Extinction Risks for Native Fishes

Recent work by Peter Moyle and colleagues (Moyle et al. 2013 and 2015)[63] assessed the vulnerability of California's native fishes to a changing climate through the end of the 21st century. In particular, Moyle et al. (2013) systematically evaluated the status of each species using 20 metrics. Using this database, we evaluated the potential for significant impacts on native fish species from continuing drought. Climate-related vulnerability factors included low flows and higher air and water temperatures—both characteristics of this drought. We therefore assumed that fish highly vulnerable to climate change would also be most vulnerable to changes caused by continuing drought. After making this initial cut, we looked at vulnerability in the wild to drought based on: species condition accounts in Moyle et al. (2008)[64] and Moyle et al. (2015); field studies conducted by the Moyle laboratory during the summer of 2014 throughout northern California; DFW website reports on their drought actions; consultations with experts on local fishes; and recent news reports.

We used this information to identify 18 species with a high risk of extinction in the wild from two or more years of continued drought (Table A9). We simplified the impacts of a continued drought into five main categories: (1) loss of rearing habitat due to reduced flows, (2) loss of spawning habitat due to reduced flows, (3) increased water temperatures, (4) increased stress from invasive species (a problem for some resident fishes), and (5) increased negative influence on wild populations from hatchery populations (a problem for some runs of salmon).

The last two categories are aggravating factors, above and beyond the direct effects on fish habitat of low flows and high temperatures. The drought is also favoring conditions for invasive fish and other species that either compete with or prey on natives. Non-native plants, zooplankton and insects also reduce the quality of habitat during drought. And for some salmon runs, the release of large numbers of hatchery-bred fishes just prior to or during droughts can harm drought-stressed wild fish through competition, predation, or interbreeding that reduces the fitness of their offspring.

Table A9 also indicates whether these fish have captive populations or populations established outside their native range. Although this would not affect the probability of extinction in the wild within the fishes' native range, it could reduce the threat of extinction as a species. This information is relevant in considering emergency measures and management actions. For instance, the use of conservation hatcheries to preserve biodiversity will be more difficult for fish at high risk of extinction that do not already have captive populations or populations that live outside of their native range.

Finally, Table A9 lists management actions that could reduce the likelihood of extinction if the drought continues. Depending on the species, actions range from the restoration of habitat and reduction of water diversions to the creation of conservation facilities to breed captive populations, should the species go extinct in the wild.

A key action for all of these species is monitoring. Every species on this list and its critical habitat should be monitored, preferably on a monthly basis, as long as the drought persists. If a population is close to being lost, emergency rescue plans and operations should be implemented (see the above discussion on rescue operations in 2014). The ability to rely on a conservation facility to maintain populations in an emergency situation will vary greatly among these species. Some species are already kept in captivity with the goal of preventing extinction (such as delta smelt, Central Coast coho salmon, McCloud River redband trout, and Central Valley winter-run Chinook salmon). Others have populations in hatcheries not oriented toward conservation of biodiversity (such as

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[63] Moyle, P.B., J. D. Kiernan, P. K. Crain, and R. M. Quiñones. 2013. Climate change vulnerability of native and alien freshwater fishes of California: a systematic assessment approach. *PLoS One*. Moyle, P.B., R. M. Quinones, J.V.E. Katz, and Jeff Weaver. 2015 (in press). *Fish Species of Special Concern in California*. Sacramento: DFW.

[64] Moyle, P.B., J.A. Israel, and S. E. Purdy. 2008. *Salmon, steelhead, and trout in California: status of an emblematic fauna.* UC Davis Center for Watershed Sciences. 316 pp.

the Southern Oregon Northern California Coast coho salmon) and will require a change in production hatchery practices (which support fisheries) to those of a conservation hatchery, in order to avoid extinction. Finally, many species have no captive breeding programs at all and will require the development of facilities in order to maintain populations.

TABLE A9-A

California's resident freshwater fish species at risk of extinction in the wild if the drought continues

	Region	Populations outside of native range or in a hatchery?	Drought impacts				Management actions to reduce likelihood of extinction
			Rearing habitat	Spawning habitat	Water temp.	Invasive species	
Long Valley speckled dace *Rhinichthys osculus. subsp.*	Owens Valley	In a special holding pond	x	x		x	• Restore former habitat • Create a conservation facility or refuge pond/stream
Santa Ana speckled dace *Rhinichthys osculus. subsp*	South Coast	No	x	x		x	• Reduce diversions and recreational use on remaining habitat • Remove Cogswell and Big Tujunga dams to allow connectivity among habitats and reduce sediment • Reintroduce to suitable habitat • Create a conservation facility
Clear Lake hitch* *Lavinia exilicauda chi*	Sacramento	No		x		x	• Restore former habitat in important spawning areas by reducing diversions and removing upstream barriers • Create a conservation facility or refuge pond/stream
Red Hills roach *Lavinia symmetricus, subsp.*	Central Valley	No	x	x			• Acquire private land and additional sources of water for the remaining habitat • Locate downstream habitat with year-long water and eliminate alien fishes present • Create a conservation facility or refuge pond/stream
Shortnose sucker* *Chasmistes brevirostris*	Klamath	No	x	x			• Reduce irrigation releases from Clear Lake Reservoir • Improve management of the Willow-Boles Creek system to improve spawning and rearing habitat • Create a conservation facility
Lost River sucker* *Catostomus luxatus*	Klamath	No	x	x			• Reduce irrigation releases from Clear Lake Reservoir • Improve management of the Willow-Boles Creek system to improve spawning and rearing habitat • Create a conservation facility
McCloud River redband trout *Oncorhynchus mykiss stonei*	Central Valley	In special holding tank at Mt. Shasta Hatchery	x	x	x		• Develop plan for reintroducing fish into upper McCloud River (would require removal of non-native trout) • Increase flows in small springs (may not be possible)
Unarmored threespine stickleback* *Gasterosteus aculeatus williamsoni*	South Coast	Populations exist in Santa Barbara and San Diego County	x	x	x	x	• Implement all recommendations in the USFWS 2009 five-year review and The Nature Conservancy's Upper Santa Clara Watershed Conservation Plan • Translocate to suitable streams in the upper Santa Clara watershed • Restore Shay Creek to serve as habitat • Create a conservation facility that could independently maintain individuals from all three populations
Delta smelt* *Hypomesus transpacificus*	Central Valley	UC Davis Fish Conservation and Culture Lab	x		x	x	• Continue monitoring • Find freshwater habitats suitable for experimental reintroductions

NOTES: * Denotes listed under federal or state Endangered Species Acts

TABLE A9-B

California's anadromous fish species at risk of extinction if the drought continues

	Region	Populations outside of native range or in a hatchery?	Drought impacts				Management actions to reduce likelihood of extinction
			Rearing habitat	Spawning habitat	Water temp.	Hatchery influence	
Upper Klamath-Trinity spring Chinook salmon *Oncorhynchus tshawytscha*	Klamath	Trinity River Hatchery	x	x	x	x	• Mark all hatchery Chinook salmon and only allow in-river and ocean fishing of marked fish • Manage some watersheds (Salmon River and South Fork Trinity River) as refuges by restricting diversions in summer • Fund efforts of Western River Conservancy and the Yurok Tribe to complete acquisition of the entire Blue Creek watershed as a Yurok Tribal Salmon Sanctuary • Develop a more sophisticated rearing program to select against hatchery traits
Klamath Mountains Province summer steelhead *Oncorhynchus mykiss*	Klamath	No	x	x	x		• Complete management plans for each subpopulation of summer steelhead • Manage some watersheds (Salmon River and South Fork Trinity River) as refuges • Fund efforts of Western River Conservancy and the Yurok Tribe to complete acquisition of the entire Blue Creek watershed as a Yurok Tribal Salmon Sanctuary • Create a conservation facility
Northern California coast summer steelhead *Oncorhynchus mykiss*	North Coast	No	x	x	x		• Declare a special entity and determine the status of remaining populations • Manage the Middle Fork Eel and Van Duzen rivers as refuges • Develop a rescue plan if drought creates dangerous conditions • Create a conservation facility
Central Valley winter Chinook salmon* *Oncorhynchus tshawytscha*	Central Valley	Livingston Stone Hatchery	x	x	x	x	• Establish a population in Battle Creek • Improve management of cold-water pool in Shasta Reservoir
Central Valley spring Chinook salmon* *Oncorhynchus tshawytscha*	Central Valley	Coleman National Fish Hatchery	x	x	x		• Accelerate the restoration of Battle Creek • Increase the protection/patrolling of Deer and Mill creeks to reduce human impacts, such as illegal diversions and poaching • Develop a special conservation facility or program to rear distinct populations
Central Valley late fall Chinook salmon *Oncorhynchus tshawytscha*	Central Valley	Coleman National Fish Hatchery	x	x	x	x	• Mark all hatchery fall-run Chinook salmon and only allow in-river and ocean fishing of marked fish • Provide adequate flows from Shasta Dam, to create low temperatures in the Sacramento River • Develop a special facility for conservation-oriented rearing
Central coast coho salmon* *Oncorhynchus kisutch*	Central Coast	Dry Creek Hatchery	x	x	x		• Shut down illegal diversions and reduce legal diversions • Focus restoration efforts on the Lagunitas Creek watershed by providing cold water, reducing recreational use, and protecting stream banks • Expand Dry Creek hatchery operations
Southern Oregon Northern California Coast coho salmon* *Oncorhynchus kisutch*	North Coast and Klamath	Several hatcheries	x	x	x	x	• Shut down illegal diversions and reduce legal diversions • Shut down production at Iron Gate Hatchery on the Klamath River to reduce influence of hatchery fish • Create a natural flow regime during summer, with lower temperatures, on the Shasta River • Create a conservation facility that can focus on wild populations and decrease or eliminate other hatchery populations
Eulachon* *Thaleichthys pacificus*	North Coast and Klamath	No	x	x	x		• The eulachon may already be extinct due drought-related changes in both rivers and the ocean • Engage with local tribal members to create a monitoring program • Improve flows in Redwood Creek during spawning season

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