California's Coastal Wetlands

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Introduction

The coastal wetlands of the world range in variety and frequency of occurrence from those typically abundant along the highly-glaciated coasts of Norway and British Columbia and along the subsiding (or subject to rising sea level) coasts of western Europe and eastern North America, through those of the extensive Mississippi delta or the humid tropic Sundarbans of the Ganges, to the sparse few wetlands characteristic of the steep, tectonically active and geologically younger coasts of Peru, the Red Sea, and California.

In general, the wetlands of the world in very recent geological times have been in almost unprecedented jeopardy, for the last several thousand years have been a period of unusual stability of sea level. The persistence of the wetlands of California, however, is even more precarious, for the slight general rise in world-wide sea level, which elsewhere maintains water levels above accumulating sediment, is almost precisely compensated by coastal land rise.

As a result of a number of unique factors acting in concert, the wetlands of California constitute a particularly precious and valuable yet vulnerable resource. The narrow coastal reach, which divides six thousand miles of ocean from three thousand miles of continent, and especially in its southern part, is particularly desirable for homes, recreation, and industry. This coastal strip and its rare oases for migratory water fowl and shore birds are thus subject to the concerted impacts of sea, flood, sedimentation, and man. The resultant conflicts and struggle for understanding, guidance, and a wise approach to management, so vital to the future of California's coastal wetlands, are set forth with admirable perspective and balance in this discussion of Coastal Wetlands.

JOHN D. ISAACS
Director
Institute of Marine Resources

Because of its low salinity, Buena Vista Lagoon in San Diego County supports a large population of freshwater-loving cattails.

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Railroad trestle at San Elijo Lagoon

The Coastal Wetlands: A Balance of Perspective

To most Californians, the phrase "coastal wetlands" brings to mind diverse and varied images. A wildlife enthusiast may think of acres of marshland habitat for migratory shorebirds. A biologist may recognize areas of unique ecological and scientific interest. A developer may see the wetlands as potentially important shoreline property for houses, condominiums, and marinas. But to those people involved with managing the future of California's coastal zone, the wetlands represent the challenging problem of how to best balance development to serve human needs while preserving natural resources.

California's coastal wetlands are the shallow-water marshes and tideflats of coastal lagoons, estuaries, and sloughs. Traditionally considered to be little more than swamps, coastal wetlands once were routinely filled for highways, airports, or refuse disposal sites or were drained to control mosquito populations. They are the areas still eagerly sought after by developers in the attempt to meet an increasing public demand for shore facilities. Dredging and filling of shallow-water marshes is often economically attractive to many dry-land developers who calculate — correctly — that the extraordinarily high market value of dry coastal land offsets dredging and filling costs. The wetlands that were filled to build San Francisco International Airport, for example, were appraised by the San Mateo County assessor at an original land value of $2,000 per acre. After reclamation, this value jumped to an industrial land value of $200,000 per acre.

Divergent uses and needs for the wetlands have brought conservationists into conflict with private developers. Caught in the middle have been the federal, state, and local agencies ultimately responsible for determining how the wetlands will be used. Most of the involved parties agree on one point: the total coastal and estuarine area in California has been reduced by 67 percent — from 381,000 acres at the turn of the century to a present total of 125,000 acres.

Rising public interest and new political emphasis in protecting California's coastal zone have brought many of the management problems associated with coastal wetlands into sharp focus. As mandated by the Coastal Act of 1976, local coastal planning must now meet development concerns in a manner that "assures orderly, balanced utilization and preservation of coastal zone resources." The Act emphasizes that conservation of the wetlands and special kinds of development should be made compatible.

But according to many coastal planners, determining whether a wetland should be left unaltered, or modified, or converted into expensive shoreline property is a difficult task. "No single factor can give us an index of

"Divergent uses and needs for the wetlands have brought conservationists into conflict with private developers . . ."

Eureka Harbor Marina, Humboldt Bay

"For California, management isn't a matter of wise husbanding of a large and exploitable resource . . . rather it's a matter of preserving and restoring a very meager and severely threatened resource."

ecological value," says one biologist presently studying California's coastal wetlands. More complicated still is the question of what might be the possible "opportunity cost," or the cost in terms of possible recreation benefits, as a result of keeping the wetlands unaltered. For boating facilities alone, the California Department of Boating and Waterways projects that by 1980 there will be a demand for over 97,000 new small-craft berthing spaces on the California coastline. The least expensive way to accommodate this demand, according to many developers, other than by using open-water waterways is by dredging coastal wetlands.

Seven state and federal agencies are currently involved in some aspect of coastal wetlands management. The agencies include the State Coastal Commission, the Coastal Conservancy, the California Department of Fish and Game, the State Lands Commission, the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, and the Environmental Protection Agency. As the first step to making the right management decisions, some of the agencies and the California Sea Grant College Program are actively sponsoring research projects in an attempt to create a "bank" of scientific information on California's wetlands. Some agencies are firmly committed to acquiring or restoring those wetlands that have been altered either naturally or by human intervention. All share the understanding that wetlands management must now involve balancing economic, social, and environmental goals.

"No single factor can give us an index of ecological value."

A Dynamic "Edge" Between Land and Sea

California's 2,400-mile marine shoreline borders a vast and diverse land region that extends from the steep, rocky headlands of the north coast to the semi-arid coastal plains and terraces in the south. More than 1,000 miles is ocean coastline backed by cliffs and bluffs, cut across by narrow river valleys and occasional expanses of sandy dunes and beaches. An additional 1,400 miles of shoreline border inland bays, estuaries, lagoons, sloughs, and tidal creeks.

California's 110 coastal wetlands* are also diverse — in size and in physical, chemical, and biological nature. They cover a broad range of types — from those that border the tidal-flushed river mouths in the north to the many closed, saline lagoons and embayments of southern California. But just as there are also many closed lagoons in northern California, so are there several open ones in southern California. Geologists maintain that this diversity is to be expected since the California coastline is actually the leading edge of a slowly-shifting continental land mass where two factors, sea level and elevation of the adjoining land, are in a constant flux.

Richard Phillips, coordinator of the Environmental Studies laboratory at the University of San Diego, has done extensive research on the natural history of California's coastal wetlands. Says Phillips, "The coastal wetlands in California are relatively recent features of our geography. They owe their existence to the rapid rise in sea level that accompanied the last retreat of the glaciers at the end of the Ice Age."

Phillips refers to a time in history when modern-day wetlands were bays and had many of the characteristics of the open ocean. However, Phillips and his team of researchers have found that this situation changed rather rapidly. As the rise in sea level subsided, longshore transport by waves deposited beach material such as sand, shingle, or cobbles at the mouth of inlets while streams and rivers deposited sediment at the heads of bays. "A dynamic equilibrium seems to have been established as the wetlands approached the state that we find them in today," says Phillips. "There is evidence that this equilibrium may last for many hundreds of years unless upset by man."

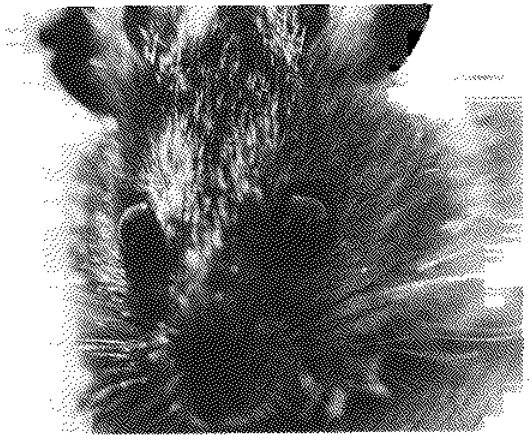
Subtle changes occur as part of the natural adaptability of life within coastal wetlands. They are tolerant of a wide range of natural variations in salinity, temperature, and the amount of oxygen received. This diversity and changeability of California coastal wetlands, however, has created problems in developing wetland management programs. Environmentalists frequently use the prototype of a "pristine" wetland, often the kind found on the eastern coast of the United States, to argue that coastal wetlands in California be "restored" to that same natural condition. Jeffery Frautschy, assistant director of the Scripps Institution of Oceanography and a geologist who has studied extensively changes in California's coastline, points out the problems associated with this point of view.

"Change is a way of life for a California wetland . . . Long-term stability is both exceptional and unnatural," says Frautschy, pointing to Tijuana Estuary in San Diego County as an example of a wetland that has undergone extensive change. "Within a few hundred years, the Estuary has gone through a cycle of being alternately opened and closed to tidal flushing," he says.

Frautschy emphasizes that what resembles an East Coast wetland today may yesterday, in terms of recent geology, have been a seasonally dry and dusty salt flat or for that matter a brackish-water pond, a freshwater pond, or a salt pond. Any of these variants could be considered "pristine" insofar as they existed without human intervention.

"If there were a single end result in wetlands management to be sought, the

*(see map on page 31)



The endangered salt marsh harvest mouse is one of the few mammals able to drink saltwater.

The coastal wetlands serve as resting, feeding, and nesting areas for many birds.

The endangered light-footed clapper rail

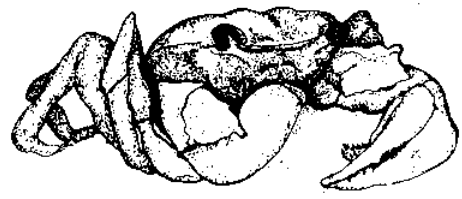
task would be less controversial," maintains Frautschy. "Instead we have to take a case-by-case approach in making management decisions. What we should probably be trying to achieve in any management program is the stabilization of those environmental characteristics that make the wetland environment attractive to humans and to those plants, animals, and birds that we especially appreciate and value."

Weighing the values that wetlands provide and then managing for a specific set of values is now the concern of California coastal planners. In the past, wetland scientists have provided much of the necessary information for making such decisions on the East Coast, emphasizing the five natural values of coastal wetlands: as shoreline buffers to reduce the impact of storm tides and waves, as natural filters to absorb pollutants, areas to absorb floodwater, sources of nutrients for the coastal ecosystem, and as important wildlife habitats. Conservationists have pointed out that wetlands offer additional values as outdoor education laboratories* and as areas providing aesthetically-pleasing open space.

But many scientists studying California's coastal wetlands maintain that these values are just now being determined and that, in many cases, have not been scientifically documented. John Clark, the executive secretary of the National Wetlands Technical Council, offers the following perspective: "The wetlands protection movement has been propelled by the hunches and instincts of some scientists and an overwhelming public support. There are intangible values perceived by the public — a wetlands ethic."[1]

One tangible value that California's coastal wetlands provide — and what many scientists think is the most important one — is their present value as natural wildlife habitat. Five endangered animal species — the light-footed clapper rail, the California clapper rail, the least tern, Belding's savannah sparrow, and the salt-marsh harvest mouse — exist only in the coastal wetlands. In addition, over 1 million migratory shorebirds use coastal wetlands for essential resting, feeding, and nesting grounds as they follow annual migration routes from their northern breeding grounds in Alaska to winter in California's coastal zone. The open water and tidal flats of the wetlands are also used by many types of waterfowl and diving birds, including ducks, grebes, loons, and gulls. As many as 240,000 of these birds use the coastal wetlands during the course of a year, feeding in open water on small fish and in the tidal flats on the crabs, clams, and worms that dwell beneath the mud.

"We shouldn't underestimate the importance of the coastal area and especially of the wetlands to migratory bird populations," says John Wolfe, a fish and wildlife biologist with the U.S. Fish and Wildlife Service. "We've ranked on a national scale the most important wetland areas that we feel should be preserved as migratory wintering habitat. The California coast is ranked third out of thirty-three such areas nationwide." According to Wolfe,



Striped Shore Crab
(Pachygrapsus crassipes)

[1] John R. Clark, quoted in "Efforts to Save Wetland Systems are Bogged Down," *Conservation Foundation Letter* (October 1978): 2.

*(see listing of Interpretive Programs on page 34)

the Fish and Wildlife Service is interested in acquiring "key" wintering habitat areas in California that are unprotected by local ordinances or state jurisdiction. Of the 70,000 unprotected acres that have been identified to date, the Service proposes to acquire and preserve 60,000 acres as part of its Migratory Bird Land Acquisition Program.[2]

Wolfe stresses the delicate interrelationship that many types of wildlife have with coastal wetlands and, specifically, how eliminating one wetland may affect animal populations at large. He asks, "If we destroy just one of the coastal wetlands that migrating birds use as an essential refueling stop during the course of a long migration route, how can we be sure that we haven't destroyed the benefits that were provided by an entire chain of coastal wetlands? We are just now becoming aware of how the natural values of the wetlands are but part of a much larger picture."

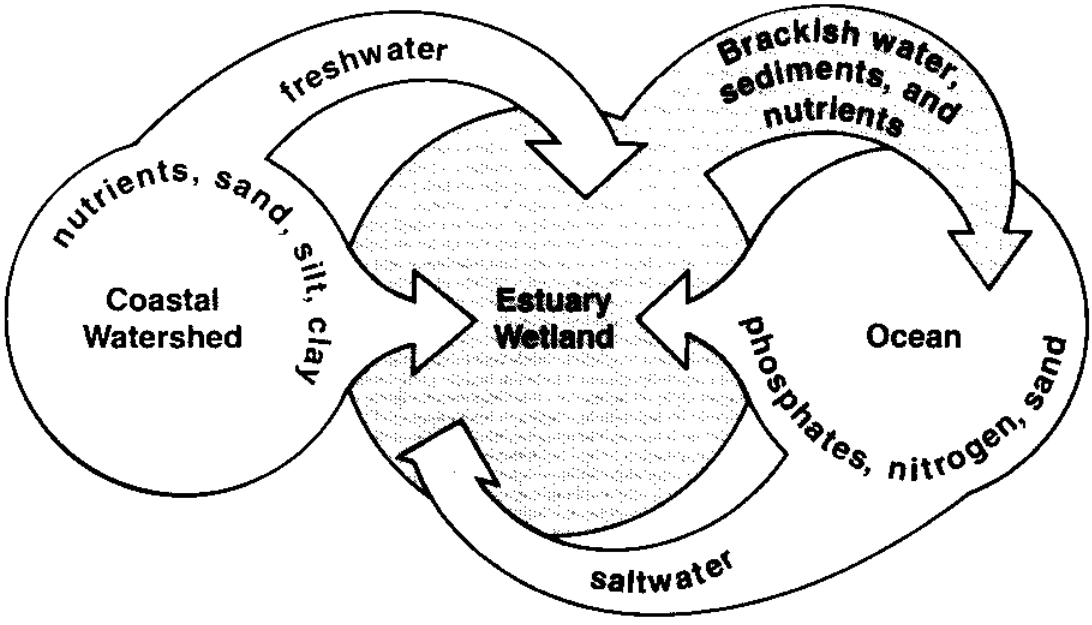
The larger picture Wolfe refers to is made of both offshore ocean and the upland watershed. In the past, management of coastal wetlands has often dealt only with the wetland area itself, rarely considering how the offshore ocean and upland watershed might change the same variables — salinity, temperature, and oxygenation — that, in turn, affect the wetland. Resource managers have debated among themselves in determining how much upland area can be modified without affecting land adjacent to it. Recently, managing the entire watershed has become important as biologists realize that often the value of a wetland cannot be measured by the surface area of its water alone.

As Wolfe points out, "If we're going to manage for a dynamic, biological system where the animal populations are often mobile, as in birds and fish, we can't just limit the area of the wetland to 100 acres, or to any other number. We have to consider the adjacent upland and also manage that ecosystem to the best of our ability."

Periwinkle on Cordgrass

[2] U.S. Department of the Interior, Fish and Wildlife Service, "Concept Plan for Wintering Waterfowl Habitat Preservation" (draft copy) 1978.

The Coastal Estuary: A Dynamic Edge Between Land and Sea



As freshwater flows from the coastal watershed to the estuary, either by river flow or underground flow, it carries with it sand, silt, clay and dissolved nutrients. At the same time, the shores of the estuary are alternately flooded and exposed during each tidal cycle. This incoming saltwater distributes sand, nitrogen, and phosphates throughout the estuary. Sediment and sand deposits from both these freshwater and saltwater sources eventually settle out to form the shallow geologic base for the estuarine wetland. There is a net transport of material to the sea.

The Productivity Question

Dr. Joy Zedler and Dr. David Mauriello, biologists at San Diego State University, have information that may help answer many of the biological questions that local planners encounter when dealing with the complex wetland environment. The researchers have been measuring the "productivity" of southern California estuaries in order to determine whether wetlands contribute significant amounts of nutrients to the estuarine food web—and possibly to the entire coastal ecosystem.

Zedler explains that live plant and animal material within a wetland is decomposed over time into dissolved chemicals, gases, and "detritus," small organic particles that, along with phytoplankton and algae, serve as the base of the wetland food web. In an estuary, a wetland usually exposed to either periodic or permanent tidal flushing, the daily flow of the tides transports this organic matter throughout the estuary itself where it is fed upon by clams, crabs, worms, and small fish. Many filter-feeders such as mussels and oysters circulate and "inhale" the water to breathe, and in the process collect and consume the detritus.

Iceplant, a coastal succulent

They are in turn fed upon by predatory fish and the shorebirds including herons, egrets, and grebes that nest in the surrounding marsh grass. Other birds, usually migratory shorebirds including the endangered least terns and pelicans, feed upon the small fish that are attracted to the wetland by the abundance of food.

Zedler emphasizes that productivity has been used in the past by legislators and conservationists to assess a dollar value to each wetland habitat, since the wetlands are often in direct competition with profit-making development enterprises. Wetland advocates cite information, such as that collected by ecologist Eugene Odum, that places monetary values on south Atlantic and Gulf Coast marshes and estuaries. Odum finds that his data show Georgia salt marshes to be at least twice as productive as fertile hay field harvests.

"West Coast wetlands have been assumed to be as productive as wetlands on the East Coast," says Zedler, referring to Odum's data. "However, our research at Tijuana Estuary in southern California shows that vascular plants are much less productive, while algae are more productive. While the total productivity comes out about the same, the form of the productivity is very different. We suspect that more food is transferred along the algal-based food chain."

Dr. Robert Holmes and Dr. Christopher Onuf, biologists at the University of California Santa Barbara, agree with Zedler that California wetlands differ from their East Coast counterparts. "For years, the rationale for protecting California coastal wetlands depended on ecological data from the East Coast to make important land-use decisions," says Onuf. "We think, however, that our wetlands differ not only in size and location, but also in function."

Both Holmes and Onuf are collecting data to determine some of the biological criteria needed for coastal wetlands management in central and southern California. As part of their research, they are studying the importance of coastal wetlands as nursery grounds for commercial fish stocks — a value often attributed to productive East Coast estuaries where juvenile fish use the sheltered and nutrient-rich waters of the

estuary to grow to commercial fishing size.

Onuf points out the problems of comparing wetlands of both coasts. He says, "In drawing this kind of analogy, we have to keep in mind that wetlands are rare to the California coastal environment; California has only one-tenth of the wetlands acreage found in an area of similar latitude, such as that between Rhode Island and South Carolina. Because of this, we doubt that wetlands in California have the same importance as fish spawning and nursery sites as East Coast wetlands. That value seems to be restricted to a relatively few wetlands and to only a few species of fish."

According to Holmes and Onuf, the wetlands in their study area are probably not important to coastal fish populations because they receive little continuous freshwater inflow and have a tendency to close, thus preventing fish access to the open sea. The researchers also point out that smaller baitfish such as topsmelt and slough anchovy, rather than larger commercially valuable fish, are more dependent on the wetlands environment and spend a larger part of their life cycle

Unlike ordinary plants that wilt and die when placed in saltwater, pickleweed has successfully adapted to its salty environment.

within the wetland. Future research to determine which wetlands are essential to offshore fish populations, suggests Onuf, may have to look to the north coast of California where the influence of freshwater is stronger and at bigger bays with larger channel openings to the sea.

The kind of information that is being collected by Zedler and Mauriello at San Diego State University and by Holmes and Onuf at the University of California Santa Barbara is needed by local coastal planners who must decide how to manage the wetlands within their coastal area. Too often maximizing all the values of a wetland is impossible; coastal planners must critically examine those values before deciding whether a wetland will be dredged to open lagoon channels, dredged and filled for a new marina, or maintained in an unaltered state. Holmes and Onuf emphasize the need for careful consideration of all the values: "For California, management is not a matter of wise husbanding of a large and exploitable resource . . . rather it is a matter of preserving or restoring and maintaining a very meager and severely threatened resource."[3]

Snowy Egret

[3]C.P. Onuf, et al, "An Analysis of the Values of Central and Southern California Coastal Wetlands." Paper presented at the American Water Resources Association National Symposium on Wetlands, Lake Buena Vista, Florida, Nov. 7-10, 1978.

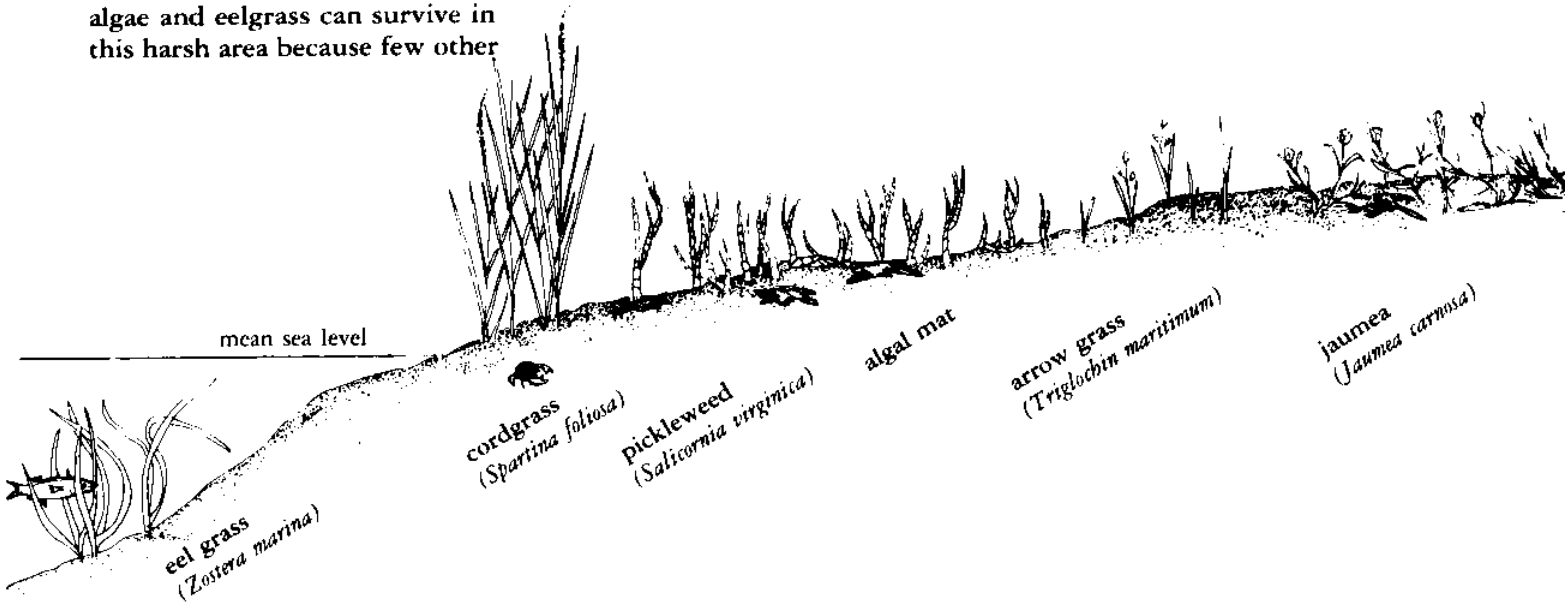
A Plant Community in a California Coastal Wetland

California's coastal wetlands, like the wetlands of the East and Gulf Coasts, are the setting for a diverse plant community. This diversity reflects the complexity of the wetland environment where tide action, salinity, temperature, and elevation play key roles in determining which plants occur in the wetland area.

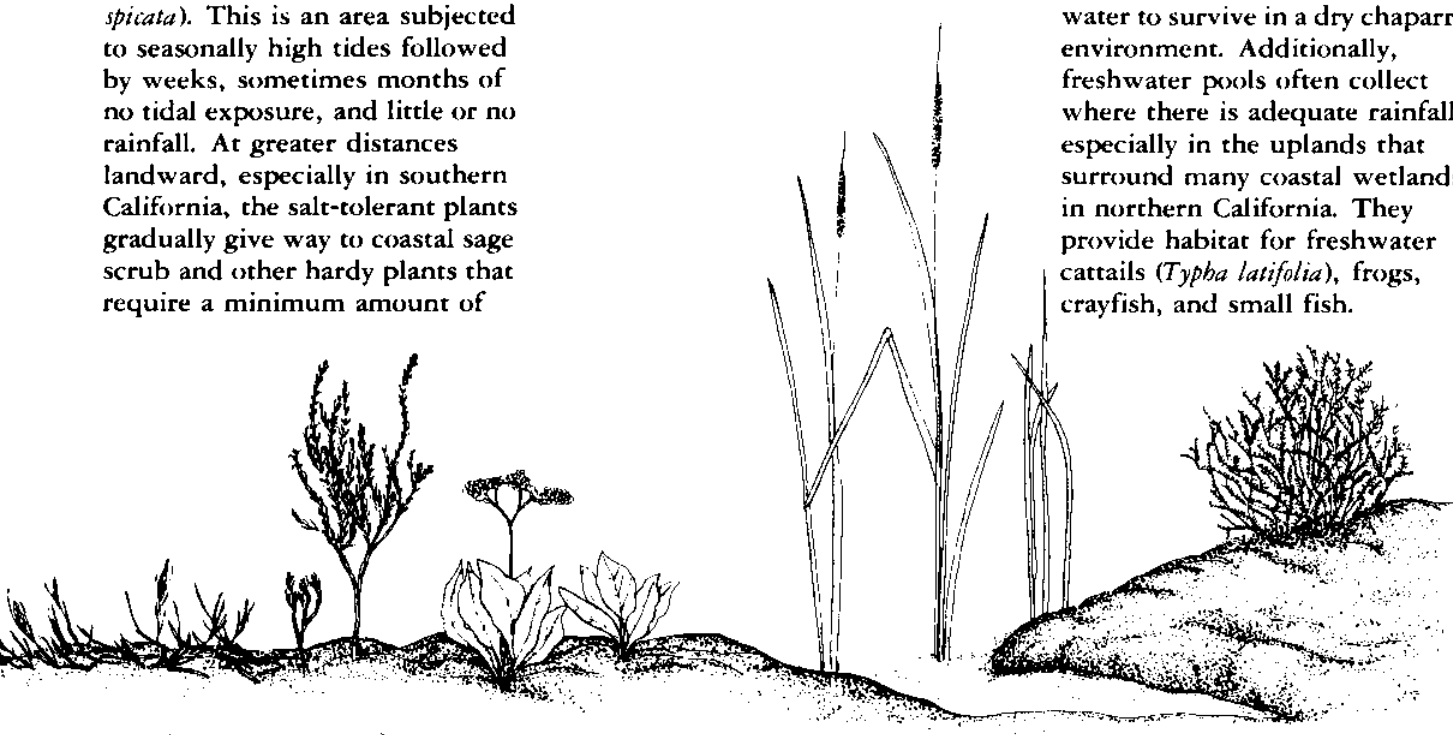
Below the limits of the low tide are the deep, submerged lands that are constantly covered by saltwater — the marine zone. Often, only a dense population of algae and eelgrass can survive in this harsh area because few other plants can tolerate the continuous exposure to high concentrations of salt.

Between the lines of high and low tide is the area that is alternately submerged and exposed twice a day by incoming tides. In those California coastal wetlands that are shallow and flat, this area is dominated by a particular marsh grass, cordgrass (*Spartina foliosa*), that requires adequate tidal flushing for survival. Many California coastal wetlands, however, slope steeply upward and receive less exposure to the tides. These wetlands are dominated by various succulents, including the fleshy, green pickleweed (*Salicornia virginica*) that has developed survival mechanisms to withstand long periods without exposure to the tide.

At the upper reaches of the high tide and landward, pickleweed becomes more interspersed with sea-blite (*Suaeda californica*), arrow grass (*Triglochin maritimum*), and salt grass (*Distichlis*



spicata). This is an area subjected to seasonally high tides followed by weeks, sometimes months of no tidal exposure, and little or no rainfall. At greater distances landward, especially in southern California, the salt-tolerant plants gradually give way to coastal sage scrub and other hardy plants that require a minimum amount of water to survive in a dry chaparral environment. Additionally, freshwater pools often collect where there is adequate rainfall, especially in the uplands that surround many coastal wetlands in northern California. They provide habitat for freshwater cattails (*Typha latifolia*), frogs, crayfish, and small fish.



Coastal erosion at San Elijo Lagoon

Stresses on the Wetlands: A Question of Limits

Life in California's coastal wetlands adapts to sudden — and often large-scale — natural disturbances as wetlands progress from one geologic stage to another, changing with time to meet the sudden impacts of heavy storms, a massive inflow of sediment, or a drastic change in temperature and salinity. As with the study of other natural systems, scientists are still trying to determine how adaptable the coastal wetlands are to another kind of disturbance — human disturbance — and what the limits are to this adaptability. The question is a complex one, but the answer may provide the biological criteria necessary for effective wetlands management.

How does ecological "disturbance" get measured? Dr. Joy Zedler, presently studying southern California estuaries, agrees that there are limits to how much stress a coastal wetland can tolerate. "When we placed mussels into a relatively undisturbed estuary," says Zedler, "we saw them grow fairly fast. But when we placed mussels into water from a highly modified wetland which had been repeatedly dredged for recreation purposes, they didn't grow well. Something vital for rapid growth of the mussels was missing.

According to Zedler, dredging and filling if used indiscriminately can seriously alter the wetland habitat. Dredging is frequently used to create deep navigation channels in bays and estuaries for shipping and recreational boating. The increased suspended sediment caused by dredging may degrade water quality and destroy mud-dwelling animals. Filling a wetland often alters the natural current and water circulation patterns within the wetland — making it impossible for many plants to receive adequate nutrients and oxygen.

The effects of dredging and filling a wetland can also be complicated by a sudden influx of pollutants. When water polluted by excessive amounts of agricultural fertilizer and sewage run-off, for example, enters a wetland, marsh plants can filter and absorb many of the pollutants as nutrients. But like any filter there is a limit to how much pollution the wetland can absorb and still function effectively. Too many pollutants can lead to water rich in dissolved nutrients but at the same time deficient in oxygen, since decomposing plant material may require more oxygen than is present in the water. Toxic poisons including pesticides, industrial residues, and chemicals that leach from boat-hull paint, can pollute a wetland for many years.

As mandated by the Federal Water Pollution Control Act of 1972, the U.S. Army Corps of Engineers must "restore and maintain water quality" by regulating the discharge of dredged or fill materials into waters of the United States and their adjacent wetlands. As part of its responsibility to protect water quality, the Corps issues permits to developers after numerous state and federal agencies, including the California Department of Fish and Game, the U.S. Fish and Wildlife Service, and the Environmental Protection Agency, review potential impacts on wetlands as a result of the proposed dredging or filling activity. The permit is granted only after the developer assures that any important wetland values, including those in the public interest such as maintaining water quality, will not be destroyed or that suitable compensation — either in terms of dollars or mitigation — will be provided.

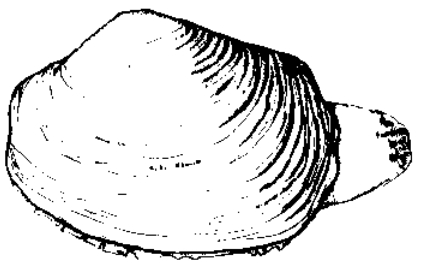
While the Corps' permit system has been favored by conservationists, it has met opposition from many developers and agriculturists who see it as a cumbersome restraint on business. "The debate seems to have obscured the fundamental purpose of the law," notes Edward Thompson, a staff attorney for the Environmental Defense Fund, "to give housing developers and highway planners incentive to finding practical alternatives to avoid damaging wetlands through alternative siting and routing."[4]

An opportunity for evaluating the

[4] Edward Thompson, *National Wetlands Newsletter* 1 (November 1978): 4

positive effects of human alteration of a southern California wetland now exists on the coast of Ventura County at Mugu Lagoon where the U.S. Navy has just completed construction of a new facility for its Pacific Missile Test Center. In order to mitigate the construction impacts, the Navy has greatly enlarged the mouth of the western arm of the lagoon, thereby allowing increased tidal exchange and enlarging the area of the lagoon that is tidally flooded. Drs. Holmes and Onuf learned of the project soon enough to expand their studies of bird utilization of the lagoon to include the areas that will be exposed to greater tidal flushing.

Says Onuf, "Wetlands, when closed off from the ocean as is true for many small southern California wetlands, have very different assemblages of plants and animals than would otherwise occur there . . . Coastal wetlands can be greatly changed by opening them up to the ocean and providing regular tidal flushing. The open mouth allows the removal of accumulated sediments as well as provides access for marine species." At present, Holmes and Onuf have collected 15 months of data for 20 areas covering almost the entire lagoon before the alteration. Eight of the areas will be subjected to increased tidal flushing. Adds Onuf, "Come back in a year or two and we should have some hard data on whether or not the benefits of opening up the lagoon measure up to expectations."



Washington Clam
(Saxidomus nuttalli)

The Eroding Watershed

"Why should we spend millions to restore and maintain a wetland when one storm could wipe it out overnight?"

Local coastal planners are increasingly examining an indirect, but nonetheless significant disturbance of the coastal wetlands — erosion of the upstream watershed.

Geologists emphasize that erosion is normally a natural, geologic process. The amount and intensity of rainfall, erodibility of the soil, the steepness of the terrain, and the amount of protective vegetation are all factors that influence the rate of soil movement.

"Natural sedimentation in California's coastal zone has always occurred . . . it's already turned those wetlands which were once open-water lagoons into shallow marshes, and in places into infrequently inundated salt pans," says Jeff Kennedy, an ecological reserve planner with the University of California Natural Land and Water Reserve System. Kennedy emphasizes that not enough is known about natural sedimentation rates to predict the long-term outcome on many coastal lagoons. But as an example of how fast the sedimentation can occur, he points to Goleta Slough located adjacent to the Santa Barbara Municipal Airport.

"The Slough was once an open harbor for sailing vessels that was used extensively during the nineteenth century until a tremendous storm and flood in 1862 filled the harbor with sediment," says Kennedy. "Since then, further siltation has made the channels no longer navigable and now anyone can easily walk on what was once deep water." Kennedy points out that a Santa

Anaheim Bay in Orange County, once a large and productive marsh area, has been extensively changed by human activities.

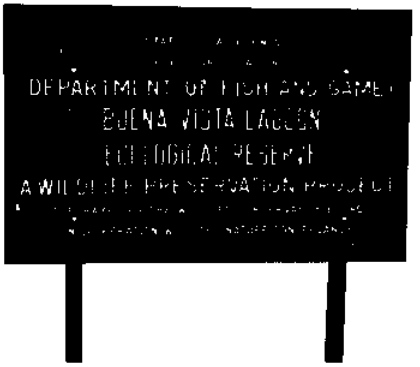
Barbara local historian, Walker A. Tompkins, has documented the change in the Slough. In his book, *Goleta: The Good Land*, Tompkins notes that a railroad trestle that was built ten feet above the ground in 1887 is now completely buried underground.

Two geologists at the Scripps Institution of Oceanography, Dr. Francis Shepard and Gerald Kuhn, are studying how erosion has affected California's coastline and how urbanization is "accelerating" natural erosion rates. According to the researchers, upstream construction, agricultural and urban run-off all increase or decrease the amount of freshwater and as a result, sediment, that flows into an estuary. Says Kuhn, "Rooftops, pavements, and roads — these are all impervious surfaces that increase water runoff by preventing it from being absorbed into the ground."

Kuhn explains that as surface runoff becomes more concentrated on its way downstream, it tends to downcut paths of weakness — such as trails or any natural indentation in the land — carrying with it sediment from eroded drainage channels and unprotected slopes. Often, improper planning of storm drains accentuates the problem, as when drainage pipes are placed at the top of steep and highly erodable bluffs or when they are built on top of the loosely consolidated remains of old landslides. "Unfortunately, when all of this sediment finally settles, it's often in lagoons and other shallow wetland areas," says Kuhn.

Both Kuhn and Shepard are collecting and preparing geological information on San Diego County's coastline in addition to studying how sediment inflow has affected one lagoon, San Elijo Lagoon in particular. As a result of intense development at San Elijo, runoff from construction sites has contributed many thousands of tons of sediment to the lagoon. Kuhn points to a report prepared by the San Diego County Department of Sanitation and Flood Control that illustrates how extensive the problem has been: within a week of a severe storm in 1976, one eroded gulley at the base of a development site yielded 13,000 cubic yards of soil — nearly all of it deposited in the lagoon.

"We suspect that other lagoons in California are undergoing the same sedimentation problems that are occurring at San Elijo Lagoon," says Kuhn. "We hope to use our research as a model that can be applied to other lagoons to see what works and what doesn't work when it comes to controlling siltation and sedimentation."



Recent legislation provides the Department of Fish and Game with funds to manage coastal wetlands as ecological reserves.

Controlling sediment flow is an important aspect of watershed management; yet many coastal planners say that it is often impossible for economic reasons. Implementing a watershed control program for a wetland is often far costlier than acquiring and restoring the wetland to its former condition. Ron Hein, a wildlife manager and biologist with the California Department of Fish and Game, offers the following estimate: "While it may cost 3 million dollars to acquire a wetland and 8 million dollars to restore it, it may cost up to five times as much, or 40 million dollars, to implement adequate control measures for the surrounding watershed."

"Yet, why should we spend millions to restore and maintain a wetland when one storm could wipe it out over night?" asks Hein. "The question is whether we can afford to win the wetland in the short run, but lose to the watershed in the long run."

Hein points out that the cost of using more expensive technologies — such as building dams and drainage channels — can be greatly reduced by relying on "softer," more biological approaches.

Says Hein, "One step toward combating the sediment problem in the future might be to plant buffer strips of vegetation in the uplands that border those wetlands particularly sensitive to sediment deposits. By stabilizing dunes and drifting sands in the uplands, we can slow down the speed of water flow into wetlands — and slow down the cutting effect that it produces on both natural and artificial channels."

The Shore Processes Laboratory at Scripps Institution of Oceanography in San Diego is approaching the sediment problem from another angle. Under the direction of Dr. Douglas Inman, the laboratory is currently testing a device that may aid in promoting tidal flushing of lagoons while removing excess sediment. The device, called a "sand-fluidizer," uses jets of water under high pressure to suspend and simultaneously transport sand away from areas of heavy accumulation towards the ocean. Inman has used his sand-fluidizer to successfully cut an 800-foot channel across the sand and cobble plug obstructing the entrance to Los Penasquitos Lagoon in San Diego County.

Inman explains that the daily tidal flushing of wetlands usually provides enough cleansing action to remove sediment deposits and maintain water quality. But too much sediment in too short of a period of time from either wave-carried sand deposited at the entrance of the lagoon or from artificial landfill can interrupt the natural flushing process. As the sediment builds up, it closes off the entrance to the wetland. In a lagoon, or a wetland with little direct access to the open sea, this isolation, combined with an influx of sewage and urban runoff can severely degrade the environment.

Artificial opening of the channel to Los Penasquitos Lagoon has been attempted in the past, says Inman, using two methods: digging by hand a trench across the closed channel and by mechanically excavating a new channel with a bulldozer. But in these attempts, the lagoon has eventually reclosed, usually within a few weeks. "We now realize how important it is to properly coordinate the opening of the lagoon with the incoming of tides and the outgoing of lagoon water," says Inman. He explains that the channel to Los Penasquitos changes frequently in size and position in response to how much sand is deposited by wave action. As part of his research, Inman is studying the dynamics of sediment transport at the lagoon entrance — measuring how changes in tide and current open and close the lagoon. Inman's sand-fluidizer may be used in the future to open lagoons in California that receive inadequate tidal circulation, particularly lagoons in the many arid parts of southern California.

Not enough is known about how well or for how long coastal wetlands can handle excessive sediment deposits. The problem is of immediate concern to land-use planners, says Thomas Dickert, a professor of landscape architecture and city planning at the University of California Berkeley. Dickert is working with Dr. James Nybakken of Moss Landing Marine Laboratories to measure changes that occur in wetland communities as a result of disturbances, including determining how changes in the amount of sediment that enters a wetland affect biological organisms. But adds Dickert, "We don't want our research to stop at just determining how tolerant a certain organism is to a particular amount of sediment. We hope to take it one step further to answer the question: given information on sedimentation rates, what can a city or county do about it?"

According to the researchers, the Elkhorn Slough watershed in Monterey County is an ideal area in which to conduct their research because it is undergoing intense pressure for development. Over 26 development projects are currently planned within the watershed. Dickert and Nybakken hope to use the Slough as a case-study area to examine existing land-use plans. They will try to determine how various usages of the adjacent watershed will impact the natural system.

Information exchange between scientists, planners, and information technologists is essential to the wise management of coastal wetlands.

Wetlands Management: A "Many-Handed" Responsibility

Two laws — the California Coastal Act of 1976 and the Coastal Conservancy Act of 1976 — now provide a means of resolving conflicting interests in wetlands decision-making. The California Coastal Act of 1976 seeks to "maintain, enhance and restore California's coastal waters, wetlands and estuaries" by specifying that the 69 cities and counties within the coastal zone prepare and implement coastal programs consistent with these objectives. The Coastal Conservancy Act implements a program for assisting local government in acquiring, restoring, and managing wetlands as part of their local coastal programs.

Both acts identify California's wetlands and estuaries as "sensitive natural resource areas" and underscore the urgent need for understanding — both biologically and geologically — how the wetlands function as natural systems. At the same time, the acts create two agencies, the California Coastal Commission and the Coastal Conservancy, to deal with the economic, social, and legal implications of managing such resource areas.

At the heart of many of the management issues that the Commission and the Conservancy must face is the difficult, and often debated, question of which wetlands are subject to the public trust. According to the "public trust doctrine," the State of California must administer tidal and submerged lands for the maximum benefit of the public. This doctrine, based on English common law, ensures that all citizens have equal access to and use of the shorelines and tidal water. Upon admission to the Union in 1850, California acquired title to all previously ungranted tide and submerged lands within its boundaries; some of these were later granted "in trust" to local public jurisdiction.

Traditionally, "tidelands and submerged lands" have been legally interpreted to be those lands lying below or seaward of the line of mean high tide and subject to the daily ebb and flow of the tide. While public trust usually has been claimed in these areas, California courts have taken a more cautious, case-by-case approach to applying public trust law to adjacent wetlands. As a result of many of the uncertainties, a large body of case, constitutional, and statutory law now applies to coastal wetlands. In 1971, the California Supreme Court set an important precedent when it ruled that the public trust issue ". . . is of great public importance, particularly in view of population pressures, demands for recreational property, and the increasing development of seashore and waterfront property.

With the recent surge of public interest in coastal resources, the public trust doctrine has become the focus of intense challenges over the rights of

property owners and the legal responsibilities of state agencies to manage coastal land "for the benefit of the public." At La Ballona Estuary, once the largest wetland area in Los Angeles County but now privately owned, conservation groups are prepared to oppose any move to convert the remaining wetland area into a marina, claiming that the estuary is the richest — and one of the few remaining — sources of birdlife in the metropolitan Los Angeles area.

Legal experts agree that determining whether a wetland is subject to public trust now involves considering a complex set of factors that include historical and physical descriptions of the land in question, boundary and title facts, and upland ownership. An important consideration is often whether the wetland was tideland in 1850 when the State of California assumed title to previously ungranted lands. Conservationists point to an additional factor that must be considered — whether maintaining the land in question is, in fact, vital to the healthy ecology of the adjacent trust lands. The Wisconsin Supreme Court recently upheld this approach in the 1972 court case *Just v. Marinette* when it ruled for strict regulation of wetlands adjacent to a lake subject to the public trust.

The State Lands Commission has jurisdiction over the three million acres of trust tide and submerged lands in California and offshore within a three-mile limit, sometimes leasing such lands to encourage development in the public interest while also conserving and protecting natural resources. Recognizing that a key wetlands management problem is often locating the fine boundaries that exist between tideland and upland, the Commission is using bits and pieces of historic and current information to prepare a report, and eventually a master map of such boundaries in California. But, says, Larry Fenske, a boundary determinations officer with the Commission, "This process is a difficult one because we don't really know much about how natural and artificial processes have altered the coastline. Sometimes settling a boundary dispute just becomes a matter of arbitration and, finally, agreement between the upland owner and the state."

Ghost shrimp are but one of the many burrowing inhabitants of coastal mudflats.

Management in Action

Managing the coastal wetlands "in the public interest" is a problem faced by local coastal planners who, as mandated by the Coastal Act of 1976, must prepare land-use plans for the wetlands within their jurisdiction. The management issue is complex, both biologically and politically. Too often local coastal planners are unaware of current scientific research that may be helpful in accomplishing these management objectives. At the same time, scientists are often unsure of how to apply their research to answering many of the practical — and often urgent — concerns of land-use planners.

"The problem is often a lack of information exchange on what could be called the 'information triangle,'" says one environmental planner. "At each angle, I place one of three groups necessary for effective wetlands management: scientists, policy-makers and information technologists — including librarians and bibliographers. Only by establishing communication between all three angles of the triangle can we somehow hope to draw the right connections between human activities and biologic impacts."

Two Sea Grant-sponsored projects are among those presently aimed at making scientific information more accessible to local coastal planners.

James Pepper, environmental studies professor at the University of California Santa Cruz, is preparing a coastal wetlands information directory that he thinks may help solve one problem often encountered by coastal planners: the need to make management decisions quickly and efficiently.

"Public planning agencies are short on time," says Pepper, "but if they know of specific information in the department, they use it. Rarely do they have time to go outside the agency and run through lists of experts." Pepper's directory will aid planners and other professionals in reaching more informed decisions by improving information exchange between management and scientific communities. To date, the directory includes compiled bibliographies for 12 California coastal wetlands.

In response to an urgent appeal of many scientists, planners, and state agencies, the State Coastal Commission and the California Sea Grant College Program recently co-sponsored a series of "wetlands workshops" to assist local governments in the preparation of wetlands management plans and to establish contact between scientists and local resource managers. The two workshops, held in Los Angeles and San Diego presented an opportunity for focusing on each wetland individually and assessing the impacts — both present and future — on each wetland system. The workshops emphasized that managing the wetlands, as in managing any other natural resource, is a function of how well information is transferred between all angles of the complex triangle of managers, scientists, and technologists.

Bays and estuaries, such as San Pablo Bay, San Francisco Bay, and the coastal estuaries at Bodega Bay, provide important nursery areas for a large portion of the Dungeness crab taken commercially.

Two agencies in particular, the California Department of Fish and Game and the U.S. Fish and Wildlife Service, are currently committed to identifying and protecting wetland habitats to ensure that fish and wildlife resources will be available for the enjoyment of future generations.

The U.S. Fish and Wildlife Service is conducting an inventory of all wetlands within the United States. Using

high-resolution aerial photography and modern computer mapping, the Service plans to locate, map, and classify the nation's wetlands as an aid to its own wetlands acquisition program and to provide a national information service for local coastal planners.

The California Department of Fish and Game has responded to public concern for the future of coastal wetlands by implementing an extensive acquisition and restoration program. Through the efforts of the Wildlife Conservation Board and in close cooperation with the State Lands Commission, the Department leases key parcels from willing parties and assumes management responsibility for these areas under long-term lease agreements. This responsibility includes providing plans for a wide range of wetlands use including hunting, fishing, birdwatching, nature study, and research.

In a recent transaction by the Department, the San Pablo Bay Wildlife Area in Marin and Sonoma Counties was established. This area comprises over 10,000 acres of tidal marshes, mudflats, and sloughs at the northern tip of San Francisco Bay, which provide habitat for over 200 species of waterfowl and four species of rare or endangered wildlife: the California clapper rail, the black rail, the California brown pelican, and the salt-marsh harvest mouse. Other land transactions by the Department have included acquiring Big Lagoon, a brackish-water lagoon located in Humboldt County, and 800 acres of marshland and tidal flats on Bair Island, located on the west shore of San Francisco Bay. Both areas are acknowledged as valuable wildlife habitats: Big Lagoon supports many shorebirds and mammals such as the Roosevelt elk, blacktail deer, and the mink; Bair Island supports the largest great blue heron and snowy egret rookeries in California.[5]

"Acquisition, however, is not the only answer to wetlands preservation; we can't have every area acquired," says Ron Jurek, an endangered species expert in the coastal wetlands program of the Department of Fish and Game. "We want to encourage local agencies to form resource protection zones through effective legislation."

One state agency in particular, the San Francisco Bay Conservation and Development Commission (BCDC), has been a forerunner in the effort to promote effective wetlands legislation. Before the BCDC came into existence, over 150,000 acres of Bay wetlands had been filled or otherwise destroyed. In 1965, citizen outcry about much of this destruction prompted the State Legislature to create the commission and give it responsibility for wisely managing the future of the Bay, including regulating all filling and dredging of wetlands.

BCDC has taken an active interest in the wetlands management of San Francisco Bay. In conjunction with the Department of Fish and Game, BCDC prepared a protection plan for Suisun Marsh, the largest brackish-water marsh in California and an important winter home for migratory ducks, geese, swans, and cranes. The plan, recently enacted into law, specifies that local coastal planners protect the unique wildlife value of the marsh, while at the same time allow for water-related industrial development adjacent to the marsh.

Many coastal wetlands have been extensively modified by manmade channels and dikes.

[5] Bob Schulenberg, "Preserving California's Wetlands," *Outdoor California* 37 (September-October 1976): 7.

Major California Coastal Wetlands

"It will be up to the people to decide whether there will be coastal wetlands or coastal development, or an admixture of both."

The Future: Citizen Concern and Involvement

What is the future of California's coastal wetlands? How can they be managed to meet the rising demands being made on the coastal zone? And what kind of biological information must be considered? These are the kinds of questions that local coastal planners must answer in their efforts to manage wetlands. While most of them agree that the Coastal Act of 1976 provides an effective framework for answering many of the political questions, they emphasize that many of the biological questions remain unanswered.

Recognizing the "need to raise thinking, policy and action to the ecosystem level," the State Resources Agency recently established a basic wetlands protection policy to be used when authorizing construction on state-owned wetlands. The policy requires that adequate compensation for wetland losses be a part of all coastal development projects.

But according to many California scientists and coastal managers, the word "compensation" is open to broad interpretation. The end result of wetland management, they emphasize, should focus on maintaining or enhancing the "functional capacity" of a wetland, that is, those natural values of a wetland that provide a social benefit. For example, filling a wetland for a marina might be balanced for by planting beds of marshgrass in a previously degraded area of the wetland, by expanding and creating new wetlands by dredging, or by restoring a degraded area within the same wetland. Whichever method is chosen, scientists point out the caution required in such a move to make sure that the end result is equal or better than the original wetland. "The replacement for a destroyed least-tern habitat," notes Bruce Browning, wetlands coordinator for the Department of Fish and Game, "must not only look right but the terns have to accept it as a nesting area — otherwise you're accomplishing nothing."[6]

Efforts are currently underway throughout the state to undo some of the damage of past management practices. At Bolsa Bay salt marsh in Orange County, once an extensive salt marsh that was developed into an oil field during the 1920's, the State of California has received 563 acres of badly-degraded marsh area in a boundary-settlement and land-exchange agreement. On a major portion of the acreage, the Department of Fish and Game has implemented a marsh restoration project to reflood and modify the area into a productive salt-marsh habitat. In San Diego Bay, the United Port District is building an 88 acre artificial island that will provide essential wildlife habitat to replace salt marshes that have been destroyed by past modifications of the Bay. And at San Dieguito Lagoon in San Diego County, the City of Del Mar is working in close association with the Coastal Conservancy to develop a resource enhancement plan to ensure that the lagoon continues to be an important feeding site for the endangered bird, the California least tern.

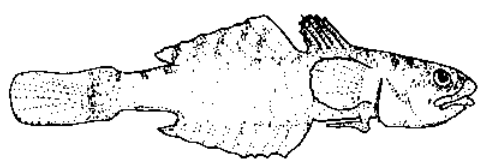
California's Coastal Act of 1976 returns much of the planning responsibility for coastal wetlands to the coastal community. While recognizing the rights of the private property owner, the Act also recognizes that coastal wetlands are a distinct resource of interest to all people. The public participation clause within the Act guarantees that all concerned citizens have the right to review and influence the wetlands program component of local coastal plans. "It will be up to the people to decide," writes Browning, "whether there will be coastal wetlands or coastal development or an admixture of both."[7]

[6] Bruce Browning, quoted by Ed Sylvester, "San Diego Marshes Essential to Wildlife Survival," *The Los Angeles Times*, 12 Nov 1978, p. 5.
[7] Bruce Browning, "Saving California's Coastal Wetlands," *Outdoor California* 38 (May-June 1977): 5.

Interpretive Programs for the Public

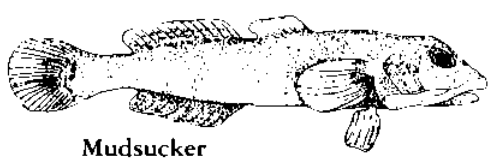
Interpretive programs for the public are offered free of charge at the following coastal wetlands in California. Contact the sponsor for more information and reservations.

SPONSOR	LOCATION
Bodega Bay Institute 240 Fort Mason San Francisco, CA 94193	Bodega Bay (Sonoma County) San Francisco Bay Tomales Bay (Marin County)
Border Field State Park Frontera Area 2725 Congress Street, Suite 2K San Diego, CA 92110	Tijuana Estuary (San Diego County)
California Department of Parks and Recreation Area Manager 1994 Harbor Blvd. Ventura, CA 93003	Santa Clara River Mouth (Ventura County)
California Department of Parks and Recreation Area Manager 28754 Mulholland Hwy. Agoura, CA 91301	Malibu Lagoon (Los Angeles County)
Coyote Hills Regional Park Interpretive Staff 8000 Patterson Ranch Road Fremont, CA 94536	San Francisco Bay — Coyote Hills Marsh
Environmental Studies Internship Program UCSC/ Nature Conservancy 317 Kerr Hall University of California, Santa Cruz Santa Cruz, CA 95064	Elkhorn Slough (Monterey County)



Tidewater Goby
(Eucyclogobius newberryi)

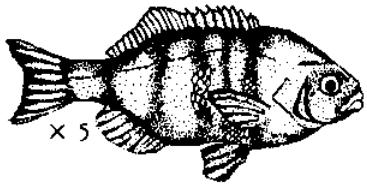
SPONSOR	LOCATION
Friends of Ballona Wetland 6953 Trolley Way Playa Del Rey, CA 90291	La Ballona Estuary (Los Angeles County)
Friends of Newport Bay Box 4088, Irvine Station Newport Beach, CA 92664	Upper Newport Bay (Orange County)
Marine Adventures College of Marin Kentfield, CA 94904	Bolinas Lagoon (Marin County) San Francisco Bay
Marine Ecological Institute 811 Harbor Boulevard Redwood City, CA 94063	San Francisco Bay
Morro Bay Museum of Natural History State Park Road Morro Bay, CA 93442	Morro Bay (San Luis Obispo County)
Newport Bay Nature Tours Chuck Schneebeck (school tours) Division of Life Science Fullerton College 321 E. Chapman Fullerton, CA 92634	Upper Newport Bay (Orange County)
Scripps Aquarium Education Department A-007 University of California, San Diego La Jolla, CA 92093	Kendall Frost Marsh (San Diego County) Los Penasquitos Lagoon (San Diego County) Tijuana Estuary (San Diego County)
Torrey Pines State Reserve P.O. Box 38 Carlsbad, CA 92008	Los Penasquitos Lagoon (San Diego County)



Mudsucker
(Gillichthys mirabilis)

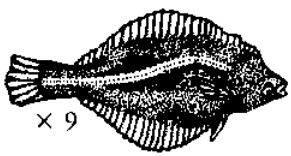
Fish of Commercial or Recreational Value Commonly Found in Central and Southern California Coastal Wetlands.[8]

Black Surfperch
(Embiotoca jacksoni)

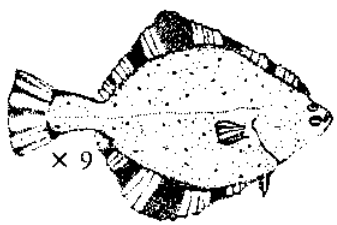


California Halibut
(Paralichthys californicus)

English Sole
(Parophrys vetulus)



Starry Flounder
(Platichthys stellatus)



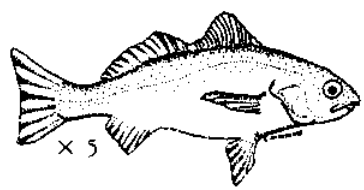
Northern Anchovy
(Engraulis mordax)

Slough Anchovy
(Anchoa delicatissima)

Topsmelt
(Atherinops affinis)

California Grunion
(Leuresthes tenuis)

White Croaker
(Genyonemus lineatus)



[8]C.P. Onuf, et al, "An Analysis of the Values of Central and Southern California Coastal Wetlands." Paper presented at the American Water Resources Association National Symposium on Wetlands, Lake Buena Vista, Florida, Nov. 7-10, 1978.

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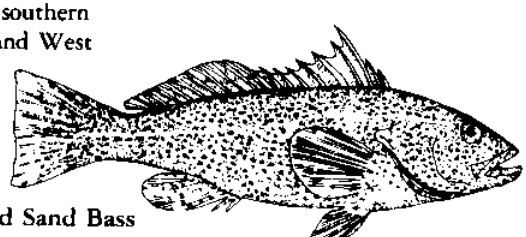

Spotted Sand Bass
(Paralabrax maculatofasciatus)

This is the second publication in the *Sea Grant Report Series*, which is intended to inform and educate the public about coastal and marine issues and research.

This booklet about California coastal wetlands was written, illustrated, edited and produced by Sana Siwolop and Henri Albert, interns from the science writing program of the University of California Santa Cruz.

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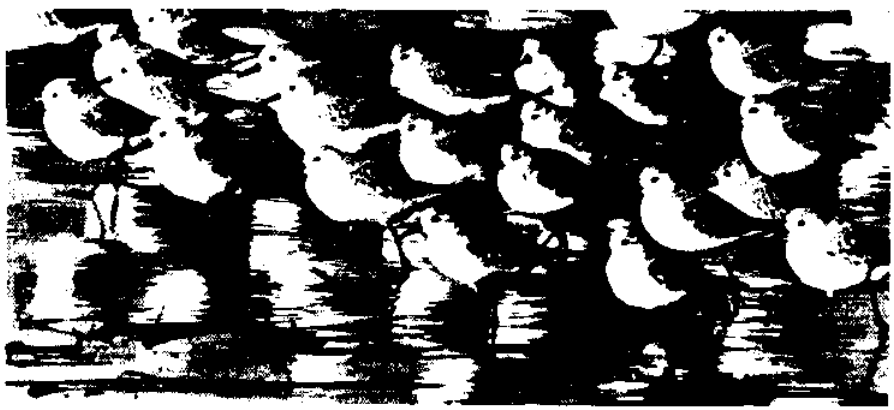

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