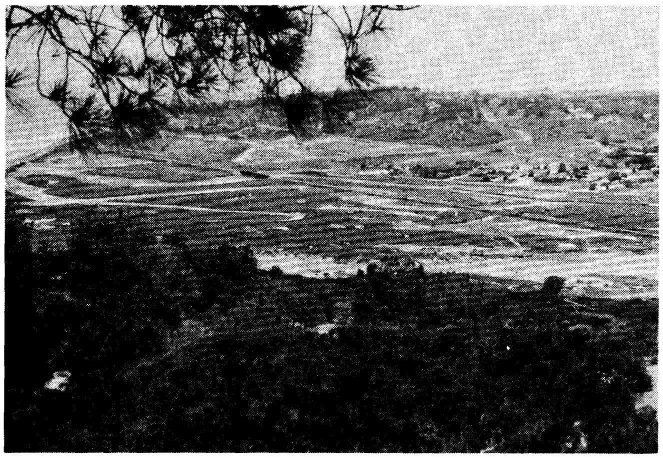
THE NATURAL RESOURCES
of
LOS PENASQUITOS LAGOON



RECOMMENDATIONS
FOR
USE AND DEVELOPMENT

STATE OF CALIFORNIA
DEPARTMENT OF FISH AND GAME
April, 1974

State of California

DEPARTMENT OF FISH AND GAME

THE NATURAL RESOURCES OF LOS PENASQUITOS LAGOON AND RECOMMENDATIONS FOR USE AND DEVELOPMENT

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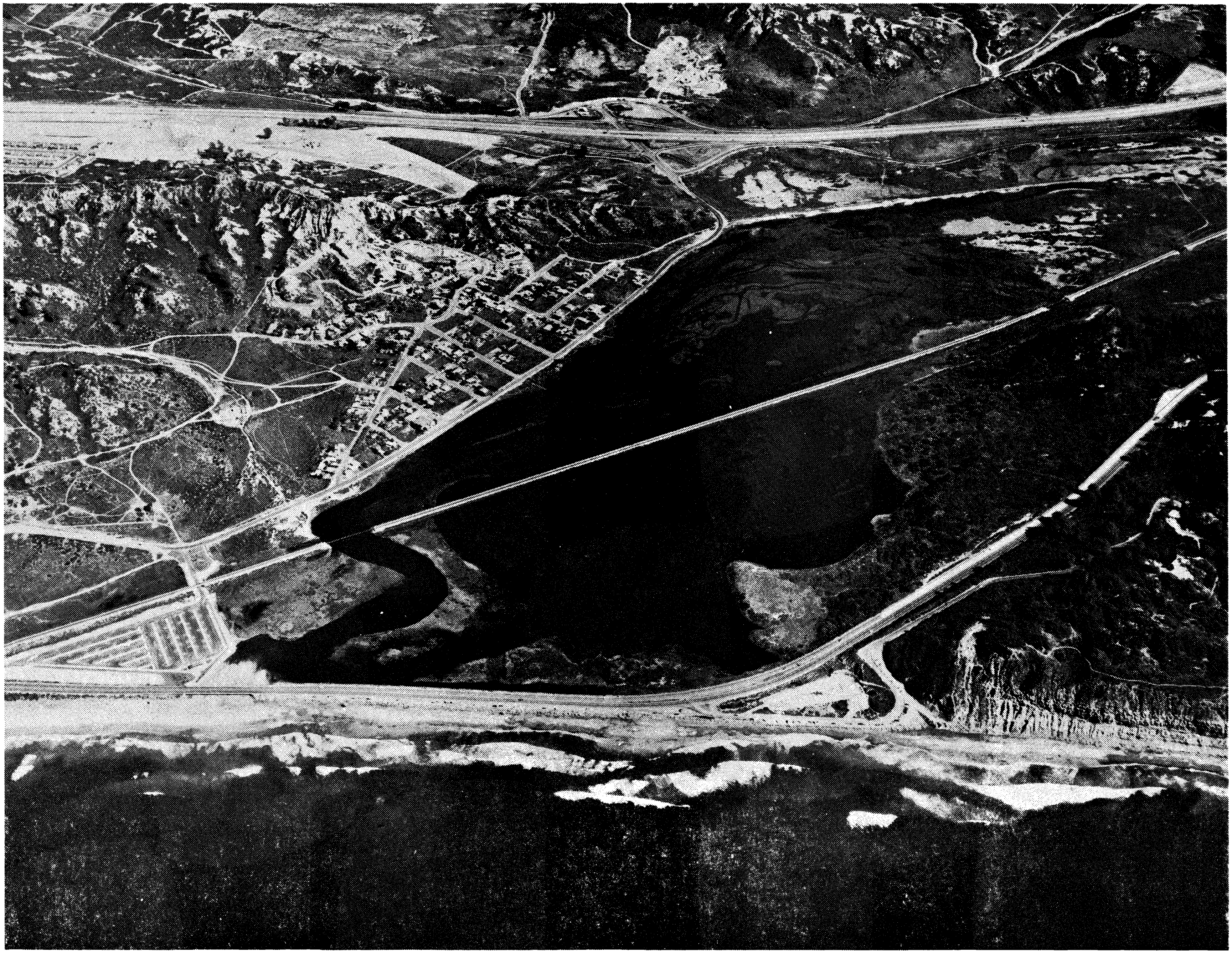
COASTAL WETLANDS SERIES #7

Cover Photos by: Herbert Clarke and Peta Mudie



Los Penasquitos Lagoon   Palamar Pictures, San Diego   January, 1970

ACKNOWLEDGEMENTS

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INTRODUCTION

The purpose of this report is to document the natural resources of Los Penasquitos Lagoon, San Diego County; to outline and evaluate proposed developments affecting those resources; and to recommend measures that will protect and enhance the lagoon and its environs.

The necessity for a report of this nature has become apparent with the progressive destruction of California's coastal wetlands over the past fifty years. These wetland resources, which are virtually irreplaceable, are essential to the continued existence of many forms of resident fish and wildlife and to the preservation of migratory shorebirds and waterfowl. Approximately 60 percent of the tidal wetlands in California has already been destroyed (Speth, 1970); and, it is estimated that only 10 percent is left of the original acreage of coastal marshland in San Diego County. The future of the remaining wetland habitats continues to be threatened. There is an urgent need, therefore, for sound planning to protect these wetlands and to prevent their otherwise inevitable disappearance as a valuable natural resource.

Los Penasquitos Lagoon has considerable historical significance. It was the subject of the first intensive scientific study aimed at identifying and documenting the outstanding ecological features of a southern California coastal wetland. The continued protection of this valuable wildlife resource in the face of the imminent urbanization of its environs now presents a serious challenge to urban planners, wildlife managers and concerned citizens. The lagoon, in effect, will provide a test case for man's ingenuity in utilizing the constructive forces of modern-day scientific and engineering prowess to solve or mitigate against the destructive effects that scientific and engineering capability can generate.

Because this report is intended to furnish public, governmental agencies and administrators with a concise account of the resources of Los Penasquitos Lagoon, much scientific and technical detail has been excluded. However, a comprehensive bibliography relating to the ecology of the lagoon has been included to allow for retrieval of details. Additional information regarding other California coastal wetland resources and their administration may be obtained from similar reports that have been prepared as a "Coastal Wetlands Series" by the California Department of Fish and Game (Upper Newport Bay, Orange County, Frey et al., 1970; Goleta Slough, Santa Barbara County, Speth, 1970; Bolinas Lagoon, Marin County, Giguere, 1970; Elkhorn Slough, Monterey County, Browning, 1972; San Diego Bay, San Diego County, Browning and Speth, 1973; Humboldt Bay, Humboldt County, Monroe, 1973).

SUMMARY

Los Penasquitos Lagoon, located near the northern limit of the City of San Diego, comprises about 385 acres of ecologically valuable coastal wetland habitat. Salt marsh vegetation covers about 235 acres of the area and there are about 30 acres of well-defined tidal channels that range in depth from 1 to 27 feet. Mudflats and salt flats comprise the remaining 120 acres of the wetland habitat in the lagoon.

Approximately half of Los Penasquitos Lagoon is owned by the State of California and has been designated as a natural preserve within the Torrey Pines State Reserve, under the administration of the State Department of Parks and Recreation. The other half is owned by the San Diego Gas and Electric Company. The hillsides on the northeastern side of the lagoon are in private ownership and are undergoing intensive development. The southeastern environs supports a light industry complex. Inland, the drainage basins tributary to the lagoon are expected to undergo extensive development in the near future.

Los Penasquitos Lagoon originated many thousands of years ago when rising sea levels flooded the Penasquitos Valley to form a deep marine embayment. Silt deposited by inflowing rivers gradually filled in the estuary over the years so that most of the area is now covered only by shallow water at high tide. Railroad and highway construction in the early 1900's resulted in significant changes in the natural drainage pattern and tidal circulation of the lagoon and greatly constricted the lagoon entrance channel. In the 1960's, the discharge of sewage effluent into the lagoon caused odor and insect problems. In 1967 tidal flushing was improved with the commencement of a program to keep the lagoon mouth open by mechanically removing the sand barrier. With the cessation of sewage discharge into the

lagoon in 1972, lagoon waters have improved considerably. However, eliminating this source of extra water has increased the difficulty of keeping the mouth open, due to an insufficient tidal prism.

A wide variety of plant species is found in and adjacent to the lagoon area. The diversity of vegetation types occurring within a relatively small area makes the lagoon particularly suitable for the study of ecology. Several rare plant species, including the salt marsh daisy, southern poverty weed and beach deerweed, have focused the attention of botanists on the area.

A total of 68 species of waterfowl and shorebirds is recorded from the lagoon and its environs. Most are migratory with peak populations occurring in April and October. The endangered light-footed clapper rail and Belding's savannah sparrow are both resident in the lagoon marshes. The endangered California least tern also nests in small numbers in the lagoon.

Twenty-one species of fish have been recorded from the lagoon channels. The most prevalent are the bay topsmelt, killifish and California halibut. Two species of small fish, the mudsucker and the short-nosed pipefish, are residents of the lagoon waters, and have become relatively scarce due to the diminution of estuarine habitat.

Several types of shellfish are abundant in some areas of the lagoon, the most common being the jackknife and bent-nose clams. Large numbers of ghost shrimp, as well as jackknife and rough piddock clams, were harvested for a local bait industry in 1969 and 1970. This commerical effort has been halted by pressure from the public who objected to the unsightly disturbance created by the harvest.

Campsites and middens of the La Jolla Indians, who occupied the area 4 to 5 thousand years ago, have been discovered in and near the lagoon area.

Primitive stone implements, animal bones, and shells of both lagoon and ocean mollusks are among the artifacts that have been found. A well preserved skeleton was recently unearthed at a burial site near the northeastern edge of the lagoon.

Nature study, photography, boating and fishing are the main recreational uses of the Los Penasquitos Lagoon. Many picnickers use the beach area where there are restroom facilities; there is some clamming on the mudflats and sandbar near the lagoon entrance. No hunting or camping is permitted in the lagoon or adjacent areas.

The lagoon rates very high in scientific interest and educational use. The area is one of the best documented coastal wetlands in southern California. College students make extensive use of the lagoon in course work and research, and many high school and elementary school students visit the lagoon on field trips. Although much of the educational and scientific use occurs on state lands the San Diego Gas and Electric Company has permitted studies to be carried out on their portion of the lagoon.

The principal problems and conflicts of use concerning Los Penasquitos Lagoon fall under the general categories of: 1) lack of adequate tidal flushing or circulation; 2) urban and industrial development in the lagoon and watershed; 3) sedimentation and pollution of its waters; and 4) a general lack of coordinated management and planning efforts.

It is anticipated that there will be increased use of the lagoon due to projected, rapid expansion of population in adjacent areas. Hence the protection and enhancement of natural resource values of Los Penasquitos Lagoon will provide a test case for the effectiveness of wildlife and land-use management principles in coping with the pressures that arise from urban and industrial encroachment. Long-term management of the lagoon will require the co-ordination of more than 20 government agencies with jurisdiction in the lagoon, and the development of enforceable regulations for the control of both on-site and basin-wide problems. The successful management of the lagoon, however, will ultimately depend heavily upon strong public support for lagoon protection and increased awareness of private landowners as to the long-term effects of altering the natural landscape of the lagoon drainage basin.

The remaining tidelands, salt marshes, lagoons, bays and estuaries of southern California are a vital link in the Pacific Flyway, the coastal migratory path taken annually by thousands of waterfowl, shorebirds and other water-associated birds. Los Penasquitos Lagoon is an integral part of that flyway and important to the open space concept that makes San Diego County so attractive to wildlife and man alike. This vital coastal wetland should be protected and maintained.

RECOMMENDATIONS

Because of the high value of the varied and important natural resources in and around the Los Penasquitos Lagoon; the increasing public need for recreational areas and open spaces; and the growing concern about the future of California's vital coastal wetlands, the Department of Fish and Game recommends that:

1. A permanent opening from the lagoon to the ocean be constructed and maintained. Adequate tidal circulation in the lagoon is necessary to maintain estuarine organisms. Good tidal flushing also would substantially decrease, or largely eliminate, problems of odor and mosquitos, which would make viewing and recreational use of the lagoon more pleasing. The construction and maintenance of the opening should not restrict the natural movement of sand along Torrey Pines State Beach.

2. The privately-owned wetlands in Los Penasquitos Lagoon be purchased and placed in the Torrey Pines State Reserve. The Department takes the position that no development should take place in the lagoon; hence, acquisition and placing this property in the status of a reserve is the best means to insure the ecological integrity of the lagoon.

3. A watershed protection and management program be implemented in the Los Penasquitos watershed to reduce the input of streamborne sediments and pollutants into the lagoon. A flood plain management program above the lagoon would best preserve the present wetlands environment and at the same time create a green belt of riparian habitat adjacent to the lagoon which would complement the wetland open space. Sediment traps should be established in water courses outside of the lagoon area, in conjunction with a flood plain management program.

Strict enforcement of Water Quality Control Board regulations would also assist in reducing sediment deposition. If necessary the program could include a channelization project constructed through the lagoon to carry sediments to the ocean.

4. The effects of direct encroachment and disturbing influences upon the lagoon be evaluated and protective measures taken against such encroachment. Appropriative and non-appropriative use of the lagoon by people; domestic animals; and recreation vehicles are disturbing influences in the lagoon. Tolerance limits and dimension of this problem should be measured and recommendations made accordingly.

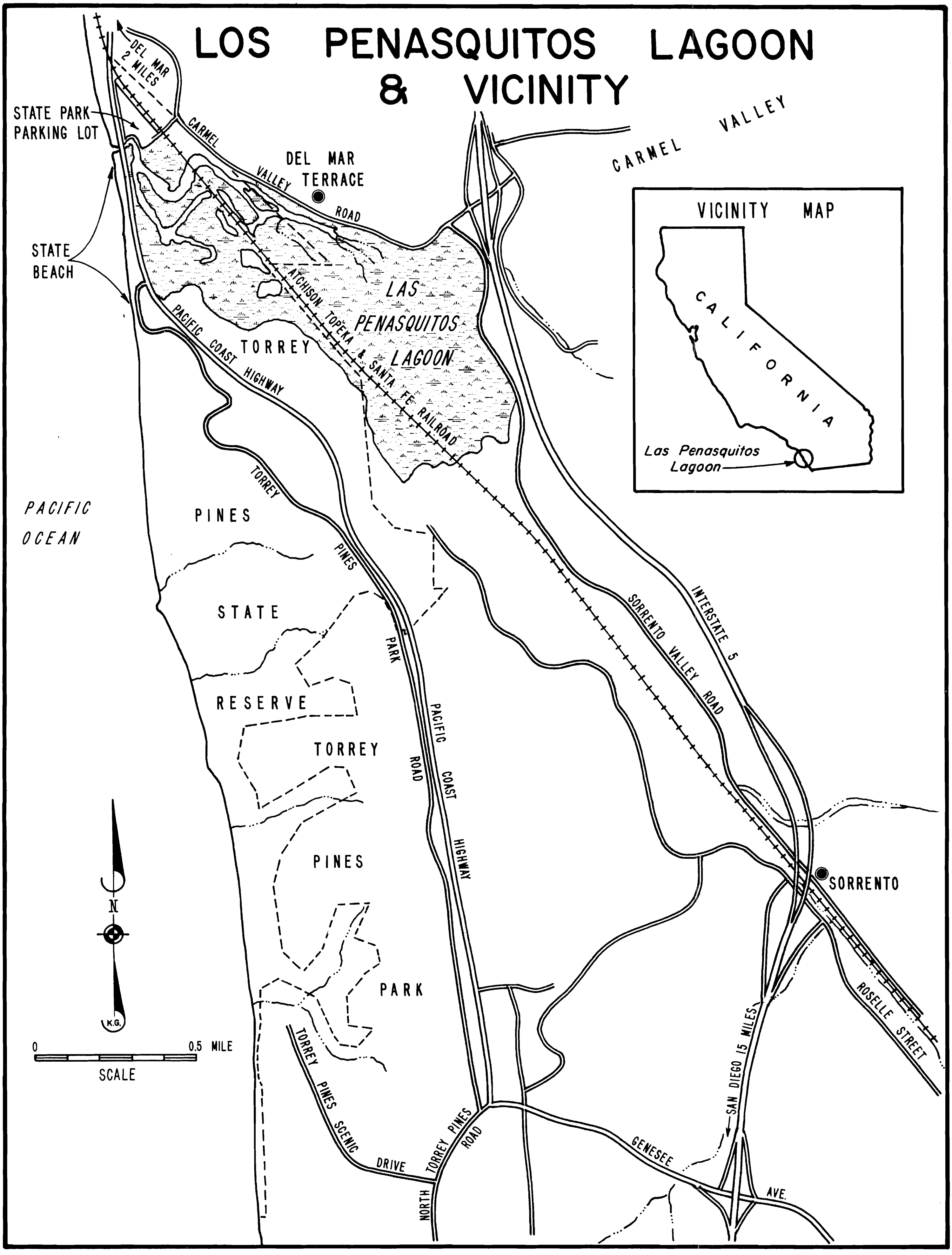
5. Mosquito abatement be accomplished with the least possible impact on the ecology of the lagoon. Until mosquitos can be biologically controlled by adequate tidal circulation and ditching to drain stagnant ponds, the judicial use of selective larvacides should be encouraged as methods of mosquito control.

6. Widening or relocation of roads on the lagoon perimeter not encroach into the lagoon. Plans for widening Carmel Valley Road and relocation of Sorrento Valley Road should be adjusted to prevent any filling or disturbance of lagoon habitats.

7. The San Diego Coastal Lagoon Management Committee be supported and funded. The goals of this committee are to set up a basin-wide program of lagoon planning and management and to insure coordination of the activity of those agencies having jurisdiction over the basin wetlands. Los Penasquitos has been

selected by the Committee as a model lagoon management study area and recommendations are now being formulated for both short and long-term management practices.

PLATE 1


LOS PENASQUITOS LAGOON
& VICINITY
DEL MAR 2 MILES
STATE PARK PARKING LOT
STATE BEACH
CARMEL VALLEY ROAD
DEL MAR TERRACE
CARMEL VALLEY
VICINITY MAP
CALIFORNIA
Las Penasquitos Lagoon
LAS PENASQUITOS LAGOON
ATCHISON TOPEKA & SANTA FE RAILROAD
TORREY
PACIFIC COAST HIGHWAY
PACIFIC OCEAN
TORREY PINES STATE RESERVE
TORREY PINES PARK
TORREY PINES PARK ROAD
PACIFIC COAST HIGHWAY
INTERSTATE 5
SORRENTO VALLEY ROAD
SORRENTO
ROSELLE STREET
SAN DIEGO 15 MILES
GENESEE AVE.
NORTH TORREY PINES ROAD
TORREY PINES SCENIC DRIVE
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SCALE

THE LAGOON AND ENVIRONS

Description of the Area

General

Los Penasquitos Lagoon is a coastal lagoon located in San Diego County, approximately 19 miles north of the City of San Diego and one mile south of the City of Del Mar (Plate 1). The lagoon, which encompasses an area about one mile long and one-half mile wide, lies at the mouth of the Los Penasquitos drainage basin, the western end of Carmel and Sorrento valleys. The lagoon consists of flat marshland, laced with deep tidal channels and interspersed with occasional tidal and salt flats. In some locations the channels reach depths of 25 feet.

The lagoon is separated from the ocean by sand dunes and beach--and old highway 101, the Pacific Coast Highway. Bluffs border the lagoon on the south and are traversed by the old highway. A State Beach parking lot lies in the northwest corner of the lagoon and the Santa Fe Railroad cuts diagonally through the entire lagoon from southeast to northwest. Southeast of the lagoon lies an area of floodplain now undergoing industrialization.

History

The lagoon takes its name from one of the creeks in the upper drainage basin. On older maps the lagoon is marked as Soledad Lagoon and is frequently referred to locally as the Torrey Pines Lagoon or the Sorrento Lagoon because of its proximity to the Torrey Pines State Reserve and Sorrento Valley.

Los Penasquitos Lagoon originated 10 to 25 thousand years ago when the melting of the polar ice-caps resulted in a rising sea level that flooded the valley of Los Penasquitos Creek to form a large marine embayment (Torrey Pines Assoc., 1972).

Indian middens on the marine terraces to the north and south of the lagoon furnish ample evidence that the lagoon abounded in shellfish and other marine life between four and five thousand years ago (Miller, 1966). Over the centuries, however, waters draining into the formerly large estuary deposited vast quantities of alluvial sediment into the bay, resulting in the gradual filling-in of the bay and formation of the lagoon. At the time of Portola's trek from San Diego to Monterey in 1769, Friar Crespi described the Soledad Valley (Los Penasquitos) as "very green and grassy." Today the deep water area of the lagoon is confined to a few miles of meandering channels which are flanked by broad areas of either salt marsh vegetation or bare salt flats.

Despite the gradual filling-in of the tidal estuary, historical records indicate that the lagoon was continuously connected to the ocean at least until 1888. Early railroad maps show that the lagoon entrance was formerly located on the extreme northwestern side of the valley. The original railroad that was built along the eastern edge of the lagoon (present Carmel Valley Road) and southwards across the salt flats, probably had little effect on the drainage pattern of the lagoon. However, construction of the present Santa Fe Railroad resulted in the southward shifting of the lagoon entrance and the blockage and relocation of many of the lagoon channels. An early photograph shows that by 1928 the lagoon was isolated from the ocean during at least part of the year. With the construction of Highway 101 in 1932, the lagoon was more or less permanently barricaded from the ocean by a high road embankment. The only possible exit for the lagoon water was beneath the highway bridge overpass on the northwest side (Karig, Univ. of Calif., Santa Barbara, Dept. Geology, pers. comm., 1971).

After the highway construction, sand deposited in the man-made channel entrance by winter storms and longshore currents formed a sand bar that isolated the lagoon from the ocean. In summertime evaporation from the impounded lagoon water caused an increase in the salinity that occasionally reached three times the salt concentration of ocean water (Carpelan, 1960). Increased salinity resulted in the death of most aquatic marine life in the lagoon. Moderate winter rainfalls, on the other hand, lowered the salinity and allowed the temporary growth of brackish water plants. Occasionally, severe winter floods washed out the sandbar at the lagoon entrance and restored tidal conditions to the lagoon. Growth of marine organisms again occurred until the formation of a new beach barrier began another cycle of ecological degradation. The indirect result of man-made alterations to the drainage pattern of the lagoon was the conversion of the formerly stable, tidally-flushed estuary into an unstable, impoverished lagoon-like habitat. In this habitat, marine conditions alternated with either a brackish water or a hypersaline environment, depending on the height of the sand barrier and rainfall conditions.

In 1965, a new influence began to dominate the lagoon ecosystem. This was the accumulation of effluent from two sewage treatment facilities that discharged their overflow into a creek on the southwestern side of the lagoon. Although this effluent was secondarily treated prior to discharge, it carried large amounts of nitrate and phosphate nutrients into the lagoon and resulted in a lowering of the salinity of the surface water (Bradshaw, 1968). This effluent promoted the growth of rafts of floating algae during the spring months. Following the death and decay of these algal mats in summer, the oxygen supply in the lagoon water became depleted and sulphurous odors arising from the lagoon became a notorious feature of the lower

Penasquitos Valley. Furthermore, accumulation of stagnant water in the lagoon and the consequent loss of predators led to the proliferation of mosquitoes and midges, the control of which required an extensive spraying program that resulted in some untoward secondary effects on the salt marsh flora and fauna.

In 1966, local citizens, alarmed by the degradation of the marshland and by potential health hazards, were instrumental in instituting a program of periodic removal of the beach bar at the mouth of the lagoon. This has usually been performed by light earth moving equipment under the auspices of the State Department of Parks and Recreation. Between 1966 and 1970 tidal flushing was more or less permanently restored to the lagoon through the continuation of this program, despite the fact that the lagoon entrance was further modified by construction of a State parking lot on the north bank in 1968. Improved tidal flow encouraged the restoration of a healthy marine fauna to the lagoon and greatly reduced the nuisance and health problems that formerly arose from the accumulation of sewage effluent in the closed lagoon. In recent years, however, there has been a net accumulation of sand in the lagoon entrance channel and it has become increasingly difficult to maintain the lagoon entrance.

Geology and Archeology

Los Penasquitos Lagoon is located in a river cut valley which is framed on the north and south by relatively high bluffs of sedimentary rock on which the famous Torrey pines grow. Spectacular views of the lagoon and the unique geology of the area may be seen from the trails which meander through the Torrey pine groves.

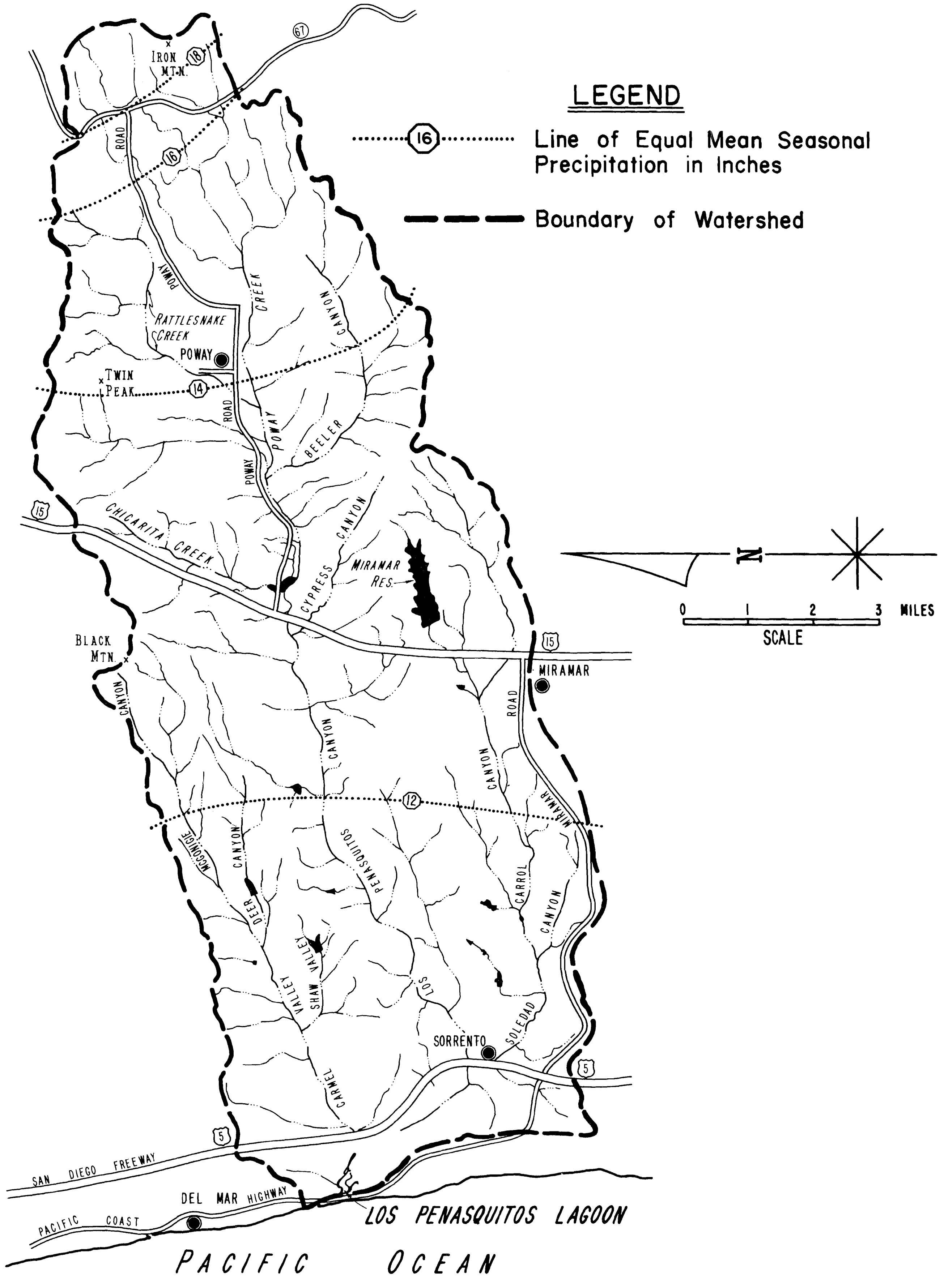
The 300-foot high bluffs of the Torrey Pines State Reserve area are mostly late Tertiary and represent several geological eras of sediment deposition during periods of marine inundation, alternating with periods of uplift and erosion (Torrey Pines Assoc., 1972). The lower third of the valley walls is composed predominantly of greenish siltstones of the Delmar formation. Spectacular deposits of fossil oysters in solidly packed layers of up to two feet in thickness are exposed in places. A total of 32 species of fossils has been identified from these sediments. Above the Delmar formation lie extensive deposits of white or buff-colored Torrey Pines sandstone. This sandstone is capped by a relatively thin layer of hard, red, iron-bearing sandstone (the Sweitzer or Linda Vista formation). More recent geological features include a low (50 foot) marine-cut terrace on the southwest side of the lagoon, extensive beach deposits along the ocean front, and a relic sand dune east of Highway 101.

Considerable archeological interest has been centered on Los Penasquitos Lagoon because of the proximity of many Indian middens and camp sites. These sites, which were occupied by La Jolla Indians between four and five thousand years ago, usually contain many shells of both lagoon and ocean mollusks, some animal bones and primitive stone implements. A well preserved skeleton was found recently at a burial site near the northeastern edge of the lagoon.

In the valley bottom, sediments underlying the lagoon basin range from greenish and grayish sand near the lagoon entrance to blue and gray sand shale and thin beds of limestone upstream in the Soledad Valley (Bradshaw, 1968). The surface sediments are comprised predominantly of fine silty clays which form the sticky, gray-brown mud found in most of the lagoon channels and salt marsh areas. These salt marsh sediments are relatively thin (less than 6 feet in depth), however, and are underlain by marine or fluvial deposited sand to depths of more than 50 feet (Mudie, 1973, unpubl. data).

PLATE 2

LOS PENASQUITOS LAGOON WATERSHED



Almost all of the soils in the lagoon area are highly saline. Extensive areas of bare salt flats occur on the southeast side of the lagoon and environs. These flats are flooded by fresh water following winter rains but become encrusted by a thin layer of salt during summer dehydration. Abundant shell fragments on or near the surface of these salt flats indicate that this area was a shallow tidal lagoon in earlier times.

Drainage

Run-off from a drainage basin of approximately 95 square miles enters Los Penasquitos Lagoon via Soledad Canyon, Los Penasquitos Canyon and Carmel Valley creeks (Plate 2). The mean seasonal rainfall of this region ranges from approximately 11 inches near the coast to 18 inches in the headwaters (U. S. Army Corps of Engineers, 1967). Most of this precipitation occurs between December and March. No data on normal run-off volumes are available. The fifty-year flood volume at the lagoon mouth is estimated as 19,000 c.f.s. and the Standard Project Flood (most severe condition expected in this region) is estimated as 40,000 c.f.s. (U. S. Army Corps of Engineers, 1967).

During most of the year there is little natural water flow in the creeks of the Los Penasquitos drainage basin. But, between 1965 and 1972, approximately one million gallons per day of secondarily treated sewage effluent entered the lagoon from Soledad Canyon Creek. Seventy-five percent of this effluent originated from the Sorrento and Callan sewage treatment plants that discharged into the creek a few miles upstream from its entrance into the lagoon. Most of the remaining effluent originated from the Poway sewage treatment plant which is located 12 miles inland. This latter effluent flowed through the Los Penasquitos Valley and entered the Soledad Canyon Creek approximately seven miles upstream from the lagoon. All of these sources of sewage effluent are now discharged into the San Diego Metropolitan Sewer system and thus no longer enter the lagoon. However, deposits of nutrient-rich organic material still remain in some areas of the lagoon and creek.

The main source of water in the Los Penasquitos Lagoon is now tidal in origin and enters from the Pacific Ocean via a 30 to 60 foot wide channel beneath the Pacific Coast Highway bridge. This channel bifurcates approximately 150 yards from the entrance. The eastern branch runs inland under the railroad trestle, then trends southeastward parallel to Carmel Valley Road, finally terminating in a series of small creeks that drain the salt flats and non-tidal marsh on the southeastern side of the lagoon. The western branch of the main channel system is generally narrower and shallower than the eastern branch. It runs in a southerly direction and terminates in a dendritic pattern of creeks that drain the mudflats and marsh on the southwestern side of the lagoon. Two of these poorly defined creeks connect with the Soledad Canyon Creek which flows into the lagoon through a narrow (approximately 10 feet wide) channel on the west side of the railroad. The curious patterns of ponds and blind side-channels in the southwestern portion of the lagoon is due to the bisection of the former natural drainage pattern by the railroad and highway embankments.

As a result of recent intensive residential development of the hillside northeast of the lagoon, there has been a significant increase in the flow of urban runoff draining into the eastern channel. During the fall of 1973, this runoff volume amounted to approximately 1,500 gallons per day. The drainage of fresh water has had a measurable diluting influence on the channel water when the lagoon entrance is closed; it may be a significant source of nutrients and pollutants in the absence of tidal flushing of the channels.

Tides

The area of the Los Penasquitos Lagoon subject to tidal inundation is approximately 185 acres. Of this acreage, approximately 30 constitute well-defined channels which range in depth from 1 to 27 feet. The remaining 200 acres of the lagoon, composed of high marsh and salt flats, are above tidal influence. When the entrance channel is closed by a sand bar, accumulation of run-off from heavy winter rains may result in the flooding of the lagoon area with brackish water to approximately the three foot contour level or higher.[1]

The maximum tide heights (spring tides) at the entrance to the Los Penasquitos Lagoon is 6 to 7 feet, each tidal height being approximately nine-tenths of the predicted tidal height at Broadway Pier, San Diego. A 6.7 tide will inundate about 185 acres of the lagoon. Tides of less than 5.0 feet will leave exposed most of this acreage of salt flats, salt marsh and mudflats. On very low tides, water is restricted to the deeper parts of the main channels.

There is a natural tendency for wave-deposited sand to accumulate at the mouth of Los Penasquitos Lagoon (see Appendix A for details). This leads to the gradual formation of a broad sand bar in the vicinity of the junction of the two main branches of the lagoon drainage system. The channels tend to become braided and constricted as the sand moves inland. When the height of the sand bar reaches approximately four feet above mean sea level, tidal circulation in the lagoon ceases. Since 1966 this sand bar has been periodically removed by excavation to restore tidal flushing in the lagoon.

1. Elevation converted to U. S. G. S. datum; to convert to tidal level, add 2.7 feet.

Before cessation of sewage effluents, each excavation kept the channel entrance open for about six to twelve months. Since then, it appears that the open period after each excavation has been shortened.

Water Characteristics

Details of the chemical characteristics of the lagoon's waters are recorded (Appendix B). In general, when the lagoon entrance is open, the temperature of the waters is slightly lower than that of the ocean during the winter, but in summer the lagoon temperatures are usually 8 to 10° higher than the ambient ocean water temperatures (Bradshaw, 1968).

Throughout the year the salinity of the water in most areas of the lagoon is usually slightly higher than that of the ocean,[1] and may be as high as 40 parts per thousand (ppt) in the shallow channels east of the railroad. When the lagoon is cut off from tidal influences, the salinity pattern changes considerably. Following winter rains, the salinity of the surface water in all parts of the lagoon may drop to approximately half that of sea water. However, the salinity at the bottom of the deeper channels remains at approximately that of sea water. These pockets of salty water provide temporary refuges that are vitally important to the survival of motile marine organisms which would otherwise be killed by the lowered salinity of the surface water.

The amount of dissolved oxygen in the lagoon water ranges between 4 and 26 parts per million (ppm) and is usually adequate for the survival of marine life. However, when the lagoon is closed, the dissolved oxygen in the salt water pockets underlying the brackish surface water frequently drops below 5 ppm and may even become totally depleted. In the past,

1. Average salinity of the ocean water is approximately 33.5 parts per 1,000 (ppt).

similar low oxygen levels occurred in some areas following the proliferation and death of algal mats, the growth of which was stimulated by the accumulation of sewage water in the closed lagoon. Such low oxygen environments are fatal to many species of marine invertebrates and to all but a few hardy species of fish (e.g. killifish and mudsuckers). Although full effects on all life stages are not known, most of the adult forms of common lagoon shellfish species (e.g. jackknife clam, mud cockle, crabs, and burrowing shrimp) can survive one or two weeks of low oxygen conditions but are killed if these conditions are prolonged. Thus, pockets of saline water that offer temporary refuge to marine animals when the lagoon is flooded by fresh water become death traps in the absence of tidal flushing.

In the past, nutrient concentrations (inorganic nitrate and phosphate) in the water of Los Penasquitos Lagoon were generally 2 to 4 times higher than adjacent ocean water (Bradshaw, 1968; Bradshaw & Mudie, 1972). Typical phosphate values ranged between .04 and .6 ppm. These nutrient concentrations varied considerably from one part of the lagoon to another and fluctuated with the height of the tide and the amount of tidal flushing. Generally, at low tide and when the lagoon was open, high nutrient concentrations were found in the upper parts of the western channel that drains Soledad Canyon Creek. These high nutrient values reflected the presence of the sewage effluent in the creek. Typical nutrient concentrations of the creek water prior to closure of the sewer plants were around 19 ppm for phosphate and 1.3 ppm for nitrate. At a discharge rate of 1 million gallons/day, the creek carried approximately 260 tons of phosphate and 60 tons of nitrate into the lagoon each year. By the time the creek water reached the mouth of the lagoon, however, the nutrient concentrations dropped to near normal ocean values. This indicates that most of the nutrients were

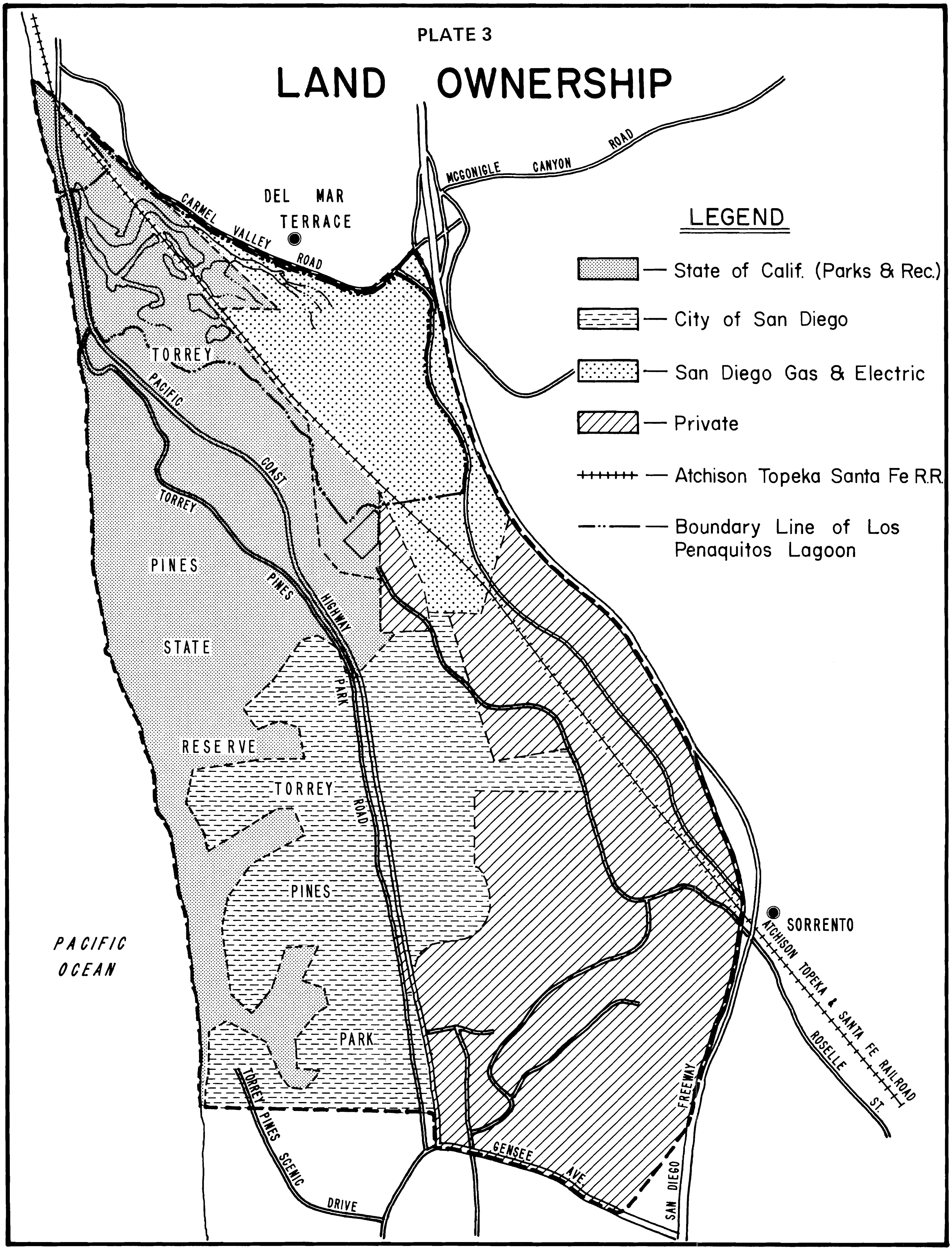


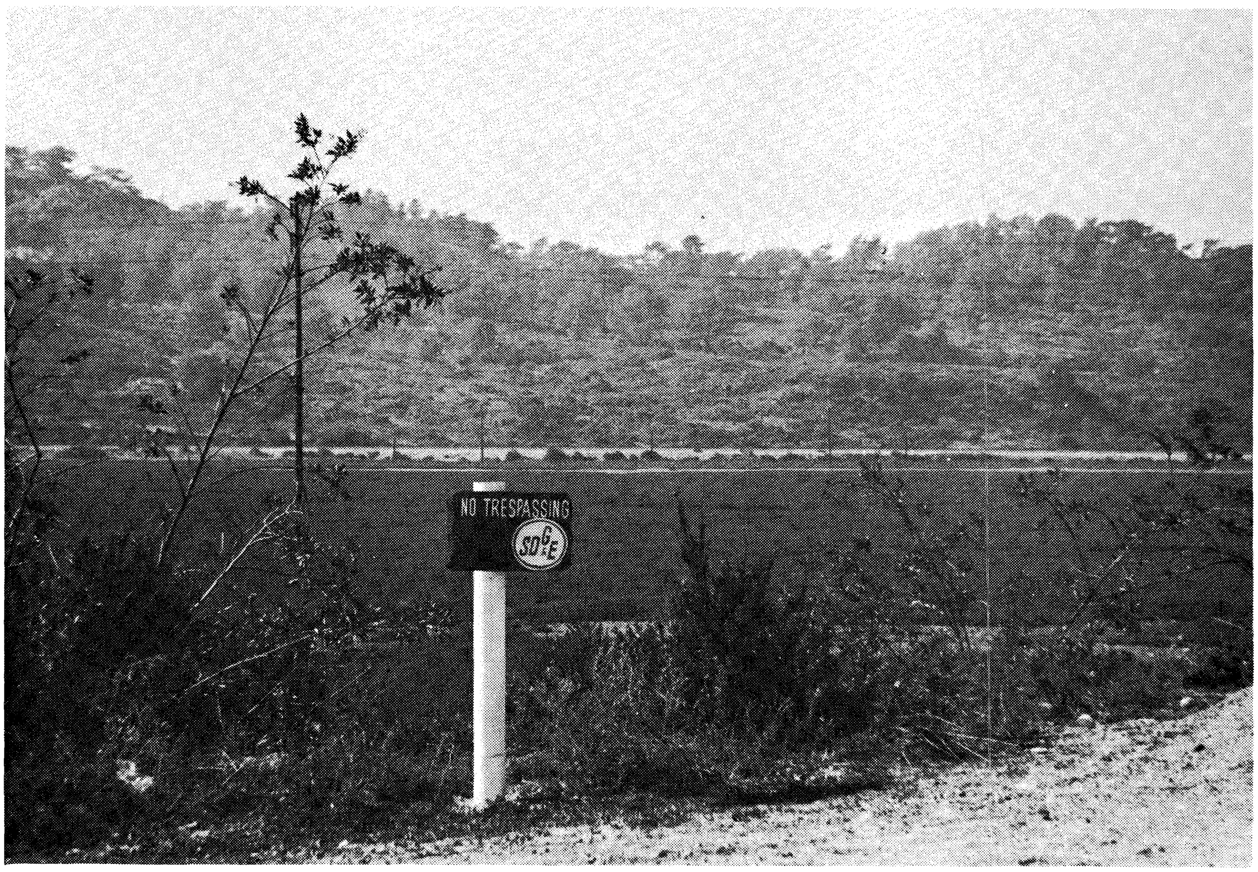
PLATE 3
LAND OWNERSHIP
LEGEND
— State of Calif. (Parks & Rec.)
— City of San Diego
— San Diego Gas & Electric
— Private
— Atchison Topeka Santa Fe R.R.
— Boundary Line of Los Penaquitos Lagoon
DEL MAR TERRACE
CARMEL VALLEY ROAD
MCGONIGLE CANYON ROAD
TORREY PINES STATE RESERVE
PACIFIC COAST HIGHWAY
TORREY PINES PARK ROAD
TORREY PINES PARK
PACIFIC OCEAN
SORRENTO
ATCHISON TOPEKA & SANTA FE RAILROAD
ROSELLE ST.
SAN DIEGO FREEWAY
GENSEE AVE.
TORREY PINES SCENIC DRIVE

absorbed by the lagoon plants, deposited in the sediment, or diluted by tidal water during the natural cleansing process.

It is anticipated that the elimination of sewage effluent will result in lower nutrient values in the lagoon waters and a concomitant reduction in problems resulting from algal blooms and sludge deposition. However, even pristine lagoons and estuaries tend to have high nutrient levels relative to open ocean water; thus without regular tidal flushing, nutrient enrichment problems might be expected to persist.

Land Ownership

Los Penasquitos Lagoon lies within the city limits of San Diego. In 1921, portions of the lagoon were presented as a gift to the City Parks Commission and named the Torrey Pines Reserve. In 1924, additional pueblo lands were added to the Reserve through an ordinance enacted by the City Council. In 1959 the ownership of this reserve and the adjacent southern uplands (a total area of 877 acres) was conveyed to the State of California for use as a natural reserve (Torrey Pines Assoc., 1972) (Plate 3). Approximately 150 acres of the state property lie in the Los Penasquitos Valley and include the best portion of the lagoon. Most of the marsh area is now classified as a "preserve" (within the Reserve) and is under the jurisdiction of the State Department of Parks and Recreation. Boating and fishing are permitted in the preserve, however no landscaping by man is allowed (Welch, Calif. Dept. Parks & Rec., pers. comm., 1971). In 1970, an additional 190 acres to the north of the Los Penasquitos Lagoon was designated as a natural park area and is being acquired by the State Department of Parks and Recreation (Torrey Pines State Park Extension). However, this property does not include any wetland habitat, nor is it contiguous with the lowland



Top and Bottom Photos: Posting of the lagoon by the San Diego Gas and Electric Company has served to limit unrestricted use and resultant destruction. Educational use, however, is encouraged on a permit basis.

Department of Fish and Game Photos,
March 1974

area. The balance of the lagoon, approximately 210 acres east of the railroad is owned by the San Diego Gas and Electric Company. This property includes approximately 150 acres of non-tidal marsh and salt flats.

The lands and beach to the south and west of the lagoon are all in the Torrey Pines State Reserve. The hillside slopes north of the lagoon are all privately owned, as is the land containing the light industry complex, south and east of the lagoon.

Land Use

Principle use of the lagoon, included in the state-owned Torrey Pines Reserve, is recreational, scientific and educational (see Resource Uses).

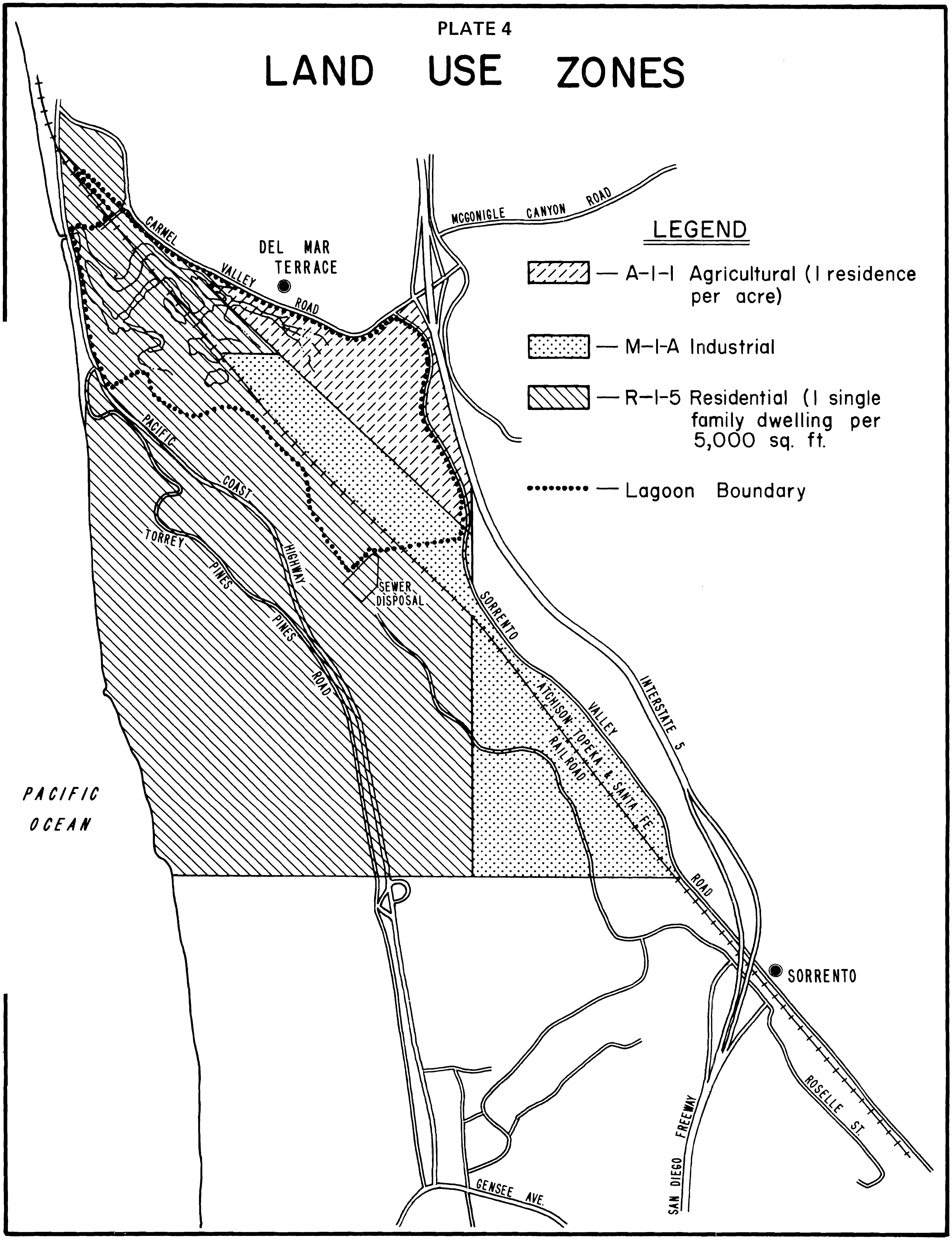
San Diego Gas and Electric Company originally planned to use part of their property as a power plant site; that plan is now in abeyance. However, SDG&E has established three small, landscaped public view sites at the edge of the lagoon. The utility company also has posted their property against trespass and fenced off an access road that was formerly used heavily by recreation vehicles which caused considerable destruction to the salt flats and some of the higher marshland. But, entry permits may be obtained from SDG&E by students interested in studying the ecosystem of the lagoon. The San Diego Gas and Electric Company is commended for these public services and its concern for maintaining the lagoon's resources.

Most of the northern section of the utility company property is under agricultural zoning (A-1-1), but the southern portion is zoned as M-1A, light industry, as is the private land to the southeast of the lagoon (Plate 4). Land zoned M-1A is designated as "general industry" in the January, 1972 revision of the General Plan for the City of San Diego.

Approximately 25 acres at the southern end of the state-owned lagoon property was formerly leased to the City of San Diego for use as a sewage

PLATE 4

LAND USE ZONES

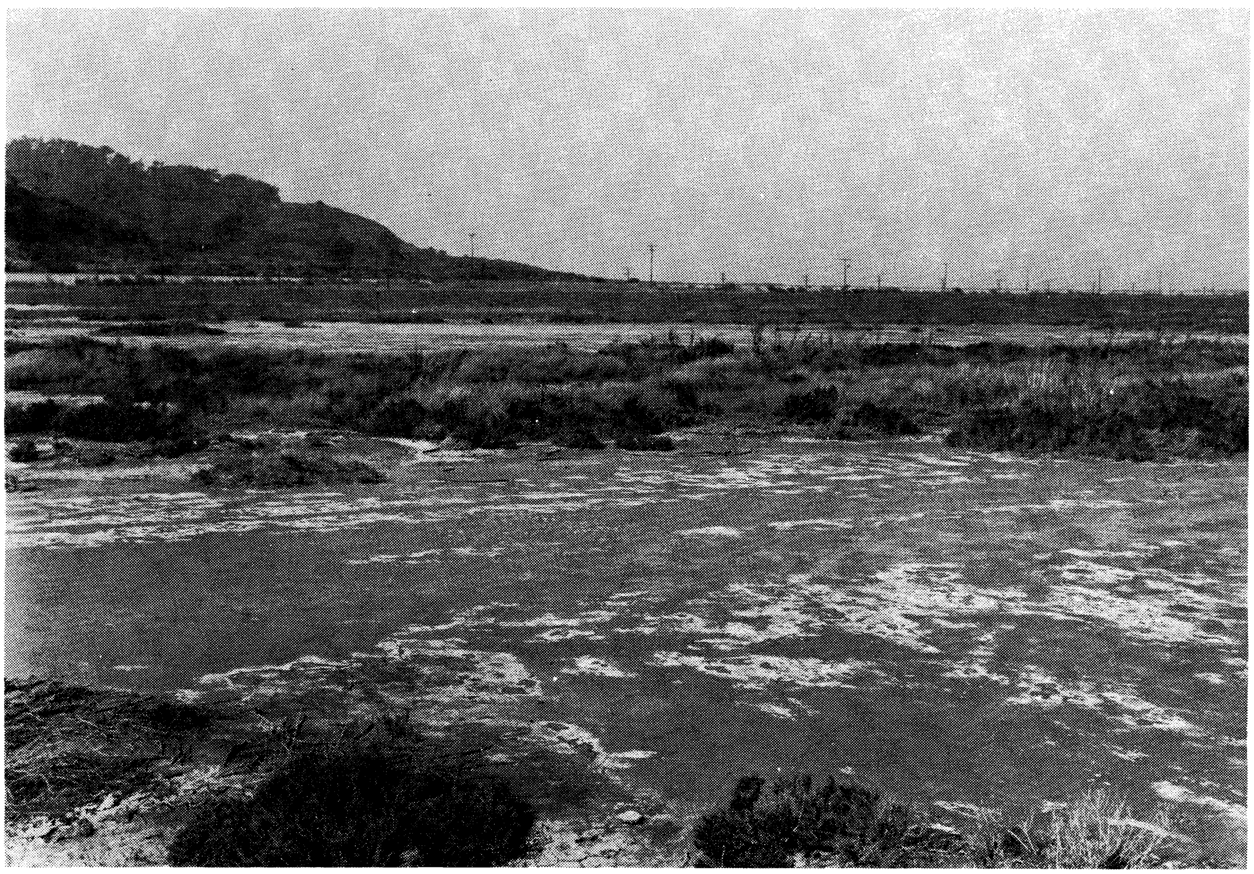


treatment facility. However, this use terminated with the completion of the new metropolitan sewer line in 1972. The sewage treatment facilities have been removed and replaced by a pumping station at the southern end of the lagoon. The former site of the sewage treatment facilities and the adjacent lower hillslope have been graded and it is anticipated that this manipulated area will eventually be colonized with native upland vegetation.

The land adjacent to Los Penasquitos Lagoon is undergoing rapid transformation as urbanization of the northern San Diego area proceeds. Most of the property on the slope north of the lagoon (north of Carmel Valley Road) is zoned for low to medium density housing. One residential community, the Del Mar Terrace is already established. Two condominium-type housing projects (Sea Point and Sea View), covering approximately 50 acres, will be completed in 1974. Proposals for the development of an additional 10 to 15 acres are under consideration by the City of San Diego. Within the next 5 years, the population of the immediate lagoon environs is expected to increase by a factor of 4 to 6 times over the 1972 level of about 1,000 persons.

The Sorrento Valley, to the south, is zoned for industry and is destined to become a regional industrial park. The establishment of light industry has commenced at Rheba, to the east of the Santa Fe railroad. In the floodplain west of the railroad and south of the lagoon area, land filling is proceeding rapidly in anticipation of future industrial development.

Further afield, housing developments have been proposed or are under construction in the Carmel Valley and Los Penasquitos drainages. A population of approximately 340,000 is anticipated in this region by 1985 following the construction of several "mini-cities." Plans for a natural park in the flood plain of the Los Penasquitos drainage area east of Interstate Freeway I-5 have been formulated by the County of San Diego. Two million dollars have been funded for land acquisition and this park probably will become a reality (Gardner, San Diego County Parks and Recreation Department, pers. comm., 1971). The County also plans to preserve the floodplains in Carmel Valley and the adjacent finger canyons as "green belt" areas. The Department commends the County of San Diego for its "open space" plans for the Los Penasquitos drainage and floodplain. Such plans are vital to the welfare of the wildlife habitat remaining in both the lagoon drainage basin and in the county as a whole.



Top Photo: Mudflats, salt marsh and tidal channels are the three most important wildlife habitats in the lagoon.

Bottom Photo: Salt flats, another significant habitat type, are flooded only during very high tides, or flood conditions.

Department of Fish and Game Photos,
March 1974

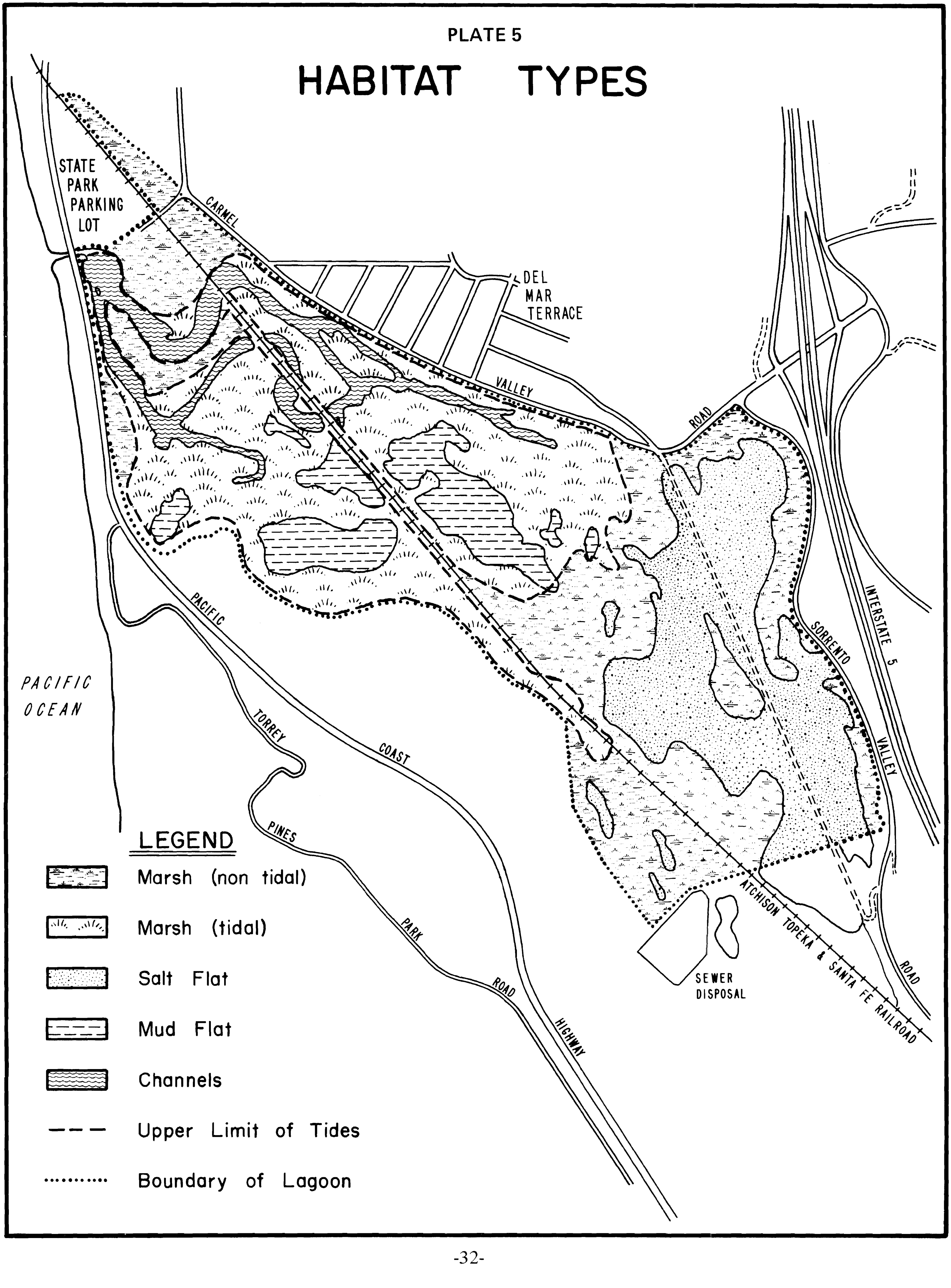


PLATE 5
HABITAT TYPES
STATE PARK PARKING LOT
CARMEL
DEL MAR TERRACE
VALLEY
ROAD
PACIFIC
PACIFIC OCEAN
TORREY
COAST
PINES
PARK
ROAD
HIGHWAY
INTERSTATE 5
SORRENTO
VALLEY
ROAD
SEWER DISPOSAL
ATCHISON TOPEKA & SANTA FE RAILROAD
LEGEND
Marsh (non tidal)
Marsh (tidal)
Salt Flat
Mud Flat
Channels
Upper Limit of Tides
Boundary of Lagoon

RESOURCES

Habitat Types

To better understand wetland habitats under tidal influence, biologists generally divide them into three zones: the marine, or sublittoral zone, that area continually under water; the littoral zone, that area subject to tidal influence; and the maritime zone, that area between the upper edge of the littoral zone and the upland vegetation. The approximate acreages of major habitats within the Los Penasquitos Lagoon (Plate 5) are:

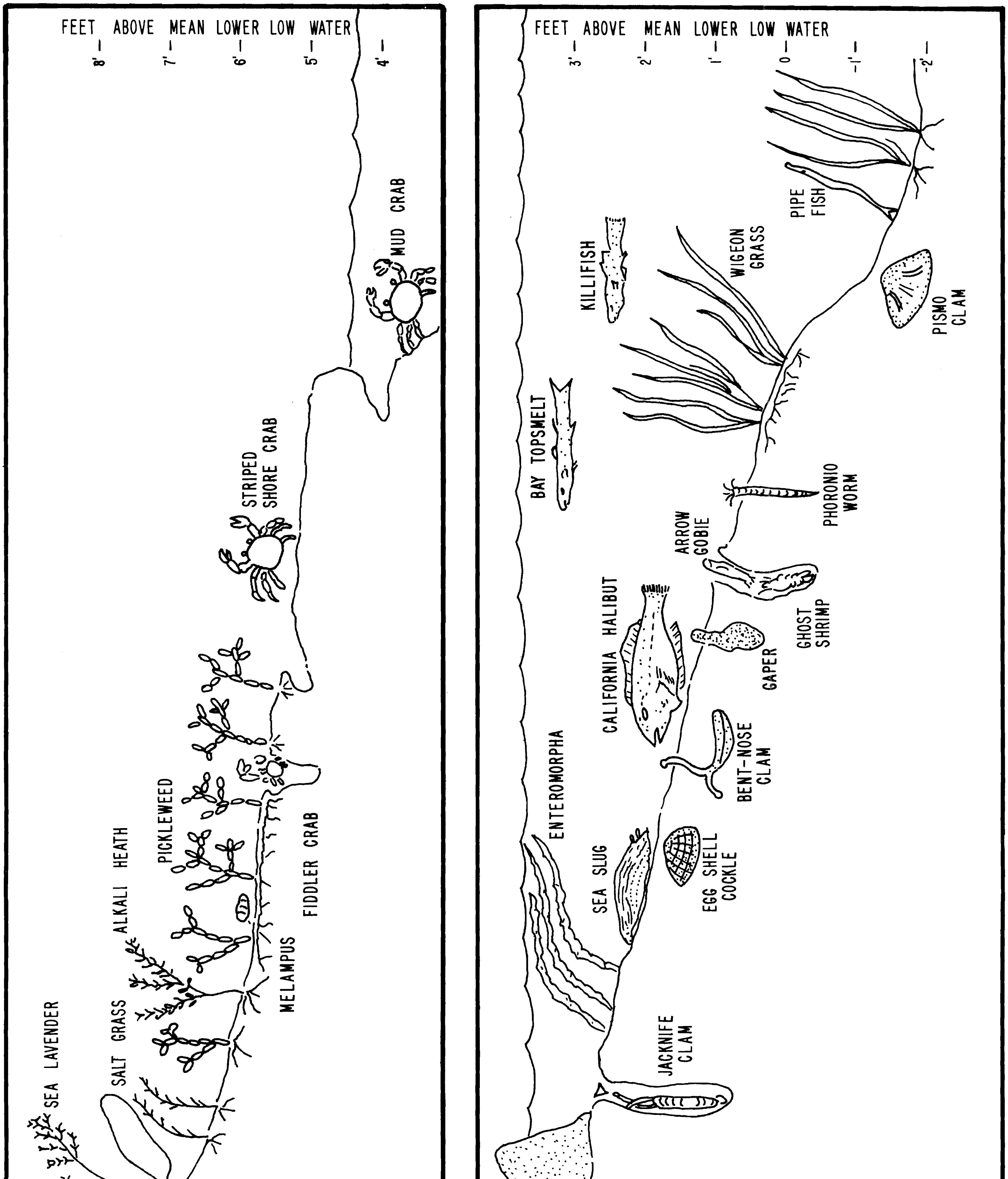
Marine		30 acres
Channels - 30		
Littoral		155 acres
Tidal salt marsh - 125		
Mud flats - 30		
Maritime		200 acres
Non-tidal salt marsh - 110		
Salt flats - 90		
	Total	385 acres

Vegetation

The plant life of the Los Penasquitos Lagoon area (Appendix C) includes four distinctive vegetation types: coastal salt marsh situated in the marine, littoral and maritime zones; and, brackish water marsh, maritime scrub and chaparral, located generally at the edge and above the maritime zone.

By far the most common vegetation type is the salt marsh which covers an area of approximately 235 acres. Salt marsh vegetation is adapted to periodic inundation by tidal water and to highly saline, poorly drained soils.

PLATE 6



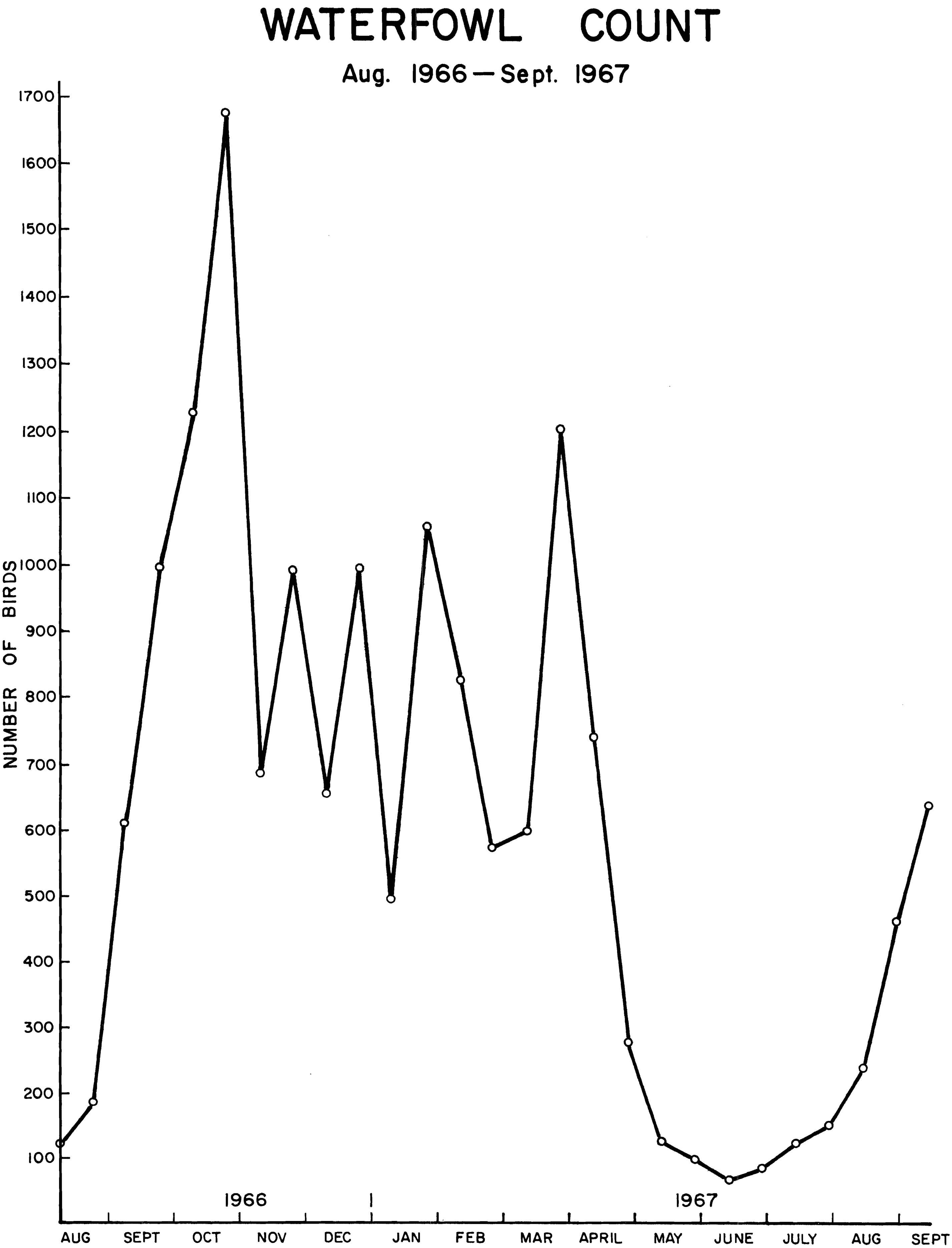
Intertidal Zonation in Los Penasquitos Lagoon and Marsh

The floristic composition of the salt marsh varies with elevation and with proximity to the tidal creeks (Plate 6). The lowest level of the marsh type (marine zone) is sparsely colonized by submergent aquatic plants, mainly widgeon grass (*Ruppia*) and a filamentous green algae (*Enteromorpha*). The occurrence of both these species is seasonal, *Ruppia* appearing in early spring and *Enteromorpha* in summer. While abundance varies from year to year, in most recent years the submergent vegetation has been poorly developed.

Between the mean higher high water tide level (MHHW) and the upper limit of tidal inundation (EHW), the salt marsh vegetation is dominated by perennial pickleweed (*Salicornia virginica*) and to a lesser extent, alkali heath (*Frankenia*). In the upper reaches of tidal influence and beyond, pickleweed is interspersed with salt grass (*Distichlis*), sea lavender (*Limonium*), and a variety of other salt-tolerant species. Fringing the extreme upper edge of the tidelands is a zone of vegetation dominated by glasswort (*Salicornia subterminalis*); this low-growing shrub is also the predominant species in the vicinity of the bare salt flats to the southeast of the railroad. Also common in this salt flat area following good winter rains is the salt marsh daisy (*Lasthenia glabrata*) an attractive annual which is very rare in southern California.

Small areas (less than 10 acres) of brackish water marsh occur where fresh water from the Soledad Canyon and Carmel Valley Creeks mingles with the saline tidal water. This vegetation type is characterized by the presence of cattails (*Typha*), several species of rushes (*Juncus*) and bulrushes (*Scirpus*). In the less saline areas upstream, thickets of arroyo willows (*Salix*) occur. Brackish water vegetation is expected to decrease in extent as a result of the cessation of sewage effluent discharge.

PLATE 7



(Adapted from Bradshaw, 1968)

Wildlife

The coastal wetlands; i.e. lagoons, bays, estuaries, are an integral part of the coastal migration route, by which millions of waterfowl, shorebirds and other water-associated birds fly between their breeding grounds located principally in Canada and Alaska and their wintering grounds in California and Mexico. Hence the most conspicuous wildlife in Los Penasquitos Lagoon are those migratory bird populations that frequent the lagoon, generally between August and May.

Sixty-eight species of water-associated birds have been listed for Los Penasquitos Lagoon (Appendix D). Censuses of waterfowl and shorebird populations were conducted in 1966-67 and again in 1970. Members of the Audubon Society conducted the 1966 survey at two-week intervals between August, 1966 and September, 1967 (Bradshaw, 1968). Peak populations of 1,700 and 1,200 birds were tallied in late October and early April, respectively (Plate 7). Fall and spring migration patterns are normal and well documented. The San Diego Field Ornithologists 1970 survey recorded 47 species and a peak population number of 1632, however their survey was conducted in Los Penasquitos Lagoon only between January and April (San Diego Field Ornithologists, unpubl. data, pers. comm.).

Thirteen species of waterfowl, including sightings of black brant and whistling swans have been observed in the lagoon. Surface feeding or dabbling ducks are the most prevalent; the pintail, shoveler, green-winged and cinnamon teal the most common. However, diving ducks also have been observed in fair numbers, particularly the ruddy duck, scaup and bufflehead. Coots, the common mud hen, often included in the waterfowl category, although actually in the rail family, are quite prevalent in the lagoon during the migratory period.

Shorebirds account for the major portion of the migratory bird population observed in the lagoon, both in total numbers and kind of species. The most commonly observed are plovers, willits, dowitchers, sandpipers, avocets, black-necked stilts, godwits and killdeers.

Los Penasquitos Lagoon is one of 19 known nesting sites of the least tern. This uncommon tern is listed as one of California's endangered species (Dept. Fish and Game, 1974). Ten pairs of least terns were recorded in the lagoon in 1969 (Craig, 1971) and four years later the number of nesting pairs increased to fifteen (Bender, 1973). Main nesting activity in 1973 occurred on a saltflat in the middle of extensive marsh vegetation where the area is well-protected by tidal channels and the only access is along the railroad right-of-way. Six nests were found in 1973. Social flocking areas for the least tern are located on sandbars just inland of the Pacific Coast Highway or near the parking lot for the Torrey Pines Beach. Human disturbance may have prevented nesting attempts at these latter locations and nesting sites recorded by Craig in 1971 alongside a dirt road and nearby salt flats were unused by the least terns in 1973 (Bender, 1973). Careful protection and management of the preferred least tern nesting sites would probably maintain or increase the population of these endangered birds.

Other terns observed in the lagoon are the royal, Caspian, elegant and Forster's terns. Gulls, as well as other water-associated birds such as the herons, egrets, grebes, cormorants and loons, are also seen about the lagoon and its environs.

The resident bird population is much smaller than the migratory population, but equally important to the ecology of the lagoon, and include several spectacular or uncommon bird species. The great blue heron, and the black-crowned night heron are a common sight, but two residents are

Los Penasquitos Lagoon is one of the few places where the light-footed clapper rail (top photo) and least tern nest successfully. Both are listed as endangered species by the Department.

Department of Fish and Game Photos by Herbert Clarke and Barbara Massey.

among the list of California's endangered species; one a member of the rail family, the light-footed clapper rail, and the other the Belding savannsh sparrow. Los Penasquitos Lagoon is one of the few coastal wetlands sites where the light-footed clapper fail is known to reside and nest. This rail is totally dependent upon salt marsh vegetation for its existence. The sora and Virginia rails also have been recorded in the lagoon, as they migrate south from the northern extension of their ranges.

The Belding savannah sparrow while classified as a passerine bird also may be classified as a water-associated bird, since it is dependent upon pickleweed dominated vegetation for its specialized habitat requirements. Los Penasquitos is one of eleven known nesting sites for this interesting endangered sparrow. Bradley (1973) censused 160 singing males, which is estimated to be fifteen percent of the state's total. The white-tailed kite, a rare but not endangered species of hawk also nests in the lagoon, at the southern extension of the marsh area.

Although no counts are made for terrestrial birds, the open space, environs and watershed of Los Penasquitos Lagoon is very important habitat for upland types of birds. The most commonly observed are the western meadowlark, red-winged blackbird and the marsh hawk.

Los Penasquitos Lagoon also attracts approximately 20 species of mammals (Appendix E). Most of the mammals reside in the upland brush fringing the lagoon and are not dependent entirely on the marshland for their existence. Several conspicuous species, however, such as mule deer, racoons, bobcats, skunks and rabbits, forage regularly in the salt marsh and brackish water marsh areas which probably provide important feeding areas during the dry season.

Fish and Shellfish

A total of 21 species of fish has been recorded from the lagoon channels (Appendix F). The most common fish are bay topsmelt and killifish, hundreds of which may be collected in seine samples. Two important sportfish, the California halibut (young) and diamond turbot, as well as the commercially important staghorn sculpin are fairly common. These fish breed in the inshore ocean waters and appear to enter the sheltered lagoon as fingerlings which later return to the ocean when they have reached a length of approximately six inches. Thus, the lagoon provides an important nursery ground for some species, furnishing young fish with an abundance of food and protection from larger predatory fish.

Resident fish include the California mudsucker, an important bait species; the opaleye perch; arrow gobies; and the curious little pipefish, a relative of the seahorse. Mullet abound in the slough during the summer months and California corbina, anchovies and queenfish are occasional visitors.

All of the above-mentioned fish species can tolerate salinities as high as or higher than sea water. The only species occurring in the brackish and fresh water areas of the lagoon is the mosquito fish which has been introduced to control aquatic insect populations.

Prior to the opening of the lagoon mouth in 1967, no marine shellfish existed in the Los Penasquitos Lagoon (Miller, 1966). However, within a year after tidal exchange had been established, 20 species of shellfish (Appendix G) were recorded in the lagoon. The rough-necked piddock became established in 1969 in the mudflats of the eastern channel in such large numbers that a commercial clam digger began to operate in that area.

The most conspicuous of the shellfish presently found in the lagoon are mudcrabs and shorecrabs which abound on the banks of the channels.

Several species of clams inhabit the muddy creek bottoms, the most common being the bent-nosed clam, the egg-shell cockle and the folded rock venus. The burrowing ghost shrimp and the fiddler crab have also become common species throughout most of the tidal channels. Small populations of mussels and rock oysters are conspicuous where rocks or pilings provide suitable attachment sites for the larvae. Many small burrowing worms occur in the mudflats, providing an important source of food for shorebirds.

Ecology

The primary value of the Los Penasquitos Lagoon ecosystem is that it provides feeding and resting areas for migratory waterfowl and shorebirds, and nesting and feeding habitat for resident birds. The lagoon also provides spawning and/or nursery grounds for a variety of estuarine and inshore fish and suitable habitat for clams, burrowing shrimp and other invertebrate organisms.

The high biological productivity of the lagoon, making it attractive feeding and nesting habitat, is due to the abundance of salt marsh vegetation and the microscopic aquatic plant life (phytoplankton) of the lagoon waters. Salt marsh plants produce a large amount of organic debris. The debris is washed into the channel-mudflat system and, during bacterial breakdown, becomes food for a wide variety of invertebrate organisms which are of great value to wildlife. These invertebrates include mollusks, insects, shrimp, crabs and annelids (marine worms). Between late fall and spring, numerous shorebirds appear on the mudflats and adjacent areas to take advantage of the invertebrate food source.

Waterfowl nest near the channel waters and dive or dabble for food in the muddy creek bottoms. Some migrants, such as terns and pelicans, feed

Top Photo: Salt marsh, comprised principally of pickleweed vegetation is important wetland habitat and should be protected wherever it remains.

Department of Fish and Game Photo, March 1974

Bottom Photo: The endangered light-footed rail depends entirely upon pickleweed salt marsh for existence.

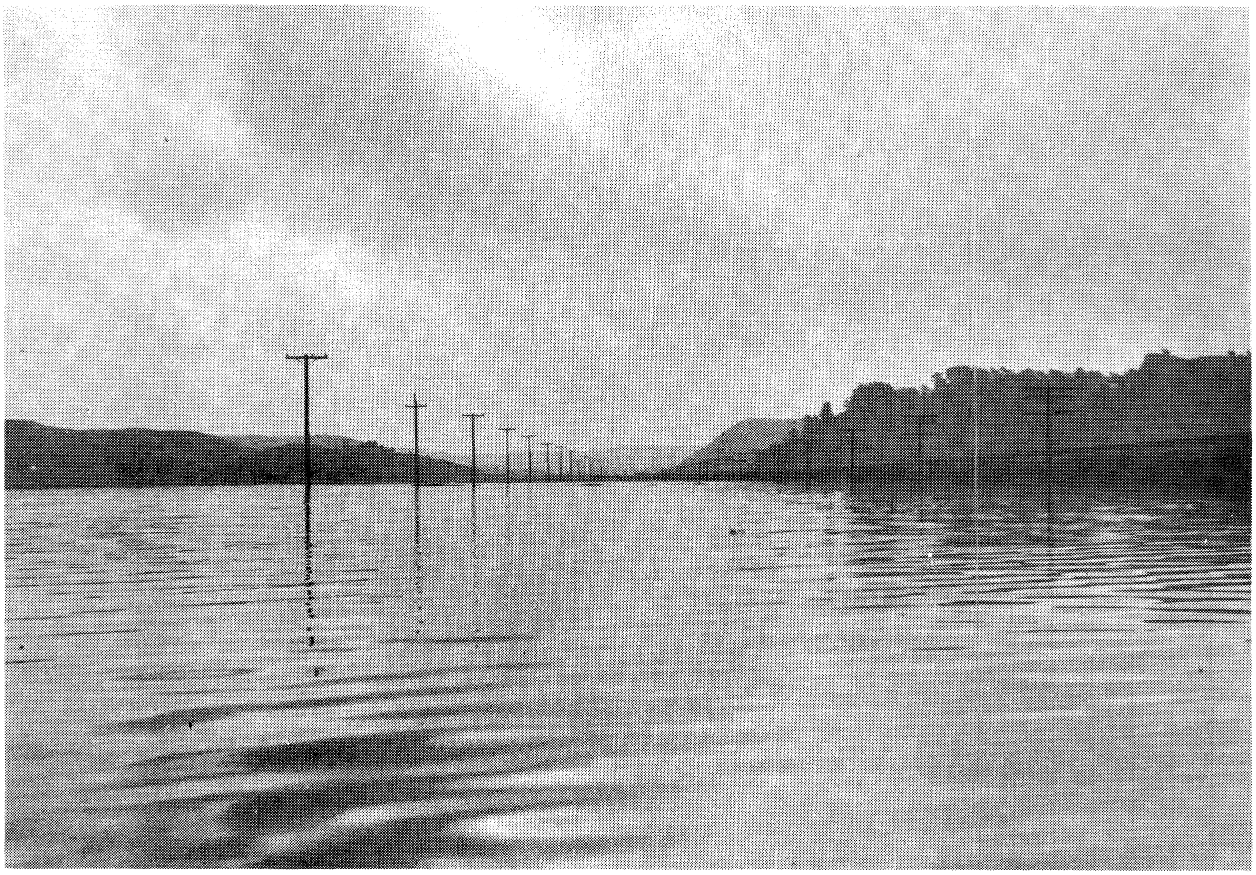
Photo by Jesse La Grange, July 1971

on small fish that are attracted to the lagoon by the abundance of invertebrate life.

The salt marsh habitat is also of critical importance to a variety of birds which require specialized habitat and reside in the vegetation bordering the channels. These birds include the light-footed clapper rail and the Beldings savannah sparrow, now in danger of extinction as a result of the restriction of this type of habitat.

Some species of resident estuarine fish, such as the mudsucker and the pipefish, also are becoming scarce because of the elimination of lagoon habitat. While extensive studies have not been made to determine the significance of the coastal wetlands to migratory fish such as halibut and turbot, the use of the lagoons, bays and estuaries as nursery grounds for these fish indicates that their population numbers could be adversely affected by the elimination of these types of habitats.

The most important factor contributing to the maintenance of a healthy lagoon environment is unquestionably the presence of good tidal flushing. The importance of tidal water exchange is well-illustrated by comparing the ecology of the Los Penasquitos Lagoon before and after the opening of the lagoon mouth in 1967. In 1966, only five hardy species of fish inhabited the lagoon and no shellfish were present. Within a year after the removal of the sand bar, 20 species of invertebrates and 6 additional fish species were recorded. Additional species of aquatic organisms colonized the lagoon the following year, and the total number of fish species increased to 21. By the winter of 1969, however, enlargement of the sandbar at the mouth of the lagoon had smothered several clam beds and resulted in a decrease in the number of migratory marine organisms. Closure of the lagoon's mouth, accumulation of sewage and rain water created conditions that led to extensive fish kills and the elimination of some shellfish species. Although some recovery of marine aquatic life has occurred following restorations of tidal action, it is apparent that the inability to maintain a permanent opening to the sea is detrimental to the establishment of a rich lagoon fauna.



Top Photo: When the entrance channel is closed, heavy winter rains may flood the lagoon to the three-foot contour level or higher.

Bottom Photo: Pockets of saline water offer the only temporary refuge for marine organisms trapped by fresh water flooding.

Photos by Jeffe La Grange, March 1970

RESOURCE USES

Past and present use of the natural resources of Los Penasquitos Lagoon primarily has been recreational, scientific and educational. Los Penasquitos Lagoon also has served as one of the "open spaces" that characterize San Diego County and make it so attractive to residents and tourists alike.

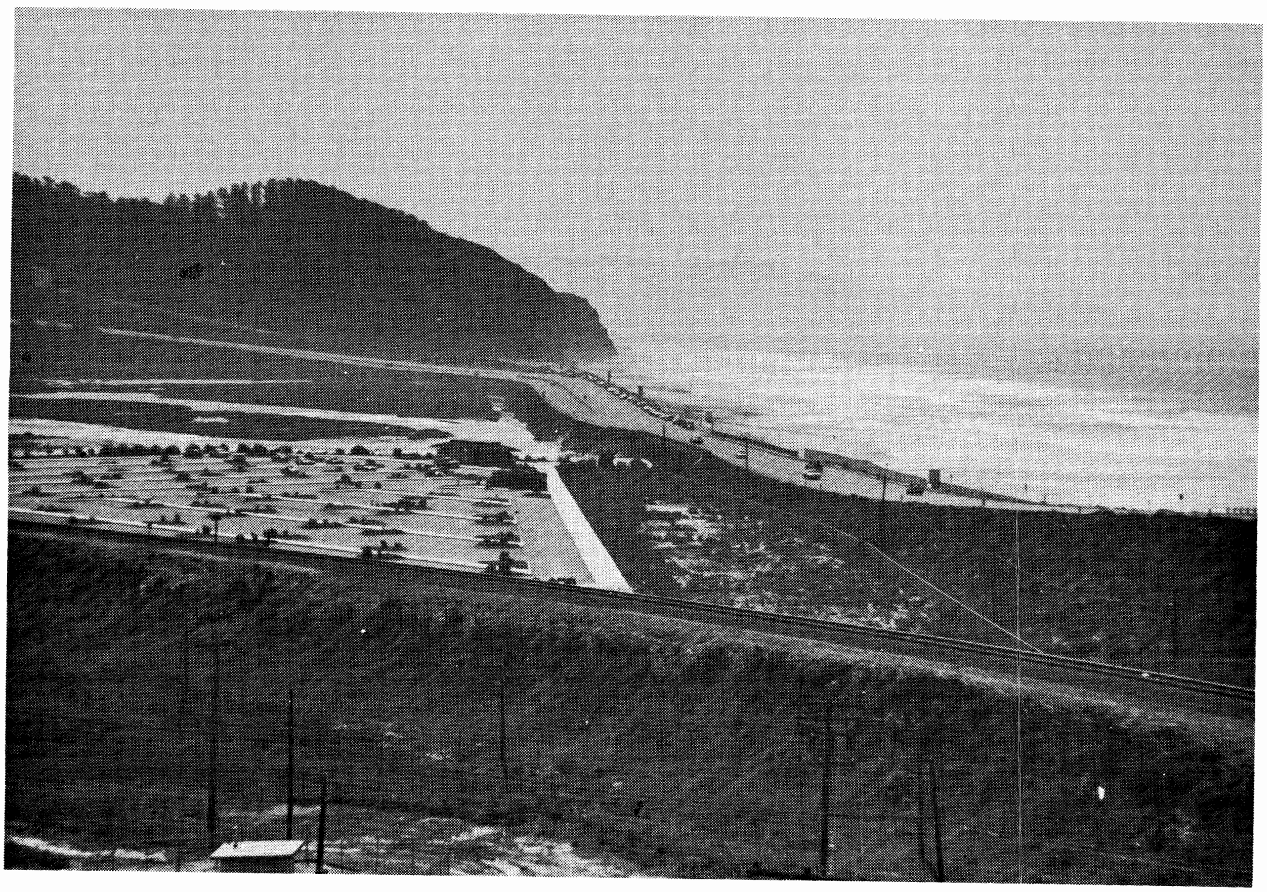
At one time limited commercial use of the lagoon existed in the form of harvesting shellfish on the mudflats and using the lagoon waters as a disposal area for treated sewage effluent. However, pressure from local residents who decried the physical and aesthetic alteration of the mudflats put an end to the commercial shellfish harvest and completion in 1972 of the Metropolitan sewage line terminated sewage disposal into the lagoon.

Sportfishing near the entrance of the lagoon is a fairly popular weekend activity but hunting in the lagoon has been precluded for sometime by local firearms closures and State Reserve regulations.

Nature Study, Bird Watching and Photography

Approximately 200 visitors, members of the San Diego Natural History Society and/or the Audubon Society, use the lagoon periodically throughout the year for nature study and bird-watching; and a smaller number of local residents regularly visit the lagoon for the same purposes.

A much wider general appreciation of the wildlife and aesthetic values of the lagoon is evident from the fact that as many as 250 nearby residents have turned out at times to dig a channel through the sand bar at the mouth of the lagoon. Similarly, the birdlife and picturesque view of the lagoon is appreciated by a much larger audience than actually visit the lagoon. Most visitors on the Guy Fleming Trail of the Torrey Pines State Reserve



Top and
Bottom Photos: The Torrey Pines State Beach and Reserve offer much recreational opportunity.

Department of Fish and Game Photos, March 1974

pause at an overlook site to admire the lagoon; visitor attendance during the fiscal year 1972-73 at the State Reserve and Beach was approximately 666,000 people (Dept. Parks and Recreation, 1973). The public demand for scenic natural vistas also is reflected in the fact that all of the first housing unit in the Sea View development on the slope north of the lagoon were sold within two weeks (Baldwin, Baldwin Construction Co., pers. comm., 1972).

Boating, Fishing and Clamming

Boating in the lagoon is more or less confined to canoes and row-boats due to restrictions on the use of motor-powered boats in the Reserve. An average of two to three small boating parties use the lagoon each weekend; activity increases during the summer months.

The railroad trestle and the highway bridge attract a small number of fishermen throughout the year, with activity increasing to approximately 20 persons per day on weekends during summer. The best catches are made at the lagoon entrance where sizable flatfish and other sportfish are obtained. Mussels from the lagoon frequently are used as bait.

Clamming is confined mostly to casual picking from the sandbar and mud-flats near the lagoon entrance. Both fishing and clamming success are highly dependent on the maintenance of the tidal ebb and flow in the lagoon.

Picnicking

Most picnicking is confined to the small beach near the entrance of the lagoon where restroom facilities are available. Tables and fire rings are not provided. However, the comparatively warm, calm water of the shallow lagoon entrance and the wind protection provided by the highway and parking lot embankments attract families with young children. During summer, an approximate average of 200 persons per week use this beach area inside the lagoon. There is a much greater potential for picnicking use, but this activity has been discouraged by the lack of provision of lifeguard protection and picnic facilities; and, previously, by the posting of pollution warnings at the lagoon mouth. However, this form of recreational use will have to be resolved with the importance of the same type of lagoon area to the endangered least tern.

Scientific and Educational Uses

The scientific interest in the ecology of the Los Penasquitos Lagoon is well attested by the intensive studies of Dr. John S. Bradshaw, University of San Diego (1968), Dr. Lars Carpelan, University of California, Riverside (1960, 1961) and Jacqueline Miller, University of California, Los Angeles (1966). In fact, until recently, Los Penasquitos Lagoon was the best documented coastal wetland in southern California.

Since 1967, considerable use has been made of the lagoon for the research and education of local college students. The continuing ecological studies of Dr. Bradshaw have involved about 20 undergraduate students per year in a sampling program conducted at approximately 6-month intervals. Several groups of approximately 25 students from San Diego State University visit the lagoon each year. A number of studies are in process or have been carried out by graduate students and staff at Scripps Institution of Oceanography. These studies include:

1. Investigation of nutrient levels in the lagoon waters (Bradshaw and Mudie, 1972).
2. Study of the sediment transport and deposition at the lagoon mouth (Karig, 1970).
3. Salt marsh vegetation salinity tolerances and requirements (Mudie, in preparation).

4. The autecology of the salt marsh daisy (*Lasthenia glabrata* subspecies *Coulteri*) (Mudie and Radlow, in preparation).

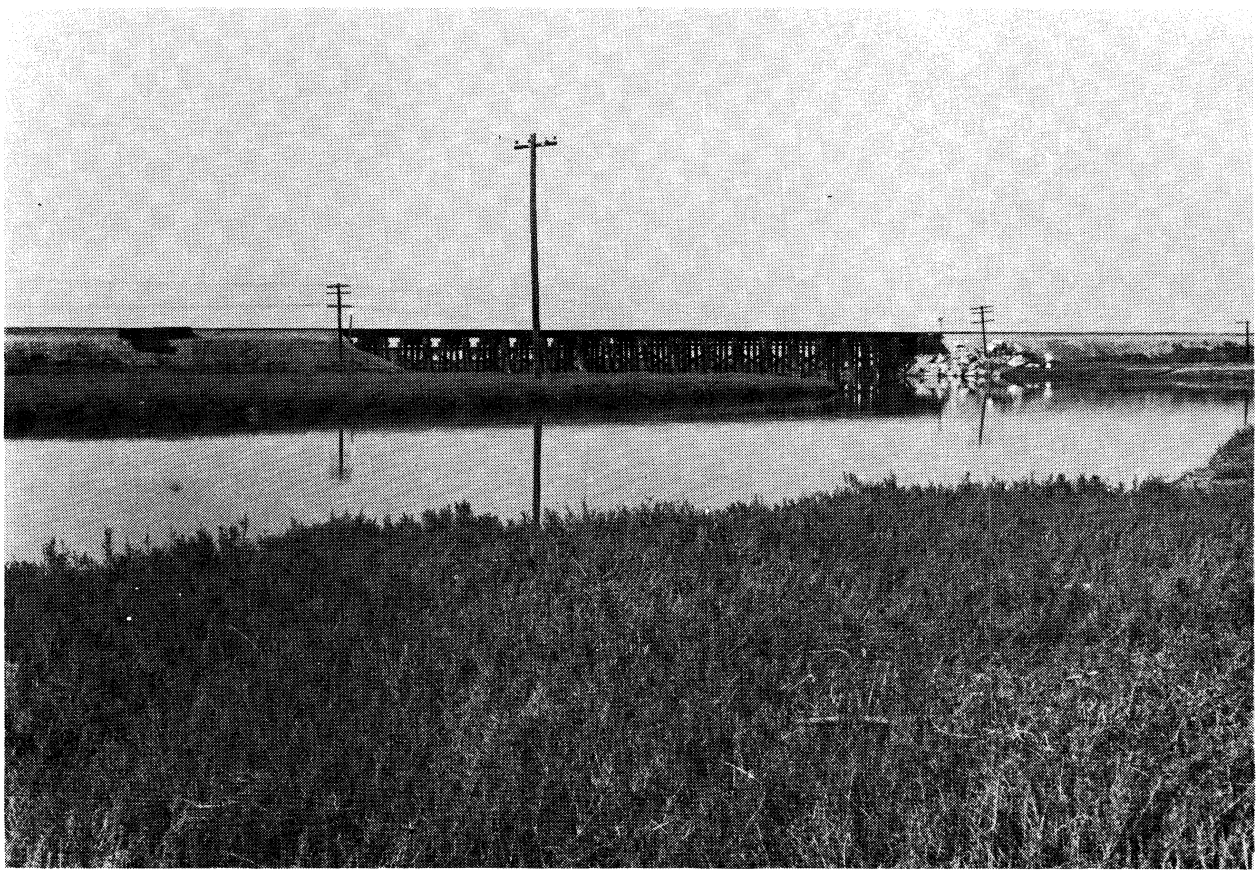
5. Investigation of the distribution and trophic relationships of lagoon zooplankton (Peter Sertic, Food Chain Research Group).

6. The recent history of the lagoon: the past 1,000 years (Professor John Isaacs, Marine Life Research Group).

7. The wave climate off the Torrey Pines State Beach (Dr. Charles Nordstrom, Shoreline Processes Laboratory).

Other short-term scientific studies that have been at least partially based on Los Penasquitos Lagoon include surveys of the breeding habits of the least tern (Longhurst, 1969; Craig, 1971; Bender, 1973), an investigation of the oxygen levels in the salt marsh soil (Mudie, 1970) and a study of the benthic fauna in two lagoon channels (NSF Student Training Program, Summer 1972). Currently, a bird population and nesting study is being carried out by a graduate student from the Department of Biology at San Diego State University, and an interdisciplinary course in environmental evaluation and management planning for Los Penasquitos Lagoon is being conducted by Drs. Charles Cooper and Joy Zelder at the State University.

Less use has been made of the lagoon by local primary and secondary schools, due partially to the fact that at present only one high school and one junior high are located within a ten-mile radius of the lagoon and partially to the unavailability of interpretive services. In 1970, approximately 300 school children visited the lagoon on school-sponsored field trips. With the predicted increase in the population of North San Diego City (340,000 by 1985), student use will undoubtedly increase dramatically.



Top Photo: Salt Flats dominate the upper part of the lagoon. The lowlands on the far side of the tracks are owned by San Diego Gas and Electric.

Bottom Photo: The railroad and highway bridges are formidable barriers to free-flowing tidal circulation into the lagoon.

Department of Fish and Game Photos, March 1974

PROBLEMS AND USE CONFLICTS

Considering that Los Penasquitos Lagoon is adjacent to areas of large human populations, and projections for population numbers are ever-upward, the lagoon is threatened by relatively few problems or conflicts of use. However, those few are critical and need immediate attention or solution. Basically they fall under the general categories of tidal flushing or circulation; urban and industrial development in the lagoon and its watershed; sedimentation and pollution in its waters; and a general lack of coordinated management efforts. Some of these problems and conflicts are interrelated and actions taken to solve one will influence the solution of another.

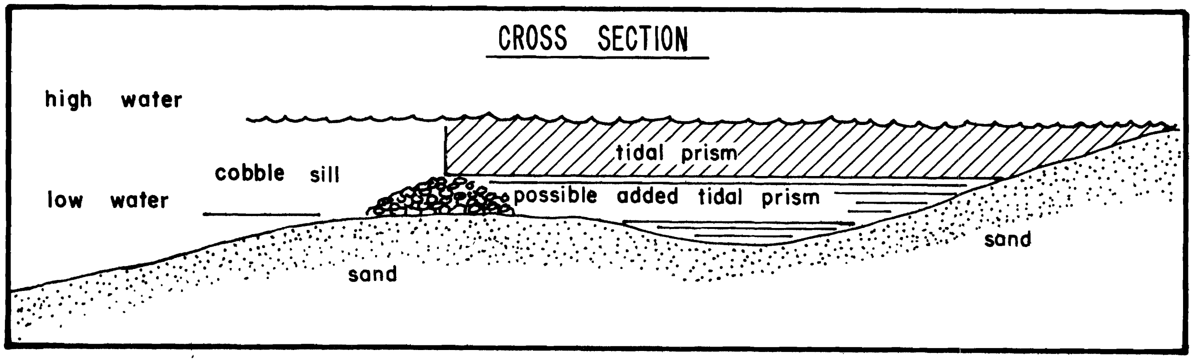
Lagoon Entrance Maintenance

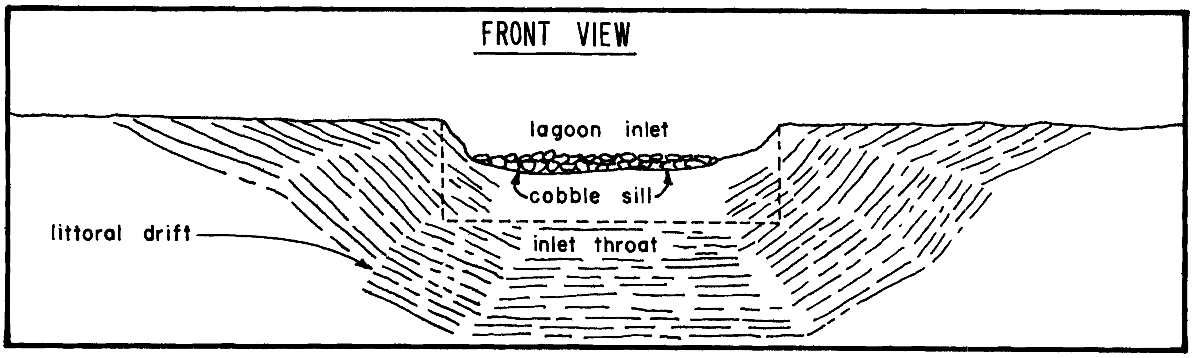
Probably the most important problem existing in the Los Penasquitos Lagoon today is a lack of adequate tidal flushing or circulation. The vitality and sustenance of estuarine and lagoon ecosystems depends upon adequate circulation of their generally nutrient-rich waters. The reproduction and development of existing fish, shellfish and other invertebrate populations, upon which the resident and migrant wildlife depend for food is suppressed by inadequate tidal flushing.

Stagnant lagoon waters also create problems with mosquitoes. Mosquito larvae thrive in static, nutrient-rich waters. When fresh or brackish water is empounded, certain types of mosquitoes, capable of transmitting disease, can breed in the lagoon. When the empounded water becomes saline, the salt water mosquito, which is a nuisance, but not a health hazard, may reproduce in large numbers. In the past, the stagnant waters have also been responsible for objectionable odors. Hence, there is a definite need to create and maintain a permanent opening from the lagoon to the ocean.

PLATE 8

COBBLE SILL





(From San Diego Environmental Task Force, 1972)

Experience has shown that reproduction and expansion of invertebrate populations are encouraged by a stable, saline lagoon environment with good circulation. And, fish are attracted to sheltered, food producing lagoons with access from the sea. However, true estuarine conditions created by a permanent opening might change the type of waterfowl using the lagoon. Surface feeding, or dabbling, ducks that are more dependent upon fresh or brackish water vegetation for food and nesting requirements probably would be replaced by diving ducks and other marine-oriented birds.

Finally, increased tidal circulation also would substantially dilute run-off from surrounding urban and industrial areas, hence reducing the pollution problems that might occur.

In theory, a lagoon will stay open if the tidal prism is large enough to produce sufficient inlet channel flow to prevent deposition of sand at the mouth (County of San Diego Environmental Task Force, 1970). The tidal prism in Los Penasquitos Lagoon is not large enough to keep the mouth open permanently under existing conditions. Half of the original tidal volume of the lagoon has been lost since 1925 due to various construction projects. To compound the problem a substantial portion of the present volume is trapped behind a cobble sill (Plate 8) which has built up in the inlet channel. The sill is positioned at mean sea level preventing water below that elevation in the lagoon from draining during a tidal cycle (Karig, 1970). Without the sill the channel would naturally lower itself another 2-1/2 feet to mean lower low water, adding an estimated 40 - 60 acre feet to the tidal prism.

The Department of Parks and Recreation has been primarily responsible for maintaining the open lagoon entrance over the past 5 years. Until 1972, the inflow of sewage effluent (1 million gallons/day) assisted mechanical efforts in keeping the mouth open. The use of light earth moving equipment has been satisfactory in this effort. However the cessation of sewage effluent has no doubt increased the difficulty in keeping the mouth open. And, it is evident that there has been a net accumulation of sand inside the lagoon further reducing the tidal prism.

Many methods have been suggested for constructing and maintaining a permanent opening to the sea. Removal of the cobble sill by dragline has been suggested as one of the most feasible and economical methods (Karig, 1970). Fluidization is another method, although this technique is still at the experimental stage. Fluidization consists of water pumped through a perforated pipe buried at a depth of about three feet. The sand above the pipe becomes fluidized by the up-rushing water, taking on the viscosity of the thick fluid, and is removed from the lagoon mouth by out-going tide. The possibility that the water rushing through the pipe might cause the pipe to become buried too deeply in the sand needs further investigation (Lowes and Kenward, 1970). Nearby Scripps Institution of Oceanography has expressed an interest in experimenting with this method and carrying out field tests in Los Penasquitos Lagoon.

Other methods of opening lagoons are under study. A self-flushing jetty system whereby wave energy flushes out the inlet has been built and tested successfully in Nova Scotia. In this latter method a vestibule is formed by two Y-shaped jettys constructed facing each other in a lagoon entrance. Sand, after being deposited in the outer portion, is carried out to sea by bottom currents (County of San Diego Environmental Task Force, 1970).

The lagoon entrance also could be kept open by means of a conventional jetty constructed at right angles to the beach. However, this and any other method that would significantly alter the distribution of sand on the Torrey Pines State Beach, should not be considered as an acceptable method of keeping open the lagoon entrance.

The feasibility of encouraging local building contractors to remove the sand from the lagoon entrance for private use has been explored by the City of San Diego. Preliminary inquiries suggest that this approach would not be economically profitable because of the saline character of the sand, demands that direct use be restricted to backfill material, and because the volume is too small to warrant transport costs for fill materials.

It is noted, however, that there is a critical need for replenishment of sand on the Torrey Pines State Beach and on the Del Mar beach. At Torrey Pines, for example, the winter beach is so narrow that wave action caused significant damage to the coastal highway early in 1973, necessitating repairs by the City of San Diego. A rough estimate of the volume of sand that could be removed from the entrance of the Los Penasquitos Lagoon (25,000 - 30,000 cubic yards) and placed on the State Beach indicated that this might raise the elevation of the beach by about 3 feet. Serious consideration should thus be given to the possibility of a regular program (say, at 5-year intervals) of sand bar removal and beach replenishment, carried out by the Street Services, or other appropriate department, of the City of San Diego.

There are many ways, then, of creating and maintaining a permanent opening of the Los Penasquitos Lagoon to the sea. Selecting the most practical and economically feasible method will fall under the jurisdiction of the San Diego Coastal Management Committee, an advisory board recently formed to carry out a basin-wide program of lagoon planning and management.

Development

Proposed Power Plant

About half of the lagoon lies in the Torrey Pines State Reserve and is adequately protected under the "reserve" status. Most of the remainder of the lagoon, about 210 acres, is owned by the San Diego Gas and Electric Company. The area owned by the Company has been proposed as a power plant site. However, there has been much local public opposition, based on aesthetic and ecological considerations, to power plant construction in the lagoon.

The Department takes the position that no industrial development, including the construction of a power plant, should take place in the lagoon, since coastal wetlands should not be destroyed unnecessarily. And, most industries do not require the natural resources of the lagoon for their successful operation and, hence, do not need to be constructed in the wetlands.

Due to seisimic and other risk factors, the State of California Resources Agency's 20-year Power Plant Siting Plan (Calif. Res. Agency, 1973) has recommended that electric utilities direct their primary site selections toward "designated optimum areas" in parts of the Sacramento and San Joaquin Valleys and southeastern California desert areas. However, economic factors and the "energy crisis" could preclude building the San Diego Gas and Electric plant elsewhere--since above-ground, coastal power plants are the most economical to build and more efficient in the use of primary energy sources. Should the power plant be built in Los Penasquitos Lagoon, mitigation for the loss of the salt marsh and lagoon channels on the site and enhancement of the surrounding areas will be required.

It is possible that the water intake-discharge system to a power plant at Los Penasquitos could be designed in a manner to be of benefit to lagoon resources. As an example, adequately cooled water discharged into the lagoon-- state and regional water resources control boards have strict regulations concerning discharge temperatures (SWRCB, 1972)-- could increase its quality and productivity by the increased flushing. Waters discharged into the lagoon could also provide a permanent solution to maintaining the ocean entrance.

Though opportunities may exist for lagoon enhancement through imaginative power plant design, past experience has shown that such developments have proven detrimental to natural resources.

Development of Watershed

Los Penasquitos Lagoon, like most coastal lagoons, is undergoing a slow demise from sedimentation. This is a natural phenomenon that begins the moment that the lagoon is first formed. But the process is hastened by disturbances in the watershed and improper management of the same. Sedimentation, then, is one of the critical problems in the Los Penasquitos Lagoon and needs a hasty solution.

Development in the lagoon environs and watershed will increase the rate of sediment flow due to erosion of unstabilized, unvegetated slopes. Both siltstone and sandstone sedimentary deposits are fairly stable under low angle cuts, but are susceptible to erosion from surface run-off and contribute large amounts of sediment during heavy rains (Rick Eng. Co., 1972). For example, intensive grading and land filling on the slopes north of Carmel Valley Road have resulted in an increased threat of sediment accumulation in the lagoon channels.

In an attempt to control the siltation threat and increased sedimentation rate from development in the Los Penasquitos Lagoon watershed and environs, the San Diego Regional Quality Control Board (RWQCB-SD) approved a resolution in 1970 (70-R26) prescribing requirements for control of siltation from construction projects in areas tributary to the lagoon. The most effective means recommended is establishment of vegetation on cut and fill slopes immediately following their construction. Alternatively, grading should procede in discreet sub-units, each stage being fully landscaped and stabilized prior to proceeding to the next phase (RQWCB-SD, pers. comm.). Siltation basins or sediment traps also are recommended procedures for slowing the rate of silt entry into the lagoon. Several such basins have been constructed adjacent to Carmel Valley Road which have slowed sedimentation down some, but not yet eliminated the problem. The Department endorses strict enforcement of RWQCB-SD stipulations to control the siltation threat to the lagoon from improper development and management of the watershed.

Flood Control Measures

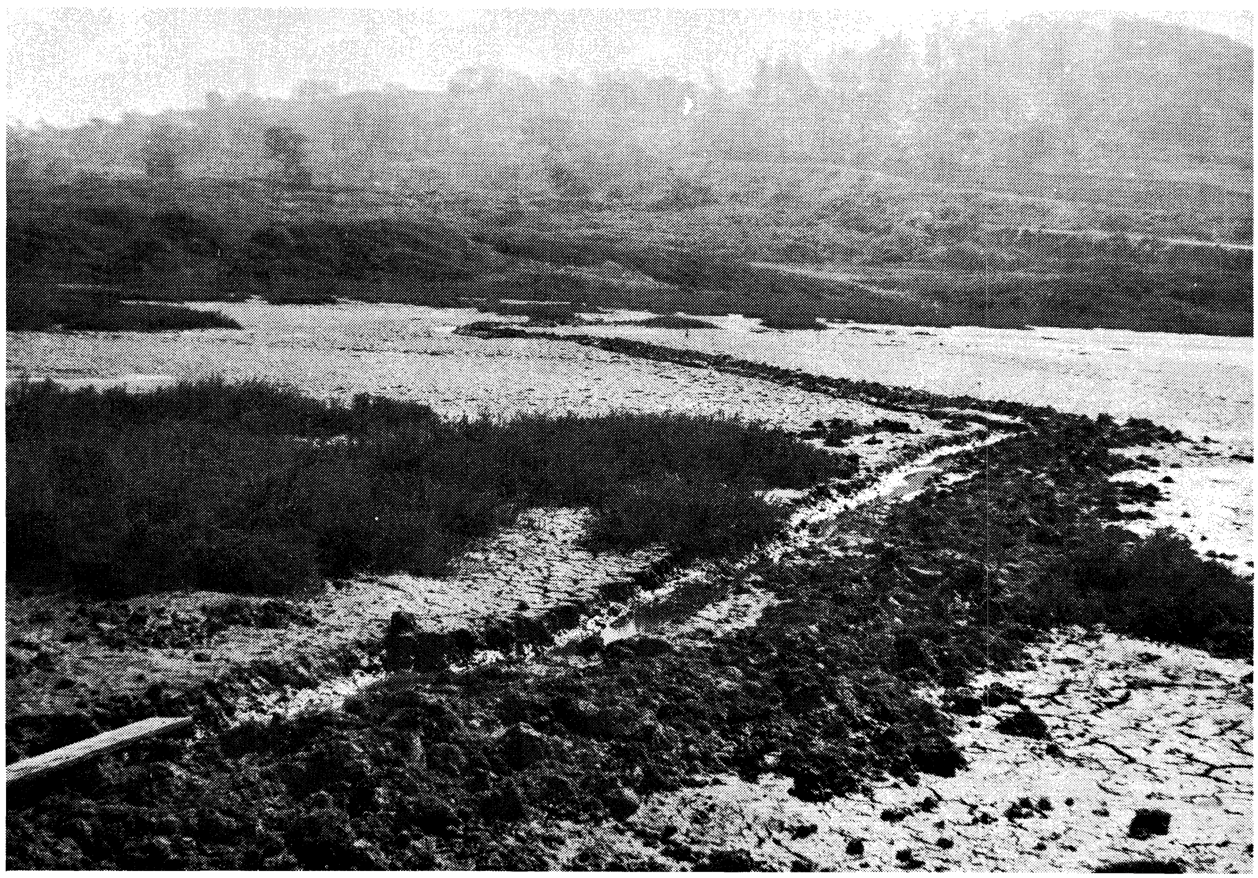
The watershed draining into Los Penasquitos Lagoon is subject to flood conditions periodically. The feasibility of a flood control system through the Los Penasquitos drainage area has been studied by the U. S. Army Corps of Engineers in cooperation with the County of San Diego (U. S. Army Corps of Engineers, 1967). At one time the Los Penasquitos Creek project was seventh in priority among 21 proposed San Diego County projects (San Diego Co. Dept. Spec. Services, 1968).

The Department endorses a flood plain management system as one of the most ecologically sound methods to control both flood damage and sedimentation problems in the lagoon and its environs. Flood plain management is accomplished by both structural and non-structural methods (City of San Diego

Plan. Dept. Water Res., 1967; San Diego Co. Dept. Spec. Serv., 1968). Structural means include levees to confine stream flows and protect special areas, swales and reservoirs to control floodwater flows into continuous discharge, and soil conservation practices necessary to retain rainfall and increase percolation into watershed soils. Non-structural methods include zoning flood plain lands to uses compatible with periodic inundation, subdivision regulations on the flood plain itself, and differential flood plain insurance rates favoring agricultural and other compatible uses. The overall objective of a well planned flood plains management program, then, would be not only to protect the lagoon from excess sedimentation from improper watershed management, but also to create a green belt riparian habitat, highly valuable to wildlife, in the upper portion of the Sorrento Valley.

Consideration also should be given to the incorporation of sediment traps and basins into the flood management system. These traps and basins should be of sufficient size to handle the run-off anticipated from maximum (100 years) storm flood, and provisions made to remove routinely the accumulated sediment from the traps. It is emphasized that the life of the lagoon ecosystem depends upon the vitality of its tidal channel system and upon the elevation of the marsh sediments surrounding the channels. Life could be terminated with a single season of excessive rainfall through the blocking of a channel by silt or the raising of the marsh surface by a half-foot of storm run-off deposited sand.

Another viable solution to the sedimentation problem is a channelization project through the lagoon itself. Experience has shown (Speth, 1970) that a well designed artificial channelized system, carefully constructed to prevent damage to the habitat and to preserve the aesthetic characteristics of the lagoon, can carry sediments on through the lagoon to the ocean.



Top Photo: Ponds isolated from the channel system are ideal breeding sites for mosquitoes.

Bottom Photo: Hand-digging trenches to natural channels alleviates the problem temporarily.

Department of Fish and Game Photos, March 1974

No one of these alternative solutions to the sedimentation problem should preclude the other; no measure to prolong the life of the vital coastal wetlands should be overlooked.

Pollution

Urban Drainage

The development of suburban housing presents additional special problems to the lagoon ecosystem. An increase in the level of pollutants is anticipated due to irrigation run-off from lawns, gardens and other landscaping features. The lagoon is presently the receiving basin for all surface waterflows from adjacent urbanized upland areas. These existing and future sources of water pollution, however, probably will be less significant than the pollution that once emanated from sewage discharges of the Sorrento, Callan and Poway sewage treatment plants.

The most effective long-term control of urban pollution would be increased tidal flushing from a permanent opening to the sea which would minimize adverse effects or urban surface water run-off. The Department, however, encourages a program to monitor pollutants in the lagoon and to determine if there is a need for a master drainage system. Such a program and study could be carried out by a local educational institution.

Mosquito Abatement

Prior to 1972, mosquito control in Los Penasquitos Lagoon was accomplished by extensive spraying with organo-phosphate pesticides in an oil base, delivered by a tracked, amphibious vehicle. This method of mosquito control was unsatisfactory from an ecological viewpoint, since it caused considerable damage to the marsh vegetation. The vehicle also left unsightly, semi-permanent scars in the marsh sediments and was disruptive to nesting waterfowl (Mudie, 1969).

Top and
Bottom Photos: Encroachment by domestic animals, recreational vehicles and other disturbances, due to the proximity of housing developments north of the lagoon, needs immediate evaluation and remedial action if necessary.

Department of Fish and Game Photos, March 1974

Since 1972, spraying has been done by hand and marsh management techniques have been employed. One such technique has been the maintenance of an open lagoon entrance through mechanical means. Good tidal flushing is not only inimical to mosquito reproduction, but also ensures maximum presence of predators that feed on mosquito larvae. Another marsh management technique has been ditching to drain areas of stagnant, empounded waters which reduces mosquito reproduction. Any further mosquito control measures should be limited to the discreet application of non-toxic (to other life forms), water-based, bio-degradable larvacides during appropriate wind and tide conditions.

Encroachment

Human and Animal Disturbance

Residential developments now being completed along the northern and eastern slopes of the lagoon and others that will dot the landscape in the future will substantially increase the human population bordering the lagoon. It is expected that the domestic animal population will also increase. The impact of human and animal encroachment upon the lagoon is not precisely known. However, qualitative observations suggest that the increased number of people and domestic animals entering the lagoon is having a disruptive effect upon resident wildlife. Nesting species are the most seriously affected.

Recently, the San Diego Gas and Electric Company posted signs prohibiting access to their lagoon property. This action has reduced public access to the lagoon waters and the salt marsh, thereby providing protection to nesting grounds and areas of the marsh that are sensitive to active human use, particularly off-the-road vehicles.

Top Photo: The Santa Fe Railroad right-of-way is a dominant feature and reduces the vitality and aesthetic quality of the lagoon.

Bottom Photo: Relocation of the Carmel Valley Road would encroach upon the periphery of the lagoon.

Department of Fish and Game Photos, March 1974

With increased encroachments into the lagoon the Department of Parks and Recreation will face an increasing problem of controlling use of the lagoon. The City of San Diego could assist in this effort with a continuing educational program to create public awareness of lagoon values.

Specific levels of use have not been established for the lagoon. As pressures mount for increased use of the lagoon, it will be necessary for the managing agency to set such levels in order to avoid damage to the resource. It is proposed that human and domestic animal use of the lagoon be monitored and that studies be undertaken to determine optimum levels of compatible uses and measures necessary to provide for and control such use.

Road Relocation

Carmel Valley Road is indicated as a major street on the General Plan for the City of San Diego. It is anticipated that the completion of the housing development on the north slope of the lagoon will create pressures for widening this road. The originally proposed 102-foot right-of-way would encroach on the lagoon. The State Department of Parks and Recreation has formally communicated to the City of San Diego its opposition to any widening of the road that would encroach on the marsh. Local residents have petitioned the City to maintain Carmel Valley Road as a relatively slow-speed scenic parkway. As a result, the City proposed as alternate design employing a narrower right-of-way and including a landscaped median strip (Rick Engineering Company, 1972).

Informal plans have been proposed to realign Sorrento Valley Road across the salt flats on the southeastern side of the lagoon (DeVore, pers.

comm., 1973). The present alignment fringes the eastern edge of the lagoon area. The proposed relocation would isolate at least 50 acres of marshland from the main drainage system unless provision is made for the exchange of water under the roadway. Traffic on a road through the lagoon would have disturbing effects on bird species that nest in the salt flat area, including the least tern, American avocet and black-necked stilt. And, the aesthetic qualities of the lagoon would be further reduced.

The Department of Fish and Game would object to any plan to fill or otherwise destroy or reduce the natural values of the lagoon unless adequate mitigation for such losses is provided.

Lagoon Management

Approximately twenty government agencies have jurisdiction over various aspects affecting the maintenance or use of Los Penasquitos Lagoon and its watershed. Several of these agencies have accumulated considerable information about the specific areas of lagoon management within their jurisdiction; for example, water quality, sediment transport, vector control and land use. On the basis of this information, some of these agencies have adopted policies designed to control potential problems, ranging from siltation control (San Diego Regional Water Quality Control Board) to the control of large-scale dredging (U. S. Army Corps of Engineers). It is evident, however, that the amount of information exchange and interdepartmental cooperation among these agencies has been very limited in the past and has had the effect of hampering efforts to execute protective lagoon management practices.

An increasing concern over the lack of interagency coordination and over the growing pressures of urban development led to the formation of the

San Diego Coastal Lagoon Management Committee. This advisory body, which was formed in June 1973 under the auspices of the Department of Parks and Recreation, is comprised of scientists, concerned citizen groups, environmental consultants and representatives of governmental agencies with expertise or common concerns in the area of lagoon management and planning.

The ultimate concern of the Committee extends to the management of all the lagoons in San Diego County. Initially, however, the Los Penasquitos Basin has been selected as a model management study area and recommendations are being formulated for both short-term and long-term management practices in the lagoon. Some of these recommendations pertain to specific actions which should be taken in the near future; for example, extensive excavation of the lagoon entrance and removal of accumulated silt from inner lagoon channels. Other recommendations are aimed at interagency coordination and at establishing a comprehensive program of research among local educational institutions and government agencies interested in the lagoon ecology and hydrology. The Committee has secured a $30,000 budget for fiscal year 1973-74 from the State Department of Parks and Recreation and has sought a matching amount from the City of San Diego. A portion of the secured funds has been used to contract preliminary improvements at the mouth of the lagoon, necessary to the construction of a permenent opening.

The eventual goal of the San Diego Coastal Management Committee is to set up a continuing, basin-wide program of lagoon planning and management. Similar committees with similar goals have been formed or recommended in other locations, such as San Francisco, Morro Bay, Humboldt Bay, etc. The Department of Fish and Game strongly recommends that this and all such committees be actively supported by the public, involved state and federal agencies and concerned private interests; for research, planning and management is critically necessary to the future of our invaluable coastal wetlands, of which Los Penasquitos Lagoon is a typical, vital and ecologically significant representative.

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Appendix A. Sand Deposition Patterns

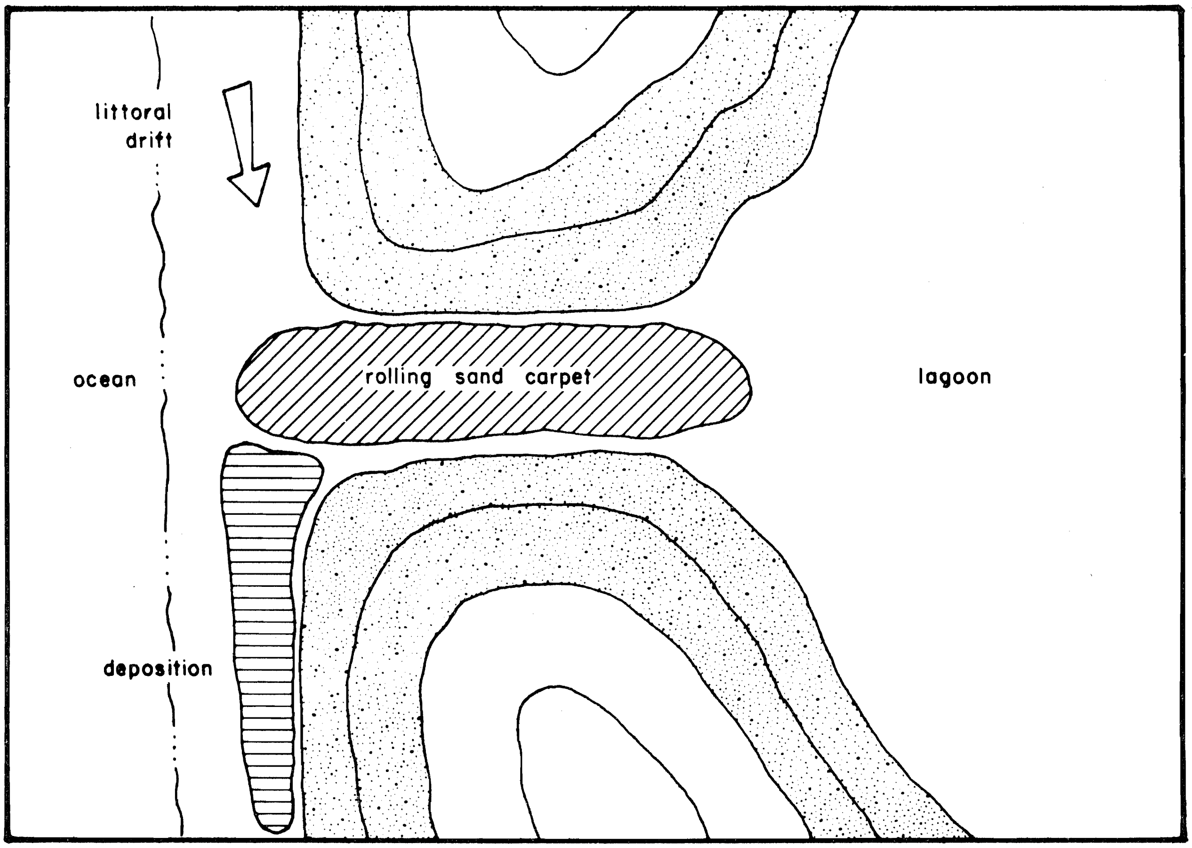


Figure 1. "Rolling Sand Carpet" skewed toward the ocean; sand deposit offshore.

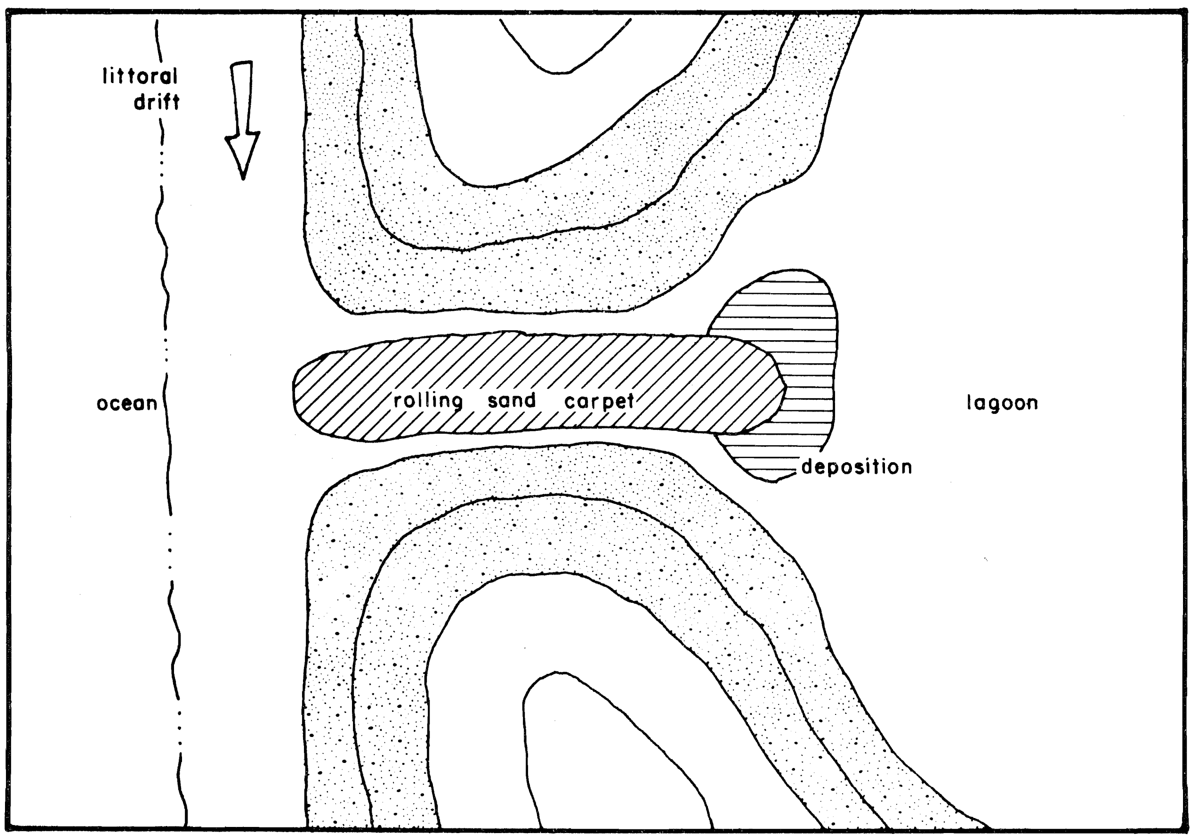


Figure 2. "Rolling Sand Carpet" skewed inshore;

(From San Diego Environmental Task Force, 1972

Appendix A
Sand Deposition Patterns

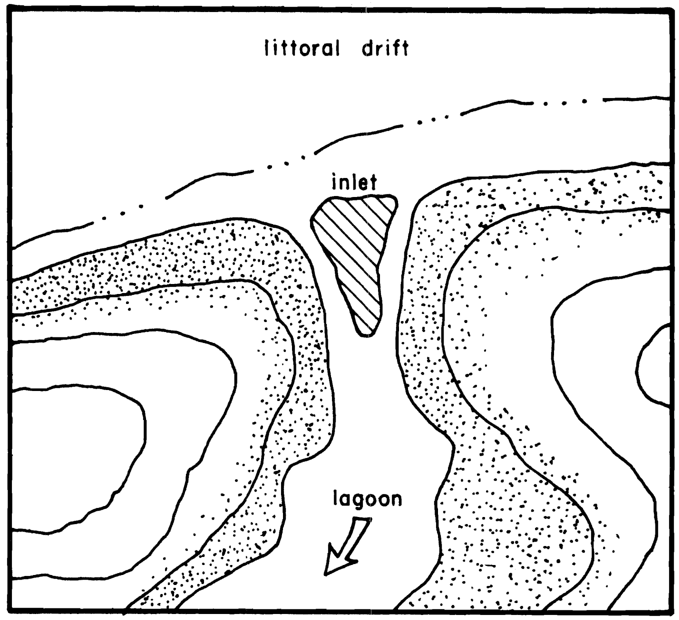


Figure 3
Inlet open

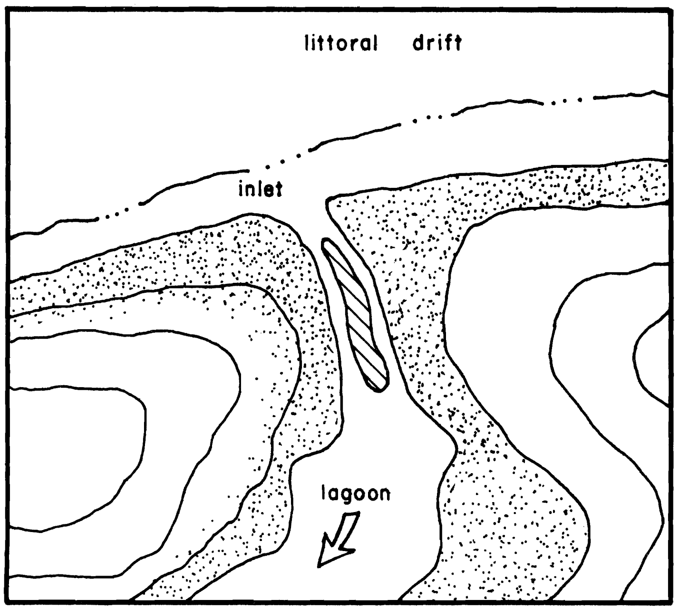


Figure 4.
Inlet closing

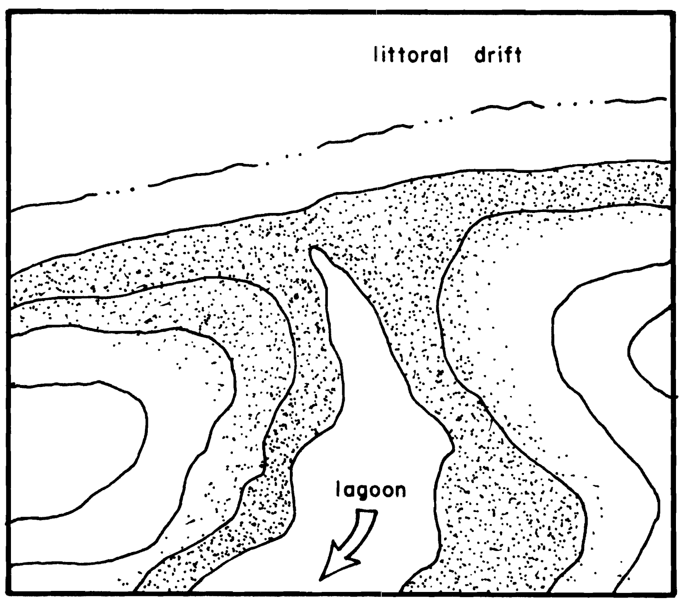
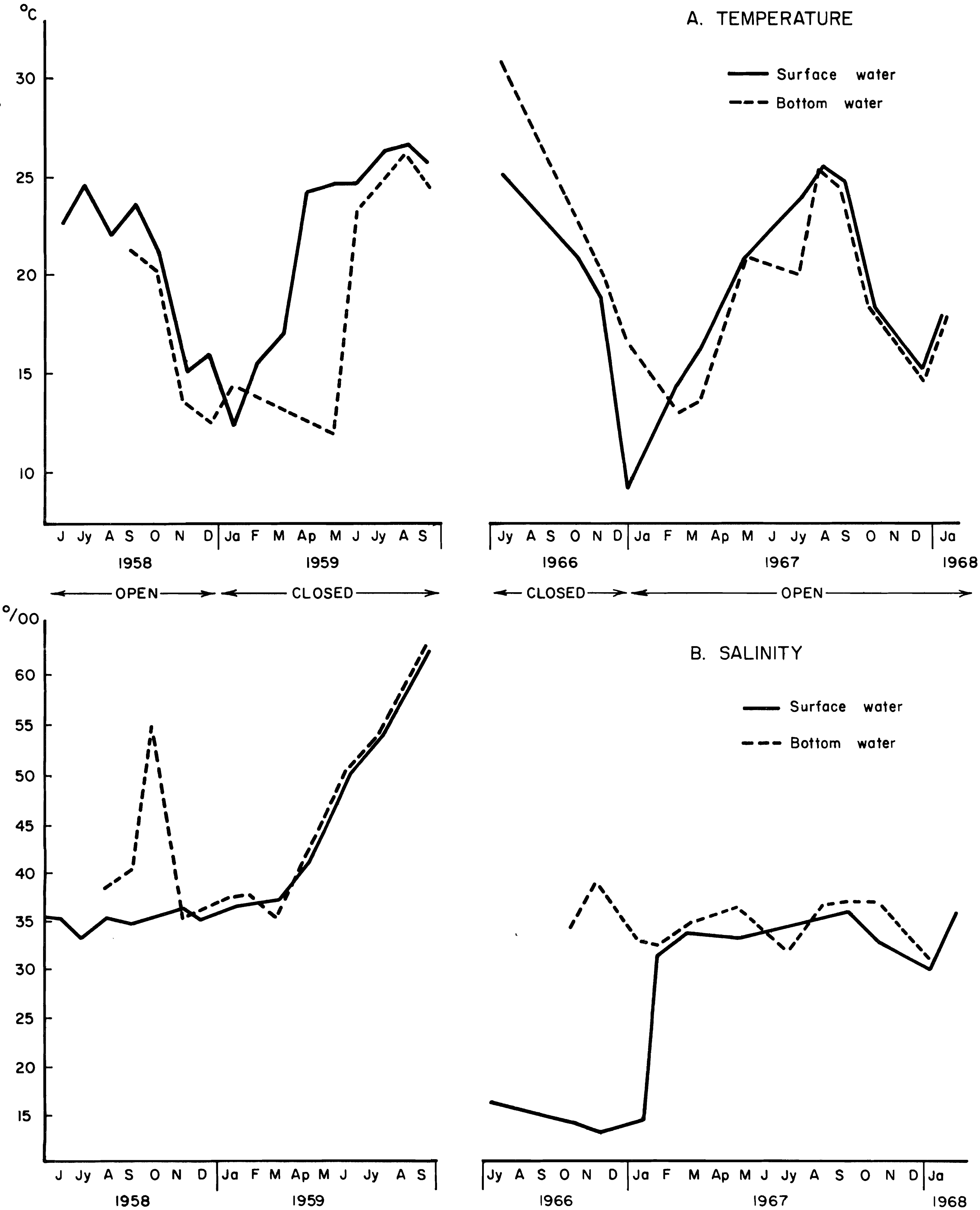


Figure 5
Inlet closed

(From San Diego Environmental Task Force, 1972)

Appendix B
Temperature and Salinity Patterns



Temperature and salinity graphs of surface and bottom water (at approximately 20 feet), showing typical annual trends under closed and open lagoon conditions, data sources: Carpelan (1960) and Bradshaw (1968):

A. Temperature. The graphs indicate that when the lagoon is open (e.g. 1958, 1967-8), there is less than 5°C difference in the temperature of the surface and bottom water, the latter usually being slightly cooler than the former. When the lagoon is closed and little fresh water is entering (see 1959), the surface water heats much more rapidly than the deep water. In contrast, when the lagoon is closed and considerable fresh water is entering (e.g. from sewage effluent after 1963), warm dense saline water may accumulate beneath the lighter brackish surface water (see July - Jan., 1966).

B. Salinity. The 1958-9 graph shows the dramatic rise in salinity that occurs in both surface and bottom water following the closure of the lagoon in the absence of a major fresh water inflow. In contrast, when substantial amounts of fresh water enter the lagoon year round e.g. sewage effluent after 1963), the salinity of the surface water in the closed lagoon is lowered considerably, even during the summer months (see July - Aug., 1966). The bottom water remains saline, however. On restoration of tidal action (see 1967-8), the salinity of the surface and bottom water remains approximately that of sea water, despite the continued inflow of sewage effluent.

In general, then tidal conditions in the open lagoon promote mixing and stabilization of water temperature and salinity. Under closed conditions, strong gradients develop between surface and bottom waters and large annual fluctuations occur.

APPENDIX C

Check List of Flowering Plants
(Bradshaw, 1968)

Note: * denotes species observed outside of Torrey Pines Park boundary.

FAMILY	SPECIES	COMMON NAME
Malvaceae	*Malva parviflora* L.	Cheeseweed
Geraniaceae	*Erodium cicutarium* (L.)L'Her.	Red-stem filaree
	E. moschatum (Burm.F.)L'Her.	White-stem filaree
Oxalidaceae	*Oxalis pes-caprae* L.	Bermuda buttercup
Euphorbiaceae	*Ricinus communis* L. *	Castor bean
Tamaricaceae	*Tamarix* sp.	Tamarisk
Frankeniaceae	*Frankenia grandifolia* Cham. & Schlecht	Alkali heath
Capparidaceae	*Isomeris arborea* Nutt.	Bladder pod
Cruciferae	*Brassica nigra* (L.)Koch	Black mustard
	Cakile edentula (Bigel.)Hook ssp. *californica* (Heller)Hult.	Sea rocket
	Hutchinsia procumbens (L.)Desv.	Nannie's purse
	Lobularia maritima (L.)Desv.	Sweet alyssum
	Matthiola incana (L.)R.Br.	Stock
	Raphanus sativus L.	Wild radish
	Sisymbrium cf. *altissimum* L.	Tumble mustard
Caryophyllaceae	*Spergularia macrotheca* (Hornem.) Heynh.	Large-flowered sand spurrey
	S. marina (L.)Griseb.	Salt marsh sand spurrey
Portulacaceae	*Montia perfoliata* (Donn.) Howell	Miner's lettuce

APPENDIX C (cont'd.)

FAMILY	SPECIES	COMMON NAME
Chenopodiaceae (cont.)	*S. subterminalis* Parish	Glasswort
	S. virginica L.	Pickleweed
	Salsola kali L.	Russian thistle
	var. *tennifolia* Tausch	
	Suaeda californica Wats.	California seablite
Primulaceae	*Anagallis arvensis* L.	Pimpernel
Plumbaginaceae	*Limonium californicum* (Boiss.) Heller	Sea lavender
	var. *mexicanum* (Blake)Munz	
Convolvulaccae	*Convolvulus aridus* Greene	Morning glory
	spp. *tenuifolius* Abrams	
	Cressa truxillensis H.B.K.	Alkali weed
	var. *vallicola* (Heller)Munz	
Cuscutaceae	*Cuscuta salina* Engelm. var. *squamigera* (Engelm.)Yuncker	Saltmarsh dodder
Hydrophyllaceae	*Phacelia distans* Benth.	Wild heliotrope
Boraginaceae	*Amsinckia intermedia* F. & M.	Yellow fiddleneck
	Cryptantha cf. *intermedia* (Gray)Greene	Nievitas
	Heliotropium curassavicum L.	Chinese pusley
	var. *oculatum* (Heller)Jtn.	
Solanaceae	*Lycium californicum* Nutt.	California boxthorn
	Nicotiana glauca Graham	Tree tobacco
Myoporaceae	*Myoporum laetum* Forst. f.*	Myoporum

FAMILY	SPECIES	COMMON NAME
Aizoaceae	*Mesembryanthemum chilense* Mol.	Sea fig
	M. crystallinum L.	Ice plant
	M. edule L.	Hottentot fig
	M. nodiflorum L.	Little ice plant
	Tetragonia expansa Murr.	New Zealand spinach
Cactaceae	*Opuntia occidentalis* Engelm. & Bigel. var. *littoralis* (Engelm.) Parish	Shore cactus
	Opuntia prolifera Engelm.	Coast cholla
Polygonaceae	*Eriogonum fasciculatum* Benth.	California buckwheat
	Pterostegia drymarioides F. & M.	California thread-stem
	Rumex salicifolius Weinm.	Willow-leaved dock
Chenopodiaceae	*Atriplex leucophylla* (Moq.) D. Dietr.	Sea scale
	A. patula L. ssp. *hastata* (L.) Hall & Clem.	Spearscale, Fat-hen
	A. semibaccata Brown	Australian saltbush
	Bassia hyssopifolia (Pall.) Kuntze	Bassia
	Chenopodium album L.	Lamb's quarters
	C. macrospermum Hook. f. var. *farinosum* (Wats.)J.T. Howell	Nettle-leaved goosefoot
	Salicornia europaea L. *	Annual pickleweed

APPENDIX C (cont'd.)

FAMILY	SPECIES	COMMON NAME
Crassulaceae	*Dudleya lanceolata* (Nutt.)Britt. & Rose	Live-for-ever
	Tillaea erecta H. & A.	Sand pigmy
Saxifragaceae	*Ribes speciosum* Pursh.	Fuchsia-flowered gooseberry
Rosaceae	*Heteromeles arbutifolia* M. Roem	Toyon
Leguminosae	*Astragalus leucopsis* (Torr.) T. & G.	Coast locoweed
	Lotus nuttallianus Greene	Beach Lotus
	L. scoparius (Nutt.)Ottley	Deerweed
	Medicago hispida Gaertn.	Burclover
	Melilotus indicus (L.)All.	Sweetclover
Salicaceae	*Salix lasiolepis* Benth.	Arroyo willow
Onagraceae	*Oenothera cheiranthifolia* Hornem ex Spreng. var. *suffruticosa* Wats.	Beach evening primrose
Rhamnaceae	*Rhamnus crocea* Nutt.	Redberry
Anacardiaceae	*Rhus integrifolia* (Nutt.)Benth. & Hook.	Lemonade-berry
	Schinus molle L. *	Peruvian pepper tree
Umbelliferae	*Foeniculum vulgare* (L.)Gaertn.	Sweet fennel
Cucurbitaceae	*Marah macrocarpus* (Greene)Greene	Wild cucumber
Compositae	*Amblyopappus pusillus* H. & A.	Coast weed
	Ambrosia psilostachya D.C. var. *californica* (Rydb.)Blake	Western ragweed

FAMILY	SPECIES	COMMON NAME
Compositae (cont.)	*Artemisia californica* Less.	Coastal sagebrush
	Baccharis viminea D.C.	Mule fat
	Centaurea meletensis L.	Tocolote, star thistle
	Chaenactis glabriuscula D.C.	Yellow pincushion flower
	Chrysopsis villosa (Pursh.)Nutt. var. *sessiliflora* (Nutt.)Gray	Golden aster
	Cotula australis (Sieber)Hook.F.	Australian brass button
	C. coronopifolia L.	Brass buttons
	Encelia californica Nutt.	Common Encelia
	Gnaphalium bicolor Bioletti	Cudweed
	Haplopappus venetus (H.B.K.) Blake ssp. *vernonioides* (Nutt.)Munz	Goldenbush
	Hemizonia fasciculata (D.C.) T. & G.	Golden tarweed
	Heterotheca grandiflora Nutt.	Telegraph weed
	Iva hayesiana Gray	Southern poverty weed
	Jaumea carnosa (Less.)Gray	Jaumea
	Lasthenia glabrata Lindl.	Salt marsh daisy
	Pluchea purpurascens (Sw.)D.C.	Salt marsh fleabane
	P. sericea (Nutt.)Cov.	Arrow-weed
	Senecio cf. *californicus* D.C.	California groundsel
	Sonchus asper L.	Prickly sowthistle
	S. oleraceus L.	Common sowthistle

APPENDIX C (cont'd.)

FAMILY	SPECIES	COMMON NAME
Compositae (cont.)	*Stephanomeria virgata* Benth.	Slender stephanomeria
	Xanthium strumarium L.	
	var. *glabratum* (D.C.)Cronq.	Cocklebur
Ruppiaceae	*Ruppia maritima* L.	Ditch grass
Zosteraceae	*Phyllospadix* sp.	Surf grass
Typhaceae	*Typha latifolia* L.	Tall cat-tail
Juncaceae	*Juncus acutis* L. var.	
	sphaerocarpus Engelm.	Spiny rush
	J. mexicanus Willd.	Mexican rush
Cyperaceae	*Scirpus californicus* (C. A. Mey.) Steud.	California bulrush
	S. robustus Pursh.	Alkali bulrush
Gramineae	*Arundo donax* L.	Giant reed
	Bromus rubens L.	Red brome
	Distichlis spicata (L.)Greene	
	var. *stricta* (Torr.)Bettle	Salt grass
	Hordeum marinum L.	Wild barley
	Lamarckia aurea (L.)Moench.	Golden top
	Monanthochloe littoralis Engelm.	Salt cedar
	Parafolis incurva (L.)C. E. Hubb.	Sickle grass

APPENDIX D

Birds of the Los Penasquitos Lagoon
(Partially from Green, 1969)

<u>KEY</u>

A - Abundant	O - Occasional
C - Common	R - Rare
U - Uncommon	M - Migrant

COMMON NAME	SCIENTIFIC NAME	
<u>Shorebirds:</u>		
Semipalmated plover	*Charadrius semipalmatus*	CM
Snowy plover	*Charadrius alexandrinus*	C
Killdeer	*Charadrius vociferus*	CA
Wilson's plover	*Charadrius wilsonia*	CR
Black-bellied plover	*Squatarola squatarola*	CM
Black turnstone	*Arenaria melanocephala*	UM
Common snipe	*Capella gallinago*	UM
Long-billed curlew	*Numenius americanus*	CM
Whimbrel	*Numenius phaeopus*	UM
Spotted sandpiper	*Actitis macularia*	U
Willet	*Catoptrophorus semipalmatus*	CM
Greater yellowlegs	*Totanus melanoleucus*	UM
Lesser yellowlegs	*Totanus flavipes*	OM
Knot	*Calidris canutus*	CM
Bairds sandpiper	*Erolia bairdii*	OM
Least sandpiper	*Erolia minutila*	CM
Dunlin	*Erolia alpinus*	CM
Short-billed dowitcher	*Limnodromus griseus*	OM
Western sandpiper	*Ereunetes mauri*	CM

Marbled godwit	*Limosa fedoa*	CM
Sanderling	*Crocethia alba*	UM
American avocet	*Recurvirostra americana*	A
Black-necked stilt	*Himantopus mexicanus*	CA
Wilson's phalarope	*Steganopus tricolor*	UM
Northern phalarope	*Lobipes lobatus*	UM

<u>Grebes, Loons, Pelicans and Cormorants</u>:

Eared grebe	*Podiceps caspicus*	CM
Western grebe	*Aechmophorus occidentalis*	CM
Pied-billed grebe	*Podilymbus podiceps*	CM
Common loon	*Gavia immer*	UM
Arctic loon	*Gavia arctica*	OM
White pelican	*Pelecanus erythrorhynchos*	R
Brown pelican	*Pelecanus occidentalis*	U
Double-crested cormorant	*Phalacrocorax auritus*	CM
Brandt's cormorant	*Phalacrocorax penicallatus*	CM

<u>Marsh Birds</u>:

Sora	*Porzana carolina*	U
Common gallinule	*Gallinula chloropus*	UM
American coot	*Fulica americana*	C
Light-footed clapper rail	*Rallus longirostris levipes*	O

<u>Wading Birds</u>:

Great blue heron	*Ardea herodias*	C
Common egret	*Casmerodias albus*	C
Snowy egret	*Leucophoyx thula*	U
Green heron	*Butorides virescens*	C

Black-crowned night heron	*Nycticorax nycticorax*	C
American bittern	*Botaurus lentiginosus*	U
Wood ibis	*Mycteria americana*	OM

__Gulls and Terns:__

Western gull	*Larus occidentalis*	CM
Bonaparte's gull	*Larus philadelphia*	UM
Heermann's gull	*Larus heermanni*	UM
Ring-billed gull	*Larus delawarensis*	CM
Forster's tern	*Sterna forsteri*	CM
Common tern	*Sterna hirundo*	UM
Least tern	*Sterna albifrons*	C
Royal tern	*Thalasseus maximus*	UM
Caspian tern	*Hydroprogne caspia*	CM

__Geese:__

Black brant	*Branta nigricans*	UM

__Surface Feeding Ducks:__

Mallard	*Anas platyrhynchos*	C
Pintail	*Anas acuta*	CM
Green-winged teal	*Anas carolinensis*	CM
Blue-winged teal	*Anas discors*	OM
Cinnamon teal	*Anas cyanoptera*	C
American widgeon	*Mareca americana*	CM
Shoveler	*Spatula clypeata*	CM

Diving Ducks:

Redhead	*Aythya americana*	CM
Greater scaup	*Aythya marilla*	CM
Bufflehead	*Bucephala albeola*	CM
Surf scoter	*Melanitta perspicillata*	UM

Stiff-tailed Ducks:

Ruddy duck	*Oxyura jamaicensis*	C

Mergansers:

Red-breasted merganser	*Mergus serrator*	CM

Vultures:

Turkey vulture	*Cathartes aura*	C

Hawks and Kites:

White-tailed kite	*Elanus leucurus*	U
Sharp-shinned hawk	*Accipiter striatus*	UM
Cooper's hawk	*Accipiter cooperii*	R
Red-tailed hawk	*Buteo jamaicensis*	C
Marsh hawk	*Circus cyaneus*	C
Osprey	*Pandion haliaetus*	U
Sparrow hawk	*Falco sparverius*	C

Birds Occurring in the Area Adjacent to Los Penasquitos Lagoon:

California quail	*Lophortyx californicus*	C
Rock dove	*Columbia livia*	C
Mourning dove	*Zenaidura macroura*	C
Roadrunner	*Geococcyx califorianus*	U
Barn owl	*Tyto alba*	C
Great horned owl	*Bubo virginianus*	R

Vaux's swift	*Chaetura vauxi*	UM
White-throated swift	*Aeronautes saxatalis*	C
Anna's hummingbird	*Calypte anna*	C
Belted kingfisher	*Megaceryle alcyon*	U
Western kingbird	*Tyrannus verticalis*	C
Ash-throated flycatcher	*Myiarchus cinerascens*	U
Black phoebe	*Sayornis nigricans*	C
Western flycatcher	*Empidonax difficilis*	U
Western woodpewee	*Contopus sordidulus*	C
Scrub jay	*Aphelcoma coerulescens*	C
Common raven	*Corvus corax*	C
Common crow	*Corvus brachyrhynchos*	C
Common bushtit	*Psaltriparus minimus*	C
Wrentit	*Chamaea fasciata*	U
Mockingbird	*Mimus polyglottos*	C
California thrasher	*Toxostoma rediviuum*	C
Hermit thrush	*Hylocichla guttata*	C
Swainson's thrush	*Hylocichla ustulata*	C
Ruby-crowned kinglet	*Regulus calendula*	C
Loggerhead shrike	*Lanius ludovicianus*	C
Starling	*Sturnus vulgaris*	A
House sparrow	*Passer domesticus*	A
Western meadowlark	*Sturnella neglecta*	C
Red-winged blackbird	*Agelaius phoeniceus*	C
Tricolored blackbird	*Agelaius tricolor*	U
Hooded oriole	*Icterus cucullatus*	U
Bullock's oriole	*Icterus bullockii*	O
Brewer's blackbird	*Euphagus cyanocephalus*	C

Black headed grosbeak	*Pheucticus melanocephalus*	C
Blue grosbeak	*Guiraca caerulea*	U
House finch	*Carpodacus mexicanus*	C
American goldfinch	*Spinus tristis*	C
Lesser goldfinch	*Spinus psaltria*	C
Lawrence's goldfinch	*Spinus lawrencei*	U
Rufous-sided towhee	*Pipilo erythraphythalmus*	C
Brown towhee	*Pipilo fuscus*	U
White-crowned sparrow	*Zonotrichia leucophrys*	A
Golden-crowned sparrow	*Zonotrichia atricapilla*	C
Fox sparrow	*Passerella iliaca*	U
Song sparrow	*Melospiza melodia*	C
Savannah sparrow	*Passerculus sandwichensis*	C

APPENDIX E

THE MAMMALS OF LOS PENASQUITOS LAGOON

(from Whitaker, 1964)

Order Marsupiala:	
Virginia opossum	*Didelphis marsupialis*
Order Insectivora	
Ornate shrew	*Sorex ornatus*
Broad-handed mole	*Scapanus latimanus*
Order Chiroptera:	
(None recorded in this survey)	
Order Lagomorpha:	
Black-tailed jack rabbit	*Lepus californicus*
Desert cottontail	*Sylvilagus auduboni*
Brush rabbit	*Sylvalagus bachmani*
Order Rodentia:	
Beechey ground squirrel	*Otospermophilus beecheyi*
California vole	*Microtus californicus*
House mouse	*Mus musculus*
California pocket mouse	*Perognathus californicus*
San Diego pocket mouse	*Perognathus fallax*
(*Peromyscus* sp.)	(possibly *P. eremicus* or *boylii*)
Deer mouse	*Peromyscus maniculatus*
Western harvest mouse	*Reithrodontomys megalotis*
Botta pocket gopher	*Thomomys bottae*
Order Carnivora:	
Coyote (probably an occasional visitor)	*Canis latrans*
Bobcat (may reside in wild areas and forage in marsh)	*Lynx rufus*

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APPENDIX E (cont'd.)

Gray fox	*Urocyon cinereoargenteus*
Striped skunk	*Mephitis mephitis*
Long-tailed weasel	*Mustela frenata*

Other carnivores that may be infrequent visitors to the marsh, although never reported are:

Raccoon	*Procyon lotor*
Badger	*Taxidea taxus*

Order Artiodactyla:

Mule deer	*Odocoileus hemionus*

APPENDIX F

FISH OF THE LOS PENASQUITOS LAGOON

Southern staghorn sculpin	*Leptocottus armatus australis*
Killifish	*Fundulus parvipinnis*
California halibut	*Paralichthys californicus*
Diamond turbot	*Hypsopsetta guttulata*
Bay topsmelt	*Atherinops affinis littoralis*
California mudsucker	*Gillichthys mirabilis*
Pipefish	*Syngnathus* sp.
Snubnose pipefish	*Syngnathus arctus*
Northern midshipman	*Porichthys notatus*
California corbina	*Menticirrhus undulatus*
Opaleye perch	*Girella nigricans*
Spotfin croaker	*Roncador stearnsi*
Queenfish	*Seriphus politus*
Anchovy	*Anchoa* sp.
Arrow goby	*Clevelandia ios*
Barred sand bass	*Paralabrax nebulifer*
Spotted sand bass	*Paralabrax maculatofasciatus*
Grass rock fish	*Sebastes rastrelliger*
Blenny	*Hypsoblennius* sp.
Striped mullet	*Mugil cephalus*
Shiner perch	*Cymatogaster aggregata*
Tidewater goby	*Eucyclogobius newberryi*

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APPENDIX G

MARINE INVERTEBRATES OF THE LOS PENASQUITOS LAGOON

Burrowing anemone	*Harenactis attenuata*
Egg cockle	*Laevicardium substriatum*
Gaper clam	*Tresus nuttalli*
Bentnose clam	*Macoma nasuta*
Jackknife clam	*Tagelus subtera*
Broad-eared scallop	*Leptopecten latiauratus*
Common littleneck	*Protothaca staminea*
Bay mussel	*Mytilis edulis*
Native oyster	*Ostrea lurida*
Purple olive	*Olivella biplicata*
California bubble shell	*Bulla gouldiana*
Sea slug	*Navanax inermis*
Sand dollar	*Dendraster excentricus*
Yellow shore crab	*Hemigrapsus oregonensis*
Striped shore crab	*Pachygrapsus crassipes*
Purple shore crab	*Hemigrapsus nudus*
Red rock shrimp	*Hippolysmata californica*
Large shrimp	*Penaeus californiensis*
Bay ghost shrimp	*Callianassa californiensis*
Salt marsh snail	*Melampus olivaceus*
Rough piddock	*Zirfaea pilsbryi*
Fiddler crab	*Uca crenulata*
Crayfish	*Procambarus* sp.

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