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COMPARISONS OF ESTUARINE MANAGEMENT NEEDS OF A TROPICAL PACIFIC MEXICAN HARBOUR AND A TEMPERATE CALIFORNIA HARBOUR

by

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ABSTRACT

Two areas of the eastern Pacific are compared, the southern California wetlands south of Point Conception and Mazatlan, Mexico.

The historical development of both areas is important in considering their present biological status. Southern California has been subjected to intensive population growth and urbanization while Mazatlan has remained relatively unchanged.

Both areas are compared biologically in regards to the fish population, thermal gradients in the harbors, salinity, nitrate, nitrite and phosphate distributions.

The economic importance of the harbors is recognized, however it is essential that measures are taken to restore or retain existing wetlands that are associated with the harbors. The harbors can serve as shelters for various organisms if water quality can either be maintained (as in the case of Mazatlan) or improved, and if input of toxic and excessive nutrients is limited.

INTRODUCTION

The eastern Pacific coastline is characterized by a narrow continental shelf bordered by coastal mountain watersheds, with limited bay and estuary formations. In southern California and northern Mexico, the coastal areas are fringed with wetlands; marshes, sloughs and embayments. True estuaries are not common because the annual rainfall, about eight to fourteen inches, occurs almost entirely between November and April. The rivers are generally dry after the rainy season. In southern California the situation has been accentuated because rivers are confined in concrete flood control channels and the land is drained rapidly after a storm by a drain system.

Until recently, these wetlands have been considered of little value, either to man or the marine ecosystem. As populations and urbanization increased, coastal environments were destroyed. The cumulative loss of biota cannot be quantitatively evaluated because baseline surveys in shallow waters were not made prior to urbanization. The only means of evaluating the impact of these changes is by qualitative statements of early writers or by comparison with undeveloped areas.

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In the present paper, two areas of the eastern Pacific will be discussed and compared. One of these areas is the southern California wetlands south of Point Conception; the other area is an estuary on mainland Mexico, approximately 1600 kilometers to the south and opposite the tip of Baja California (Fig. 1). Both of these areas have been used for international

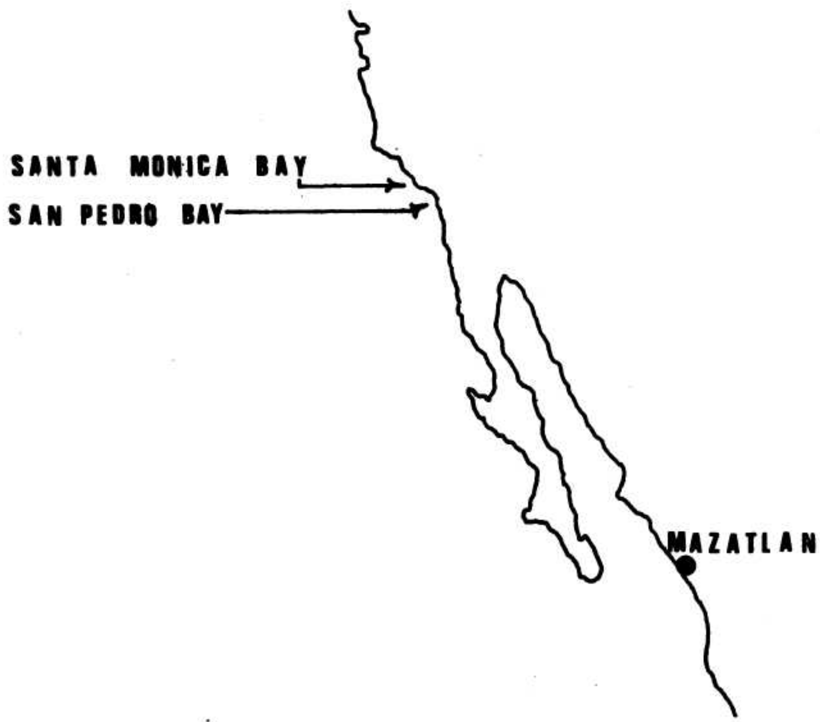

Figure 1. Map of Pacific Coast of North America from San Fransisco to Mazatlan.

shipping for the last 150 years, with infrequent use previously dating from the days of Spanish colonization. Southern California has been subjected to intensive population growth and urbanization while Mazatlan has remained relatively unchanged.

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SOUTHERN CALIFORNIA

Historical

The city of Los Angeles sprawls for 400 square miles, and supports a population of some two million people. There are perhaps another four million people in contiguous urban areas. Most of this population growth has occurred since World War II. There are two major embayments, Santa Monica and San Pedro.

Santa Monica Bay

The Ballona Creek watershed originally drained into the western shore of Santa Monica Bay (Fig. 2). In 1924 Venice was developed as part of a small coastal subdivision. Further development occurred in 1944; but it was not until 1964 that the most drastic alteration occurred. This was the opening of the largest man-made marina in the world, with space for about 6000 boats (Fig. 3). The area south of Venice has not been developed because it is largely controlled by the Hughes Aircraft Company. There is now controversy between the environmentalists, who wish the state of California to buy up private lands such as those owned by Hughes Aircraft — and worth millions of dollars — in order to restore the estuary, and those who wish to develop high rise residences or another large marina. Because the original watershed has been greatly altered by urbanization, restoration is probably impossible, although a small lagoon could be preserved and enhanced.

San Pedro Bay

South of Santa Monica Bay the coastline turns eastward, to San Pedro Bay. In 1901 this was a shallow, open bay which was fed by the Los Angeles River and San Gabriel River watersheds (Fig. 4). At that time ships were unloaded offshore and the goods were ferried in with smaller craft. In case of severe storms the ships were moved to the leeward side of the offshore islands. Subsequently the bay has been deepened and protection from storm has been acquired by the building of a breakwater. An 1872 survey map (Fig. 5) has been superimposed on the port facilities as they existed in 1971. Most of the harbor is controlled by the ports of two cities, Los Angeles and Long Beach; together they constitute the second largest port in terms of commerce in the United States.

From early maps it is evident that large wetlands existed inland from the present harbor and there were artesian wells. There was sufficient ground water pressure that freshwater springs existed in the bay. The pumping of oil

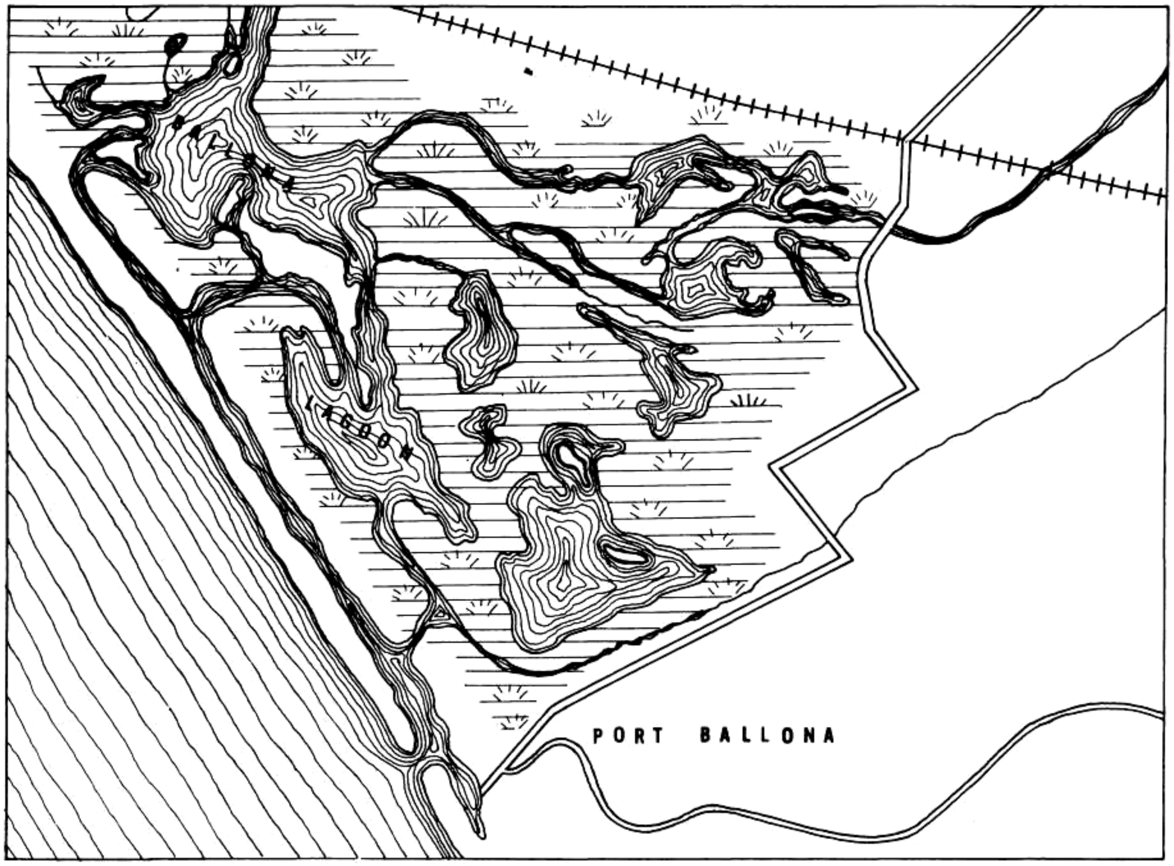

Figure 2. Ballona Creek, California, 1896. Watershed as it originally drained into Santa Monica Bay.

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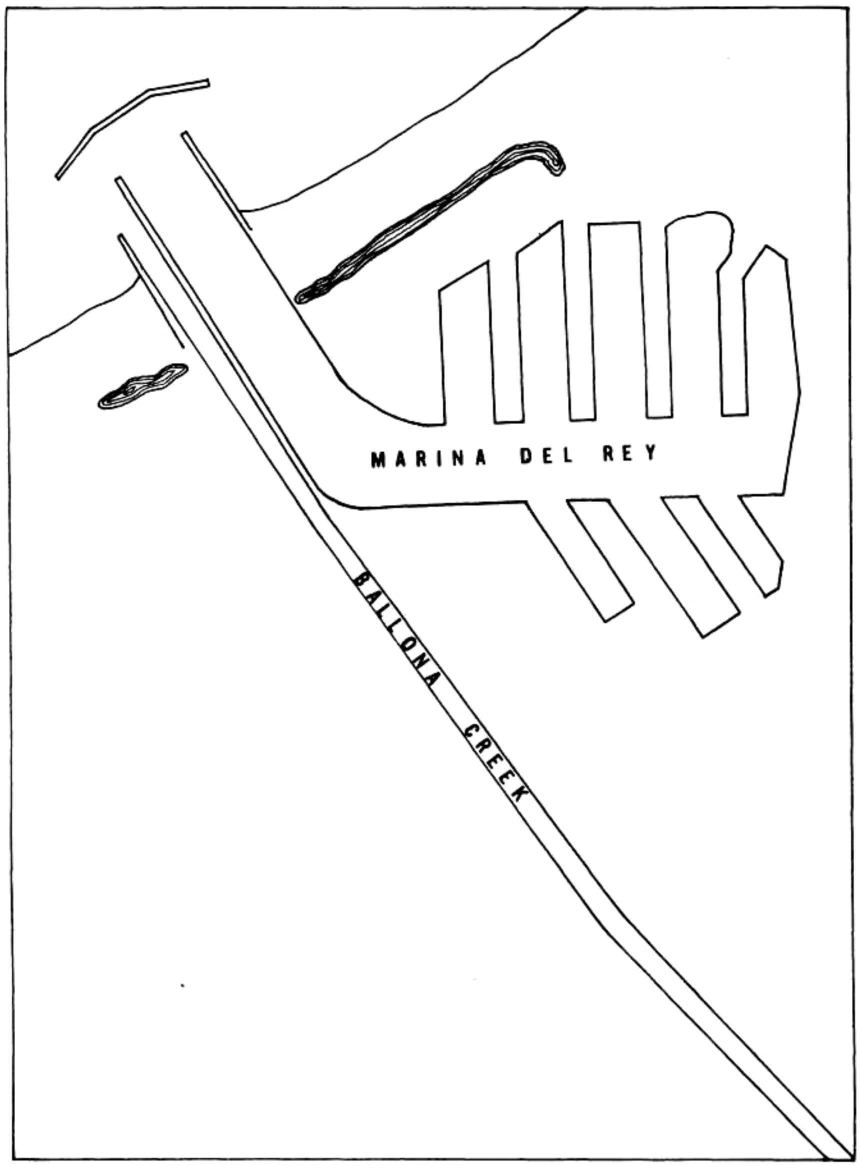

Figure 3. Marina Del Rey, Calitornia, 1964. Map indicates proximity and outlet into Santo Monica Bay.

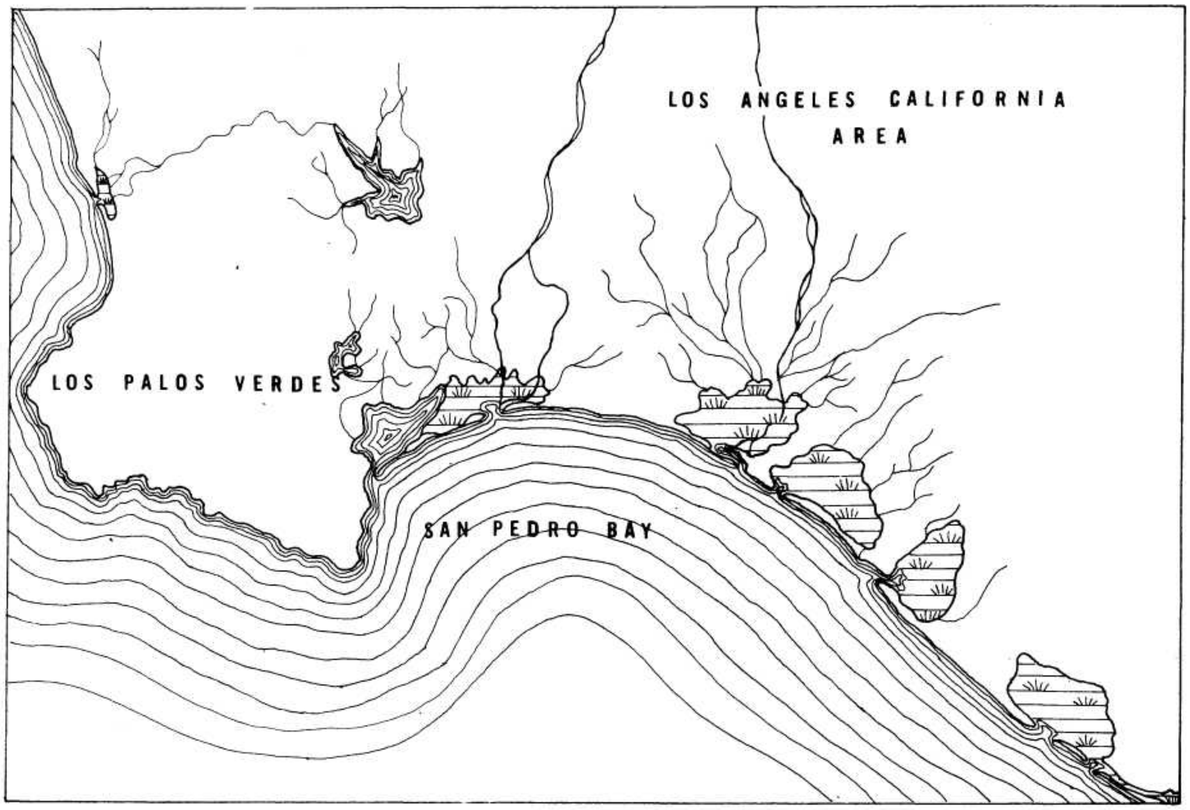

Figure 4. San Pedro Bay, California, 1901. Wetlands are indicated.

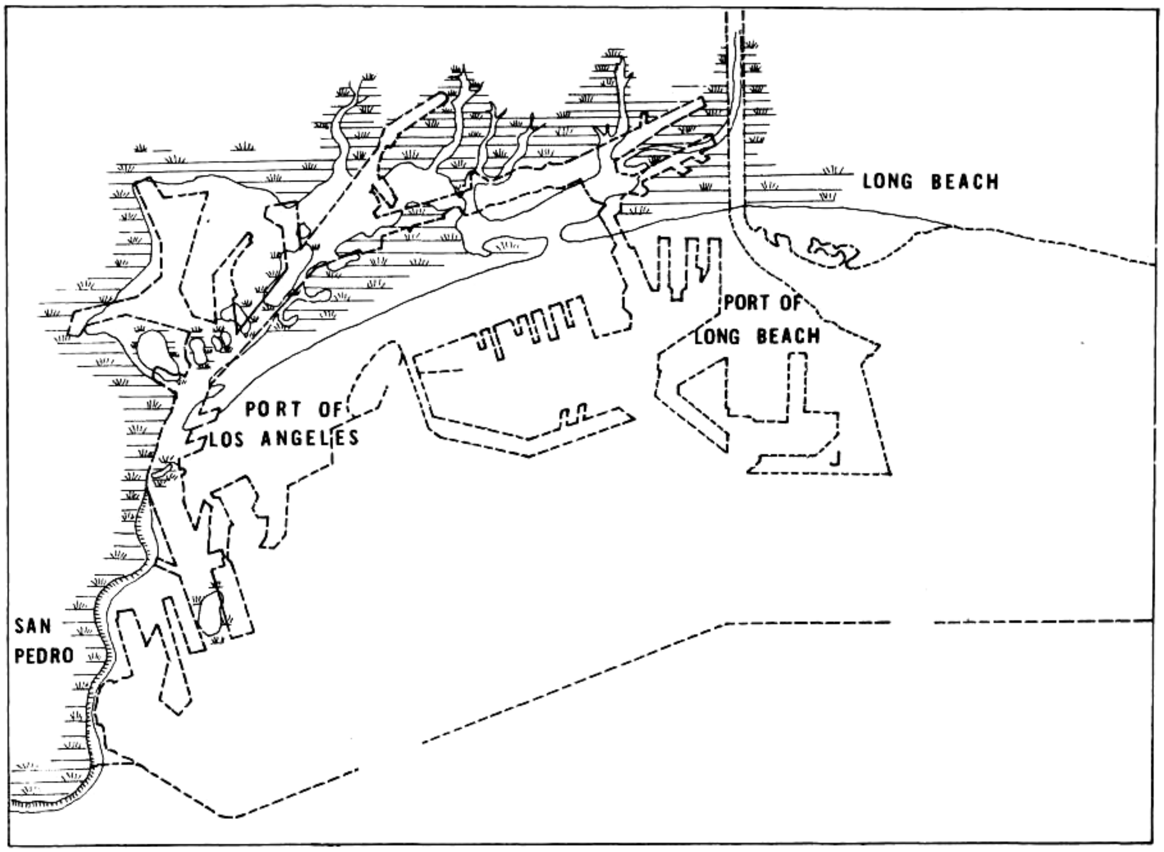

Figure 5. An 1872 survey map of San Pedro Bay, California, superimposed on a 1971 map of the harbor.

from the harbor area caused subsidence (ALLEN 1973) of the earth, while pumping of water inland caused the intrusion of seawater into the water table.

The harbor was used as a sewer and a dump for all manner of wastes until by the 1920's complaints of sulfide fumes were recorded. An increase in shipping, extension of the breakwaters and increased industrial waste combined to produce a virtually dead inner harbor by 1950. The outer harbor was relatively healthy since land fills had not reduced the circulation. In 1969, with federal EPA legislation, many sources of industrial and oil refinery wastes were prohibited or reduced, dockside toilets were prohibited, and canneries were required to screen solid fish wastes. By 1971 there was improvement in water quality in the inner harbor, even though a major landfill, Pier J. (Fig. 5) was completed, thus altering flushing patterns in the entire harbor.

Biological

Prior to initiation of studies by Harbor Environmental Project, University of Southern California in 1971, no complete baseline surveys of the biotic and abiotic qualities of the harbor existed. Various authors (MCFARLAND 1966; CHACE & CHACE 1967; DELAUBENFELS 1932), have either incorporated specific aspects of the harbor fauna into a larger treatise, or have dealt with only one aspect of the fauna (BARNARD 1958; MENZIES , MOHR, WAKEMAN 1964; REISH1959, 1961, 1971). Present investigations have included circulation and current studies (SOULE & OGURI 1972), monitoring of temperature, salinity, dissolved oxygen, nutrients, pH and light transmittance (SOULE & OGURI 1976), sediment composition (CHEN & Lu 1974) and oxygen demand incidents of heavy metals and pesticides (HARBOR ENVIRONMENTAL PROJECT 1975). Biotic studies include microbiology (JUGE & GRIEST 1972), primary productivity (OGURI 1974), zooplankton (HARBOR ENVIRONMENTAL PROJECT 1975), settling and fouling organisms (HARBOR ENVIRONMENTAL PROJECT 1975), benthic fauna (HILL&REBH 1975), fish (CHAMBERLAIN 1973; SCHAFER & SWAN 1973) and marine birds (HARBOR ENVIRONMENT PROJECT 1975). Several aspects of the above studies will be discussed below.

In spite of the stresses of wastes in the puter Los Angeles Long Beach Harbor, the fish population is greater inside than it is outside the harbor (CHAMBERLAIN 1973; STEPHENS, GARDINER. TERRY 1973) in either the rocky reefs of kelp beds. It appears that the harbor is an important nursery ground for some fish including the anchovy, *Engraulis mordax* (BREWER 1975). Anchovy eggs are shed outside the breakwater and eggs or larvae are carried into the warmer outer habor. Their first year is spent here, at which time the anchovies move to colder and deeper offshore waters. No commercial seining of anchovies is permitted in the harbor, but "light-boats" catch live bait for sport fishing. Sport fishing has a greater cash for southern California than the commercial anchovy fishery.

As stated above, the harbor is warmer than the waters outside. Within the harbor there is usually a thermal gradient from the warmer channels and slips of the inner to the cooler outer harbor (HARBOR ENVIRONMENTAL PROJECT 1975). There is a similar pattern for salinity, nitrate, nitrite and phosphate. There are exceptions to these statements. Areas of freshwater and waste discharge differ in salinity, temperature, phosphate, nitrate and nitrite from immediately adjacent areas.

Since the Environmental Protection Agency (EPA) legislation in 1969, various aspects of the fauna have returned, such as the green algae *Ulva*, tunicates, worms, crustaceans and molluscs. REISH (1959,1961, 1965, 1971) has documented some of these changes.

Outside the harbor area, along the open rocky coast, there were formerly extensive kelp beds. WHEELER NORTH (1964) noted the demise of these beds in some areas. With the increase in urban populations in southern California, there has been a concomitant increase in waste effluents. It is entirely possible that the enormous flow of chlorinated fresh water may have damaged these kelp beds. Furthermore, surf grass habitats *(Phyllospadix* and *Zostera),* sandy beaches and rocky reef areas may be affected in the same manner. Coupled with toxic industrial wastes such as heavy metals and pesticides carried in the city sewer and street drainage system, the impact may be more severe than was earlier believed.

MAZATLAN, MEXICO

In June and July of 1973 a brief survey of the marine biota and physical parameters of Mazatlan Harbor was carried out by Harbor Environmental Project, University of Southern California. The primary reason for the survey was to analyze a tropical harbor in the early phase of development.

Prior to this, there appears to be little information concerning the physical water quality of the Gulf of California. RODEN'S paper (1958) is the only major oceanographic work dealing with the Gulf of California. His data was largely based on the "E.W. Scripps" expeditions in 1939, plus publications of the Servicio Meteorologico Mexicano, the United States Coast and Geodetic Survey and the United States Hydrographic Office. No work has been found dealing with the harbors of mainland Mexico on the Pacific side. Taxonomic papers (AMERICAN MUSEUM NATURAL HISTORY NOVITATES 1958-1964; ALLAN HANCOCK PACIFIC EXPEDITIONS 1935—1962) on the other hand, have dealt with various groups of organisms since Busies (1855) paper on bryozoans, but these did not generally provide environmental data.

The harbor in Mazatlan has been dredged and a channel runs the length. Enlargement of the harbor by further dredging was occurring during the study. Areas that were not dredged were shallow, the inner harbor consisted of mudflats and mangroves. Many fishing boats were anchored, and a busy boat building industry was in evidence, as fourteen new commercial fishing vessels were in various stages of construction. The harbor also serves as a point of debarkation for various agricultural products grown in the region.

The area outside the harbor has a booming tourist industry. All along the beach front there are large hotels, with new ones being built. On the northern fringes of the city in the Punta Sabala area, are many new hotels, trailer parks and golf courses, all to attract and entertain more tourists.

There are no central sewage treatment plants; raw sewage is disposed of by numerous pipes which end at the shoreline both inside and outside the harbor. The disposal of sewage is not continuous but intermittent and odoriferous. Because of the relatively limited quantity and the discontinuous discharge, there appear to be no serious health problems at the present.

Most of the dredging has been limited to the main channel, reaching a depth of nine meters. The mudflats and mangroves in the harbor (Fig. 6) has not been severely altered. The dredging has probably reduced flushing in the inner channels, but a diverse invertebrate fauna was found (Fig. 7) just above the juction of the main channel and inner channel, in an area with shelly bottom deposits (Fig. 8). It is not known whether the deposits are autochthonous or a result of dredging and filling. The shelly bottom deposits and occasional rock outcrops on the mud bottom provide excellent substrates for bryozoans, tunicates and sponges. Most of the bottom is composed of mud, sandy mud, and sand (Fig. 8). The primary inhabitants of the mud are worms but algae and gorgonians are also present (Fig. 7). Other inhabitants of the harbor are coelenterates, amphipods, isopods, bony fish, *Aplysia,* skate, crabs and barnacles. The skeletal remains of sea urchins and corals were found.

In the main channel an intrusion of colder water occurs, the extent of which varies with the tide. This intrusion is lower in salinity and dissolved

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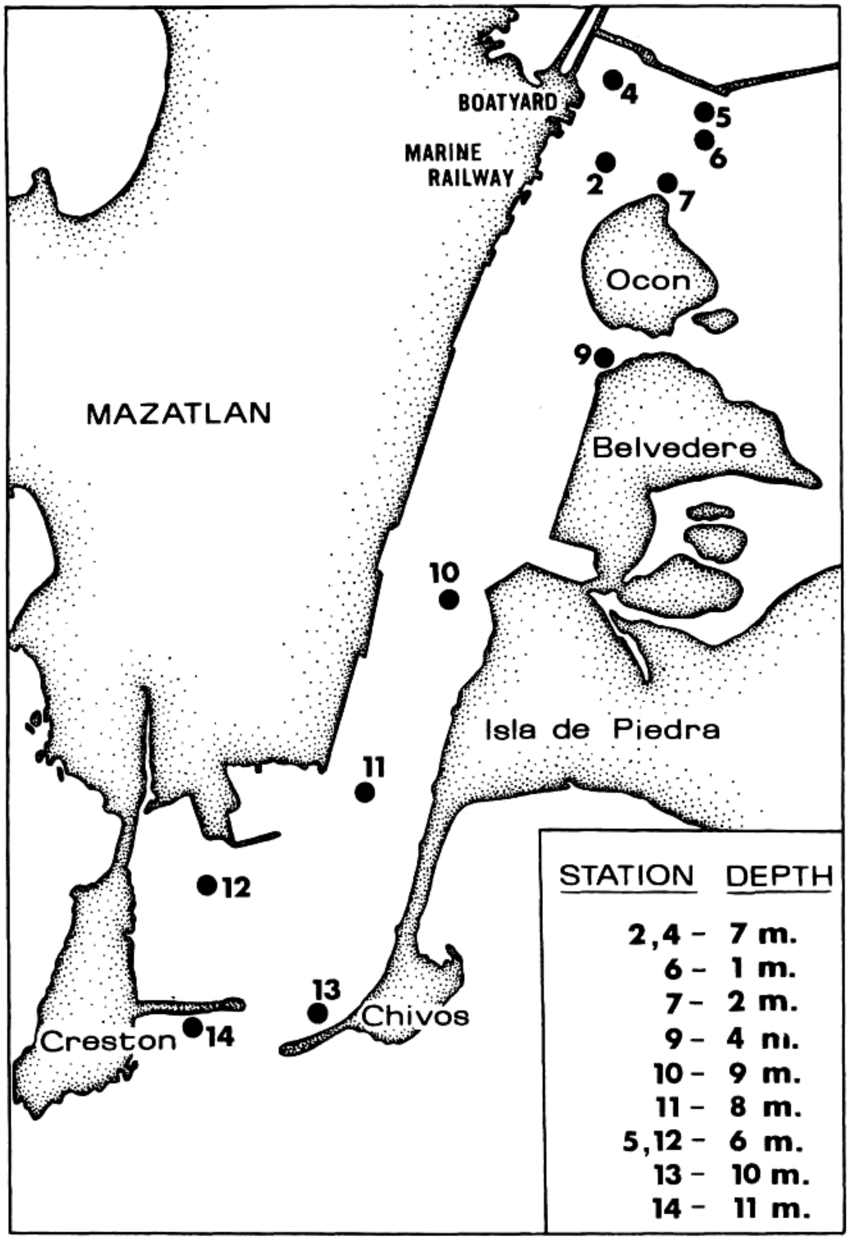

Figure 6. Mazatlan, Mexico. Stations and depths are indicated in the harbor.

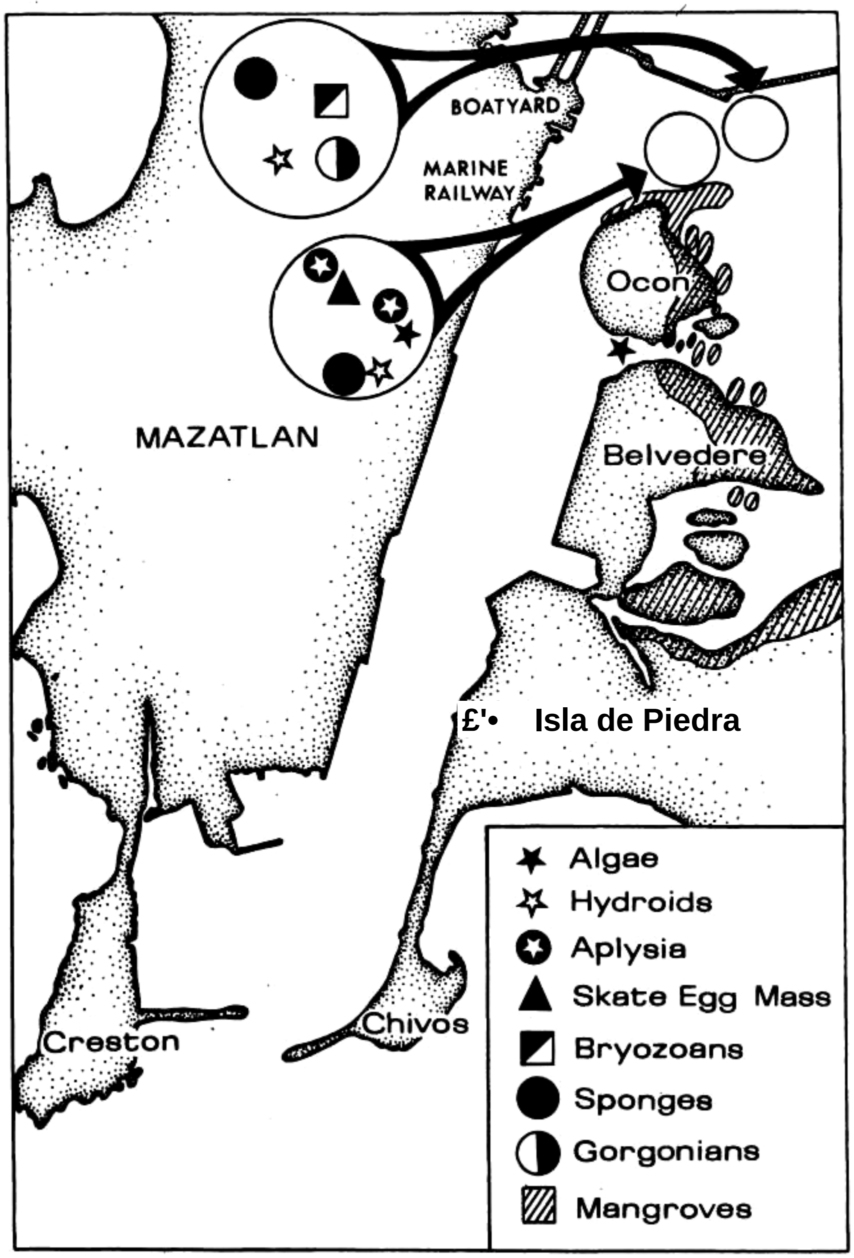

Figure 7. Mazatlan, Mexico. Invertebrate fauna (excluding polychaetes) and mangroves in the harbor.

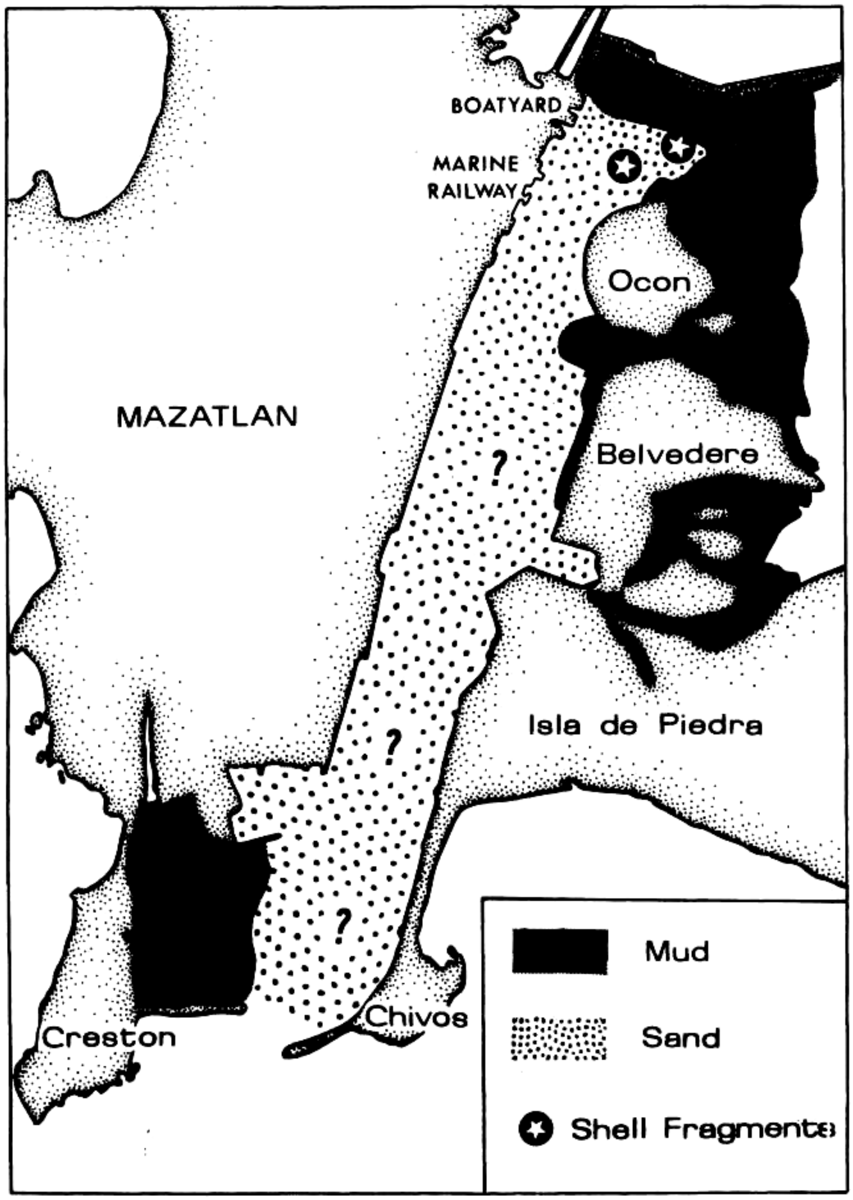

Figure 8. Mazatlan, Mexico. Distribution of sediments in the harbor.

oxygen than the surrounding water. It occurs approximately 8 meters below the surface near the channel entrance and occurs as far as station 10 (Fig. 6) at high tide.

The overall surface temperature varies from 28.0° to 30.8° C. The highest temperatures were in the inner, the lowest in the outer harbor (Fig. 9).

Dissolved oxygen also differed between the inner and outer harbor. Overall, the lowest dissolved oxygen values were found in the inner harbor, the highest in the outer. The lowest occurred in the embayment adjacent to the boatyard, 4.6 ppm. The highest salinities, temperatures and the lowest dissolved oxygen values were found in shallow areas of the inner harbor.

Mangroves have a dominant effect on the shoreline. They occur on either sandy beaches or estuarine mudflats. The roots function to trap fine sediment and debris. The leaves fall, and are also trapped in the root system. A fauna develops that is unique to the mud and mangroves. Mangroves serve as nurseries (AUSTIN 1971) protection against storms (ACKER 1972; CAENESTRI & Ruiz 1973), chemical buffer for pollutants runoff (ACKER 1972), and possibly in the regeneration and replenishment of nutrients (SARMAN & GANAPATI 1971).

Unchlorinated raw sewage is released into both the harbor and beach areas, but there are few industrial wastes, except for the boatyard (Fig. 6). The currents appear to dissipate these wastes fairly rapidly, since the only restrictions on swimming are during periods of release. In the harbor, adjacent to the fisheries school, there is an outflow. The boys from the school net large numbers of fish adjacent to this outflow. Outside the harbor there is a rich biota and the only sign of apparent stress in that area is indicated by the overgrowth of blue-green algae on the scattered coral patches.

DISCUSSION

Although the areas of southern California and Mazatlan are separated geographically, and the former is warm temperate, while the latter is tropical, comparisons can be made. In both areas the warmest temperatures and highest salinity and nitrate values were in the inner harbors. Apparently sewage waters do not adversely affect fish populations but on the contrary attract them. The presence of industrial wastes is probably more critical in San Pedro Bay, as the harbor serves as an important nursery ground for the anchovy and for other juvenile fish. Mangroves serve a similar function for various marine organisms. Because of the above comparisons and others are not discussed here, the following statements can be made.

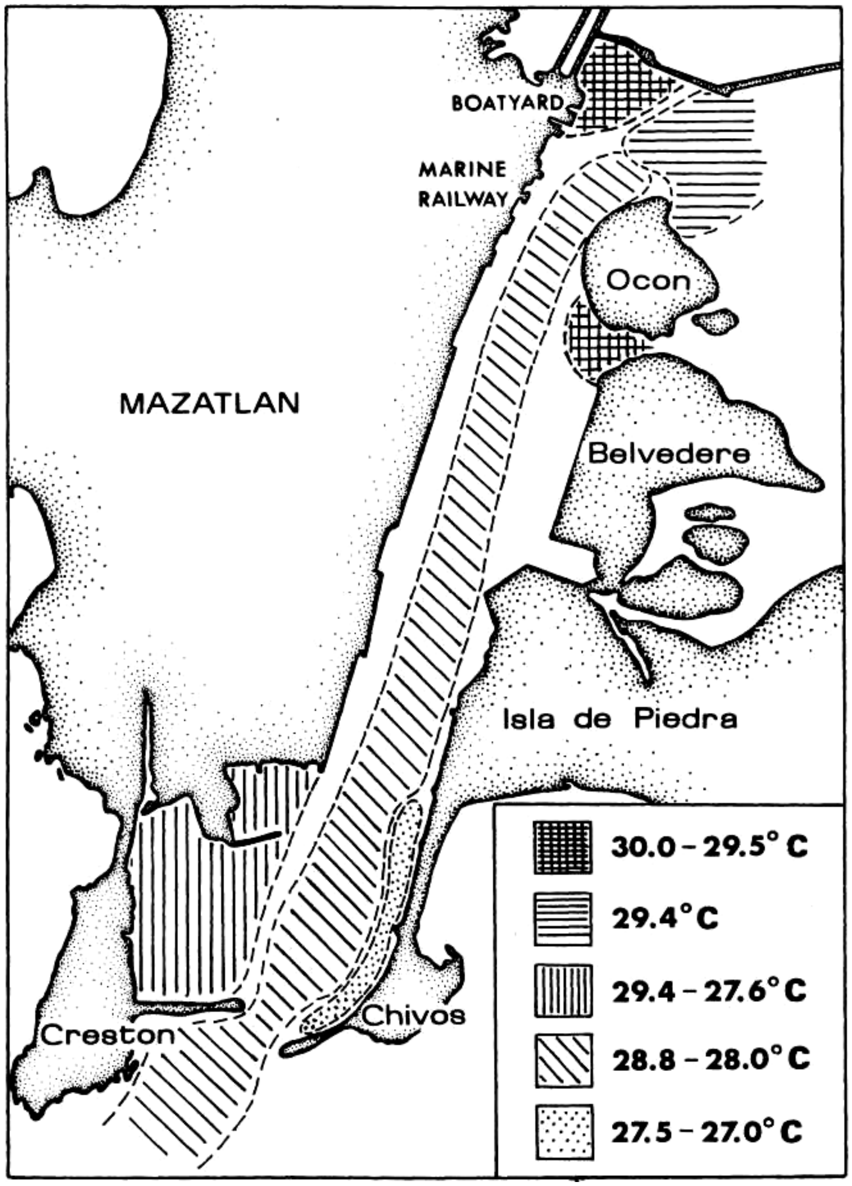

Figure 9. Mazatlan, Mexico. Distribution of thermal gradients in the water column.

1. The wetlands of coastal southern California have been progressively reduced by urbanization. This has been concomitant with a reduction of fauna that inhabited the mudflats and marsh grasses.
2. Reductions have reduced the fauna that formerly used the inshore waters for reproduction or for shelter of juveniles which later seek deeper waters.
3. Draining and filling, and channelization of storm runoff has caused salinity intrusion into formerly brackish and fresh water areas. Pumping of fresh water wells and of oil cause further saline intrusion of ground water tables and loss of artesian wells. In Long Beach, California, at Terminal Island in the harbor, oil wells in operation for a number of years, have caused the ground to sink. Reinjection of waste water and brine pumped into the ground has halted the subsidence.
4. Destruction *of Phyllospadix* (surf grass) on the open coast has destroyed nursery grounds of the spiny lobster *Panularis* (ENGLE 1976). The lobster was sheltered in the grass until it reached the 50 mm size.
5. More than one million people go to Los Angeles, California area beaches on a summer weekend, further impacting shoreline mollusc, crustacean and algal communities. In Mazatlan the impact of people occupying the beaces is just beginning. Not only are sand dune areas destroyed by individuals tramping down plants, but people tend to have little regard for the invertebrate life. Mollusc and starfish in particular attract weekend collec tors. These collectors remove the animals from their environment, take them home, allow them to die and then toss them into the dust bin.

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