develop Decision Support systems such as SIAM (Klamath River System Impact Assessment Model) and SALMOD, and most recently, the Stream Salmonid Simulator or S^3 Model. The S^3 Model is an integrated set of sub models used to predict the effects of water management alternatives on the production of juvenile Chinook salmon. The S^3 Model tracks causes of mortality throughout the sub-adult life history of Chinook salmon (redd scour, habitat limitations, disease, water quality, 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.



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 represents the breakpoint between fry and parr.

A critical component of the S^3 Model is a fish disease module that has been developed through an on-going partnership between the Arcata Fish and Wildlife 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. Current efforts are focused on calibrating and validating the S^3 Model to the historical abundance estimates of juvenile Chinook salmon. Once complete, the S^3 Model will allow managers to run state of the art simulations of juvenile Chinook salmon production under different flow management alternatives that can be used to better inform water management decisions in the Klamath Basin. The S^3 Model is also being extended into the Trinity Basin, with the addition of an ocean component and upstream adult migration sub module. These improvements will transform the S^3 model into a full life cycle model that can be used by the Trinity River Restoration Program to evaluate the effectiveness of channel rehabilitation projects, gravel injections, large wood augmentation, flow regimes, etc. by isolating ocean versus in-river influences on fish production.

Trap used to monitor juvenile salmon abundance (USFWS photo)



Juvenile Chinook salmon health research (USFWS photo)

Monitoring flows (USFWS photo)

U.S. Department of Interior
US Fish & Wildlife Service
http://www.fws.gov

Federal Relay
1 800/877-8339 Voice and TTY
June 2013

CONTACT INFORMATION

U.S. Fish & Wildlife Service Arcata Fish & Wildlife Office
Fisheries Program
1655 Heindon Road, Arcata, California
95521 (707) 822-7201

CONSERVING AMERICA'S *Fisheries*

Cover photo - Klamath River (USFWS photo)

Printed on recycled paper