Chapter 5. Freshwater and Marine Habitat Communities

Peter Adams[1], Scott VanderKooi[2], and Thomas Williams[1]

Introduction

The Klamath Basin is the second largest river system in California, and is a complex and dynamic environment from its headwaters to its estuary and out into the nearshore marine environment. The Basin is in a seriously degraded state due to the large number of anthropogenic stresses resulting in fish kills, very low fish population levels, fisheries closures, and large-scale disease epidemics. Biological communities throughout the Basin are all stressed by a variety of environmental impacts, whose effects are not completely understood. The Freshwater and Marine Habitats and Communities Plenary Session of the Klamath Science Conference focused on fish and fish biology. This is because fish provide a good integrated view of the environmental linkages and constraints throughout the Klamath Basin, and because there are a significant number of Endangered Species Act (ESA) listings of fishes: coho salmon, green sturgeon, eulachon, Lost River sucker, shortnose sucker, and bull trout (scientific names and distribution in table 5-1). Also, this is because we have more information on the fish communities than on other animals in the ecosystem due to the cultural, economic, and social values of these fishes. Also, it is thought that the processes and conditions that are beneficial for fish will also be beneficial to the other parts of the aquatic (and terrestrial) communities and will result in the conservation of the Klamath Basin as a whole.

The geographic framework used here is to divide the Klamath Basin into an upper subbasin, a lower subbasin, and an estuary and nearshore marine environment. The demarcation of the upper and the lower subbasins was created by the Copco dams in the early 1900s and later by Iron Gate Dam in the early 1960s. Strong physical and ecological features differentiate the upper and lower subbasins around these dams. The separation between the two subbasins can be plainly seen in the underlying geology, average maximum air temperature, and annual average precipitation. The Klamath Basin has been called "a river turned upside down" due to its unique geology. The upper subbasin is a large alluvial watershed and has a number of slow-moving, shallow streams and rivers above and below Upper Klamath Lake. The Klamath River then pushes through the Klamath Mountains and becomes the much more energetic, deeply-incised system of the Lower Basin. The lower subbasin is a much more active classical fluvial system, receiving rainfall from strong storm systems and periodic inputs of sediment and wood. This is the reverse of what many consider a normal river system where the energetic fluvial system is located upstream and the slower-moving shallow rivers are downstream. The third area, the estuary and nearshore marine environment, is demarked by the impact of salinity from the tidal zone and extends into the nearshore coastal ocean. These three geologic and physical areas result in important and unique biological structuring to the fish communities resulting in large numbers of species, particularly anadromous ones, and some of the largest numbers of endemic species of any river system.

The challenge of this session was to develop a working conceptual model of the biological communities of the Klamath Basin System from these three units: the upper subbasin, the lower subbasin, and the estuary and nearshore environment. This Klamath Basin conceptual model will be a central tool in the current discussion and planning of how to restore Klamath Basin communities given

[1] Southwest Fisheries Science Center, Fisheries Ecology Division, National Marine Fisheries Service.
[2] U.S. Geological Survey, Southwest Biological Science Center.

the substantial anthropogenic impacts that have occurred and are occurring there. The question of dam removal is at the forefront of these restoration considerations, but a long list of impacts (agricultural draining, water quality, toxic algae blooms, water temperature regimes, and others) will also need to be addressed. Finding common ground on how to restore these natural communities and yet maintain the other societal uses of the Klamath River Ecosystem will be difficult. It is important that decisions made for ecosystem restoration be based on our best understanding of species and processes that control this system. A conceptual model of the Klamath Basin that includes biological communities in the geographic framework described above will be central to science planning and decision making processes that endeavor to balance species recovery and societal goals. The conceptual model will need to include the physical, biological, and social-economic attributes of the upper and lower subbasins and the estuary and nearshore environment. In this chapter we describe the fishery resources in each of these sections of the Klamath Basin.

The Upper Klamath Subbasin

The geological and hydrological processes of a watershed in combination with life-history processes are the factors that determine which fish faunas are present. Evidence of this interaction between the physical and biological is demonstrated in the fishes of the Klamath River Basin. The unique “upside-down” features of this watershed, combined with its geologic history have led to unusually high levels of endemism for native fish species. This is particularly true for the Upper Klamath Subbasin: those areas upstream of Iron Gate Dam. The aquatic habitats of the upper portion of the watershed are dominated by large shallow lakes, extensive marshlands, and relatively low-gradient rivers. Other defining features include a semi-arid climate, nutrient-rich volcanic soils, and high elevation ranging from 1,257 to 2,865 m with a mean elevation of 1,545 m, as well as numerous springs and other sources of groundwater inflow. Over geologic time the watershed has drained in a variety of directions: west to the Pacific Ocean, south into the Sacramento River drainage through the Pitt River, southeast into the Great Basin, and northeast into the Snake River.

Historically the Upper Klamath Subbasin harbored at least 19 native fish species belonging to five families including lampreys, minnows, salmon and trout, sculpins, and suckers (table 5-1). Four of these were anadromous fishes that migrated to and spawned in tributaries of the upper reaches of the Klamath River and above Upper Klamath Lake. There is ample evidence that Chinook salmon, coho salmon, steelhead trout, and Pacific lamprey were all present prior to the construction of dams on the mainstem Klamath River early in the twentieth century. Of the resident species, lampreys are notable—the Klamath Basin has the highest lamprey diversity in the world. At least four species are found in the upper basin including the Klamath-Pit brook lamprey, Klamath River lamprey, Miller Lake lamprey, and a likely undescribed Upper Klamath Lake lamprey. Native minnows include the blue chub, tui chub, and speckled dace. Two resident salmonid species, bull trout and redband trout, are native to the upper watershed as are three sculpins, the Klamath lake sculpin, Upper Klamath marbled sculpin, and slender sculpin. The remaining native fishes in the upper basin are four sucker species: the Klamath largescale sucker, Klamath smallscale sucker, Lost River sucker, and shortnose sucker.

Most of the information available on the historic status and distribution of resident fishes in the upper subbasin concerns species targeted for harvest. Anadromous species were seasonally abundant with Chinook salmon and steelhead migrating past Upper Klamath Lake into the Sprague and Williamson Rivers and coho salmon and Pacific lamprey moving as far upstream as Spencer Creek and possibly further. Lost River, shortnose, and Klamath largescale suckers were among the most abundant fishes in upper basin lakes and large rivers. Redband trout were also widely distributed in the streams, rivers, and lakes of the upper basin. Less information is available on other species, but many like blue chub, tui chub, speckled dace, and Upper Klamath marbled sculpin are thought to have been abundant and widely distributed. Others were likely limited in distribution due to specific habitat preferences (e.g., bull trout) or geographic isolation from the watershed (e.g., Miller Lake lamprey).

Settlement by people of European descent and subsequent development in the upper subbasin brought about a number of changes that have directly and indirectly affected native fish populations. Some of these include channelizing, damming and diverting rivers and streams, diking and draining of wetlands, overharvest of native fishes like suckers, and introduction of at least 18 non-native fish species. These changes have adversely affected several fish species at a population level. Effects include the extirpation of anadromous fishes and the associated loss of marine-derived nutrient inputs from the upper basin, the loss of critical rearing habitats for young fishes, habitat fragmentation, degradation of water quality, and the introduction of exotic predators and competitors including fathead minnow, yellow perch, largemouth bass, and brook trout. Substantial declines in populations have also occurred for a number native fish species including Lost River sucker, shortnose sucker, redband trout, bull trout, and slender sculpin. Declines have been severe enough to warrant listing under the Endangered Species Act (ESA) for Lost River sucker (Endangered), shortnose sucker (Endangered), and bull trout (Threatened).

A number of actions have been taken to protect fish in the upper subbasin with the goal of stopping and reversing declines in fish populations. These include reduction or elimination of harvest, legal protections for some species and habitats, changes in land use practices, and habitat restoration. A great deal of time and effort has been directed at restoration activities. More than 400 habitat restoration projects were completed from 1994 to 2008 across the upper subbasin. The vast majority of them aimed at improving conditions for aquatic dependent species. Some are as simple as fencing to exclude livestock from streams or planting willows to stabilize stream banks. Others are large-scale efforts to restore key habitats like the Williamson River Delta Restoration Project or improve fish passage like the removal of Chiloquin Dam.

Efforts to recover and restore key native fish populations are ongoing with numerous restoration projects in progress or proposed in the Upper Klamath Subasin. Areas of emphasis include restoring key habitats and providing access to restored and existing habitats. Likely the largest and most far-reaching future restoration activities are proposals to reintroduce anadromous fishes to the upper basin and remove four Klamath River dams. Dam removal would allow anadromous species unimpeded access to the upper subbasin for the first time in over 100 years.

Dam removal and other large-scale restoration projects are designed to limit or remove some of the major constraints anthropogenic activities have placed on the watershed and the native fishes that live there. These actions, however, won't remove all constraints. This leads to the question of what will fish populations of the upper subbasin, and for that matter the entire Klamath Basin, look like in the future. Given the dramatic changes in the watershed, it's simply unrealistic to think that restoration will turn the clock back and return everything to a pre-development condition. Determining what fish populations will look like if dam removal occurs will require an understanding of what constraints remain basinwide. It will also require careful planning along with research and monitoring to address key uncertainties.

Two plans for reintroduction of anadromous fish have been developed for the upper subbasin; one by the Klamath, Karuk, and Yurok Tribes and another by the State of Oregon. Both plans are part of a process to identify and describe the research and management needs for salmon reintroduction and recovery. These include the method of reintroduction (passive, active, or some combination), stock selection, disease issues, interaction and competition with resident species (native and exotic), restoration and monitoring priorities, and natural resource management strategies with emphasis on water and key species.

The Lower Klamath Subbasin

The geologic nature of the Lower Klamath Subbasin is that of a deeply incised channel into bedrock and this, along with a wetter, more marine climate as one moves west, leads to high flows and cooler temperatures in this part of the basin so that it is more like upper basins of most river systems. Historical fish communities were dominated by anadromous fishes, particularly salmonids, along with a few other cool-water fishes (table 5-1) due to these conditions (T. Shaw, U.S. Fish and Wildlife Service and M. Mohr, National Marine Fisheries Service, personal communication). Chinook salmon, coho salmon, steelhead, and cutthroat trout are among the most abundant fishes in the lower basin. Chum salmon and pink salmon were also present in the lower basin, but may now be extinct. Lampreys were the other group of prominent lower basin fishes, including Pacific lamprey, river lamprey, and Klamath River lamprey. Green sturgeon, white sturgeon, eulachon, and threespine stickleback also were abundant anadromous fishes in the lower subbasin. Other cool-water and estuarine-related species were prickly sculpin, coastrange sculpin, Lower Klamath marbled sculpin, Klamath speckled dace, and Klamath smallscale sucker.

Anthropogenic impacts, including dams and hatcheries, land and water management, and mining and forestry practices have greatly changed the species and abundance composition of the Lower Klamath Basin fish community. Dams have been the main impact in the lower subbasin, cutting off habitat for anadromous fishes and changing flow regimes. Salmonid hatcheries associated with the dams have also had substantial impacts; replacing natural production, reducing effective population size, and promoting disease problems in the Lower Basin. Iron Gate Hatchery has released around 3 million fall-run Chinook salmon annually, starting with numbers below 1 million until 1986, peaking up to 4 million from 1987 until 1992, and averaging 2.3 million up to the present. The releases have been consistently about 85 percent fry and 15 percent yearlings. These Chinook salmon releases are joined with around 2 million fall-run fry from the Trinity River Hatchery in the lower river. Harvest of Iron Gate hatchery salmon peaked at 53,000 in 1988 and has remained in the 100s to 15,000 fish since 1990. Beginning in 1990, the ocean salmon fishery has been restricted in most years to minimize the harvest of Klamath River Chinook.

Disease associated with the myxosporean parasites *Ceratomyxa shasta* and *Parvicapsula minibicornis* are of particular concern for juvenile salmon in the Klamath River. The high prevalence and severity of infections observed in most years likely result in substantial mortality rates among juvenile coho and Chinook salmon emigrating from the Klamath River and its tributaries to the ocean. Although both parasites are native to the Basin, changes in the watershed may have shifted the host-pathogen relationship in favor of these parasites. These disease organisms occur naturally in the Klamath Basin and have coevolved with the fish. However, when water quality deteriorates, the fish are stressed, or when parasite spore loads are extremely high, then lethal disease outbreaks can occur. Water quality conditions that can lead to increased fish stress include crowding in response to diminished flows, elevated water temperatures, low dissolved oxygen conditions, high pH (alkalinity), and unionized ammonia. The 2002 mass mortalities of at least 33,000 Chinook salmon in the lower subbasin were unprecedented events. The direct cause of these mortalities was a pathogen infection resulting from the transmission of disease due to crowding of fish and other stressful conditions associated with low flows, high temperatures, and other factors. The causes of the mass mortality are not completely known.

Anadromous salmonids are dominant members of the lower subbasin fish community and their populations have been substantially impacted by anthropogenic factors. Coho salmon are ESA listed and Chinook salmon and steelhead populations have been considered for listing. Another concern is the low abundance of summer steelhead. In addition, fall Chinook salmon populations are dominated by hatchery fish. Salmon and steelhead provide a useful example to illustrate the connections of aquatic habitat throughout the Klamath Basin and provide a vivid picture of how constraints on these connections can impact the viability of fish populations.

Development of recovery planning is being guided by viability criteria that are recommendations as to the minimum population and Evolutionary Significant Unit (ESU) or Distinct Population Segment (DPS) characteristics that would result in a specific ESU having a high probability of long-term (> 100 years) persistence. The foundation of ESU viability and for restoration of fish populations in the lower subbasin is built upon the ability of populations to function in an integrated manner and persist across the landscape. This integration includes dispersal among populations and habitat throughout the Basin (i.e., connectivity) and a diversity and distribution of habitat types and conditions that allow for the expression of a range of life-history types. In short, for an ESU (or population, or aquatic community) to persist, it must be able to track changes in environmental conditions. When the location or the distribution of a species' (or community's) habitat changes, it can avoid extinction either by adapting genetically to the new environmental conditions or by spatially tracking the environmental conditions to which it is adapted.

Changes in environmental conditions can constrain the ability of a species or community to track changes in the environment. For example, cold water areas can provide seasonal refuge for salmon during critical portions of their life cycle or for occasional warm/drought conditions happening at longer time scales (decadal). When access to cold water areas is constrained or lost, or the cold water areas are lost, this fish species or life stage cannot track the change and is threatened with localized extinction. Anthropogenic changes throughout the Klamath Basin have modified the environmental conditions and have constrained opportunities for aquatic species, particularly fish species in the lower subbasin, to track changes in the environment. Spatial scales can range from localized impacts (e.g., affecting portions of one or a few populations) to regional impacts from severe events such as droughts that affect all populations throughout the basin and adjacent basins. Temporal scales can range from a site-specific impact resulting from a short-term, albeit catastrophic, event (e.g., landslide temporarily blocking passage on a large mainstem river) to interannual variability of various environmental conditions (e.g., marine conditions, annual precipitation patterns), to long-term environmental changes such as climate change that have the potential to impact all populations within the ESU.

Interaction among populations within the lower subbasin and throughout the whole Klamath Basin buffers against catastrophic loss of many populations, maintains long-term demographic and evolutionary processes through connectivity, and maintains sufficient diversity so that the populations have the potential to cope with changing environmental conditions. Some populations need to have sufficiently large numbers of individuals to disperse and provide the needed connectivity among populations. Habitat throughout the Basin serves different life stages of different species to various degrees (e.g., mainstem spawning habitat for Chinook salmon, tributary habitat for coho salmon spawning, mainstem tributary junctions for juvenile rearing habitat, etc.). Barriers to movement across the landscape, either permanent such as a dam or temporal such as seasonal reduction in streamflow, constrain the ability of salmon populations to track changes in the environment. As ecological constraints in the basin result in continued divergence from historical ecological conditions in which these populations evolved, the risk of extinction increases.

Estuary

The Klamath Basin estuary and nearshore marine environment begin at the highest intrusion of saltwater into the basin and extend out into the coastal ocean. The Klamath Basin estuary is relatively small in relation to the size of its watershed compared with other large river systems like the Sacramento-San Joaquin or Columbia Rivers. This is due to the deeply incised and sharply confined nature of the lower subbasin river after it emerges from the Klamath Mountains. The length of the estuary is variable, since saltwater intrusion varies seasonally, but significant saltwater influence only extends about 6 km upriver. The Trinity River, which enters the Basin 32 km upriver, contributes significantly to the estuarine flow. This flow is controlled by the Trinity River Dam.

The Klamath Basin estuary has experienced historical change which probably began shortly after the establishment of a European settlement at Klamath City in 1850; however, overall impact is less than other large rivers, perhaps due to its small size and relatively large volume of freshwater entering the estuary in relation to its size. An early map of the estuary does not look dramatically different than the estuary today; however, the historical change of the estuary can only be documented from 1936 from a time-series of aerial photographs. The overall size of the estuary has varied both larger and smaller over time, but has remained a relatively constant size of just over 2,000 km^2. Erosion has only slightly modified the morphology of the upper and lower estuary during this period. The most dramatic change in the estuary has been the loss of island habitat since 1936, starting with 221 km^2 and reaching a high of 772 km^2 in 1963, then dropping to the 10 to 15 km^2 more recently. There have also been substantial changes in the estuary due to natural variations in river flow. The most extreme flooding event occurred in 1964. From a regional perspective, habitat losses in the Klamath Basin estuary are small compared to the changes in the San Francisco Bay and Columbia River estuaries.

The Klamath Basin estuary can be characterized as a limited exchange system due to its interface with the marine environment. The estuary has a low diversity of fishes compared to other coastal estuaries along the Pacific, probably due to its small size and large freshwater flows. Like other estuaries it is important transitional habitat for salmon beginning their seaward migration and returning adults. Euryhaline and marine native fishes along with introduced fishes known to inhabit the estuary are listed in table 5-1 (M. Wallace, California Department of Fish and Game, personal communication). Many of these native anadromous fishes have severely depressed populations with coho salmon and eulachon now receiving special protections through ESA listings. Green sturgeon is Federal ESA listed immediately to the south of the Klamath River. Chinook salmon are largely supported by hatcheries, but have been at such low levels that the fishery has needed to be closed in certain years. Pink and chum salmon have not been found in the Klamath for several decades. Steelhead and Pacific lamprey are also at low population levels.

The Klamath Basin estuary is not only important habitat for euryhaline and anadromous fishes, but also the endpoint for all of the impacts that have occurred upriver. Well-documented impacts due to changes in flow, and accompanying changes in temperature and water quality, are understood in the lower subbasin, but are not in the estuary. The changes in the flow regime from the headwaters due to Iron Gate and Trinity dams are mitigated somewhat by lower subbasin rainfall. However, the warming of water temperature, increased organic loading, and alteration in timing of flows has impacted the freshwater-saltwater interface of the estuary. The impacts to estuarine habitat associated with increased sedimentation from timber practices and mining are not well understood. Nor is the role of the estuary in the transmission of diseases to migratory anadromous fishes. The cumulative effect of these potential interactions on the fishes using the Klamath Basin estuary are unknown and are a major source of scientific uncertainty. Finally, the largest future impact on the Klamath Basin estuary is climate change induced sea level rise. Average predictions of sea level rise include a 30 cm increase by 2060 and an average “worst-case” scenario of a 1.4 m rise. Clearly, such changes will have a profound effect on the estuary and lower river habitats.

Nearshore Marine Environment

The nearshore marine environment has some of the highest levels of upwelling observed in the California Current. The upwelling process is induced by offshore winds and delivers cold, high nutrient-laden waters to the surface. These conditions support high biological productivity in the nearshore marine. Because coastal waters are dynamic, habitat conditions are patchy with respect to marine productivity. The match and mismatch of ocean conditions with the occurrence of juvenile salmon and other anadromous species has a major influence on population growth and survival during early phases of their marine life history. Patterns of habitat use in the nearshore marine environment are best understood for Chinook salmon. Growth and survival of juvenile Chinook directly corresponds to the abundance of suitable prey. Similar relationships are assumed for other anadromous species. Information about the marine distribution and survival of Pacific salmon and steelhead and other fishes is becoming available through the Pacific Ocean Shelf Tracking (POST) Program. POST is a large-scale ocean telemetry and data management system that operates fixed lines of electronic tag receivers along the West Coast of North America. The program provides new insights into fish movement and migration behaviors.

Finally, there needs to be a cautionary note about the impact of climate change in the nearshore marine environment. Eulachon were the first species listed under the ESA whose principal threat was climate change impacts on the marine environment. We can expect more climate change caused impacts throughout the marine environment. We really have very little understanding of the impacts that climate change will have for these fishes and their ecosystems.

The Klamath Basin estuary and nearshore marine environment are areas of complex ecosystem interactions due to the interface of freshwater and saltwater habitats. These habitats are less studied than their freshwater counterparts upriver. Differences in quality and content of scientific resource information make informed prediction about these environments extremely difficult. The estuary may not have been as dramatically altered as those of other large rivers systems but it is terminal and the integrative endpoint of all of the impacts that have occurred upstream. The nearshore marine environment is very dynamic where small differences in upwelling events influence marine productivity and quality of salmon (and other fishes) habitat. These changes are hypothesized (match – mismatch hypothesis) to impact year-class strength in salmon populations and for other species. Climate change effects may significantly impact estuarine and nearshore marine environments. These impacts can be expected to alter ecosystem structure and function.

Conclusion

The Klamath Basin’s historical fish community was strongly adapted to its “upside-down” geologic nature. The upper subbasin with its habitats of broad valleys, shallow lakes, and low-gradient rivers in a semiarid climate produced a historical fish community, which had a high number of endemic species, particularly of suckers, sculpins, and lampreys. Some of this high level of endemism is also due to landform changes resulting in the separation of upper and lower subbasin habitats over geologic time. Anadromous fishes, particularly salmonids and lampreys, were a prominent part of historical fish communities, providing a biological connection with the lower subbasin and marine environment. The lower subbasin, with its narrow-channel, high-flow nature, led to a historical fish community made up largely of anadromous fishes: salmonids, lampreys, green sturgeon, and eulachon, along with a few other cool-water species. The Klamath Basin estuary was small with a historical fish community of both

Basin fishes and other more common euryhaline and marine species. The distinctive "upside-down" geologic nature of the Klamath Basin led to a unique historical fish community different from any other on the Pacific Coast.

The current Klamath Basin fish community is vastly changed in many ways by anthropogenic impacts including dams, agriculture, land management activities, hatcheries, and introduced species. These impacts have resulted in a loss of diversity and abundance throughout the Basin. Upper subbasin impacts have included damming, diverting, and channelizing rivers and streams, diking and draining of wetlands, overharvest of native fishes like suckers, and introduction of at least 18 non-native fish species. The most obvious cause of lost diversity is the barrier imposed upon anadromous fishes at Iron Gate Dam. In some instances anthropogenic changes in habitat and population size have resulted in ESA listings of key species of fish.

Dam removal would be the largest and most dramatic habitat restoration activity for both the upper and lower subbasins. It is important to recognize that numerous other restoration projects are currently in progress or are proposed in the upper subbasin to restore key habitats and native fish populations. The lower subbasin's largest impacts are from dams. The construction of dams has resulted in loss of riverine habitats and changes in flow regime. Other human activities including hatchery, forestry, and land management practices have also had significant impacts. The Basin's salmonid populations have been dramatically affected by these practices. Access to and the quality of key habitats has been diminished and population abundance and diversity has suffered over time. The effects of aquaculture need continued research. For example, hatchery and wild fish interactions are not well understood but may have genetic and disease underpinnings. Habitat conditions in the Klamath Basin estuary seem to be less affected by the upper and lower subbasins. The nearshore marine environment is vast and has been considered stable but climate change effects may be profound.

Future research planning needs to be conducted at the Basin scale. A piecemeal approach to planning has not provided the resource information that will be needed for large-scale restoration and salmon reintroduction that may be forthcoming. Of course, there are exceptions to this generalization. For example, current efforts in support of disease ecology studies of salmon in the Klamath Basin have involved multi-agency planning to address parasitic infestations at the right time and spatial scales. However, this represents only one aspect of ecosystem management and there are many others that will require watershed understanding.

Unfortunately, at present, basin-level planning must follow a two track process: one that incorporates the dam removal initiative and one that does not until the Secretarial Decision. The Secretarial Decision will have a large impact on whether a Klamath Basin conceptual model will be interconnected or whether it will remain segmented into the upper subbasin, the lower subbasin, and the estuary and nearshore marine environment. Future research planning strongly depends on what the goals and priorities are set for the Basin. This will require a significant effort and multi-organizational governance strategy. Adaptive management is an extremely attractive model for research planning and it will require better initial planning to be successful. A priority objective of watershed restoration for salmon recovery should focus on the natural ecosystem processes that will preserve and enhance resiliency in these populations. Resiliency can be related to population productivity and abundance, variations in life history traits, and genetic diversity. This focus, requiring an ecosystem approach and other related objectives, will need to be identified and described in a formal Klamath Basin Science Plan. Climate change and disease ecology represent science areas that will need to be addressed. The science plan will need to be accompanied by an ongoing organizational structure for the participating agencies and an independent science board to provide overview and advice for future research. All of this will require agreement among the participating agencies.

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Table 5-1. Distribution and Status of Klamath Basin Fishes. Distribution and Status are coded as Present (P), ESA Listed (E), Historically present but currently 'absent' (XX),Introduced (I), Condition unkown (?).

		Distribution and Status		
Species		Estuary	Lower	Upper
Common	Scientific			
White shark	*Carcharodon carcharias*	P		
Big skate	*Raja binoculata*	P		
Pacific lamprey	*Lampetra tridentata*	P	P	XX
Klamath-Pit brook lamprey	*Lampetra lethophaga*			P
Klamath River lamprey	*Lampetra similis*	P	P	P
Miller Lake lamprey	*Lampetra minima*			P
River lamprey	*Lampetra ayers*	P	P	
Undescribed Upper Klamath Lake lamprey	*Lampetra sp.*			P
Green sturgeon	*Acipenser medirostris*	P	P	
White Sturgeon	*Acipenser transmontanus*	P	P	
Wakasagi	*Hpyomesus nipponensia*		I	
Pacific herring	*Clupea pallasi*	P		
Northern anchovy	*Engraulis mordax*	P		
American shad	*Alosa sapidissima*	I	I	
Goldfish	*Carassius aurtatus*	I		
Golden shiner	*Notemigonus crysoleucas*	I	I	
Coho salmon	*Oncorhynchus kisutch*	E	E	E/XX
Pink salmon	*Oncorhynchus gorbuscha*	XX	XX	
Chum salmon	*Oncorhynchus keta*	XX	XX	
Chinook salmon	*Oncorhynchus tshauytscha*	P	P	XX
Kokanee	*Oncorhynchus nerka*		I	
Steelhead	*Oncorhynchus mykiss*	P	P	XX
Redband trout	*Oncorhynchus mykiss nuberrii*			P
Coastal cutthroat trout	*Oncorhynchus clarkii clarki*	P	P	?
Bull trout	*Salvelinus confluentus*	P	P	?
Brown trout	*Salmo trutta*	I		
Brook trout	*Salvelinus fontinalis*	I	I	
Eulachon	*Thaleichthys pacificus*	E/XX	E/XX	
Surf smelt	*Hypomesus pretiosus*	P		
Longfin smelt	*Spirinchus thaleichthys*	P		
Pacific hake	*Merluccius productus*	P		
Pacific tomcod	*Microgadus promimus*	P		
Blue chub	*Gila coerulea*			P
Tui chub	*Gila bicolor*			P
Speckled dace	*Rhinichthys osculus*	P	P	P
Klamath speckled dace	*Rhinichthys osculus klamathensis*		P	
Fathead minnow	*Pimephales promelas*	I	I	I
Lost River sucker	*Deltistes luxatus*			E
Shortnose sucker	*Chasmistes brevirostris*			E
Klamath largescale sucker	*Catostomus snyderi*			P
Klamath smallscale sucker	*Catostomus rimiculus*			P
Brown bullhead	*Ictalurus nebulosus*	I	I	I
Jacksmelt	*Atherinopsis californiensis*	P		
Topsmelt	*Atherinops affinis*	P		

		Distribution and Status		
Species		Estuary	Lower	Upper
Common	Scientific			
Threespine stickleback	*Gasterosteus aculeatus*	P	P	
Brook stickleback	*Culea inconstans*		I	
Bay pipefish	*Syngnathus leptorhynchus*	P		
Striped bass	*Morone saxatilis*	I		
Klamath lake sculpin	*Cottus princeps*			P
Upper Klamath marbled sculpin	*Cottus klamathensis klamathensis*			P
Slender sculpin	*Cottus tenuis*			P
Prickly sculpin	*Cottus asper*		P	
Coastrange sculpin	*Cottus aleuticus*		P	
Lower Klamath marbled sculpin	*Cottus klamathensis polyporus*		P	
Sharpnose sculpin	*Clinocottus acuticeps*	P		
Staghorn sculpin	*Leptocottus armatus*	P		
Sturgeon poacher	*Agonus acipenserinus*	P		
Largemouth bass	*Micropterus salmoides*	I	I	I
Black crappie	*Pomoxis nigromaculatus*	I	I	
Spotted bass	*Micropterus punctulatus*		I	
Smallmouth bass	*Micropterus dolomieui*		I	
Bluegill	*Lepomis macrochirus*		I	
Green sunfish	*Lepomis cyanellus*	I	I	
Pumpkinseed	*Lepomis gibbosus*		I	
Yellow perch	*Perca flavescens*	I	I	I
Redtail surfperch	*Amphistichus rhodoterus*	P		
Shiner perch	*Cymatogaster aggregate*	P		
Striped surfperch	*Embiotoca lateralis*	P		
Walleye surfperch	*Hyperprosopon argenteum*	P		
Zebra perch	*Hermosilla azurea*	P		
Arrow goby	*Clevelandia ios*	P		
Saddleback gunnel	*Pholis ornate*	P		
Pacific sandlance	*Ammodytes hexapterus*	P		
Speckled sandab	*Citharichthys stigmaeus*	P		
Starry flounder	*Platichthys stellatus*	P		
Butter sole	*Isopetta isolepis*	P		

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Edited by Lyman Thorsteinson, Scott VanderKooi, and Walter Duffy

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KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

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