SOS II: FISH IN HOT WATER

Status, threats and solutions for California salmon, steelhead, and trout.

Based on a report by Dr. Peter B. Moyle, Dr. Rob Lusardi and Patrick Samuel commissioned by California Trout.

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	SPECIES COMMON NAME	SPECIES SCIENTIFIC NAME	SPECIES STATE AND FEDERAL LISTING STATUS	STATUS SCORE	LEVEL OF CONCERN	
SALMON	California Coast Chinook Salmon	*Oncorhynchus tshawytscha*	Federally threatened	2.9	HIGH	
	Central Valley Fall-run Chinook Salmon	*Oncorhynchus tshawytscha*	Federal Species of Special Concern	2.7	HIGH	
	Central Valley Late Fall-run Chinook Salmon	*Oncorhynchus tshawytscha*	State and Federal Species of Special Concern	2.1	HIGH	
	Central Valley Spring-run Chinook Salmon	*Oncorhynchus tshawytscha*	State and Federally threatened	1.7	CRITICAL	
	Sacramento River Winter-run Chinook Salmon	*Oncorhynchus tshawytscha*	State and Federally endangered	1.3	CRITICAL	
	Southern Oregon/Northern California Coast Chinook Salmon	*Oncorhynchus tshawytscha*	Federal Sensitive Species	3.1	MODERATE	
	Upper Klamath–Trinity Rivers Fall-run Chinook Salmon	*Oncorhynchus tshawytscha*	Federal Sensitive Species	3.1	MODERATE	
	Upper Klamath–Trinity Rivers Spring-run Chinook Salmon	*Oncorhynchus tshawytscha*	State Species of Special Concern, Federal Sensitive Species	1.6	CRITICAL	
	Central California Coast Coho Salmon	*Oncorhynchus kisutch*	State and Federally endangered	1.3	CRITICAL	
	Southern Oregon/Northern California Coast Coho Salmon	*Oncorhynchus kisutch*	State and Federally threatened	1.7	CRITICAL	
	Chum Salmon	*Oncorhynchus keta*	State Species of Special Concern	1.6	CRITICAL	
	Pink Salmon	*Oncorhynchus gorbuscha*	State Species of Special Concern	1.6	CRITICAL	
STEELHEAD	Central California Coast Steelhead	*Oncorhynchus mykiss irideus*	Federally threatened	2.0	HIGH	
	Central Valley Steelhead	*Oncorhynchus mykiss irideus*	Federally threatened	3.1	MODERATE	
	Klamath Mountains Province Summer Steelhead	*Oncorhynchus mykiss irideus*	State Species of Special Concern	1.9	CRITICAL	
	Klamath Mountains Province Winter Steelhead	*Oncorhynchus mykiss irideus*	Federal Sensitive Species	3.3	MODERATE	
	Northern California Summer Steelhead	*Oncorhynchus mykiss irideus*	Federally threatened	1.9	CRITICAL	
	Northern California Winter Steelhead	*Oncorhynchus mykiss irideus*	Federally threatened	3.3	MODERATE	
	South-Central California Coast Steelhead	*Oncorhynchus mykiss irideus*	Federally threatened	1.9	CRITICAL	
	Southern Steelhead	*Oncorhynchus mykiss irideus*	Federally endangered	1.9	CRITICAL	
TROUT	Bull Trout*	*Salvelinus confluentus*	Extinct	0.0	EXTINCT	
	California Golden Trout	*Oncorhynchus mykiss aguabonita*	State Species of Special Concern	1.9	CRITICAL	
	Coastal Cutthroat Trout	*Oncorhynchus clarkii clarkii*	State Species of Special Concern	2.7	HIGH	
	Coastal Rainbow Trout	*Oncorhynchus mykiss*		4.7	LOW	
	Eagle Lake Rainbow Trout	*Oncorhynchus mykiss aquilarum*	State Species of Special Concern, Federal Sensitive Species	2.3	HIGH	
	Goose Lake Redband Trout	*Oncorhynchus mykiss newberrii*	State Species of Special Concern	3.1	MODERATE	
	Kern River Rainbow Trout	*Oncorhynchus mykiss gilbertii*	State and Federal Species of Special Concern	1.4	CRITICAL	
	Lahontan Cutthroat Trout	*Oncorhynchus clarkii henshawi*	State and Federally threatened	2.0	HIGH	
	Little Kern Golden Trout	*Oncorhynchus mykiss whitei*	State Species of Special Concern, Federally threatened	2.0	HIGH	
	McCloud River Redband Trout	*Oncorhynchus mykiss stonei*	State Species of Special Concern	1.4	CRITICAL	
	Paiute Cutthroat Trout	*Oncorhynchus clarkii selenirus*	Federally threatened	2.1	HIGH	
WHITEFISH	Mountain Whitefish	*Prosopium williamsoni*		3.4	MODERATE	

*Bull trout are not trout, but actually a member of the char family.

INTRODUCTION

A LIFE HISTORY INTERTWINED WITH OURS

Salmon, trout, and their relatives are the iconic fishes of the Northern Hemisphere. These salmonid fishes are characteristic of the region's cold, productive oceans, rushing streams and rivers, and deep cold lakes. They are adapted for life in dynamic landscapes created by glaciers, volcanoes, earthquakes, and climatic extremes. Salmonids thrive through their mobility, moving freely between ocean and river systems; they show an extraordinary ability to adapt in isolation to extreme local conditions from deserts to rain forests. This has resulted in a handful of species producing hundreds of genetically distinct runs, races, and subspecies, all with life histories superbly tuned to local habitats.[4] [5]

Not surprisingly, salmonids have a long history intertwined with that of diverse peoples. Salmon appear as images in Cro-Magnon cave art of 10,000 or more years ago and have been important food for indigenous peoples wherever they occur. The importance of salmonids to humans stems from their accessibility and high nutritional content; salmon bring nutrients and calories from the rich northern oceans into streams, while trout and other inland forms concentrate scarce resources present in cold water streams and lakes. In both situations they become available for human harvest. In the 17th century, at the beginning of the Industrial Revolution, angling for trout developed in Europe as a source of recreation (Walton 1653). This peculiar aesthetic led to trout, mainly Brown trout and Rainbow trout, being introduced into streams and lakes all over the world. The importance of salmon for food and sport also led to the introduction of Chinook salmon, Atlantic salmon, and Rainbow trout into the Southern Hemisphere to support fisheries and canneries. Today, Atlantic salmon and Rainbow trout are cultured worldwide.

The natural ability of salmon and trout to rapidly adapt to changing conditions is the characteristic that has made them relatively easy to culture. Their behaviors, life histories and other characteristics have been modified in response to hatchery environments and to match the desires of hatchery managers. This has resulted in some varieties of trout and salmon that are true domestic animals, wonderful for meat production but poor at surviving in the wild. For anadromous salmon and steelhead, hatchery operations were established to enhance wild populations, mainly for fisheries, and to replace lost production due to the construction of dams. As a result, such operations have sought to satisfy two rather contradictory goals: production of large numbers of fish, which requires producing fish adapted to artificial environments, and production of fish that will survive and grow in the wild. Their mixed success at satisfying the second goal is best indicated by the gradual decline in most fisheries that depend on hatcheries, rapid decline of many wild salmonid populations that interact with hatchery fish,[6] and the listing of many salmonids as species threatened with extinction under the statutes of multiple countries.

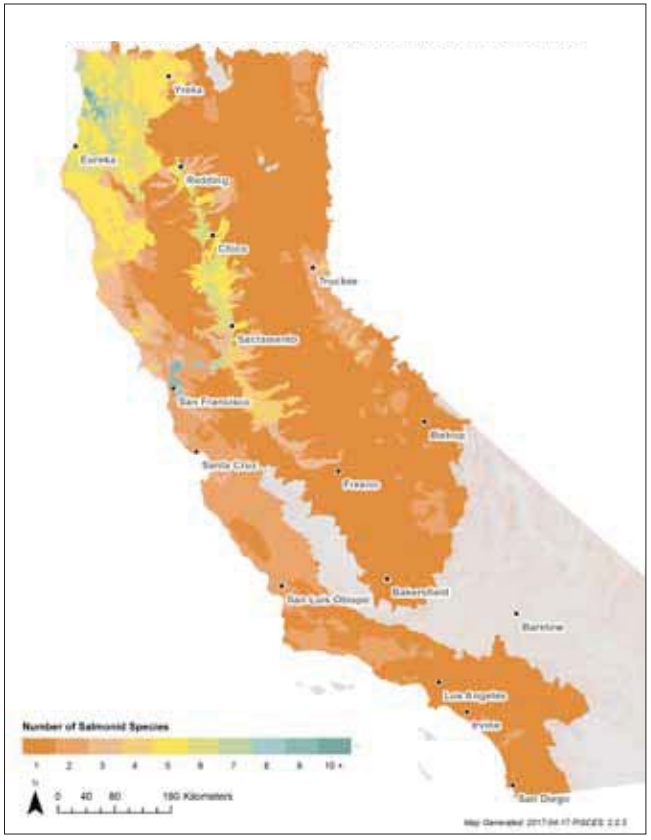
Despite their adaptability, ease of culture, and economic importance, salmonid fishes are in severe decline in many of their native habitats; many populations have been extirpated.[7] The reasons for this are complex and multiple, but boil down to a combination of human competition for use of high quality water, alteration of the landscapes through which rivers and streams flow, overfishing, use of production hatcheries to maintain fisheries, and introductions of alien species as predators or competitors. Concern for the loss of salmonid fisheries led to some of the earliest fish conservation efforts in Europe, but during the 20th century, the principal responses were to culture them in hatcheries and to limit take by fisheries. Habitat restoration, especially restoration of flows to degraded rivers, has generally been a low priority.

[4] Behnke, R. J. 2002. *Trout and salmon of North America.* The Free Press, New York.

[5] Moyle, P. B. 2002.

Nowhere in the world is the diversity of salmonids and their problems more evident than in California (Figure 1). The state not only marks the southern end of the range of all anadromous species on the Pacific Coast, but its dynamic geology and climate has resulted in the evolution of many distinctive inland forms, such as three kinds of Golden trout in the southern Sierra Nevada. The diversity of salmonids is also the result of California's large size (411,000 km2), length (spanning 10° of latitude), and adjacent location to the California Current of the Pacific Ocean, one of the most productive ocean regions of the world.[8] All this has resulted in the evolution of hundreds of genetically distinct populations, although there are just eight recognized native species.

Redwood Highway, Salmon Fishing on the Klamath River, Requa, California.
Photo: Humboldt County Historical Society.



Left: Figure 1. Current native salmonid species richness in California.

Areas in orange and brown indicate low salmonid richness, or a low total number of salmonid species in a watershed, while blue to green areas indicate watersheds with relatively higher numbers of salmonid species. The areas with the highest salmonid diversity are near the mouth of the Klamath River in far northern California and the San Francisco Estuary.

The mouth of the Klamath River. Photo: Thomas Dunklin.

[6] Levin, P. S., Zabel, R. W. and Williams, J. G. (2001). "The road to extinction is paved with good intentions: Negative association of fish hatcheries with threatened salmon." *Proceedings of the Royal Society,* London. Series B Biological Sciences 268, 1153–1158.

[7] Montgomery, D. 2003. *King of Fish: The Thousand-year Run of Salmon.* Westview Press, Boston, MA.

[8] Moyle 2002.

CALIFORNIA'S SALMONIDS

We recognize 32 distinct salmonids in California, 21 of them anadromous, 11 of them non-anadromous (Table 1, page II). Of these salmonids, 22 are endemic to California and only five are shared with neighboring states. These salmonids can all be recognized as species for management purposes under definitions in the federal Endangered Species Act (ESA) of 1973.

However, they are a combination of species, subspecies, Evolutionary Significant Units (ESUs), and Distinct Population Segments (DPSs, Box 1), as defined by National Marine Fisheries Service (NMFS) and the U.S. Fish & Wildlife Service (USFWS), the federal management agencies with oversight for ESA endangered or threatened salmon, steelhead, and trout species.

Many (15, 47%) of California's salmonids are already recognized as threatened, endangered, or extinct by state and federal governments (Table 1, page II), but the only focused overviews of all salmonids in the state have been those sponsored by California Trout.[9] [10]

We undertook these overviews to compile information for all ESA-listed and non-listed California salmonids because they:

- are characteristic of most of California's inland and coastal waters, so they serve as umbrella species for much broader aquatic conservation efforts
- are exceptionally vulnerable to climate change, through rising temperatures and changing streamflow patterns
- are in a general state of decline
- are the state's most valuable and charismatic groups of fishes in its inland waters
- are not being monitored as closely as they should be, especially forms not listed under state and federal Endangered Species acts (ESAs).

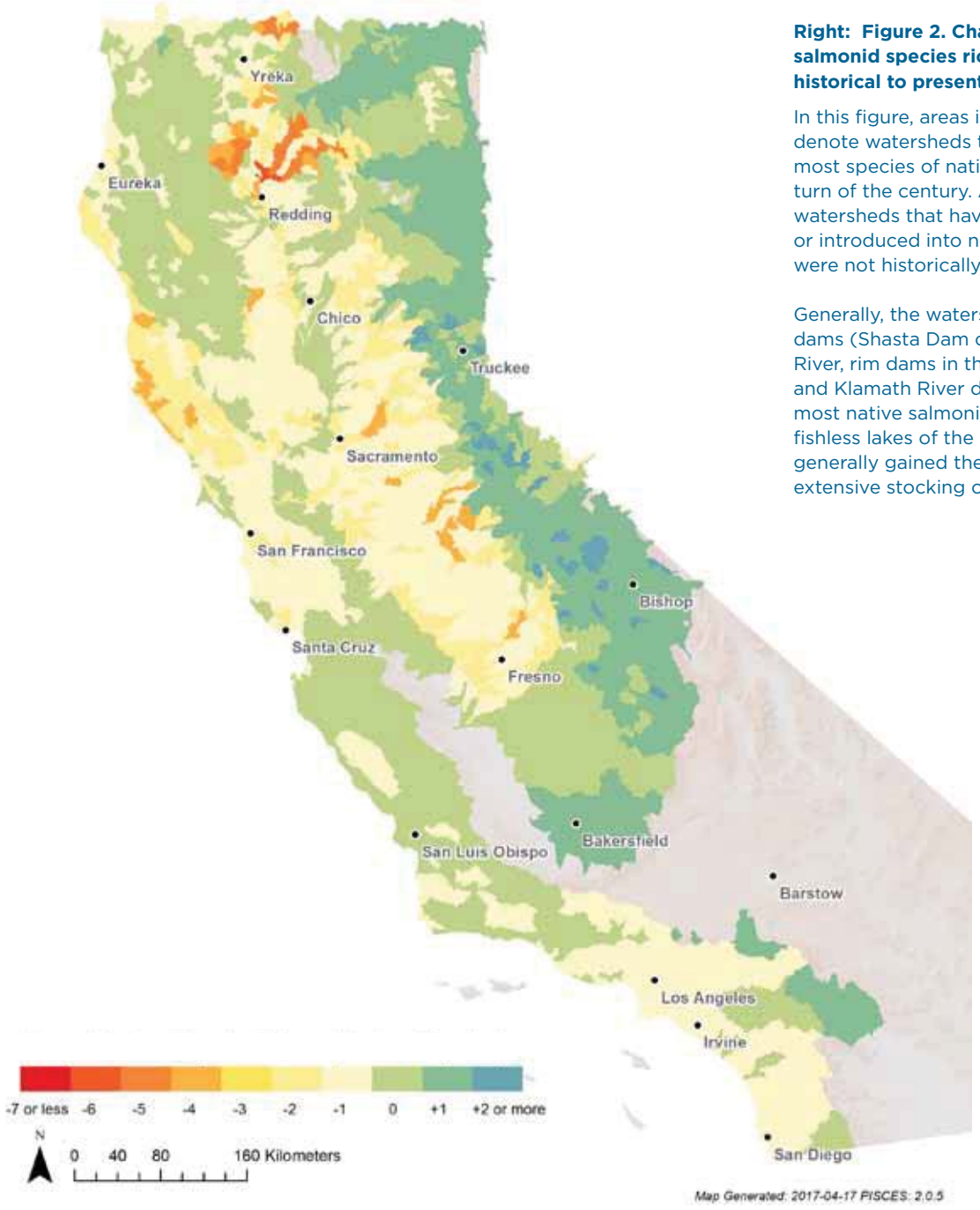
Most importantly, our goal has been establishing baseline evaluations of status that will enable repeatable, systematic comparisons of species status over the years, in response to environmental changes, climate change and other anthropogenic factors affecting populations.

It has also been our perception (and still is) that current lists of threatened and endangered species do not reflect the true condition of all salmonids in California, which have seen considerable changes on the landscape due in large part to myriad human-caused threats, considerable habitat restoration, and efforts to reintroduce species to their historical habitats (Figure 2).

Iron Gate Dam. Photo: Mike Wier.

[9] Moyle, P. et al. (2008). *Salmon, Steelhead, and Trout in California. Status of an Emblematic Fauna.* 316pp.

[10] Katz, J. et al. (2012). "Impending Extinction of Salmon, Steelhead, and Trout *(Salmonidae)* in California." *Environmental Biology of Fishes* 96:1169-1186.



Right: Figure 2. Change in native salmonid species richness in California, historical to present.

In this figure, areas in red and orange denote watersheds that have lost the most species of native salmonids since the turn of the century. Areas in blue denote watersheds that have had species stocked or introduced into new habitats where they were not historically found.

Generally, the watersheds behind major dams (Shasta Dam on the Sacramento River, rim dams in the Sierra Nevada foothills, and Klamath River dams) have lost the most native salmonids, while the historically fishless lakes of the Sierra Nevada have generally gained the most species through extensive stocking over decades.

BOX 1

Evolutionary Significant Units

An ESU is a cluster of populations that had a common evolutionary history and trajectory. While this worked to protect purely anadromous fishes, such as salmon, it did not work for anadromous rainbow trout, which often were one genetic population that included resident trout populations. This necessitated a different management unit, the Distinct Population Segment.

Distinct Population Segment

NMFS and USFWS created the Distinct Population Segment (DPS) management concept for steelhead, in order to list anadromous forms of Rainbow trout under the Endangered Species Act due to the sharp declines in abundance, while not listing resident forms, which were relatively more abundant in most watersheds.

SUMMARY AND FINDINGS

A GLOBAL LOSS OF DIVERSITY?

In this State of the Salmonids II report we explore the following questions:

What is the status of all California salmonids, both individually and collectively?

What are major factors responsible for their present status, especially of declining species?

How can California's salmonids be saved from extinction?

This second edition is timely. During the writing of the first edition of the State of the Salmonids report in 2008, the commercial salmon fishery was closed due to low adult returns. Each year since then, the fishery has been restricted or constrained in some way.

At the writing of this report, the commercial salmon fishery is again closed for the 2017 season. The northern part of the state is emerging from historic drought (2012-2016), which saw significant negative impacts on salmonid populations and juvenile survival.

Further, new information, especially in the form of federal and state agency reports, and genetic and life history research that was not available before have been published, helping to paint a clearer picture of the true plight of California's salmonid populations. While California's climate, precipitation patterns, and trends in salmonids has changed, monitoring efforts, especially for species not listed under the Endangered Species Act, remain insufficient.

In 2015, our partners at Trout Unlimited released the *State of the Trout* report,[11] which provided a broad overview of the status, trends, and threats facing the trout species across the United States. While that report provided a general overview, this report dives more deeply into the status and trends facing all of California's salmonids at the southern edge of their range.

Status reviews are needed more frequently to alert managers and others on changes in the trends of the salmonids across California. While considerable efforts were made to compare the results of this second edition with the first edition of the *State of the Salmonids* report (2008), the level of information available for most species has greatly improved, as has our understanding of the threats they face and their impacts on salmonid populations. As a result, our current effort uses vastly improved metrics to portray what we feel is a considerable improvement in the quality of the status assessments for each species.

This report will alert agencies, stakeholders, and the public to the potential extent of the problem with declining salmon, steelhead, trout and their waters in order to encourage strategic conservation, especially in the face of climate change. In fact, the decline of California salmonids is a problem of national significance. Because of its complexity, California produces conditions similar to conditions throughout the range of salmonids, but its southern location and extreme development of water resources means the state's problems presage those of other areas. Loss of California's salmonids means a global loss of diversity.

[11] Trout Unlimited. (2015). *State of the Trout: A Report on the Status and Trends of Native Trout in the United States.* Trout Unlimited, Arlington, VA.

[12] Moyle, P. et al. (2013). *Climate Change Vulnerability of Native and Alien Freshwater Fishes of California: A Systematic Assessment Approach.* PLoS ONE 8(5): e63883.

SOS! STATE OF THE SALMONIDS

At the current rate, California stands to lose 45% of its remaining native salmonids, including 11 of 21 anadromous species and 3 of 10 of its inland species, in the next 50 years unless significant actions are taken to stem the decline. (Figure 3). **Under present conditions, 23 of the remaining 31 species (74%) are likely to be extinct in the next 100 years.**

There are three main reasons for changes in the Level of Concern across nearly all salmonids since 2008 (Figure 4):

1. the 2012-16 historic drought in California,
2. improved information, and
3. increased understanding of climate change impacts on salmonids.

The Level of Concern is increasing for California's salmonids, but especially for its anadromous species. In general, anadromous species in California face a higher risk of extirpation from their range than inland native trout because they depend on access to diverse, high quality habitat during various parts of their life cycle, and are therefore exposed to numerous anthropogenic and environmental threats throughout their lives.

For most species, abundance generally declined due to reductions in suitable habitat stemming from drought impacts. An improved understanding of genetics, abundance, and species range information has also positively or negatively impacted species status. For example, the Level of Concern for Central Valley steelhead remained the same (Moderate) since 2008 due to a better understanding of the nature of steelhead/resident Rainbow trout interactions and genetics, despite recent low adult returns. Conversely, the Central Valley fall-run Chinook salmon Level of Concern increased significantly (from Low to High) since 2008 due to a better understanding of the limited abundance of wild individuals without signs of hybridization with hatchery fish.

Finally, the climate change scoring in this report has built upon recent work[12] and a better understanding of the specific impact climate change is likely to have on each species, which led to a score reduction of the climate change factor in nearly all cases.

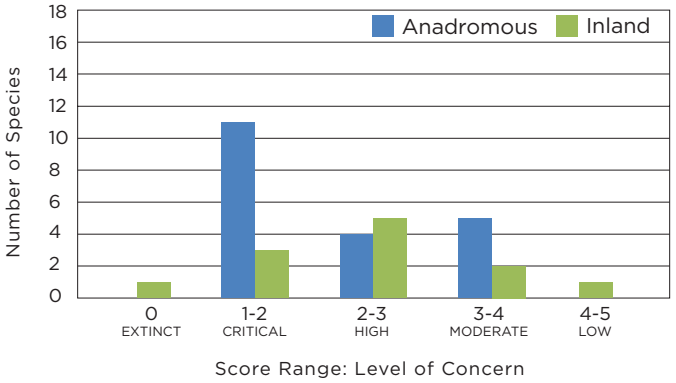


Figure 3. Status of California salmonids; 21 anadromous species and 11 inland species.

Anadromous species include all salmon, steelhead and Coastal Cutthroat trout. Inland species include all trout (with the exception of Coastal Cutthroat and Bull trout) as well as Mountain Whitefish.

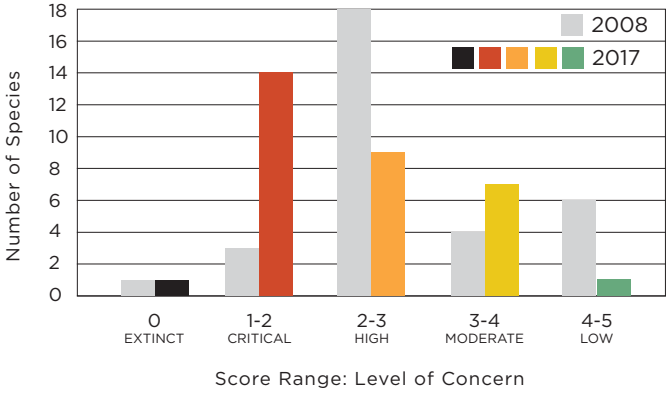
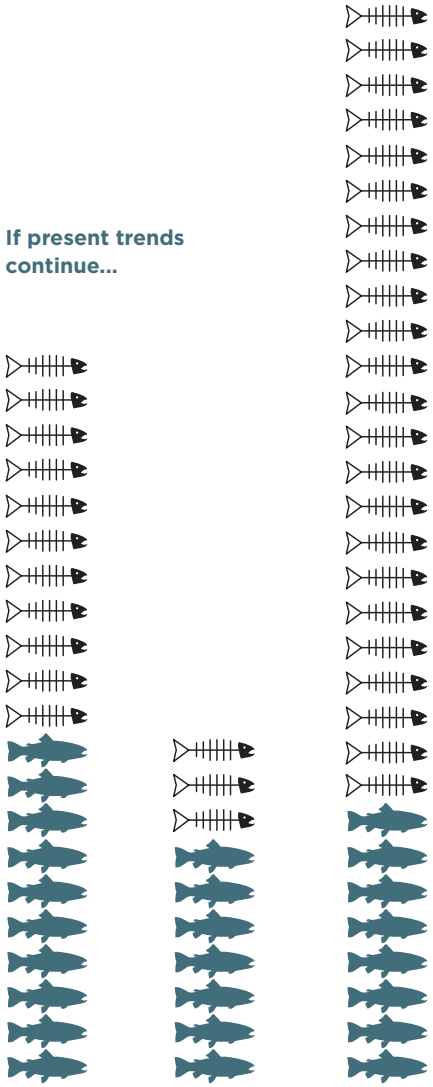


Figure 4. Change in Level of Concern 2008 to 2017

If present trends continue...



Within 50 years 11 of 21 (52%) of California's anadromous species are likely to be extinct.

Within 50 years 3 of 10 (30%) of California's inland species are likely to be extinct.

Within 100 years 23 of California's remaining 31 species (74%) are likely to be extinct.

MAJOR THREATS

OPEN HERE
TO SEE
ANTHROPOGENIC
THREATS

THE EFFECTS OF CLIMATE CHANGE ON CALIFORNIA SALMONIDS

Climate change was scored as a critical or high threat for 26 of 31 species (84%).

It is the major, overarching anthropogenic threat affecting salmonids in California. Due to its high impact and importance to the long term survival of all salmonids in California, it is highlighted below.

Climate change was scored a critical or high threat for a majority of species, and was considered a low threat to only one species.

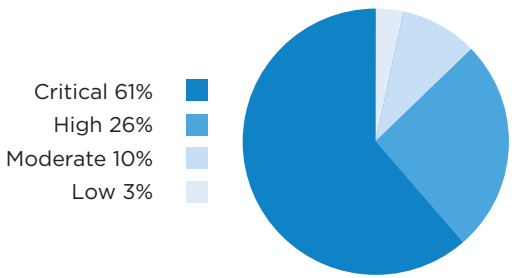


Figure 5. Climate change threat score (%) for California's 31 remaining salmonids.

1. LACK OF COLD WATER

Salmon, steelhead, and trout in California rely on cold, clean water to survive. Climate change is likely to reduce availability and access to cold water for salmonids in California through increasing average air temperatures and decreasing precipitation. In general, dry areas are likely to become drier, while wet areas are likely to get wetter. Particularly at higher elevations in California, precipitation is likely to fall as rain rather than snow, reducing overall snowpack and the critical snowmelt that provides cold water year-round to California's salmonid species.

2. LOW AND VARIABLE STREAMFLOWS

Earlier runoff during the spring is anticipated, causing prolonged periods of low streamflows during summer and early fall. Variability in weather will also increase, causing more frequent, prolonged drought and high intensity storm events. Higher magnitude winter floods, reductions in annual streamflow, and broad declines in cold water habitat for fishes are already occurring, with increasing rates of these changes anticipated.

3. CONSTRICTED HABITAT

All salmonids require thermal refuge areas, diverse habitats, and broad ranges to persist in the face of climate change. Species with very limited ranges, such as Eagle Lake Rainbow trout, and those that over summer in freshwater waiting to spawn, such as spring-run Chinook salmon and summer steelhead, are most susceptible to climate change because they are least able to access these refuge areas, which are largely inaccessible behind dams, diversions, and waterfalls.

4. REDUCED HABITAT SUITABILITY AND SURVIVAL

As temperatures increase and streamflow regimes change, habitats become less suitable for native salmonids and invasive species tend to thrive. Alterations in the amount and timing of streamflows reduces the survival of all juvenile salmonids. In the Pacific Ocean, sea surface temperatures are likely to increase, making ocean habitats less suitable for growth and survival of salmon and steelhead in the future.

5. FOOD WEB ALTERATION

In the Pacific Ocean, climate change is likely to reduce the powerful upwelling of the California Current, which drives primary productivity and supports the entire food web for all marine life, including anadromous fishes. Increased ocean acidification is also likely to impact ocean productivity.

6. RISING SEA LEVELS

Rising sea levels are likely to inundate and degrade important estuarine and lagoon habitats, historically critical components of the juvenile salmon and steelhead life cycle.

The majority of salmonid species in California is currently facing, or is likely to face, extinction from climate change if present trends continue. Salmon, steelhead, and trout have adapted to a wide variety of climatic conditions in the past, and could likely survive substantial changes to climate in the absence of other anthropogenic stressors. By taking actions to reduce anthropogenic threats identified in this report, allowing salmonid species access to a variety of high-quality habitats at appropriate times, and increasing population abundance, species resilience to climate change can be improved.

ANTHROPOGENIC (HUMAN-CAUSED) THREATS

The population of California is approaching 40 million people. We live in a highly altered natural environment. As such, the human impact on the state's salmonids were important to include in the SOS II report because:

1. California's salmonids can adapt to natural environmental change, but that ability is limited when faced with these human-induced threats.
2. Human-caused threats limit the long-term viability of salmonid populations by decreasing their resilience to change.
3. Determining which threats have the greatest impact on species can help to target conservation and restoration efforts, providing a roadmap for a return to resilience.

For each species, an analysis was conducted of 15 anthropogenic factors (illustrated at left) which limit, or potentially limit, a species' viability. The threats were rated for each species by critical, high, medium, low, or not applicable (n/a).

The top three anthropogenic threats, after climate change, vary by anadromous and inland species as would be expected given their different life histories. The top threats to anadromous species are overwhelmingly estuary alteration, major dams, and agriculture, while inland species face threats from alien species, fire, and hatcheries.

For more information on the impact of each anthropogenic threat to California's salmonids, see the illustration fold-out at left.

For more details on how the anthropogenic threats were ranked visit Methods at the back of this report.

TOP 3 ANTHROPOGENIC THREATS TO ANADROMOUS SPECIES

ESTUARY ALTERATION

Estuary and lagoon habitat has been significantly reduced through conversion to support the state's growing population and myriad land uses. Loss of these productive rearing habitats statewide, but especially in the highly altered Sacramento-San Joaquin Delta, reduces survival for all salmonids.

CRITICAL/HIGH THREAT:
13 of 21 (62%)
anadromous species

MAJOR DAMS

Dozens of major and thousands of smaller dams block access to historical salmon and steelhead habitat. Dams also alter flow regimes by changing the timing, magnitude, duration, rate of change and frequency of historical streamflows.

CRITICAL/HIGH THREAT:
13 of 21 (62%)
anadromous species

AGRICULTURE

California's booming agricultural industry reduce the survival and productivity of all salmon runs in the state. Agricultural demands on water reduces and alter the timing of streamflows that degrade water quality and habitat.

CRITICAL/HIGH THREAT:
8 of 21 (38%)
anadromous species

TOP 3 ANTHROPOGENIC THREATS TO INLAND SPECIES

ALIEN SPECIES

Brown and Brook trout have been introduced extensively across California, and are sources of competition and predation for native trout. These non-native species are generally better able to survive in degraded habitats historically occupied by native species.

CRITICAL/HIGH THREAT:
7 of 10 (70%)
inland species

FIRE

Fires may potentially wipe out entire populations through direct mortality, sedimentation and siltation of habitat, and destruction of riparian habitat, especially for species with very limited ranges. Climate change is likely to increase the risk of more frequent and intense fires in California in the future.

CRITICAL/HIGH THREAT:
2 of 10 (20%)
inland species

HATCHERIES

Hatchery-origin Rainbow trout strains have been widely stocked across California for over a century. These fish hybridize with native Redband, Rainbow, Golden, and Cutthroat trout, and their offspring replace genetically pure populations in the limited habitats they still occupy.

CRITICAL/HIGH THREAT:
2 of 10 (20%)
inland species

ANTHROPOGENIC THREATS

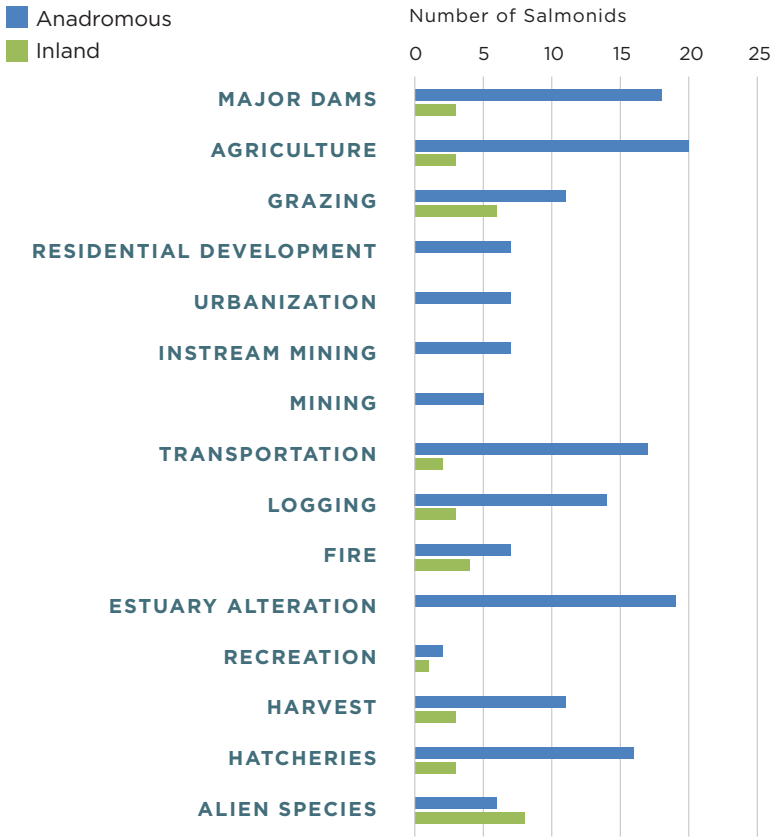


Figure 6. Number of anadromous and inland salmonids with critical, high and medium threat levels by anthropogenic threat.

FIRE

Wildfires are a natural component of California's landscape. However, fire suppression, coupled with climate change, has made modern fires more frequent, severe and catastrophic. The transition from relatively frequent understory fires to less frequent, but catastrophic, crown fires can have a severe impact on fish habitat and wipe out populations with narrow habitat ranges.

LOGGING

Many heavily logged watersheds once supported the highest species diversity and abundance of fishes, including anadromous salmon and steelhead. Improperly managed logging increases sediment in streams, increases solar input which increases stream temperatures, and degrades riparian cover. Stream habitat is also degraded by the extensive network of unpaved roads that supports timber extraction.

RECREATION

Human use of streams, lakes, and surrounding watersheds for recreation has greatly increased with population expansion. Boating, swimming, angling, off-road vehicles, ski resorts, golf courses and other activities or land uses can negatively impact salmonid populations and their habitats. The impacts are generally minor; however, concentration of multiple activities in one region or time of year may have cumulative impacts.

INSTREAM MINING

Widespread and often severe instream mining impacts occurred mid-19th to early 20th century due largely to hydraulic mining. Many rivers were excavated, dredged, and hydraulically mined for gold, causing dramatic stream degradation. Instream gravel mining also removed riparian vegetation and spawning gravels and degraded riparian habitats. Such mining is now largely banned, but lasting impacts remain in many areas.

HATCHERIES

Hatcheries and releases of hatchery reared salmonids into the wild can negatively impact wild populations through competition, predation, disease, and loss of fitness and genetic diversity. Hatchery influences are especially apparent to for anadromous species where dams blocked access to spawning habitat and hatcheries were established as mitigation. Inland trout can also be impacted with stocking of hatchery fish for recreation.

MAJOR DAMS

Dams block access to historical spawning and rearing habitats. Downstream, dams alter the timing, frequency, duration, magnitude, and rate of change of flows decreasing habitat quality and survival.

AGRICULTURE

Impacts from agriculture include streams polluted by agricultural return water or farm effluent; reduced flow due to diversions which can affect migratory patterns; and increased silt and pesticides in streams. Marijuana grow operations, legal and illegal, were considered in this metric.

GRAZI

Improperly livestock g damage str limit riparia and increas This can res habitat com stream tem decreased s conditions. meadow str down cuttir meadows d reductions

NG

managed
razing can
reambanks,
n vegetation
e sedimentation.
sult in a loss of
nplexity, increased
peratures, and
spawning habitat
Severe grazing in
reams can cause
ng resulting in
rying out and
in streamflow.

MINING

This factor refers to hard rock mining, from which contaminated tailings, mine effluents, and toxic pollutants may have been dumped or leached into streams, mostly from abandoned mines. Mercury mining, used for processing gold in placer and dredge mining, left a lasting negative impact on wildlife.

ESTUARY ALTERATION

All anadromous salmonids depend on estuaries for rearing during a portion of their lives. Most estuaries in the state are highly altered from human activities, especially diking, draining, and sandbar removal between the estuary and ocean. Land-uses surrounding estuaries often involve extensive wetland reclamation, greatly reducing ecological function and habitat complexity.

RESIDENTIAL DEVELOPMENT

As California's population grows, rural development increasingly encroaches along or near streams. Resulting impacts include water diversions, groundwater pumping, streambed alteration (to protect houses from flooding, construct road crossings, etc.), and pollution (especially from septic tanks and illegal waste dumping).

URBANIZATION

Development of towns and cities often negatively affects nearby streams through alteration for flood prevention, channelization, and water diversion, and increased pollution. The timing and magnitude of flows are altered by the increase in impervious surfaces such as pavement. Pollution from surface runoff, sewage discharges, and storm drains can degrade water quality and aquatic habitats.

HARVEST

Harvest relates to legally regulated commercial, tribal, and recreational fisheries, as well as illegal harvest (poaching). Over-harvest can have substantial impacts on fish populations, particularly for those with already limited abundance or distributions, those which are isolated or reside in discrete habitats making them easy to catch (e.g. summer steelhead), or those that attain large adult size (e.g., Chinook salmon).

ALIEN SPECIES

Non-native species (including fishes and other aquatic organisms) are ubiquitous across many of California's watersheds; their impacts on native species through hybridization, predation, competition, increased disease transmission, and habitat alteration can be severe.

TRANSPORTATION

Transportation corridors such as highways confine stream channels and increase sedimentation, pollution, and habitat degradation from storm runoff and altered streamflows. Culverts and other passage or drainage modifications associated with roads often block migration and restrict fish movements, which can fragment populations.

RETURN TO RESILIENCE

SAVING CALIFORNIA'S SALMONIDS FROM EXTINCTION

The science behind this report has made it clear: many of salmon, steelhead, and trout are in poor condition with the last several years of severe drought pushing several species to the edge of extinction. To reverse the extinction trend, more Californians need to care.

We must do a better job of making the case that diverse and resilient wild populations of trout, steelhead and salmon matter not just to fish lovers, but to all Californians. Resilient fish populations indicate healthy waters, important for drinking water, agriculture, commerce, and the health of people and the environments in which we live. Declining fish populations indicate degraded waters, which threaten the health and economic well-being of all Californians.

The good news is that 31 of our 32 salmonid taxa still persist. We have an opportunity to reverse this trajectory toward extinction, but the findings of this report underscore that we must act now. We must take bold, scientifically informed, and innovative actions to improve resilience of our native salmon, steelhead, and trout and the waters upon which we all depend.

Improving resilience requires an improvement in salmonid life history diversity. Salmonids have responded and adapted to environmental change for more than 50 million years due to variation in their life histories and behavior. Much of this variability is tied to differences in the timing of fresh water and ocean migrations. These timing differences contribute to life history diversity which, in turn, promotes species resilience to change. Over the last century, life history and behavioral diversity has been greatly diminished due to changes in habitat, discontinuity between habitats, genetic homogenization, and interactions with non-native species. The relatively recent reduction in salmonid life history and behavioral diversity means that salmonids are less able to adapt to a rapidly changing California. Access to diverse and productive habitats, and reductions in interactions between hatchery and wild salmonids, are fundamental to restoring salmonid resilience throughout California. Many of the historically productive and diverse habitats used by salmonids are either blocked behind dams and levees or are significantly altered and no longer function properly. Restoring such habitats and access to them is of paramount importance.

Improving salmonid status throughout California requires investing in productive and diverse habitats that promote salmonid diversity and resilience. Here is California Trout's action plan to return our rivers and salmon, steelhead, and trout to resilience. If fully implemented, many of the species in this report will thrive.

PROTECTING AND RESTORING PLACES THAT MATTER MOST

STRONGHOLDS: PROTECT THE BEST

We must protect the best of what habitats are left. Few fully functioning river ecosystems, with relatively intact watersheds and high-quality habitat, exist today in California, such as the Smith River, Blue Creek, the Eel River and Butte Creek, among others. This is reason enough to make managing systems like these in perpetuity the highest priority, to protect salmonid diversity and production.

PROTECT AND RESTORE SOURCE WATERS

Protecting and restoring source waters including meadows, springs, and groundwater will allow them to continue to provide refuges for salmonids during stressful times and buffer the effects of climate change. Source headwaters are key to hydrologic connectivity and are vital during periods of low streamflows and drought.

RESTORE PRODUCTIVE AND DIVERSE HABITATS

Restoring function to once-productive but now highly altered habitats can greatly improve rearing conditions for juvenile salmonids, especially floodplains, coastal lagoons, estuaries, and spring-fed rivers, can greatly improve rearing conditions for juvenile salmonids. These types of habitats are relatively scarce, yet are vital nurseries for juvenile fishes and support robust growth rates when compared with typical in-river conditions. Improved growth prior to ocean migration and high life history diversity increases the likelihood of marine survival and adult returns to natal tributaries.

STRATEGIES TO PROMOTE

ADOPT RECONCILIATION ECOLOGY AS THE BASIS FOR MANAGEMENT: WILD FISH IN WORKING LANDSCAPES

Reconciliation Ecology recognizes that most ecosystems are altered by human actions, with people as a key part of the ecosystem. Therefore, highly managed ecosystems in working landscapes must play a major role in contributing to salmon diversity and abundance. If the mechanisms supporting salmonid growth and life history diversity can be restored or recreated in human-dominated ecosystems, these "working landscapes" can be put to work to recover salmonids throughout California. Current work on the Yolo Bypass in the Central Valley, for example, shows that managing rice fields to mimic natural floodplains creates substantial growth benefits for juvenile salmon.

IMPROVE HABITAT CONNECTIVITY AND PASSAGE TO HISTORICAL SPAWNING AND REARING HABITAT

Removing dams and fish passage barriers or providing volitional passage to historically important spawning and rearing habitats is key for persistence of many anadromous salmonids. Access to lost habitats will help boost population abundance, improve life history diversity, and population resilience to environmental changes. For populations downstream of dams, there is a need to institute scientifically based environmental streamflow regimes throughout California that favor native species.

IMPROVE GENETIC MANAGEMENT

Broad changes to the way salmonid hatcheries are operated throughout California need to be instituted. Changes should include reducing gene flow between hatchery and wild salmonids, minimizing hatchery straying into non-natal watersheds, and marking all hatchery fish with an adipose fin clip so that they can be readily distinguished from wild fish, and using strict mating protocols to discourage inbreeding and fitness reduction.

We call this plan a "Return to Resilience" because both salmonids and their managers must be resilient in response to change wrought by the ever-increasing human demands on the planet.

Without this kind of plan, and commitments to implement it, the main option is to accept the loss of most salmonid diversity in California, with a few populations maintained as low-diversity "boutique" populations, to remind us of our lost past and bleak future.[13]

[13] Lackey, R., Lach, D., and S. Duncan. 2006. Salmon 2100: *The Future of Wild Pacific Salmon.* American Fisheries Society, Bethesda, MD, i-vii, (2006).

CALTROUT: PROTECTING CALIFORNIA'S FISH AND WATERS SINCE 1971

California Trout's mission is to ensure resilient wild fish thriving in healthy waters for a better California. Our unique business model provides science-based solutions to complex resource issues while balancing the needs of wild fish and people. The *SOS II: Fish in Hot Water* Report informs our blueprint and ensures our work is focused on the right priorities. These are:

PROTECT STRONGHOLDS

There are still rivers in California that produce abundant wild steelhead and salmon – and we intend to keep them that way.

RESTORE SOURCE WATERS

Source water areas are the life blood of the state – in particular the Sierra headwaters and the volcanic spring aquifers of the Mt. Shasta area.

WILD FISH, WORKING LANDSCAPES

California's rivers and landscapes have been highly altered and, as a result, wild fish populations have suffered. CalTrout is finding innovative ways to put nature back into the mix, bringing wild fish back into California's working landscapes.

CalTrout's "Nigiri Project" at Knaggs Ranch; working with agricultural floodplains to regenerate salmon populations. Photo: Mike Wier.

We are California-focused. Our expert staff are rooted in local communities, hard at work implementing over 30 large-scale, on-the-ground conservation projects in key geographical areas where wild fish influence the community: North Coast, Mount Shasta/Klamath, Sierra Headwaters, Central California, and Southern California.

We lead innovative, science-based solutions that work for the diverse interests of fish, farms, commerce, and community. Our successful proof-of-concept projects establish precedent, empowering partners and influencing statewide policy.

This work would not happen without the support of our partners and donors. Thank you for trusting CalTrout to protect our state's fish and waterways.