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Managing Water in the West

Nonnative Game Fish Emigration, Distribution, Impacts and Perception In the West

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14. ABSTRACT
Reclamation has been the lead agency in developing water, mainly in the form of reservoirs, in the West where Federal, state, local, and tribal game and fish agencies have introduced nonnative game/sport fish for food or recreational purposes. Entrainment of fish into reservoir discharge water and into streams and rivers is well documented. Escapement over spillways during high flow events is greater for all life stages of fish compared to passage through bottom outlets. With the implementation of the Endangered Species Act and the designation of critical habitat, some rivers and streams downstream of Reclamation reservoirs have been identified as critical habitat for native fish but are continually impacted by the escapement of nonnative game (and forage) fish. Immediate negative impacts created by nonnative fish introductions include competition, predation, parasitism, interbreeding, disease transmission, and physical changes to aquatic habitat. Reservoirs identified as having high nonnative fish escapement potential should re-evaluate operational guidelines to minimize and/or eliminate spillway releases or add devices on the discharge outlets (or spillway) to prevent escapement. The current perception of managing nonnative game fish is reflected by Reclamation personnel where areas with ESA fish issues are more cognizant of negative impacts caused by nonnative game fish.

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Nonnative Game Fish Emigration, Distribution, Impacts and Perception in the West

Prepared by: Raymond C. Bark
Fish Biologist, Fisheries and Wildlife Resources Group, Technical Service Center, 85-829000

Peer Review: Michael J. Horn, Ph.D.
Manager, Fisheries and Wildlife Resources Group, 85-829000

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Acronyms and Abbreviation

Acronym/Abbreviation	**Description**
ESA	Endangered Species Act
SD	Standard Deviation
U.S.	United States
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Service

Executive Summary

The U.S. Bureau of Reclamation has been the lead governmental agency in developing water, mainly in the form of reservoirs, in the West for municipal, industrial, and agricultural purposes during the last century. Concurrently, nonnative game and sport fish introductions into water impoundments for food or recreational fishing purposes have also occurred extensively over the last century. The popularity of fishing as a source of food or for recreational purposes continues to be one of America's favorite pastimes.

Published studies identifying the distribution of ichthyofaunal species and their relative proportion of nonnative to native species in biological communities are limited. Most available information only identify the presence or absence of fish species on a regional or state by state basis and often species distributions can only be estimated within basins and on an eco-regional scale. Because of insufficient aquatic inventory and monitoring data, the U.S. Environmental Protection Agencies' Environmental Monitoring and Assessment Program developed a probabilistic database and framework of the distribution of nonnative aquatic species for natural resource managers (Lomnicky et al. 2007).

Over the years federal, state, local and tribal game and fish agencies have introduced nonnative game and sport fish into western reservoirs and waterways managed by the U.S. Bureau of Reclamation. Emigration of nonnative fishes from reservoirs is often by movement over spillways during high flow events or from passage through discharge waters. Fish escapement from reservoirs with bottom release outlets normally discharge hypolimnetic waters where oxygen levels and numbers of fish are typically low when compared to fish escapement over spillways. With the implementation of the Endangered Species Act and the designation of critical habitat for the conservation of threatened and endangered fish species, many rivers and streams downstream of Reclamation reservoirs have been identified as critical habitat for fish and other aquatic species but are continually impacted by the escapement of nonnative game and sport fish along with nonnative forage (bait) fish.

To address the issue of nonnative fish emigration from Reclamation reservoirs is first to identify streams and rivers throughout the 17 western states that have been designated as critical habitat waters for Endangered Species Act listed fishes. The next step is to identify the reservoirs that are upstream and near designated critical habitat areas where surface water is hydrologically connected and there are no barriers for fish movement. The next step would then be to evaluate the extent of nonnative fish escapement from those reservoirs. Reservoirs identified as having high potential for nonnative fish escapement should then re-evaluate their operational guidelines to minimize escapement by eliminating spillway discharges. If escapement is occurring though bottom discharges, a site specific fish exclusionary device should be designed, tested, and then installed until the level of escapement is abated.

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Introduction

Throughout the western United States (U.S.) nonnative fish, as well as other aquatic species, are becoming increasingly prevalent in reservoirs, rivers, and other waters managed by the Bureau of Reclamation (Reclamation). While many game fish have been purposefully stocked into reservoirs, rivers, streams, ponds, natural lakes and wetlands throughout the western U.S., other aquatic taxa have been intentionally or inadvertently introduced. Nonnative fish can be introduced into water bodies through bait-bucket dumping, aquaria dumping, escapement from failed enclosures, and other means such as by-product mixing with other aquatic organisms where they can establish populations in local aquatic systems (Moyle 2002, Lomnicky et al. 2007). Entrainment of game fish into reservoir discharge water and through dam outlet structures and into the receiving river is well documented (Cramer and Oligher 1964, Bentley and Raymond 1969, Beamesderfer and Reiman 1991, Berge et al. 1996, Coutant and Whitney 2000). While many aquatic species have been unintentionally introduced into aquatic systems, nonnative game fish continue to be intentionally introduced for angling and has occurred for well over a century (Moyle 2002) and continue to be problematic to native fish throughout most of the western U.S. (Lomnicky et al. 2007).

Nonnative fish impact the aquatic ecosystem into which they have been introduced in various ways. Albeit unknown, unforeseen, or unintentional yet resulting in mostly negative ecological impacts occur to native fish and to their populations where nonnative fish, mainly nonnative game fish, have been introduced. Of the 12 western states surveyed for nonindigenous aquatic species by the U.S Environmental Protection Agency, Brook Trout (*Salvelinus fontinalis*), Brown Trout (*Salmo trutta*), and Rainbow Trout (*Oncorhynchus mykiss*) were the most common nonnative aquatic species found in the western U.S. where the state of California had the greatest amount and the state of Idaho had the fewest. A review of fish introductions of three continents found native fish populations disappeared altogether or decreased more than 75 percent of the time after nonnative fish were introduced (Lomnicky et al. 2007).

The most immediate negative impact created by nonnative game fish introductions is that of direct competition where nonnative game fish outcompete native fish for food and habitat resources. Also at a later life stage, nonnative game fish can predate on native fish that are smaller in size thus, creating an anomalous food source. In addition to the impacts of the more common nonnative salmonids (Brook, Brown and Rainbow Trout), the Upper Colorado River Endangered Fish Recovery Program has identified Northern Pike (*Esox lucius*), Smallmouth Bass (*Micropterus dolomieu*) and Channel Catfish (*Ictalurus punctatus*) as a significant threat towards the recovery of endangered fish in the Colorado River system due mainly from predation. Even the larger sized native fish are being consumed as prey by these three introduced nonnative game fish (Johnson et al. 2014). In addition to competition for habitat resources and outright predation, parasitism, interbreeding, disease transmission, and physical

changes to aquatic habitat are some of the more common impacts to native fish communities caused by introductions of nonnative fish. Many introduced fish species tend to be well-adapted to a variety of environmental conditions allowing for a competitive advantage over their native counterparts (Ptacek et al. 2005). Several other nonnative game fish: Lake Trout (*Salvelinus namaycush*), Largemouth Bass (*Micropterus salmoides*), Walleye (*Sander vitreus*), Common Carp (*Cyprinus carpio*), Green Sunfish (*Lepomis cyanellus*), Bluegill (*L. macrochirus*), Yellow Perch *(Perca flavescens*), White (*Pomoxis annularis*) and Black Crappie (*P. nigromaculatus*), and Bullheads (*Ameiurus spp*.) have been introduced into waters throughout the western U.S. as recreational game and sport fish have also contributed to the decline of native fish and has inhibited the effort to restore their populations (Upper Colorado River Endangered Fish Recovery Program 2018). See Appendix for fish species in the 17 western states that are currently listed as endangered or threatened under the Endangered Species Act and designated critical habitat at USFWS websites:
https://www.fws.gov/endangered/
https://ecos.fws.gov/ecp/report/table/critical-habitat.html.

Nonnative Game Fish Emigration

The potential of nonnative game fish to escape downstream from a host reservoir and into designated critical habitat waters for Endangered Species Act (ESA) listed fish require that the fish becomes entrained into discharge water and then survives reservoir passage. In general there are two contributing factors, fish-related factors and reservoir-related factors that must occur concurrently for fish to emigrate downstream (Johnson et al. 2014).

Fish Related Factors

The most significant fish-related factor for reservoir escapement is that the fish must be in proximity to the dam outlets. Susceptibility to entrainment into surface or subsurface releases can only occur when the fish is near the spillway, penstocks, or bypass outlets and then becomes entrained into the discharge flow-fields (Johnson et al. 2014). Fish behavior in the flow field also contributes to entrainment probability, fish facing in the upstream direction of the flow field are more likely escape entrainment by swimming against the currents entering deep intakes while also swimming upward in the water column as they were drawn deeper (Johnson et al. 2014, Coutant and Whitney 2000). Although when the flow field velocity increases (i.e. beyond their swimming ability), many salmonids where found to swim with their heads facing downstream (Coutant and Whitney 2000). Coutant and Whitney also found that many of the juvenile salmonid species attempting to out-migrate from large reservoirs were oriented more towards the surface than the bottom and that they were more likely to attempt reservoir passage at night. The fishes’ swimming ability to escape entrainment flows is also largely determined by what type of species it is. Lacustrine species and non-migratory game fish introduced into reservoirs may have few current-related adaptations (e.g. salmonids versus centrarchids) potentially making them more susceptible to incidental entrainment into discharge flows. The behavior of resident reservoir fish influences their entrainment probability and are likely to be highly site specific, depending on habitats and species encountered (Coutant and Whitney 2000).

In spite of what type of fish species it is, earlier life-stages of fish are more vulnerable to entrainment into the discharge flow due to their underdeveloped swimming abilities. Many fish (and nonnative game fish) species in the western U.S. spawn during the spring-summer period where, their timing at the larval stage may coincide with late-spring and early summer peak discharge flows thus, increasing their entrainment risk probability. Entrainment risk is also increased for pelagic or semi-pelagic larvae (or embryos) because of their life-history trait that compels them to move towards open water where their proximity to entrainment into dam discharge flows can increase (Johnson et al. 2014).

Proximity to the shoreline was also a major factor influencing entrainment, especially for non-salmonids who tend to follow shorelines as part of their normal behavior. Fish with a higher water temperature preference (e.g., many non-salmonids) were also more likely to be higher in the water column and entrained into discharges such as in surface releases through spillways. However, entrainment through reservoirs for non-salmonid game fish (i.e., Large and Smallmouth Bass, Walleye, Yellow Perch and Black Crappie, etc.) was found to be episodic but did occur throughout the year and most entrained fish were small in size (Coutant and Whitney 2000).

Reservoir Related Factors

Reservoir related factors (dam operations, dam configuration and water quality conditions) also contribute towards the entrainment risk and potential live-escapement of its resident fish. The most significant factor contributing to fish escapement from reservoirs is created by the operation of the facility itself. Fish residing inside of the reservoir would not be able to pass through or over the structure if water is not actively discharged from the facility. Fish passage though surface or sub-surface discharges via penstocks, bypass outlets or over the spillway are the only methods of reservoir escapement. The configuration of the reservoir, such as the location of the spillway also contributes to the probability of entrainment. Surface discharges where the spillway is near the shoreline, such as those located on the dam crest, have a greater proclivity to entrain fish versus spillways located in open water or towards the center of the reservoir (Coutant and Whitney 2000). Fish that survive reservoir passage can potentially establish populations downstream of their host reservoir and prey on native fish as well as compete for favorable habitat, food, and other scarce resources (Rieman et al. 1991).

The potential of fish at entrainment risk inside the reservoir can be thought of as being proportional to the amount of water discharged from the reservoir (i.e. increased discharges increases entrainment risk). Thus, a decrease in reservoir water residence time increases entrainment risk where water residence time (WRT) equals reservoir capacity (CAP) divided by the volume released (REL) where, WRT=CAP/REL, considering that fish tend to follow the flow of water but are not mutually buoyant particles (Johnson et al. 2014). Johnson et al., developed an index of emigration risk which is the product of four dam-related emigration risk factors. Emigration Risk Index (ERI) is calculated by ERI = ST x SL x SF x SD where ST is the spillway type (controlled = 0.5, uncontrolled = 1.0), SL is the spillway location (center = 0.5, edge = 1.0), SF is the spill frequency (percent of years spills occur), and SD is the mean spill duration (percent of days of the year).

Reservoir Water Quality Factors

Reservoir water quality conditions, or physio-chemical, along with reservoir operations and the dam/spillway configuration, are the third key component of the key factors contributing towards the entrainment of resident reservoir fishes. Water quality conditions within the reservoir greatly influence spatial and temporal patterns of fish at entrainment risk by affecting their behavior (Johnson et al. 2014). The water body within the reservoir typically experience stratification during the summer season where water masses with different physio-chemical properties form layers that act as a barrier to mixing. As a result of increased solar radiation during the summer period, the upper-layer of reservoir water warms to become the epilimnion whereas, the colder and more-dense water sinks to the bottom forming the hypolimnion and the layer between them is called the metalimnion. Therefore, reservoir fish species that prefer the higher temperature water (typically non-salmonids) will congregate in the epilimnion where they become more susceptible to entrainment into surface water releases through the spillway, especially during years of high run-off. Fish species preferring colder water conditions, such as salmonids, may congregate in the hypolimnion. If oxygen levels are too low for them in the hypolimnion (hypolimnetic waters are usually low in dissolved oxygen), they will congregate in the metalimnion seeking out a more optimum water temperature for consumption and growth. However by congregating in the lower cooler layer of water during the summer period, many reservoir salmonids may be inadvertently exposed to deep-water discharges through hydro-electric turbines and/or to deep water bypass releases. Conversely, the greatest amount of entrainment of warm-water reservoir fish may occur when the reservoir is drawn down and the epilimnion overlaps with the penstock outlets. The differences in thermal preferences of reservoir fish can influence the relative position and entrainment risk of each species of fish in the water column when the reservoir is stratified (Johnson et al. 2014).

Past research has concluded that the live-escapement of game fish from reservoirs occurs mostly by passing over the dam through the spillway outlet during periods of high surface spills. However, non-salmonid (and salmonid) reservoir fish may disperse more under isothermal conditions becoming more susceptible to deep-water and surface entrainment during colder periods than during summer. Also during colder (and cooler) periods, survival of all species of fish is considerably higher when entrained through spillway releases and through deep water turbine or bypass discharges. While larger fish experience higher levels of mortality passing through hydropower turbines and are less likely to become entrained into spillway flows, smaller fish have a greater chance of survival through turbines and through spillway releases. Therefore, the downstream emigration of all reservoir species is possible during earlier life stages, regardless of the dam configuration and water operations (Coutant and Whitney 2000).

Nonnative Game Fish Distribution in the West

Introductions of nonnative game and sport fish have occurred extensively throughout the western states for well over a century. Many of the nonnative game and sport fish introductions were in effort to provide a readily available and inexpensive food source for local residents (Moyle

2002). One of the most successful introductions of a nonnative (game) fish as a cheap food source was the Common Carp (*Cyprinus carpio*), introduced widely in the late 1800s and thought to be superior to most other (native) fish (Moyle 2002).

The Common Carp (imported from Europe) was relatively easy to farm and capable of rapid growth however, once it became well established, it was not used much as a food source and not sought after by many anglers. However, the Common Carp did adversely impact the productivity of the water it inhabited mostly by 'rooting' up aquatic vegetation causing an increase in turbidity and subsequent decrease in aquatic vegetation photosynthesis (Wydoski and Whitney 2003). The Common Carp is also known to outcompete native fish for limited aquatic resources while also being able to endure temperature extremes and survive in polluted, high-salinity, low-oxygenated waters better than almost every native fish it has encountered (USGS 2018). Besides the Common Carp, some also considered that nonnative game fish and hatchery-reared surrogates were introduced to replenish economically important fish stocks when their abundances declined or disappeared altogether (Wydoski and Whitney 2003). Still others believed that the stocking of the Common Carp (and other nonnative game fish) coincided with westward expansion via the railroad (USGS 2018), because of their familiarity to European migrants and to easterners moving west and bringing with them their favorite fish.

In a 5-year study of aquatic assemblages in 12 conterminous western states Lomnicky et al. (2007) sampled a total of 1,361 sites representing 213,600 kilometers of streams/rivers using electro-fishing equipment. From the 1,361 sample sites, 711 sites (90,000 km) were considered to have been sampled sufficiently and aquatic vertebrates were captured however, some areas where listed species were known to occur were not permitted for electro-fishing and excluded from the study. From the 90,000 km of streams and rivers (711 sites), a total of 190 aquatic vertebrates were sampled where 166 were fish species and 61 of the fish species collected were identified as nonnative fish, most of which were nonnative game fish and the others were nonnative bait or forage fish. From all sample sites where aquatic vertebrates were captured, the 166 fish species represented 75 percent of the fish known to occur in the 12 state area where there were also 17 fish species that were listed as federally endangered or threatened under the Endangered Species Act. Sixty-nine percent (131) of the 190 vertebrate species collected were found solely within their native range and only 17 species were considered as game fish and were not native to the locations where they were found (Lomnicky et al. 2007).

Each state in the Lomnicky et al., survey was sampled at 50 or more sites excluding large rivers such as the Columbia River and most of the mainstem sections of the Colorado and Missouri Rivers and each site was grouped into one of three categories; Mountain, Xeric or Plains ecoregion's. Of the rivers and streams surveyed in 12 western states, Lomnicky et al., found that nonnative fish comprised more than 50 percent of the total amount of individual fish in twenty-two percent of the surveyed stream and river segments. In eighteen percent of the surveyed stream and river segments, nonnative fish ranged between 10 to 50 percent and only in twelve percent of the survey segments did nonnative fish make up less than 10 percent of the total amount of individual fish. Of all of the streams and rivers surveyed West-wide, nonnative fish were present in fifty-two percent of the 711 sampling sites. Eight of the twelve states contained 50 percent or more nonnative fish where the stream or river segments were surveyed. Where nonnative fish were found, their presence increased from 36 percent in first-order streams to around 93 percent in fifth-order streams (and rivers) or larger. For each of the ecoregions that each site was categorized into, the Mountainous ecoregion had the least estimated percentage of nonnative fish at approximately 45 percent whereas, areas in the Plains and Xeric ecoregions ranged as high as 67 percent. All states contained two or more ecoregions except for North Dakota (Plains ecoregion) and almost all of Nevada (Xeric ecoregion) and on the state level, Colorado and Montana had the greatest percentage of nonnative fish occurrences at 86 percent. Whereas, the Pacific Northwest states of Oregon and Washington had the lowest percentage, 20 and 21 percent respectively (Lomnicky et al. 2007).

Prior to any nonnative fish introductions, the states of Oregon and Washington already have had well established fish communities present in their streams and rivers whereas, an estimated 95 percent of headwater streams and lakes in mountainous areas throughout the west (e.g., Colorado and Montana) did not contain fish (Bahls 1992). Oregon was the only state that did not have an introduced fish among its 12 most common aquatic vertebrates, however, Smallmouth Bass, a notorious introduced predatory game fish was found in 5 percent of the surveyed streams and rivers and is the most widespread nonnative fish there (Lomnicky et al. 2007). Conversely, Arizona had the most nonnative fish where 8 of the 12 most prevalent fish were of nonnative origin. Red Shiner (*Cyprinella lutrensis*), a nonnative forage fish (and bait) fish, and the Common Carp were the first and second most common fish found in the surveys in Arizona and the Green Sunfish were the fourth most common fish and third most common nonnative fish (Lomnicky et al. 2007).

Rainbow Trout and Cutthroat Trout (*O. Clarkii*) were the fish most often found to still exist in their natural range at 29 and 23 percent respectively. Rainbow Trout are native to the states along the west coast (and Idaho) where both the anadromous form (Steelhead) and resident form originated. Cutthroat Trout are variously distributed throughout most western states where there are at least 14 different sub-species, most of which remain in fragmented habitats with isolated populations (Behnke 1992). Ironically, trout were also the most widely distributed nonnative fish throughout the West. In 8 of the 12 states in the West, Brook Trout, Brown Trout, and Rainbow Trout (as a nonnative) were present in 17, 16, and 14 percent respectively, of the assessed stream and river sites (Table 1). Other common nonnative game fish include the Common Carp, Green Sunfish, Smallmouth Bass, Largemouth Bass, Yellow Perch, Pumpkinseed (*L. gibbosus*), Northern Pike, and Yellow (*Ameiurus natalis*) and Black Bullhead (*A. melas*). Fathead Minnow (*Pimephales promelas*) and the Red Shiner, both now common as forage and bait fish, were also among the top 15 nonnative fish (Lomnicky et al. 2007).

Introduced fish species distribution varied by ecoregion where the Fathead Minnow is the most widespread native fish in the Plains region but has been introduced to at least 6 percent of streams and rivers outside their native range in the Plains ecoregion and to 20 percent of the Xeric and 2 percent of the mountain ecoregions. Green Sunfish, Common Carp, Yellow Perch, Yellow Bullhead, Pumpkinseed and Red Shiner, were all also native to areas within the Plains ecoregion but also now occur extensively outside their native range. Smallmouth Bass, native to many streams and rivers between the Hudson Bay and middle Mississippi River basin, has been widely introduced as a game fish into temperate zones in North America and is the most common nonnative fish in the Xeric region. Rainbow and Brook Trout are the most common nonnative fish introduced into the Mountain ecoregion but Brown Trout have been more evenly introduced across all three ecoregions (Lomnicky et al. 2007).

Nonnative Fish Species * Forage/bait Fish	Scientific Name	Percent of assessed stream length occupied
Brook trout	*Salvelinus fontinalis*	17 (+/- 3) %
Brown trout	*Salmo trutta*	16 (+/- 3) %
Rainbow trout	*Oncorhynchus mykiss*	14 (+/- 3) %
Common carp	*Cyprinus carpio*	10 (+/- 2) %
*Fathead minnow	*Pimephales promelas*	5 (+/- 2) %
Green sunfish	*Lepomis cyanellus*	4 (+/- 1) %
Smallmouth bass	*Micropterus dolomieu*	4 (+/- 2) %
Largemouth bass	*Micropterus salmoides*	2 (+/- 1) %
Yellow perch	*Perca flavescens*	2 (+/- 1) %
Yellow bullhead	*Ameiurus natalis*	2 (+/- 1) %
Pumkinseed	*Lepomis gibbosus*	2 (+/- 1) %
*Red shiner	*Cyprinella lutrensis*	2 (+/- 1) %
Northern pike	*Esox Lucius*	1 (+/- 1) %
Black bullhead	*Ameiurus melas*	1 (+/- 1) %

Table 1. Average percentage (and 95 percent confidence interval) of the fifteen most common nonnative fish found in 12 western states (Lomnicky et al. 2007).

Impacts of Nonnative Game Fish

Nonnative game fish have radically changed the aquatic environment where they have been introduced and in some places, they are more abundant than the native fish. For the most part, nonnative fish species are most abundant in aquatic habitats that have been modified by human activity. In central California for example, the sunfishes have been found to quickly colonize segments of streams and rivers that have been bulldozed, dammed, altered for a water diversion, or changed significantly in one way or another for the benefit of people (Moyle 2002). Reservoirs and man-made lakes constructed for flood control, hydroelectric generation and water development are typically stocked with nonnative game fish and sometimes followed by the stocking of nonnative forage fish (Moyle 2002), for the benefit of the game fish but ultimately, for the benefit of anglers. In almost all reservoirs the most abundant fishes are not native, even though the streams and rivers feeding into them are dominated by native fish. Unnatural aquatic habitats such as reservoirs as well as stream and river that have been significantly disturbed, generate conditions and biotic interactions that favor the introduced species. These interactions include, but are not limited to; competition, predation, habitat interference, disease, and hybridization (Moyle 2002).

Competition

Competition between two (or more) fish species is usually for limited resources such as food and habitat, both critical to the survival of each species. When competition favors the nonnative fish species over the native fish species in an unnatural environment, it has a high potential to invoke faunal changes to the extent that the native species will be displaced or is eliminated altogether. However if the nonnative fish species manages to survive and persist in a natural environment, it is likely to reach some sort of population equilibrium with the native fish species already present impacting their population, but not eliminating them. A prime example is California's Sacramento Perch (*Archoplites interruptus*) that gradually disappeared from its native habitat of the Sacramento – San Joaquin River system, likely as a result of the introduction and proliferation of nonnative game fish, the Black Crappie and Bluegill. However, the Sacramento Perch was a popular sport and game fish before their numbers declined and were introduced into many reservoirs, lakes, and ponds in California where their populations continue to persist. The common factor in the waters where the Sacramento Perch now persists is that there is not a competing species, native or nonnative, that is more aggressive in fulfilling its niche (Moyle 2002).

Predation

Throughout the western U.S., one of the most immediate and direct impacts caused by the introduction of nonnative game fish has been predation on native species. Most nonnative game fish, once they reach a life stage where they can become piscivorous, prey on various smaller fishes inhabiting the same waters (Moyle 2002) and without regard of their origin (or ESA status). In new reservoirs in the Pacific Northwest, native fish were known to be abundant after impoundment completion but after Smallmouth Bass and Largemouth Bass were introduced, native cyprinids such as the Northern Pike-Minnow (*Ptychocheilus spp.*) and Hardhead (*Mylopharodon conocephalus*) started to slowly disappear once the bass populations became established. Similarly, the disappearance of the California Roach (*Hesperoleucus symmetricus*), a native cyprinid to many streams and rivers in central California, has also thought to have been attributed to the introduction of game fish such as the Green Sunfish (Moyle 2002). More currently, predation on out-migrating juvenile Chinook Salmon by Striped Bass (*Morone saxatilis*) in California's Sacramento – San Joaquin Rivers and Delta areas, have shown to have a synergistic effect when coupled with anthropogenic habitat modification thus, exacerbating mortality via predation (Sabal et al. 2016). Predation on out-migrating juvenile salmonids (Chinook Salmon and Steelhead) in the Columbia River system has also been well documented and attributed to nonnative game fish such as; Smallmouth Bass (Tabor et al 1993, Fritts and Pearsons 2006), Smallmouth Bass and Walleyes (Reiman et al 1991, Zimmerman 1999), and Smallmouth Bass, Walleyes and Channel Catfish (Poe et al 1991, Vigg et al 1991). However, all of the authors also identified the native Northern Pike-Minnow (*P. oregonensis*) as a problematic piscivore except for Zimmerman (1999) whose research was on the lower Yakima River (major tributary to the Columbia River) and identified both the Smallmouth Bass and Largemouth Bass as problematic nonnative game fish.

Albeit there is no other river in the western U.S. that has as many migrating fish as the Columbia River, the Colorado River is comparable with the number of impoundments and does have similar predation issues caused by nonnative game fish. According to Yard et al., (2011), predation on endangered fish such as the Humpback Chub (*Gila cypha*), by nonnative salmonids (Rainbow Trout and Brown Trout) have been hypothesized as one of the leading factors for the decline of native fishes. During a multiyear study of a 15 kilometer (km) segment of the Colorado River near the Little Colorado River confluence, field efforts captured 20,000 nonnative fish, of which 90 percent were nonnative salmonids. They found Rainbow Trout were 50 times more abundant than brown trout and on average, both game fish species ingested 85 percent more native fish than nonnatives (estimated 30,000 total fish consumed) despite native fish comprising less than 30 percent of the available small fish (Yard et al 2011). In addition to Rainbow and Brown Trout, Tyus and Saunders III (2000) have identified Channel Catfish, Flathead Catfish, Common Carp, Northern Pike, Black Crappie, Green Sunfish, Largemouth Bass, Smallmouth Bass, Sunfish species and Bullhead species as the leading cause for the decline of four endangered Colorado River fish; Colorado Pike-Minnow (*P. Lucius*), Bonytail (*G. elegans*), Razorback Sucker (*Xyrauchen texanus*) and Humpback Chub. Tyus and Saunders III (2000) along with a panel of experts, identified that the number one control measure needed in the upper Colorado River system was to prevent the movements of game fishes out of reservoirs and minimize their future stocking throughout the region while increasing their harvest.

Habitat Interference and Disease

Other major impacts to native fish populations caused by the introduction of nonnative game fish species include habitat interference, disease transmission and hybridization. Habitat interference occurs when an introduced fish, or multiple introduced fish species, impact the aquatic environment to the extent that they alter the existing habitat to the degree where native fish are forced to leave or their populations diminished (Moyle 2002). As discussed earlier, the introduction of the Common Carp (as well as other herbivorous fishes) is the most widely known nonnative fish to cause habitat alterations. Disease transmission to native fish from introduced fish is not well documented nor is it a well-known method by which one species replaces another. Although not common, some introduced fish can carry diseases and parasites with them. When introduced, they can impair the immune system of the native fish already inhabiting the same waters and sometimes to the extent, that the disease(s) or parasites will kill them (Moyle 2002). Most notably are Pacific Salmon (*Oncorhynchus spp.*) species who can carry bacterial kidney disease (BKD) *Renibacterium salmoninarum*, in both hatchery and wild fish populations and is easily spread between salmon stocks simply by migrating or moving hatchery salmon from one place to another. Bacterial kidney disease is endemic among Pacific Salmon and is an unrelenting source of morbidity and mortality (NOAA Fisheries 2018).

Hybridization

Another issue caused by the introduction of nonnative fish and is becoming increasingly more recognized is that of hybridization between introduced fish and native fish. Hybridization, commonly known as crossbreeding, is the mating of unrelated strains of the same species (Piper at al. 1998). The possibility for hybridization between fish species occurs when one fish species is transported into another river basin where there is another closely related species (or sub-species) and they are able to mate. The most common occurrences of hybridization throughout the western U.S. has been between releases of hatchery Rainbow Trout and populations of genetically pure wild Cutthroat Trout. Hatchery Rainbow Trout have been introduced throughout the West for more than a century and have since hybridized with native Cutthroat Trout populations to the extent where native strains of Cutthroat are now only found in a fraction of their historical range. Hybridization now represents one of the leading threats to the remaining 14 populations of native Cutthroat (USGS 2018). Genetically pure strains of well-renowned Cutthroat, such as the Lahontan Cutthroat Trout (*O. clarkii henshawi*), and the famous Golden Trout (*O. aguabonita*) have also hybridized with introduced Rainbow Trout (Moyle 2002). In the Colorado River basin, several species of native suckers have since hybridized with the nonnative White Sucker (*C. commersonii*). Although not sought after as a game fish and likely introduced intentionally into lakes and reservoirs as a forage fish and unintentionally into various places through bait bucket releases, the white sucker and many of the western suckers (Razorback, Bluehead, Flannelmouth, etc.) appear to lack any significant mechanism to isolate reproductive individuals and now the distribution and abundance of white sucker hybrids are increasing (Ptacek et al. 2005). An example of an extreme case of hybridization occurred in California where the Mojave Tui Chub (*Siphateles bicolor mohavensis*) is now an endangered species because it has hybridized with the Arroyo Chub (*G. orcuttii*) throughout most of its natural range (Moyle 2002). Almost all hybrid fish are sterile and the vast majority will not reproduce but some fish hybrids do reproduce however, the process reduces the exchange of genetic variants between species (Johnson 2008).

Existing Perception of Nonnative Game Fish Escapement from Reclamation Reservoirs

Despite the fact that nonnative game fish have been introduced throughout all of the 17 western states (including almost all of the reservoirs owned, operated and managed by Reclamation) for over a century and fishing is one of the country's favorite past-times, the perception of introducing nonnative game fish into man-made water impoundments without consequence to threatened or endangered fish continues to evolve. As part of this research, I conducted an informal email poll to help gage the perception of Reclamation personnel on whether or not nonnative game fish escapement from Reclamation reservoirs into areas of critical habitat for listed fish species was perceived as an issue or not.

The email survey was distributed to Reclamation personnel who may be directly or indirectly involved in fishery management issues within their Region or Area home office jurisdiction. However, each Reclamation Region (and Area offices) have unique fishery and related environmental issues according to the river basins and Reclamation infrastructure that they manage therefore, each Region has different personnel needs. So, the survey was unintentionally distributed disproportionately to Regions with greater numbers of fisheries and environmental personnel.

The survey consisted of a single question and six multiple choice answers covering a wide range of possible answers and was electronically distributed to 164 Reclamation employees in Reclamation's Regional and Area offices. Reclamation personnel in the Denver and Washington D.C. offices were intentionally excluded from the survey because these two offices provide technical assistance, financial management, human resource and other oversight services. The survey also intended to keep the responders (and those that chose not to respond) anonymous so the target audience would feel free to respond without managerial oversight or fear of any sort of retaliation and the email survey was distributed to them via 'blind copy'.

A copy of the survey is below between the dashed lines.

This survey is for the Science and Technology (S&T) Research and Development Office regarding the stocking of nonnative game fish into Reclamation reservoirs and their potential escapement (upstream or downstream) into areas designated as critical habitat for the recovery of threatened or endangered fish.

Please respond to my one question survey regarding the **perception** of the live escapement of nonnative game fish from Reclamation reservoirs within your home Region/Area office jurisdiction.

If necessary, please forward this email question to Reclamation folks who are involved in fishery management issues for Reclamation reservoirs within your home Region/Area office.

<u>All responders (and non-responders) will remain anonymous.</u>

One Question Survey:

What is your perception on the live escapement of nonnative game fish from Reclamation reservoirs into areas designated as Critical Habitat for Endangered Species Act fish species listed as endangered or threatened ?

A. No information available regarding game fish escapement in home Region/Area office.
B. Does not occur in home Region/Area office.
C. Does occur but not to the extent that it is an issue in home Region/Area office.
D. Does occur and is an issue in home Region/Area office.
E. Does occur and home Region/Area office addressed/addressing the issue.
F. Not an issue for home Reclamation Region/Area office to address (State or USFWS issue).

Threatened and Endangered Species:

https://www.fws.gov/endangered/

Threatened and Endangered Species List with Critical Habitat Maps:

https://ecos.fws.gov/ecp/report/table/critical-habitat.html

Participants began responding to the survey immediately after it was distributed and responses continued to come in several weeks afterward. Only one participant changed their initial answer and three participants replied with two answers, all other responders selected a single answer. Proportionately and numerically, personnel in the Great Plains Region had 11 responders to the survey or a 33.3 percent response rate. Conversely, the Mid-Pacific Region had only 7 responders out of 56 participants (the largest group) for a 12.5 percent response rate. The Pacific Northwest and Upper and Lower Colorado Regions had only 5 to 6 responders and a response rate of 19.35, 30.0 and 25.0 percent respectively. No Region responded with all six possible responses while the Upper Colorado Region selected only two of the possible responses and the Great Plains Region selected five. Figure 1 is a summary of each Region's responses to the survey question and Figure 2 is a summary of survey answer responses by Reclamation personnel from all five Regions.

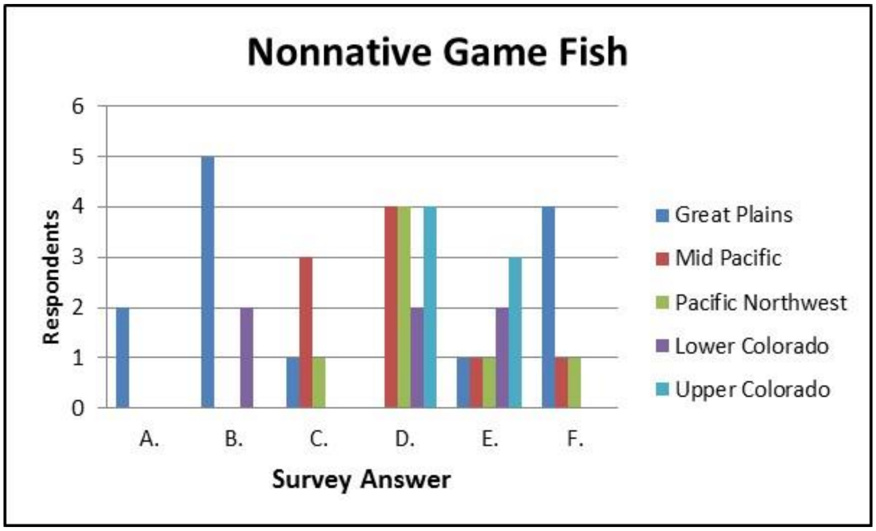

Figure 1. Survey answer responses by each Reclamation Region.

Overall, there were 36 respondents to the survey or a 21.95 percent response rate. Responses to the survey were somewhat consistent between each given survey answer except for answers A and D. Survey answer A - "No information available regarding game fish escapement in home Region/Area office" was selected by only two personnel from the Great Plains Region. The Great Plains Region covers several mid-western states and is in a semi-arid environment where there are very few fisheries issues. However, most responders selected answer D - "Does occur and is an issue in home Region/Area office". The Mid Pacific, Pacific Northwest and Upper and Lower Colorado Regions selected this response probably because of the number of ESA listed fish species within their Regions coupled with the degree of recreational fishing that has historically occurred in their area.

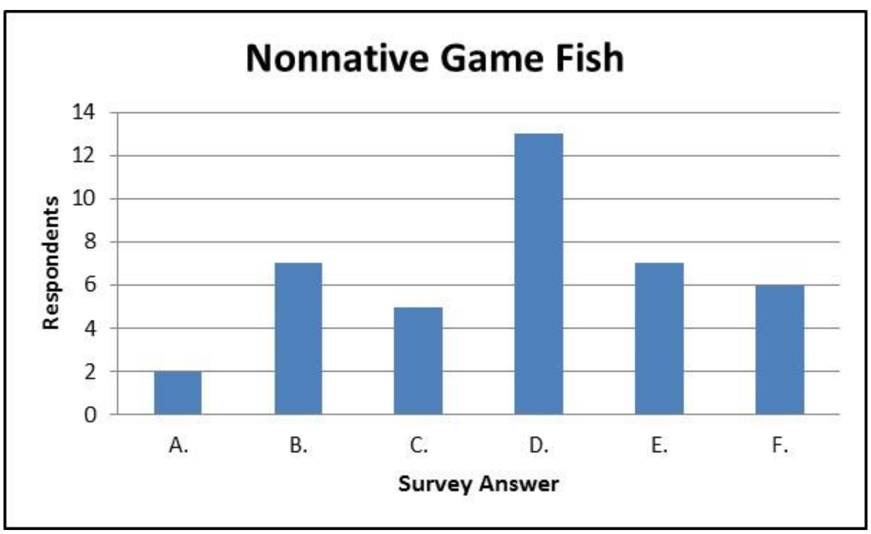

Figure 2. Summary of survey answer responses by Reclamation personnel from all five Regions.

Discussion

Reservoirs identified as having high nonnative fish escapement potential should re-evaluate operational guidelines to minimize and/or eliminate escapement or add devices on the discharge outlet works or spillway to prevent escapement. Tyus and Saunders III (along with a panel of experts) identified that the number one control measure needed in the upper Colorado River system was to prevent the movements of game fishes out of reservoirs. Movement of game fish out of reservoirs typically occurs through surface reservoir discharges where greater discharges increase the probability of escapement. Escapement probability and survival is also significantly greater through spillway discharges versus bottom discharges, especially deep discharge outlets, and can include all life stages of game fish. Spillway discharges normally occur only when the water level within the reservoir is at or near capacity. So, if reservoir managers are able manage water levels below the spillway outlet at all times, game fish escapement from reservoirs can be significantly reduced. If escapement is occurring though bottom discharges, an outlet works fish exclusionary device should be designed, tested, and installed until the level of escapement is abated.

While many Reclamation reservoirs have negatively impacted native fish in the West, many have not. Of the 103 freshwater fish species listed as endangered or threatened within the 17 western states, approximately 38 fish species can or already have been impacted by nonnative fish from Reclamation reservoirs (author's estimation). However, many of the common nonnative game fish have previously been widely introduced prior to the passage of the Endangered Species Act (1967) and some prior to reservoir impoundment. The current perception of nonnative fish management is reflected in the results of the one question survey. Areas in the western U.S. where there are few to no ESA fish issues responded appropriately (A, B, or F). However, areas with ESA fish issues responded differently (C, D, or E) where several survey respondents included information regarding local ESA fisheries issues saying their home office no longer sponsored the stocking of nonnative game fish or that they are currently considering not to stock nonnative game fish. Albeit, fishing continues to be one of America's favorite pastimes but the perception of managing nonnative game fish continues to evolve. We, as the caretakers of vital water resources in the West - have to be mindful of what we are fishing for!

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Appendix

Common Name	Scientific Name	First Listed	ESA Status	Federal Registar	Where Listed	Critical Habitat	Area of	USBR
						Designation Date	Critical Habitat	Impact
Apache trout	*Oncorhynchus apache*	11-Mar-67	Threatened	32 FR 4001	Wherever found		NA	No
Big Bend gambusia	*Gambusia gaigei*	11-Mar-67	Endangered	32 FR 4001	Wherever found		NA	No
Clear Creek gambusia	*Gambusia heterochir*	11-Mar-67	Endangered	32 FR 4001	Wherever found		NA	No
Colorado pikeminnow	*Ptychocheilus lucius*	11-Mar-67	Endangered	45 FR 27710	Wherever found, except EP	3/21/1994	65546.2 acres	Yes
Comanche Springs pupfish	*Cyprinodon elegans*	11-Mar-67	Endangered	32 FR 4001	Wherever found		NA	No
Cui-ui	*Chasmistes cujus*	11-Mar-67	Endangered	32 FR 4001	Wherever found		NA	Yes
Desert dace	*Eremichthys acros*	11-Mar-67	Threatened	32 FR 4001	Wherever found	12/10/1985	2494.6 acres	No
Devils Hole pupfish	*Cyprinodon diabolis*	11-Mar-67	Endangered	32 FR 4001	Wherever found		NA	No
Gila topminnow (incl. Yaqui)	*Poeciliopsis occidentalis*	11-Mar-67	Endangered	32 FR 4001	Wherever found		NA	No
Gila trout	*Oncorhynchus gilae*	11-Mar-67	Threatened	32 FR 4001	Wherever found		NA	Yes
Greenback Cutthroat trout	*Oncorhynchus clarki stomias*	11-Mar-67	Threatened	32 FR 4001	Wherever found		NA	No
Humpback chub	*Gila cypha*	11-Mar-67	Endangered	45 FR 27710	Wherever found	3/21/1994	13754.3 acres	Yes
Little Colorado spinedace	*Lepidomeda vittata*	11-Mar-67	Threatened	32 FR 4001	Wherever found	9/16/1987	200.2 acres	Yes
Pahrump poolfish	*Empetrichthys latos*	11-Mar-67	Endangered	32 FR 4001	Wherever found		NA	No
Paiute cutthroat trout	*Oncorhynchus clarkii seleniris*	11-Mar-67	Threatened	32 FR 4001	Wherever found		NA	No
Owens pupfish	*Cyprinodon radiosus*	11-Mar-67	Endangered	32 FR 4001	Wherever found		NA	No
Moapa dace	*Moapa coriacea*	11-Mar-67	Endangered	32 FR 4001	Wherever found		NA	No
Fountain darter	*Etheostoma fonticola*	13-Oct-70	Endangered	35 FR 16047	Wherever found	7/14/1980	126.4 acres	No
Kendall Warm Springs dace	*Rhinichthys osculus thermalis*	13-Oct-70	Endangered	35 FR 16047	Wherever found		NA	No
Lahontan cutthroat trout	*Oncorhynchus clarkii henshawi*	13-Oct-70	Threatened	35 FR 16047	Wherever found		NA	Yes
Pahranagat roundtail chub	*Gila robusta jordani*	13-Oct-70	Endangered	35 FR 16047	Wherever found		NA	No
Pecos gambusia	*Gambusia nobilis*	13-Oct-70	Endangered	35 FR 16047	Wherever found		NA	No
Mohave tui chub	*Gila bicolor ssp. mohavensis*	13-Oct-70	Endangered	35 FR 16047	Wherever found		NA	No
Warm Springs pupfish	*Cyprinodon nevadensis pectoralis*	13-Oct-70	Endangered	35 FR 16047	Wherever found		NA	No
Woundfin	*Plagopterus argentissimus*	13-Oct-70	Endangered	35 FR 16047	Wherever found, except EP	1/26/2000	2973.1 acres	Yes
Unarmored threespine stickleback	*Gasterosteus aculeatus williamsoni*	13-Oct-70	Endangered	35 FR 16047	Wherever found		NA	No
Leopard darter	*Percina pantherina*	27-Feb-78	Threatened	43 FR 3711	Wherever found	1/27/1978	2618.3 acres	No
Little Kern golden trout	*Oncorhynchus aguabonita whitei*	15-May-78	Threatened	43 FR 15427	Wherever found	4/13/1978	82421.9 acres	No
Bonytail chub	*Gila elegans*	23-Apr-80	Endangered	45 FR 27710	Wherever found	3/21/1994	58213.7 acres	Yes
Borax Lake chub	*Gila boraxobius*	28-May-80	Endangered	45 FR 35821	Wherever found	10/5/1982	631.4 acres	No
San Marcos gambusia	*Gambusia georgei*	14-Jul-80	Endangered	45 FR 47355	Wherever found	7/14/1980	44.5 acres	No
Leon Springs pupfish	*Cyprinodon bovinus*	15-Aug-80	Endangered	45 FR 54678	Wherever found	8/15/1980	27.8 acres	No
Ash Meadows Amargosa pupfish	*Cyprinodon nevadensis mionectes*	10-May-82	Endangered	47 FR 19995	Wherever found	9/2/1983	134.5 acres	No
Ash Meadows speckled dace	*Rhinichthys osculus nevadensis*	10-May-82	Endangered	47 FR 19995	Wherever found	9/2/1983	64.7 acres	No
Chihuahua chub	*Gila nigrescens*	11-Oct-83	Threatened	48 FR 46053	Wherever found		Proposed	No

Common Name	Scientific Name	First Listed	ESA Status	Federal Registar	Where Listed	Critical Habitat Designation Date	Area of Critical Habitat	USBR Impact
Yaqui catfish	*Ictalurus pricei*	31-Aug-84	Threatened	49 FR 34490	Wherever found	8/31/1984	19.5 acres	No
Yaqui chub	*Gila purpurea*	31-Aug-84	Endangered	49 FR 34490	Wherever found	8/31/1984	19.5 acres	No
Beautiful shiner	*Cyprinella formosa*	31-Aug-84	Threatened	49 FR 34490	Wherever found	8/31/1984	19.5 acres	No
Ozark cavefish	*Amblyopsis rosae*	1-Nov-84	Threatened	49 FR 43965	Caves - AR, MO,OK		NA	No
Big Spring spinedace	*Lepidomeda mollispinis pratensis*	28-Mar-85	Threatened	50 FR 12298	Wherever found	3/28/1985	36.2 acres	No
Hutton tui chub	*Gila bicolor ssp.*	28-Mar-85	Threatened	50 FR 12302	Wherever found		NA	No
Foskett speckled dace	*Rhinichthys osculus ssp.*	28-Mar-85	Threatened	50 FR 12302	Wherever found		NA	No
Owens Tui Chub	*Gila bicolor ssp. snyderi*	5-Aug-85	Endangered	50 FR 31592	Wherever found	8/5/1985	114.3 acres	No
White River spinedace	*Lepidomeda albivallis*	12-Sep-85	Endangered	50 FR 37194	Wherever found	9/12/1985	17.6 acres	No
Hiko White River springfish	*Crenichthys baileyi grandis*	27-Sep-85	Endangered	50 FR 39123	Wherever found	9/27/1985	22.4 acres	No
Warner sucker	*Catostomus warnerensis*	27-Sep-85	Threatened	50 FR 39117	Wherever found	9/27/1985	912.4 acres	Yes
White River springfish	*Crenichthys baileyi baileyi*	27-Sep-85	Endangered	50 FR 39123	Wherever found	9/27/1985	6.7 acres	No
Desert pupfish	*Cyprinodon macularius*	31-Mar-86	Endangered	51 FR 10842	Wherever found	3/31/1986	3.9 acres	No
Railroad Valley springfish	*Crenichthys nevadae*	31-Mar-86	Threatened	51 FR 10857	Wherever found	3/31/1986	474.6 acres	No
June sucker	*Chasmistes liorus*	31-Mar-86	Endangered	51 FR 10851	Wherever found	3/31/1986	4.4 miles	No
Sonora chub	*Gila ditaenia*	30-Apr-86	Threatened	51 FR 16042	Wherever found	4/30/1986	70.9 acres	No
Spikedace	*Meda fulgida*	1-Jul-86	Endangered	51 FR 23769	Wherever found	2/23/2012	581.1 miles	No
Loach minnow	*Tiaroga cobitis*	28-Oct-86	Endangered	51 FR 39468	Wherever found	2/23/2012	559.3 miles	No
Pecos bluntnose shiner	*Notropis simus pecosensis*	20-Feb-87	Threatened	52 FR 5295	Wherever found	2/20/1987	2379.6 acres	Yes
Chinook salmon	*Oncorhynchus tshawytscha*	27-Feb-87	Endangered	52 FR 6041	Sacramento River winter-run ESU	7/16/1993		Yes
Lost River sucker	*Deltistes luxatus*	18-Jul-88	Endangered	53 FR 27130	Wherever found	12/11/2012	117775.1 acres	Yes
Shortnose Sucker	*Chasmistes brevirostris*	18-Jul-88	Endangered	53 FR 27130	Wherever found	12/11/2012	123657.4 acres	Yes
Virgin River Chub	*Gila seminuda (=robusta)*	24-Aug-89	Endangered	54 FR 35305	Wherever found	1/26/2000	2973.1 acres	Yes
Independence Valley speckled dace	*Rhinichthys osculus lethoporus*	10-Oct-89	Endangered	54 FR 41448	Wherever found		NA	No
Clover Valley speckled dace	*Rhinichthys osculus oligoporus*	10-Oct-89	Endangered	54 FR 41448	Wherever found		NA	No
Pallid sturgeon	*Scaphirhynchus albus*	6-Sep-90	Endangered	55 FR 36641	Wherever found		NA	Yes
Razorback sucker	*Xyrauchen texanus*	23-Oct-91	Endangered	45 FR 27710	Wherever found	3/21/1994	285427.4 acres	Yes
Sockeye salmon	*Oncorhynchus nerka*	20-Nov-91	Endangered	56 FR 58619	Snake River ESU	3/23/1999		Yes
Chinook salmon	*Oncorhynchus tshawytscha*	22-Apr-92	Threatened	57 FR 14653	Snake River fall-run ESU	3/23/1999		Yes
Chinook salmon	*Oncorhynchus tshawytscha*	22-Apr-92	Threatened	57 FR 14653	Snake River spring/summer-run ESU	10/25/1999		Yes
Delta smelt	*Hypomesus transpacificus*	5-Apr-93	Threatened	58 FR 12854	Wherever found	1/18/1995		Yes
Tidewater goby	*Eucyclogobius newberryi*	4-Feb-94	Endangered	59 FR 5494	Wherever found	12/20/2000	9.0 miles	No
Rio Grande Silvery Minnow	*Hybognathus amarus*	20-Jul-94	Endangered	59 FR 36988	Wherever found, except EP	2/19/2003	15113.3 acres	Yes
White sturgeon (Kootenai R.)	*Acipenser transmontanus*	6-Sep-94	Endangered	59 FR 45989	ID, MT (Kootenai R.)	7/9/2008	1631.0 acres	No

Common Name	Scientific Name	First Listed	ESA Status	Federal Registar	Where Listed	Critical Habitat Designation Date	Area of Critical Habitat	USBR Impact
Coho salmon	*Oncorhynchus kisutch*	31-Oct-96	Endangered	61 FR 56138	Central California Coast ESU	3/17/2000		No
Coho salmon	*Oncorhynchus kisutch*	6-May-97	Threatened	62 FR 24588	Southern OR- Northern CA Coast ESU	3/17/2000		No
Steelhead	*Oncorhynchus mykiss*	18-Aug-97	Threatened	62 FR 43937	Snake River Basin DPS	2/16/2000	17209.2 miles	Yes
Steelhead	*Oncorhynchus mykiss*	18-Aug-97	Threatened	62 FR 43937	Upper Columbia River DPS	2/16/2000	17209.2 miles	Yes
Steelhead	*Oncorhynchus mykiss*	18-Aug-97	Threatened	62 FR 43937	Upper Willamette River DPS	2/16/2000	17209.2 miles	Yes
Steelhead	*Oncorhynchus mykiss*	17-Oct-97	Threatened	62 FR 43937	Central California Coast DPS	1/2/2006	8211.6 miles	Yes
Steelhead	*Oncorhynchus mykiss*	17-Oct-97	Threatened	62 FR 43937	South-Central California Coast DPS	1/2/2006	8211.6 miles	Yes
Steelhead	*Oncorhynchus mykiss*	18-Aug-97	Endangered	62 FR 43937	Southern California DPS	9/2/2005	8211.6 miles	Yes
Steelhead	*Oncorhynchus mykiss*	19-Mar-98	Threatened	63 FR 13347	California Central Valley DPS	9/2/2005	8211.6 miles	Yes
Steelhead	*Oncorhynchus mykiss*	19-Mar-98	Threatened	63 FR 13347	Lower Columbia River DPS	2/16/2000	17209.2 miles	Yes
Bull Trout	*Salvelinus confluentus*	10-Jun-98	Threatened	63 FR 31647	Conterminous 48 states	10/18/2010	512265.8 acres; 20542.0 miles	Yes
Arkansas River shiner	*Notropis girardi*	23-Nov-98	Threatened	63 FR 64772	Ark R. Basin (AR, KS, NM, OK, TX)	10/13/2005	30266.4 acres	Yes
Topeka shiner	*Notropis topeka*	15-Dec-98	Endangered	63 FR 69008	Wherever found, except EP	7/27/2004	6573026.1 acres	No
Chum salmon	*Oncorhynchus keta*	25-Mar-99	Threatened	64 FR 14508	Columbia River ESU	2/16/2000	662.8 miles	No
Chum salmon	*Oncorhynchus keta*	24-Mar-99	Threatened	64 FR 14508	Hood Canal summer-run ESU	2/16/2000	662.8 miles	No
Steelhead	*Oncorhynchus mykiss*	25-Mar-99	Threatened	57 FR 14517	Middle Columbia River DPS	2/16/2000	17209.2 miles	Yes
Sockeye salmon	*Oncorhynchus nerka*	25-Mar-99	Endangered	64 FR 14528	Ozette Lake ESU	2/16/2000	38.9 miles	No
Chinook salmon	*Oncorhynchus tshawytscha*	24-Mar-99	Endangered	64 FR 14308	Puget Sound ESU	2/16/2000	748541.7 acres; 4921.9 miles	No
Chinook salmon	*Oncorhynchus tshawytscha*	24-Mar-99	Threatened	64 FR 14308	Lower Columbia River ESU	2/16/2000	748541.7 acres; 4921.9 miles	No
Chinook salmon	*Oncorhynchus tshawytscha*	24-Mar-99	Endangered	64 FR 14308	Upper Columbia spring-run ESU	2/16/2000	748541.7 acres; 4921.9 miles	Yes
Chinook salmon	*Oncorhynchus tshawytscha*	24-Mar-99	Threatened	64 FR 14308	Upper Willamette River ESU	2/16/2000	748541.7 acres; 4921.9 miles	Yes
Chinook salmon	*Oncorhynchus tshawytscha*	16-Sep-99	Threatened	64 FR 50394	California Coastal ESU	9/2/2005	2481.2 miles	No
Chinook salmon	*Oncorhynchus tshawytscha*	16-Sep-99	Threatened	64 FR 50394	Central Valley spring-run ESU	9/2/2005	2481.2 miles	Yes
Devils River minnow	*Dionda diaboli*	20-Oct-99	Threatened	64 FR 56596	Wherever found	8/12/2008	14.8 miles	No
Santa Ana sucker	*Catostomus santaanae*	12-Apr-00	Threatened	65 FR 19686	3 CA river basins	12/14/2010	9273.0 acres	No
Neosho madtom	*Noturus placidus*	22-May-90	Threatened	55 FR 21148	Wherever found		NA	No
Steelhead	*Oncorhynchus mykiss*	7-Jun-00	Threatened	65 FR 36074	Northern California DPS	9/2/2005	8211.6 miles	Yes
Coho salmon	*Oncorhynchus kisutch*	28-Jun-05	Threatened	70 FR 37160	Lower Columbia River ESU	2/1/2016	2088.8 miles	No
Gila chub	*Gila intermedia*	2-Nov-05	Endangered	70 FR 66664	Wherever found	11/2/2005	9758.5 acres	Yes
green sturgeon	*Acipenser medirostris*	6-Jun-06	Threatened	71 FR 17757	Wherever found		NA	Yes
Steelhead	*Oncorhynchus mykiss*	11-May-07	Threatened	72 FR 26722	Puget Sound DPS	2/1/2016	2,031 miles	No
Sharpnose Shiner	*Notropis oxyrhynchus*	4-Aug-14	Endangered	79 FR 45273	Wherever found	8/4/2014	583.3 miles	No
Smalleye Shiner	*Notropis buccula*	4-Aug-14	Endangered	79 FR 45273	Wherever found	8/4/2014	583.3 miles	No
Zuni bluehead Sucker	*Catostomus discobolus yarrowi*	25-Aug-14	Endangered	79 FR 43131	Wherever found	6/7/2016	31.0 miles	No