California's Living Marine Resources: A Status Report

The Errata

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The Errata

The "Salmonids" Section on "Coastal Cutthroat Trout" has been reproduced from the original report article and is included with this errata sheet. In addition, for the Section on "Bay and Estuarine Finfish Resources," please insert the enclosed new article on "Gobies." The following are corrections for typographical errors in articles that appeared in the original report.

P. 85, Bathymetry of the Southern California Continental Shelf: "Channel Islands National Marine Sanctuary" (in red) should include "Santa Barbara Island."

P. 201, photo: "Pacific Sanddab, Citharichthys sordidus" should read "Speckled Sanddab, Citharichthys stigmaeus."

P. 219, line 19: "By 1916," should read "The southern California...."

P. 123, Spot Prawn, References: "Butler, T.H." should read "Sunada, J.S."

Coastal Cutthroat Trout

History of Fishery

Coastal cutthroat trout (Oncorhynchus clarki clarki) inhabit California in rivers from the Eel River delta to the Oregon border. This distribution represents the southern extent of their range. Coastal cutthroat trout exist in small populations, and by some estimates, occur in less than three percent of the stream habitat occupied by other salmon and steelhead in California. This limited distribution has resulted in a general lack of awareness of these fish among sport anglers in California. While no commercial fishery exists for coastal cutthroat trout, their catchability and striking appearance make them a popular sport fish for those few anglers familiar with their seasonal movements. Most angling effort for coastal cutthroat trout in California occurs in coastal lagoons and the Smith River basin. Because these fish can be similar in appearance to steelhead, many anglers are not aware they have caught a coastal cutthroat trout. Moreover, the difficulty in distinguishing juvenile steelhead and coastal cutthroat trout hampers management and research; typically these two species are identified only as "trout." Little information on the historic distribution and abundance of coastal cutthroat trout is available, and current information is sparse.

Coastal cutthroat trout are susceptible to harvest by sport angling; but their low numbers, variable movement patterns, and patchy distribution result in limited sport harvest. Because of their vulnerability to angling, fishery managers in California and across the range of coastal cutthroat trout are implementing special regulations to maintain or rebuild depleted populations.

Status of Biological Knowledge

The coastal cutthroat trout is the most widely distributed subspecies of cutthroat trout. They occupy habitats ranging from small to large rivers that drain the coastal rainforest between the Eel River, California, and Prince William Sound, Alaska. Anecdotal information suggests that they may occasionally be found in basins south of the Eel River. In general, coastal cutthroat trout are the most widely distributed salmonid species in those basins where they are found, with individuals occupying habitat from the estuary to the most upstream reaches of a basin, often with populations above migration barriers (*e.g.*, waterfalls) that anadromous fish can not pass. Coastal cutthroat trout are usually found in headwaters and smaller tributaries, and may also occur in small streams upstream from sloughs where steelhead are often absent.

Life-history traits of coastal cutthroat trout differ from other anadromous salmonids of the Pacific Coast, but exhibit some similarity to steelhead. Coastal cutthroat trout have both anadromous (often referred to as sea-run cutthroat trout) and potamodromous (life-history forms that migrate entirely within freshwater, sometimes moving over large distances). Like steelhead, anadromous coastal cutthroat trout may spawn more than once, but rely on freshwater and estuarine habitat for a greater portion of their life cycle than do Pacific salmon and steelhead. Downstream migration and movement into the marine environment typically occurs in late spring or early summer after two or three years in freshwater, although movement from upper tributaries into downstream areas may occur after a year.

Coastal cutthroat trout appear to have strong fidelity to their natal stream, perhaps because they do not make extensive ocean migrations. Anadromous adults return to freshwater between June and April. Run times appear to be relatively consistent from year to year within a stream but vary widely among streams. Spawning usually occurs between December and June. Coastal cutthroat trout have a higher incidence of repeat spawning than steelhead, although they may not spawn every year. Anadromous individuals rarely spawn before age four while potamodromous individuals may mature at an earlier age. Anadromous coastal cutthroat trout commonly overwinter in fresh water, although their affinity to natal streams for nonspawning purposes is not well understood. Tagging studies in Alaska and Washington have found adult coastal cutthroat trout moving into non-natal freshwater habitat seasonally, either for over-wintering or perhaps feeding purposes. Since migrations to freshwater can be made for reasons other than spawning, the term amphidromous may be more appropriate than anadromous to describe the migration pattern of coastal cutthroat trout. Anadromous individuals do not obtain the large size of other anadromous Pacific salmon and steelhead.

Genetic data suggest that coastal cutthroat trout are characterized by smaller, more genetically diverse local populations that act in a more independent, isolated manner than has been observed for other species of Pacific salmon and steelhead. Genetic research on coastal cutthroat trout indicates hybridization occurs between coastal cutthroat trout and steelhead in the wild. It is unclear whether this is a result of these species' relatively recent evolutionary split, past hatchery practices that reared and released hybrid individuals, reduction in the quality and quantity of habitat, or a combination of these and other factors. It does not appear that this phenomenon can be attributed solely to anthropogenic factors since suspected hybrid individuals have been identified in relatively pristine habitats devoid of hatchery releases

in southeast Alaska. Still, the greatest frequency of suspected hybrids in recent genetic surveys have been found in areas subject to a range of land management activities and hatchery releases. The occurrence of hybrids and similarities in appearance between "pure" coastal cutthroat trout and steelhead provide many challenges to researchers and managers.

Habitats for coastal cutthroat trout include gravelly lowland coastal streams, large and small rivers and estuaries, and nearshore ocean areas. Although there is some disagreement in the literature over preferred habitat of juveniles, young-of-the-year coastal cutthroat trout will use pool, run, and riffle habitat. Some studies found a preference for pool habitat by young-of-the-year individuals, while other studies have found a preference for faster, shallow water and shifts in habitat use in response to the presence of juvenile steelhead and salmon. Little is known about movement of smolts through esturine habitat into the ocean, but the few data that exist suggest that they remain in nearshore waters. Although the proportion of the lifecycle that coastal cutthroat trout spend in the marine environment is short compared to that observed with Pacific salmon and steelhead, the marine environment is critical for the subspecies' persistence. The marine environment provides opportunities for individual fish to move among river basins and enables dispersal and recolonization following localized extinctions, or as new habitat becomes available.

The diet of juvenile coastal cutthroat trout, like that of other juvenile salmonids, consists mainly of aquatic and terrestrial insects and other invertebrates. Fish, particularly salmonids, make up an important part of the diet of coastal cutthroat trout. In the marine environment they feed on crustaceans and fish. Little is known about predation on coastal cutthroat trout; however, piscivorus fishes such as steelhead and pike minnow, and avian predators probably prey on juveniles and smolts. Scars observed on adult coastal cutthroat trout in Oregon indicate potential predation in the marine environment.

Status of Population

Populations of coastal cutthroat trout tend to be smaller than populations of other Pacific salmonids. Information on adult coastal cutthroat trout abundance is available only for a few streams. Data on juvenile abundance can be confounded by misidentification with steelhead, and estimates of out-migrants are often imprecise since the capture efficiency of downstream migrant traps is usually poor for coastal cutthroat trout. Overall, the abundance of coastal cutthroat trout in California appears to be reduced from historical levels. What little information there is suggests that recent abundance of coastal cutthroat trout is relatively stable, although depressed, and may be slightly increasing in some streams. Interestingly, in 1940, one researcher observed a decline in cutthroat abundance in northern California streams since he first fished them in 1897. It is unclear whether this was the first observation of what is believed to be an overall decline in the size of coastal cutthroat trout populations or if these populations have always cycled between periods of abundance and extinction.

Two of the greatest concerns with coastal cutthroat trout are the changes in suitable habitat which can reduce or eliminate dispersal among populations, and the loss of certain life history types. Although the number of individual fish within a basin may appear to be stable, perhaps increasing in some areas, the number of anadromous and potamodromous individuals may be declining. These life history types are required for the persistence of the subspecies, enabling dispersal and recolonization. Degradation and modification of mainstem river and esturine habitat has limited the opportunity for the expression of these life history type and reduced the capacity for these populations to respond to disturbances and conservation efforts. In addition, the ability of coastal cutthroat trout to use habitat from tidewaters to headwaters within a basin may give a false impression of stability, since they appear to be well distributed, but reasonable estimates of abundance are needed to assess long-term persistence.

Management Considerations

This Management Consideration is provided for informational purposes only. These views, submitted by the authors, do not necessarily represent the views of either the California Department of Fish and Game or the California Fish and Game Commission, and no endorsement of any of these views by these agencies is implied.

Sportfishing regulations in many waters have been changed to catch-and-release, enabling sport fishing to continue while reducing direct harvest.

1. Catch and release regulations should be continued and expanded to waters where direct harvest still occurs.

2. Data on abundance and distribution of coastal cutthroat trout should be collected in the context of habitat conditions so that the relationship between the fish and ecological processes can be understood.

3. Programs should implement conservation measures and restoration of habitat to allow dispersal among populations and the expression of the range of life history types of coastal cutthroat trout. This will require the preservation and restoration of ecological processes that create and maintain aquatic habitat through time.

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Gobies

General

The gobies, (Gobiidae), comprise about 2,000 small, elongate, benthic spiny-rayed fishes mostly in the warm tropical marine regions worldwide, but with some species extending into the temperate zone such as in California. They rarely exceed four inches in length and often inhabit burrows or other crevices in the substrate. California has 12 native species that can be conveniently divided into three ecological groups. One group of three species is marine and occurs in association with hard substrates — bluebanded goby (*Lythrypnus dalli*), zebra goby (*L. zebra*), and blackeye goby (*Coryphopterus nicholsi*). These two genera are represented by more species farther south in the tropics. Two other marine species are temperate zone forms that are partially or completely blind as adults and live secluded in crevices or burrows — halfblind goby (*Lethops connectens*) and blind goby (*Typhlogobius californiensis*). The largest group is comprised of seven largely bay, estuarine, and brackish water species that are endemic to the eastern Pacific Ocean from Baja California to British Columbia — longjaw mudsucker (*Gillichthys mirabilis*), arrow goby (*Clevelandia ios*), bay goby (*Lepidogobius lepidus*), shadow goby (*Quietula y-cauda*), cheekspot goby (*Ilypus gilberti*), tidewater goby (*Eucyclogobius newberryi*), and longtail goby (*Ctenogobius sagittula*). Only two of these species, the arrow and bay gobies, range north of California to British Columbia. In addition to these 12 native species, four non-native or exotic estuarine and freshwater species have become established in California since the early 1960s — yellowfin goby (*Acanthogobius flavimanus*), chameleon goby (*Tridentiger trigonocephalus*), shimofuri goby (*T. bifasciatus*), and shokihaze goby (*T. barbatus*). The shimofuri goby apparently did not become established until the mid-1980s, and the shokihaze goby was first collected in 1999. These undoubtedly came from Japan or nearby Asia due to human activity, but the mode of entry remains unknown, as well as whether the movement was accidental or intentional. Ballast water of large ships is suspected to be a likely mode of transfer.

Tidewater Goby, *Eucyclogobius newberrvi*
Credit: Camm Swift

History of the Fisheries

Some of the California gobies have both sport and commercial value as aquarium and baitfish, although the fisheries are minor. The bluebanded and zebra gobies have striking "blaze" orange coloration with neon blue stripes that make them attractive aquarium fishes. They are occasionally sold in marine aquarium fish stores and are often used for educational displays in marine educational facilities. Blind gobies live commensally with burrowing shrimp and also are often displayed in artificial, transparent burrows with innkeeper worms or burrowing shrimp.

At least two other larger goby species are used for bait. The longjaw mudsucker was harvested from the salt ponds in southern San Francisco Bay for many years, and when local stocks diminished, fish were imported from southern and Baja California. Anglers often catch their own with minnow traps in coastal salt marshes. The mudsucker's tolerance for a wide range of salinities and ability to obtain oxygen from the air allows it to survive under a wide range of conditions of use and transport. It is used for live bait for striped bass, sturgeon, and catfish in San Francisco Bay, and for largemouth bass and other large freshwater game fish throughout the state, including the Colorado River. Mudsuckers were introduced into the Salton Sea in the 1930s, still thrive there, and are used for bait for orangemouth corbina. Fortunately mudsuckers do not reproduce in strictly freshwater situations such as rivers and lakes, where they are often released (illegally) by anglers. The other large goby used for bait is the introduced yellowfin goby which individual anglers trap for use in San Francisco Bay. Shrimp trawlers in San Francisco Bay are allowed to retain and sell gobies for bait, and much of their catch is comprised of yellowfin gobies. Annual catches of mudsuckers have been reported to over 6,000 pounds. A dozen individuals average about one-half pound, therefore estimated annual catches may be as high as 150,000 individuals

Status of Biological Knowledge

The yellowfin goby, longjaw mudsucker, and longtail goby reach lengths of eight inches or more. The other California goby species may attain four inches. The longtail goby is very rare in California, invading from the south as far north as the Los Angeles area during occasional intense El Niño events. Although it is the longest California goby (to 12 inches), it is not common enough to be used for bait. The 1998-1999 El Niño invasion of longtail gobies made one year class relatively common, although no evidence of local reproduction had been detected by the end of 2000.

The greatest value of the gobies is ecological by transferring food energy from the lowest levels of the food chain upward into the top predators valued by society. All California gobies eat very small shrimp, beach hoppers, worms, snails, and other animals. In turn gobies are important food for juveniles of California halibut, striped bass, staghorn sculpin, steelhead, and undoubtedly, many other larger predatory fishes important in California fisheries. In southern San Francisco Bay, the yellowfin goby is the most common prey of harbor seals. Many mudflat feeding shore birds prey on the species of burrowing bay gobies along with burrowing invertebrates, such as clams and the innkeeper worm, as the fish often inhabit the burrows made by the invertebrates. Because they are often in burrows, the tremendous numbers of gobies present in estuaries has not been appreciated.

At least one species of introduced Asian gobies, the shimofuri goby, has been shown to compete with native gobies in captivity, and the extent of their effects in natural habitats is not well documented. The appearance of the yellowfin goby coincided with the disappearance of the tidewater goby in tributaries of San Francisco Bay. The much larger yellowfin may have contributed to this disappearance. Fortunately, while the yellowfin goby has spread into most of the larger tidal estuaries of California, it rarely occurs or does not become established in the small, often brackish coastal lagoons where the tidewater goby abounds. The continued existence of the tidewater goby probably partly depends on this apparent inability of the yellowfin gobies to become established in smaller brackish lagoons. The tidewater goby was designated a federally endangered species in 1994 after many years of state protection. Its restriction to the brackish portions of estuaries made local populations vulnerable to extirpation. Without a significant marine stage in its life-cycle, populations that become extirpated rarely if ever re-establish. As a federally listed species it has an indirect economic impact since any development in or near its habitat must take the fish's needs into account. Thus, it adds another element to the many already involved with coastal development in California. The fact that mudsuckers began to be imported from Mexico in the mid-1960s indicates that California stocks may have been overfished, but changes in mudsucker populations have not been documented.

All gobies are distinguished by having the pelvic (ventral) fins fused into a disc that often supports them on the substrate. The species are distinguished by size (noted above), presence or absence of eyes in adults, size of dorsal fin, amount of space between the dorsal fins, pigmentation features, tooth shape, presence and development of scales, and the configuration of lateral line pores on the head. Several of these features change with growth, and small individuals often require careful examination under magnification to satisfactorily identify them. In dietary studies of larger predatory fishes, digestive processes often leave only the otoliths, or ear bones, which can be diagnostic to the species level as well.

Gobies feed on almost any animal that they can subdue and swallow, including small fishes, in the case of larger species. The species of Tridentiger have minute forked or trifid teeth (with three tines to the fork) often found in plant feeding fishes, but their diet is largely animal in origin as far as is known.

Reproduction in gobies occurs in a burrow or crevice in the substrate where one of the parents, usually the male, guards the elongate, club-shaped eggs distinctive for this family of fishes. Each egg has a clump of fine hair-like sticky filaments at one end for attachment to rock or even sand grains in the walls of the burrow. The male guards from a few hundred to a few thousand eggs depending on the size of the species and the eggs typically take five to 10 days to hatch. The larvae leave the protection of the burrow and enter the plankton for an unknown period of time, probably a month or less. Most California goby larvae are restricted to coastal areas except for blackeye, bluebanded, zebra, and bay gobies that regularly occur in oceanic plankton samples as well. These latter four species are the most marine of California goby species. Goby larvae settle to live on or in the substrate for the rest of their life. The sexes are separate except in blackeye gobies which change sex with age, turning from female to male (protogynous), and the bluebanded and zebra gobies, which have both male and female gonads functional simultaneously (hermaphroditic). All gobies are territorial in the breeding season with the males defending a small territory where the crevice or burrow for the eggs is found. In the tidewater goby and possibly other species of bay gobies, the females are more strikingly colored and aggressive than the males during the breeding season, a condition rare in the animal kingdom. All but one California goby species have only slight sexual dimorphism outside the breeding season. The one exception, the longtail goby, has a striking contrast in color and length of the tail between the male and female.

Some of the species seem to be territorial all of the time whereas others move around with the tides or the seasons at least within bays and estuaries. The sedentary species probably spend their whole life within a few square meters or less of substrate. Blind gobies probably spend most of their lives in the burrow of one shrimp. Because of their small size gobies are difficult to tag and monitor for movement from one place to another. The small species are probably mostly annual species, living only one year. This has been confirmed for arrow and tidewater gobies. The other species, particularly the larger

ones like mudsucker and yellowfins, may live for a few years. This reflects two life-history strategies. Small fish mature early, spawn multiple times, and have an almost complete annual turnover of the population. The larger gobies mature later, spawn less frequently, and may live multiple years.

Status of Populations

Accurate local population estimates have not been made for any of the gobies. This is partly because the numbers of fish present varies greatly with the season, particularly in the small, annual species. In small coastal lagoons in southern and central California numbers of tidewater gobies can go from a few thousand in early spring, after winter flushing of lagoons, to several hundred thousand in late fall before onset of winter storms. In larger tidal estuaries sampling of small enclosures of a few square meters or yards on mud and sand flats has produced good estimates of the local density of small species like arrow gobies, ranging from 11 to 43 fish per square foot of substrate. These efforts have not been carried out long enough or with sufficient precision to determine changes in numbers of fish over several years time. The endangered status of the tidewater goby was justified by the loss of whole individual populations, usually coastal lagoons. Each site was seldom if ever recolonized because of the lack of a marine phase in the life history of this goby. This approach measured the decline of the species by the irreplaceable loss of populations despite the fact that large numbers of fish occurred at some localities at least seasonally. Many of these same populations overwintered with much smaller numbers of fish. The introduced species of gobies all increased rapidly to large numbers in San Francisco Bay, presumably soon after being introduced. No reduction in native species has been documented despite considerable monitoring in the San Francisco Bay region. The yellowfin goby was one of the few fish species not declining in the Sacramento-San Joaquin estuary in the mid-1990s. The shokihaze and shimofuri gobies are still in their expansion phases, have invaded freshwater more than the yellowfin and chameleon gobies and their impacts are still uncertain.

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