Proceedings, California and the World Ocean Conference
March 24-27, 1997, San Diego CA.

Tidewater Goby *(Eucyclogobius newberryi)* Management in California Estuaries

Mark H. Capelli[1]

Abstract

The Tidewater goby is a small brackish water fish endemic to California estuaries. Loss and degradation of California estuaries has reduced historically suitable habitat and resulted in the extirpation of over half of the disjunct populations within the specie's known range. Remaining habitat is threatened by a variety of on-going habitat modifications, including artificial breaching of sand and cobble berms which seasonally form at the mouths of most estuaries and create the brackish water regime requisite for the Tidewater goby. Breaching causes rapid fluctuations in water salinity levels, as well as in the amount of suitable habitat, which can adversely impact the reproductive and recruitment life phases of the species. The classification of the Tidewater goby as a federally endangered species creates challenges for the management of naturally restricted estuarine habitats along the California Coast. Alternative approaches to controlling water levels and other factors affecting artificially managed estuaries are necessary to protect the small suite of endemic estuarine species such as the Tidewater goby.

Introduction

Coastal streams along the 1000 mile coast of California terminate in estuaries ranging size from several square kilometers to a few square meters. Those seasonally closed off to the ocean with a sand and cobble berm provide a protected habitat of brackish water for a small estuarine species, the Tidewater goby, which is restricted to the coast of California. These estuaries lie within the California Coastal Zone established by the California Legislature in 1976, and are subject to the planning and regulatory authority of the Commission pursuant to the California Coastal Act of 1976 (California Legislature 1976, 1997).

1. Coastal Program Analyst, California Coastal Commission; Lecturer, Environmental Studies Program, University of California, Santa Barbara, CA

Because many California estuaries are surrounded by urbanized areas, or areas occupied by recreational or agricultural uses, elevated water levels which develop following the seasonal closure of the mouths of estuaries often create problems for adjacent landowners, including flooding, odors, and an increase in insect vectors. The pooling of polluted waters can also create problems for fish and wildlife and recreational activities involving water body contact. As a result, artificial breaching of the mouths of estuaries has become a common means of controlling the water levels and increasing tidal flushing in many California estuaries. Artificial breaching of closed estuaries by mechanical means can result in the sever alteration of the amount and quality of brackish water habitat, affecting both reproductive behavior and subsequent recruitment of Tidewater gobies. The California Coastal Commission has addressed the conflicting interests in the maintenance of estuarine water levels using a variety of management techniques.

Tidewater Goby Distribution and Habitat Characteristics

Tidewater gobies have been reported from estuaries in California ranging from Tillas Slough at the mouth of the Smith River (Del Norte Co.) to Agua Hedionda Lagoon (San Diego Co.). The distribution of the Tidewater goby corresponds to the distribution of sand deposition within the littoral cells along the California coast. These cells supply the sediment which facilitate the seasonal formation of sand and cobble berms which close off the mouths of most California estuaries for a majority of the year (California Department of Navigation and Ocean Development 1977; Cooper 1967; Swift 1975).

The distribution of Tidewater goby populations along the California coast is marked by several large geographical gaps. The geographical gaps north of Tomales Bay (Marin Co.), as well as between San Francisco Bay and San Gregorio Creek (San Mateo Co.), and between the Salinas River (Monterey Co.) and Arroyo del Oso (San Luis Obispo Co.) may be natural, due to the precipitous nature of the coastline and the absence of estuaries with extended periods of seasonal closure to the ocean. The gap south of Agua Hedionda Lagoon (San Diego Co.) may be the result of pre-World War II extirpations, but no historical occurrences of Tidewater gobies have been documented to date (Ballard and Swift 1996; Swift 1975; Swift et al. 1989; Swift, personal communication.).

Estuaries which provide suitable Tidewater goby habitat exhibit a brackish water regime ranging from 5 to 20 ppt, with Tidewater gobies displaying a preference for salinity levels between 10 and 15 ppt. Extensive brackish water areas are generally associated with estuaries which develop a seasonal

sand and cobble berm at their mouths. Estuaries with a more permanent connection with the ocean have a more saline water regime (20 < 33 ppt) and often do not support Tidewater gobies. Where the build up of a seasonal sand and cobble berm creates a brackish water regime throughout the estuary, Tidewater gobies may utilize the entire estuary, including vegetated backwater areas. In larger estuaries with prolonged exposure to tidal action Tidewater gobies are generally restricted to the upper reaches of the estuary near the freshwater-saltwater interface. Estuaries supporting Tidewater gobies vary in size from a few square meters to several square kilometers. Today most estuaries supporting Tidewater gobies are small, ranging from approximately 1 to 2 hectares (Ballard and Swift 1996; Swenson 1995; Swift et al. 1989).

Figure 1. Malibu Creek Estuary, Los Angeles County. Typical Tidewater goby estuarine habitat is closed to the ocean by a seasonal sand and cobble berm until naturally breached by winter run-off. Natural breaching pattern of this estuary has been altered by upstream wastewater discharges and mechanical breaching practices.

Tidewater goby habitat is naturally subject to considerable seasonal fluctuations. This variability is most strongly affected by the Mediterranean climate which is characterized by a short wet winter and a long dry summer. In coastal California a majority of the precipitation falls between December and February, and frequently during a few brief storms lasting three to five days. Little or no rain falls between March and November. As a result of

this climatic regime, the freshwater flows into estuaries are episodic, and frequently of short duration. The mixed semi-diurnal tidal regime along the Pacific coast, with two unequal high and low tides per twenty-four hour period, results in frequent changes in the salinity levels of the estuary when the mouths remain open to the ocean.

Following winter rains, upstream flows decline sufficiently by April or May to allow the surf and littoral current to build up a sand and cobble berm at the mouths of the estuaries. The seasonal formation and natural breaching of the sand and cobble berms at the mouths of California estuaries is also influenced by the marked winter/summer seasonal variations in littoral sand movement along the California coast. During the winter months steep high energy waves erode sand from beaches and berms and facilitate the natural breaching of the sand and cobble berms at the mouths of estuaries. During the summer months shallow low energy waves move sand from off-shore sand bars landward and build up deposits of sand and larger sediments along beaches and berms at the mouths of estuaries (Davis 1985; Komar 1976).

Under natural conditions estuarine water levels during the late spring through early winter months remain relatively stable as a result of a balance between upstream freshwater inflow, evaporation, and percolation through the porous sand and cobble berm. Occasional surf washing over the sand and gravel berm during the summer and fall, along with percolation of marine water through the berm, into the estuary also helps sustain the mildly brackish water regime required by the Tidewater goby (Smith 1990; Swift et al. 1989).

These seasonal variations in freshwater inflow from rivers and streams during the spring, summer, fall, and winter months, coupled with changes in the wave climate and mixed semi-diurnal variations in tides, results in the prolonged closure of most California estuaries to the ocean. The closure of the estuary during the late the spring, summer and fall months and the gradual conversion of the estuary from a marine to a low salinity brackish water regime creates a maximum amount of suitable spawning and rearing habitat for the Tidewater goby (Josselyn and Zedler 1990; Shapovalov and Taft 1954; Smith 1990; Swift et al. 1989).

Tidewater Goby Natural History

The Tidewater goby *(Eucyclogobius newberryi)* is one of six species of gobies native to California, and one of only three fish species along the Pacific coast dependent upon a low salinity water regime. The other two species of estuarine fishes of California which are dependent upon low water salinity (Delta smelt *Hypomesus transpacificus* and Splittail *Pogonichthys macrolepidotus*) are known only from the fresh and brackish waters of the

Sacramento-San Joaquin Delta of San Francisco Bay (Moyle 1976). As such, the Tidewater goby is an important indicator of the health of the unique low salinity brackish water conditions characteristic of California estuaries.

The other native gobies (Arrow goby *Clevelandia ios,* Cheekspot goby *Hypnus gilberti*, Shadow goby *Quietula y-cauda*, Bay goby, *Lepidogobius lepidus*, Longtail goby *Gobionellus sagittula*, and Longjaw mudsucker *Gillichthys mirabilis)* generally do not occupy the same niches as the Tidewater goby. Three of these goby species (Shadow, Cheekspot, and Bay gobies) are found in more marine intertidal habitats and have not been collected with the Tidewater goby. The Longjaw mudsucker is strongly associated with fresh water, and the Longtail goby is apparently extinct in California (Swift et al. 1989, 1993; Swift and Ballard 1996).

The Tidewater goby is a relatively small and inconspicuous species which may be confused with other commonly associated species such as the Longjaw mudsucker *(G. mirabilis)*. Both males and females vary in color from translucent gray brown to olive with darker mottling, and are marked with a distinctive white or clear tipped spinous dorsal fin. Tidewater gobies reach a maximum length of 50 millimeters. Tidewater gobies generally occur in 1 to 2 meters of standing water over a sandy or mixed sandy/silty bottom. They are weak swimmers, and generally avoid swiftly moving waters which can act has a velocity barrier preventing movement upstream of the estuary (Swenson 1995; Swift et al. 1989).

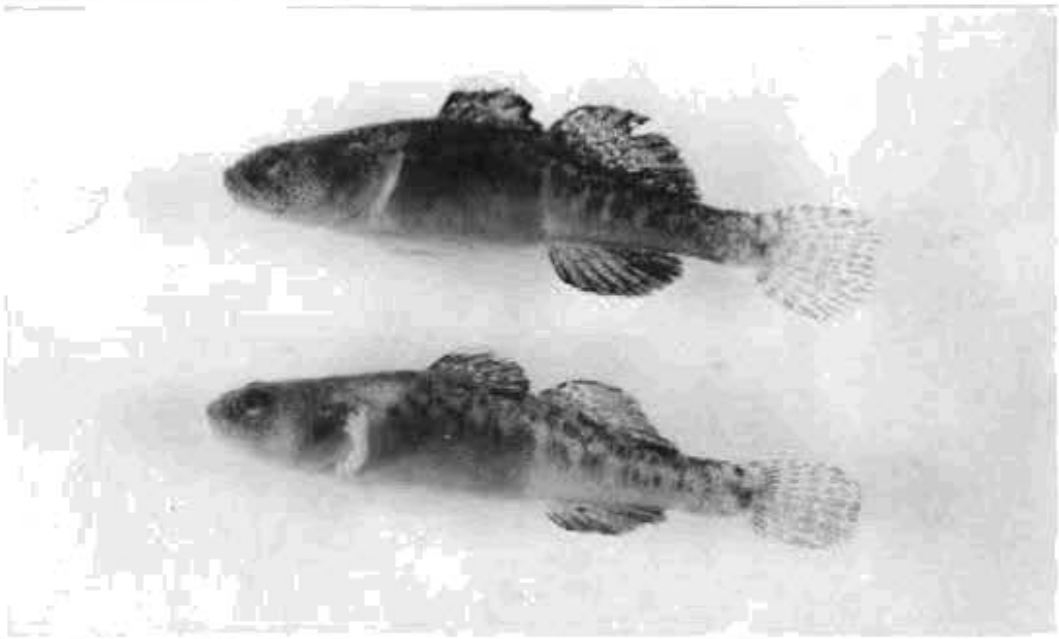

Figure 2. Adult Tidewater goby *(Eucyclogobius newberryi)* from Aliso Creek Lagoon, Orange County. Top: Female, c. 38 mm. Bottom: Male, c. 40 mm. Photograph courtesy Camm C. Swift.

The Tidewater goby is a short lived species, with a majority of individuals completing their life cycle within one year. The life cycle of the Tidewater goby is closely tied to the annual hydrologic cycle of California estuaries, with successful recruitment dependent on an adequate amount of spawning habitat and a suitable salinity regime during the reproductive and rearing period. Spawning is most prevalent from spring to mid-summer when most California estuaries are naturally closed to the ocean and exhibit low-salinity brackish water conditions. Spawning is generally halted by the onset of colder weather and the first winter rains which result in breaching of the sand and cobble berm and the temporary conversion of the estuary to fresh water. However, spawning activity may persist into early fall and winter if water temperatures remain warm, and freshwater inflow is not increased sufficiently to breach the sand and cobble berm at the mouth of the estuary (Swenson, 1995, 1997; Swift et al. 1989).

Before spawning, males excavate breeding burrows in clean, unconsolidated sand. Females aggressively compete with other females for access to the males with burrows. Females lay between 400 and 600 eggs per clutch, which are attached to the sand grains in the ceiling and walls of the burrow. Tidewater gobies typically produce multiple clutches (4 to 6) during the spawning season. The eggs are tended by the males, which may simultaneously support several clutches from different females. Tidewater goby eggs hatch in 7 to 9 days depending on water temperature. The young remain planktonic for several days before becoming benthic oriented. Tidewater gobies become sexually mature within three to six months, depending on the timing of hatching, and the rearing conditions (i.e., water temperatures, salinity regime, and available food supply). Juveniles and adults feed on a wide variety of non-marine benthic invertebrates, including ostracods, amphipods, snails, and chironomid larvae and pupae (Swenson, 1995, 1996, 1997; Swift et al. 1989).

The Tidewater goby spends its entire life cycle within the estuary, though there are records of fish moving several kilometers upstream in shallow gradient streams such as San Antonio Creek, Santa Barbara County (Ballard and Swift 1989; Swift, personal communication). The lack of a marine phase in the life history suggest that there is little likelihood that populations from disjunct estuaries form metapopulations. This isolation is supported by genetic investigations which have identified fixed allelic differences between the extreme northern and southern populations, and some variation in populations from the central portion of the goby's range (Crabtree 1985). However, recent recordings of Tidewter gobies from sites from which gobies had apparently been extirpated during the 1987-92 drought suggests that there may be some recolonization and/or genetic exchange between populations from nearby estuaries (Ambrose 1995; Ballard, personal

communication).

Habitat Modifications

Populations of Tidewater gobies have suffered declines in parallel with the degradation of California coastal wetlands. It has been estimated that approximately 75-90% of the original estuarine wetland acreage of California has been lost since 1850 (California Department of Fish and Game 1983; California Department of Parks and Recreation 1988). Of the 110 sites from which Tidewater gobies have been historically reported, 55 sites (51%) currently do not support Tidewter gobies (Ballard and Swift 1996). Recent regional investigations, however, have reported Tidewater goby populations from estuaries where the species was previously thought to be extirpated (Ambrose 1995; Ballard personal communication).

Encroachment of development, channelization of coastal streams, diversion of surface flows, groundwater extraction, importation of point and non-point sources of pollution (including sedimentation), and the introduction of exotic species of plants and fishes have all contributed to the loss of estuarine habitat and the extirpation of individual populations of Tidewater gobies (Ballard and Swift 1996; Ferren et al. 1995, 1996).

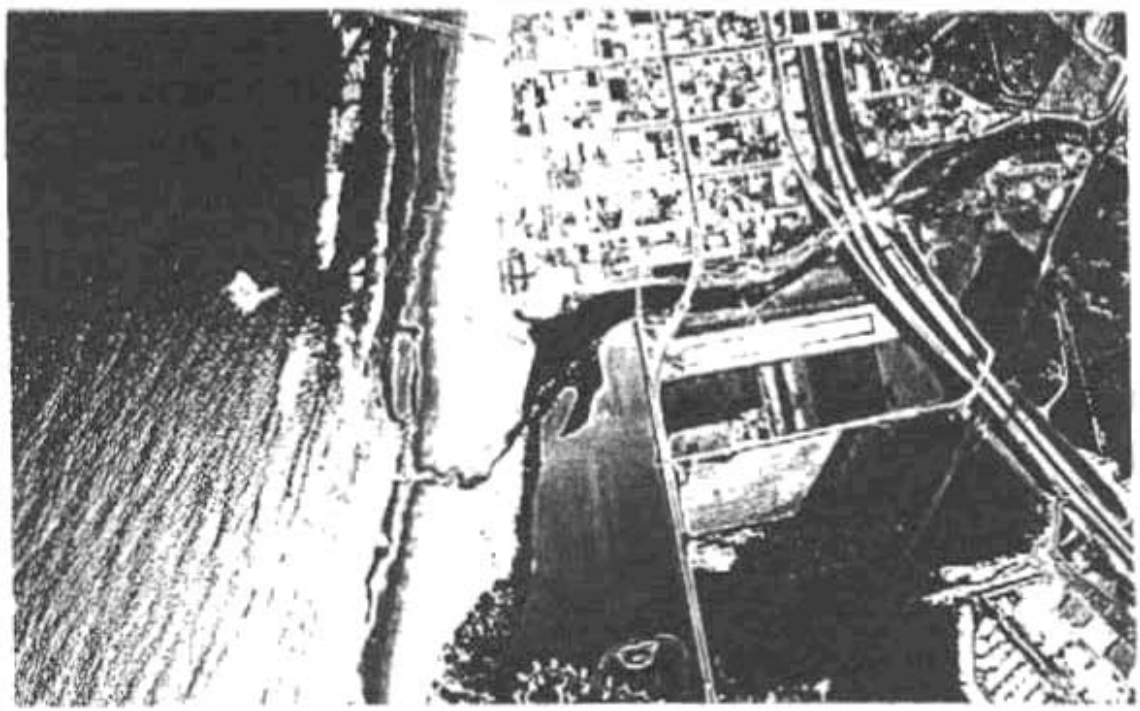

Figure 3. Pismo Creek Estuary, San Luis Obispo County. Urban development encroaching on the coastline of California has exacerbated conflicts between habitat maintenance and adjacent land uses. The agricultural field adjacent to the mouth of the estuary has been converted to recreational uses since this photograph was taken in 1973.

The mouths of some estuaries have also been modified through the installation of jetties which have resulted in the permanent opening of the mouth and the conversion of the seasonal brackish water regime to a permanent marine water regime unsuitable for Tidewater gobies. In several instances Tidewater gobies in artificially created tidal conditions have become extirpated after a few years of exposure to continuous tidal flushing. Examples of estuaries which formerly supported Tidewater gobies before permanent artificial modification of the mouths include Morro Bay Estuary, Carpinteria Salt Marsh, Goleta Slough, Mugu Lagoon, and the Santa Margarita River Estuary. Other estuaries which have been subjected to regular and frequent artificial breaching and no longer support Tidewater gobies include Freshwater Lagoon, Ten Mile River, and the Elkhorn/Bennett Slough. Humboldt Bay is the only remaining tidal system which currently supports Tidewater gobies (Ballard and Swift 1996; Swift, personal communication).

Figure 4. Ormond Beach Estuary, Ventura County. Hand-dug channel between Ormond Beach Estuary and ocean, cut to lower lagoon water levels.

In addition to the widespread loss of estuarine habitat, the viability of remaining Tidewater goby habitat is threatened by the practice of artificially breaching the seasonal sand and cobble berms which form at the mouths of estuaries. The methods of breaching the sand bar can involve the use of mechanical equipment (e.g., bull-dozer or back-hoe), or can be accomplished with hand-tools (e.g., shovel, hoe, or stick). Because of the ease of digging through unconsolidated sand and the elevated water level of the estuary above the adjacent marine water, cutting a small channel several inches wide

and deep can initiate a flow from the estuary to the ocean which can quickly expand the channel through erosion and result in the rapid draining of the estuary. Draining can be particularly catastrophic if the artificial breaching occurs during minus or low tide conditions. While the sand and cobble berms may reform relatively quickly (within a few days or weeks), if breaching occurs during the spring or summer months when freshwater inflow is substantially reduced, estuarine water levels may stabilize at a significantly lower level (Smith 1986, 1990; Smith and Robinson 1987; Swift et al. 1989).

Artificial breaching of estuaries through mechanical means has become an increasingly common practice as a result of development encroaching into periodically flooded areas. Artificial breaching of estuaries is undertaken for a variety of reasons: to lower water levels which inundate adjacent land uses (e.g., agricultural, residential, commercial, and recreational), to reduce surface water areas supporting mosquitoes or other insect vectors; to improve water quality in the estuary by increasing tidal circulation; to increase recreational birding activities by exposing mud-flat habitat; to alter the configuration of off-shore sand bars to improve recreational surfing conditions; and to induce the upstream movement of anadromous fishes for sport fishing. Some of these activities are conducted by state or local governmental authorities as part of routine maintenance activities, while others are carried out by private individuals without supervision or authorization.

The life-cycle of the Tidewater goby is adapted to the natural seasonal breaching cycles of estuaries but can be disrupted by artificial breaching, particularly during the spring and summer. Breaching results in immediate reduction in the depth and aerial extent of the estuary. Because the water level in closed California estuaries is generally several feet above mean sea-level, and as much as 6 feet above lower-low mean sea-level, breaching can result in the complete draining of the estuary. Sudden lowering of water levels can sweep Tidewater gobies into the marine environment, or strand fish in shallow pools or on exposed substrates, increasing their vulnerability to predation by shore and other water birds. The sudden artificial breaching of the estuary mouth, unlike natural breaching in response to rainfall and increased runoff, provides no natural cues which may allow Tidewater gobies to seek refuge in backwater or marginal areas of the estuary.

The artificial draining of a closed estuary in late spring or summer may result in the estuary being dominated by marine water for extended periods until winter run-off increases the inflow of freshwater into the estuary. Marine water is denser than freshwater and will dominate the lower depths of the estuary directly over the substrate where Tidewater gobies congregate. This

marine water acts as a solar collector heating up and reducing oxygen levels, and thus providing sub-optimal or lethal conditions for the Tidewater goby. The sudden influx of marine water as a result of artificial breaching can also sharply reduce the abundance of non-marine invertebrates which provide the primary food source for the Tidewater goby.

Artificially breaching the lagoon during the spring, summer and fall seasons can adversely affect the reproductive and rearing life-history phase of the Tidewater goby. Lowering of water levels can expose juveniles and incubating eggs in breeding burrows to the air, leading to desiccation and death (Smith 1990; Swenson 1995; Swift et al. 1989). Recent research has indicated that vegetated areas at the margins of the estuary serve as refugia for rearing Tidewater gobies. These areas can become isolated from the main water body of an estuary as a result of artificial breaching and draining, thus depriving Tidewater gobies of productive rearing sites and effective protection from predators (Swenson 1995; Worcester 1992).

The natural pattern of breaching of estuaries (i.e., timing, frequency, and location of breaching) has been further modified as a result of changes in the watersheds of California estuaries. Upstream water withdrawals as a result of both surface diversions and groundwater extractions has resulted in lowering the input of freshwater into some estuaries, reducing estuarine water levels, and delaying the conversion from a marine to a low-salinity brackish water regime following the closure of the mouth. In some cases, summer base stream flows have been substantially increased as a result of upstream municipal wastewater discharges, particularly in southern California. These flows have modified the natural breaching regimes of estuaries by advancing the timing and increasing the frequency of spring and summer breachings (Ballard and Swift 1996).

Coastal Commission Jurisdiction

The California Coastal Commission has both planning and regulatory authority within the Coastal Zone. Landward of the mean high-tide line this zone varies from as little as 100 yards, to over five miles; seaward of the mean high-tide line the zone extends three miles. The Coastal Zone includes every estuary within California, with the notable exception of San Francisco Bay, which is outside the Coastal Commission's jurisdiction, and is governed by the San Francisco Bay Conservation and Development Commission.

Under the California Coastal Act, the Coastal Commission retains permitting authority over historically tidally influenced lands, and appeals jurisdiction over those areas which are generally seaward of the first public road paralleling the coast. As a result, the Commission has in may cases

exclusive, state land use regulatory responsibilities over the habitat of the endangered Tidewater goby. Specific policies of the California Coastal Act provide for the protection, and where feasible, the restoration of the biological productivity of coastal waters, including streams, wetlands, and estuaries. Additionally, the Coastal Act places stringent limits on the diking, filling, or dredging of coastal wetlands, including estuaries. Where there are conflicts between the protection of natural coastal resources and other Coastal Act objectives (e.g., protection of agriculture or recreational opportunities), the Coastal Act provides that "such conflicts be resolved in a manner which on balance is the most protective of significant coastal resources." (California Legislature 1976, 1997)

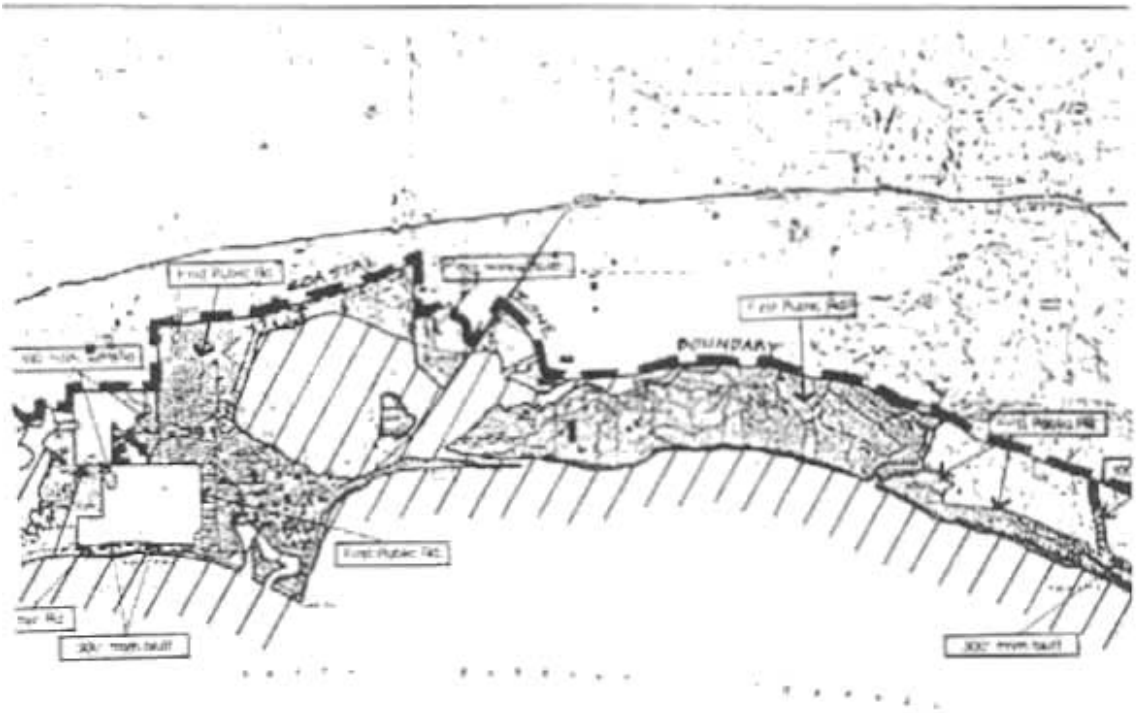

Figure 5. Coastal Zone along a portion of the California Coast from Coastal Oil Point to Summerland, Santa Barbara County. Original permit jurisdiction (cross-hatched lines), and appeals jurisdiction (shaded area).

Tidewater Goby Management Issues

Management of Tidewater gobies is inseparably linked to the management of California's remaining estuaries. Maintenance of water quality (through regulation of point and non-point sources of pollution), prevention of the physical modification of habitat (through regulation of filling, ditching draining, and disturbance of native vegetation), regulation of consumptive and non-consumptive human uses (through regulation of fishing, claming,

swimming, and boating), and the control of exotic species (through regulation of the release of fishes or amphibians, or the introduction of non-native plants), is critical for the maintenance of Tidewater gobies, as well as a suite of other native estuarine species. Control of fine sediments originating within the watershed is also important to ensure that the sandy substrate preferred by Tidewater gobies is not overlain with muds and silts.

Maintenance of the hydrological regime is recognized as the single most important objective in preserving the composition and ecological functions of estuarine habitat (Macdonald 1977; Mitsch and Gosselink 1996; Onuf 1987; Onuf and Zedler 1987). Of particular importance for the maintenance of Tidewater gobies is the regulation of water levels and salinity regimes in estuaries (Smith 1990; Swenson 1995; Swift et al. 1989).

One rationale for artificially breaching of the seasonal sand and cobble berms at the mouths of California estuaries has been the improvement and maintenance of water quality, particularly in southern California estuaries, where depressed dissolved oxygen levels as a result of eutrophication is a common phenomenon. In many estuaries regular tidal flushing has been accomplished by dredging extensive areas of the estuary to increase the tidal prism and through the construction of jetties at the mouths of estuaries. While the direct physical impacts on estuarine habitat of some of these practices have been questioned, the maintenance of regular tidal flushing in California estuaries, which naturally experience protracted seasonal closure of the mouth and only irregular tidal flushing, has frequently been viewed as an acceptable management strategy for the maintenance of water quality in California estuaries (Elwany et al. 1997).

This view reflects a more general tendency to view the functions of Pacific coast estuaries in terms of Atlantic coast estuarine systems. Recent investigations of Pacific coast estuaries, particularly in central and southern California, however, have emphasized important differences between Pacific and Atlantic coast estuarine systems (Ferren et al. 1995, 1996; Josselyn and Zedler 1990; Lewis 1995; Zedler et al. 1992). Atlantic coast estuaries have developed on a tectonically divergent coast with a broad continental shelf, and a temperate climate. They are characterized by extensive intertidal floodplains which are subjected to both regular fresh-water inflow and a simple diurnal tidal regime. As a result, they are subjected to daily inter-change between the terrestrial and marine hydrologic systems. Pacific coast estuaries have developed on a tectonically convergent coast with a narrow continental shelf, and a Mediterranean climate. Many small California estuaries are formed at canyon mouths and do not have extensive intertidal floodplains. Almost all Pacific coast estuaries experience only episodic fresh-water inflow, and a short seasonal connection with the ocean (Davis

1985; Macdonald 1986).

A result of the recent listing of the Tidewater goby as an endangered species, the disruptive effects of artificial breaching of estuaries supporting populations of Tidewater gobies are being more carefully scrutinized, and alternative methods of controlling water levels are being explored (U.S. Fish and Wildlife Service 1994). Artificial breaching activities which had been previously undertaken without regulatory review are increasingly being subjected to the California Coastal Commission's regulatory process, and estuarine management plans are being developed to address the control of estuarine water levels (Habitat Restoration Group 1994; Swanson and Associates et al. 1993; Philip Williams and Associates 1993).

The California Coastal Commission has reviewed and provisionally approved a number of techniques for controlling estuarine water levels to protect Tidewater gobies from the adverse effects of artificial breaching. These include: regulating the frequency and timing of breaching (e.g., Russian River, Lake Earl and Lake Talawa, Salinas River, Carmel River), redirecting the location of breaching (Malibu Creek), installing a sill at the mouth to limit the level of drainage (e.g., Soquel Creek), and installing temporary culverts in the sand berm at a set elevation to limit the level of drainage (e.g., San Lorenzo River, Batiquitos Lagoon). The Commission has also considered proposals for installing pumps to allow the regulated lowering of estuarine water levels (e.g., Ormond Beach Lagoon). None of these efforts have monitored on a long time basis and their long-term cumulative effects is unknown. (California Coastal Commission 1992, 1993a, 1993b, 1996a, 1996b, 1996c, 1997a, 1997b, and 1997c).

Discussion

The listing of the Tidewater goby has focused renewed attention on the management of California's estuaries, particularly the management of the hydrologic regime. Of particular note has been the attention paid to small estuaries - including those measuring only a few square hectares - which have been frequently been over-looked because they do not provide habitat for significant numbers of estuarine species.

Inducing regular tidal flushing has been frequently viewed by estuarine managers as a useful, and in many cases necessary strategy, for the maintenance of ecological functions of California estuaries. The effects of artificial breaching of naturally closed estuaries on species such as the Tidewater Goby which are sensitive to sudden changes in the estuarine water regime will require a re-examination of this management technique. The regulation of water levels in estuaries through artificial breaching for flood

Figure 6. Ormond Beach Estuary, Ventura County. This estuary had been regularly breached for flood control and mosquito abatement before the discovery of Tidewater goby. With the cessation of breaching the estuary has expanded from less than 1 acre to over 20 acres. Expansion has impinged on flood control facilities and adjacent lands.

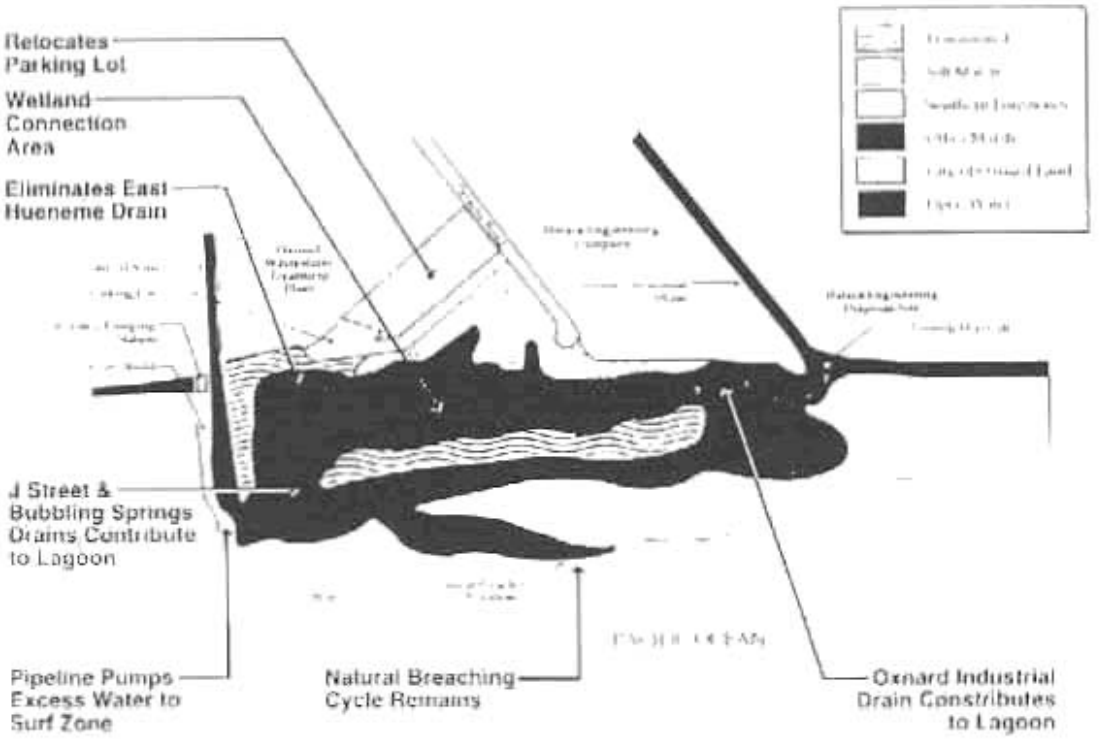

Figure 7. Ormond Beach Estuary, Ventura County. Conceptual proposal to regulate water levels in the estuary through the installation of water pumps to discharge estuarine water into the surf zone (Impact Sciences, Inc. 1995).

control, mosquito abatement, and various recreationally related purposes must be reconciled with the habitat requirements of the Tidewater goby and a suite of other estuarine species which are sensitive to salinity levels.

Alternative means of addressing conflicts between Tidewater goby habitat requirements and adjacent land uses should be explored. These include controlling the amount and quality of upstream waste discharges, and modifying land uses to accommodate naturally fluctuating estuarine water levels. Where artificial breaching is necessary to address problems associated with the natural seasonal rise in estuarine water levels, artificial breaching patterns should mimic natural breaching patterns to the maximum extent practicable to minimize impacts to the spawning and rearing phases of the Tidewater goby. Mechanical breaching of the sand and gravel berm provides the least control over the ultimate reduction of estuarine water levels and should be used only when other methods are not practicable. Complete draining of the estuary, in particular, should be avoided; this can be achieved to some extent by breaching at the onset of a rising high-tide to minimize the elevational difference between the water level in the estuary and the adjacent ocean.

Each estuary presents a unique set of circumstances which must be evaluated in terms of over-all management objectives of the estuary. In assessing the effects of artificially lowering estuarine water levels on Tidewater goby, the effects on other fish species must also be considered. Of particular importance are anadromous fishes such as Chinook salmon *Oncorhynchus tshawytscha*, Coho Salmon *O. kisutch*, and Steelhead trout *O. mykiss* which utilize estuaries for portions of their life-cycle (e.g., rearing, acclimating to fresh or marine water). Finally, other species such as the California least tern *Sterna antillarum*, Belding's savannah sparrow *Passerculus sandwichensis beldingi*, California clapper rail *Rallus longerostris obsoletus*, and Light-footed clapper rail *R. longerostris levipes*, are also depedent on estuarine habitat and sensitive to suden changes in estuaring water levels (e.g., post-hatch feeding of juvenile Least terns) and therfore must also be considered in the regulation of estuarine water levels.

As one of the few species in California that is restricted to a low salinity brackish water habitat, the Tidewater goby is a significant component of the estuarine community. Historically Tidewater gobies were one of the most abundant small fishes in California estuaries and have played important roles as both a secondary invertebrate predator and as prey for other estuarine species of fishes and birds. The Tidewater goby's decline can be an important indicator of the general health of individual estuaries, and its loss could have subtle but significant effects on the over-all ecological functioning of California's remaining estuaries.

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