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Coastal Erosion Along the Todos Santos Bay, Ensenada, Baja California, Mexico: An Overview

Roman Lizarraga-Arciniega† and David W. Fischer‡

†Inst. Invest. Oceanologicas/
UABC

‡Fac. Ciencias Marinas/UABC
Km. 103 Carret. Tijuana-
Ensenada
Ensenada, B.C. Mexico

ABSTRACT

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This paper presents an overview of the factors influencing the erosion regime in Todos Santos Bay, Ensenada, Baja California, Mexico. Such factors include the geomorphology of the area, the degree of coastal erosion along the bay's cliffs and beaches, the area's climate and sediment supply, sea level, and human intervention. Human intervention is rapidly becoming the most significant factor influencing coastal erosion, as urbanization and its associated infrastructure have disrupted coastal processes and the sediment budget. The management of coastal erosion was found to be limited to attempts to buttress the shoreline with a variety of materials. The coastal laws of Mexico are silent on erosion issues, leaving erosion to be viewed as a natural threat to human occupancy of the shoreline. It is suggested that for a coastal management program to be effective for the Bahia de Todos Santos, it is critical to integrate local authorities, local scientists, land owners and major developers into a management forum.

ADDITIONAL INDEX WORDS: *Coastal erosion, coastal zone management, Mexico.*

INTRODUCTION

Among the diversity of problems that tend to limit human development in areas adjacent to the ocean, the loss of coastal territory, as a consequence of occurrence of certain events, whether catastrophic or not, natural or man-induced, is a phenomenon that is affecting most coastal countries. It is estimated that 70% of sandy beaches of the world have retreated toward the continent (erosion) and less than 10% have accreted toward the ocean due to the combined effects of natural forces and human intervention (BIRD, 1987). These problems are reaching a critical level, particularly in the so called developing countries, where money to conduct hazard analysis studies and enforce regulatory policies or specific measures for environmental conservation is scarce. In this paper the case of an eroding coastline in northwestern Baja California, Mexico, and its relation to management is discussed.

The growth of infrastructure and urban services along the coastal zone of the Bahia de Todos Santos (BTS), Baja California, Mexico (Figure 1), has generated several environmental modifications leading to increased coastal vulnerability from the effects of such natural phenomena as earthquakes, coastal mass slides, inundations, sea level rise and coastal erosion. Particularly, our interest is focused on coastal erosion as a process that in recent years has increased significantly along some localities of the bay. It is considered that an analysis of the evolution of erosion processes could improve the possibilities for rational use of coastal land and minimize risk for human lives, environmental quality and property losses.

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This paper summarizes the nature and causes of shoreline erosion along the coast of the BTS and points out the urgent need for the development of an adequate management program in which local community participation should play an important role in deciding the type and magnitude of their own coastal development.

Geodemography of the Area

The County of Ensenada has a surface area of 52,500 km^2, and it is the largest in the country representing 73% of the state's territory and 2.6% of the national territory (DEBC, 1989). Similarly, of nearly 1,300 km of the state's shoreline, Ensenada County has 550 km on its western margin (Pacific Ocean), 350 km on the eastern margin (Gulf of California) and almost 75,000 hectares of coastal lagoons (insert map, Figure 1). In combination, these characteristics lead to a geographic area with a wide variety of coastal resources.

The BTS is located to the NW of the County of Ensenada and is limited in the north by Punta San Miguel and to the south by the rocky peninsula of Punta Banda (Figure 1). Along this stretch of coastline is the City of Ensenada, the major urban settlement of the county. Other urban areas of smaller population as shown in Figure 1, are El Sauzal to the north and Ejido Chapultepec, Maneadero, Estero de Punta Banda and La Joya to the south. Along the coastal area of BTS is concentrated nearly 72% (207,000) of the total population of the county; the remaining population is distributed widely over its extensive territory (INEGI, 1994).

Agriculture, commercial fisheries and commerce are the main economic activities of Ensenada and account for 15% of the state's gross product. These activities are oriented mainly

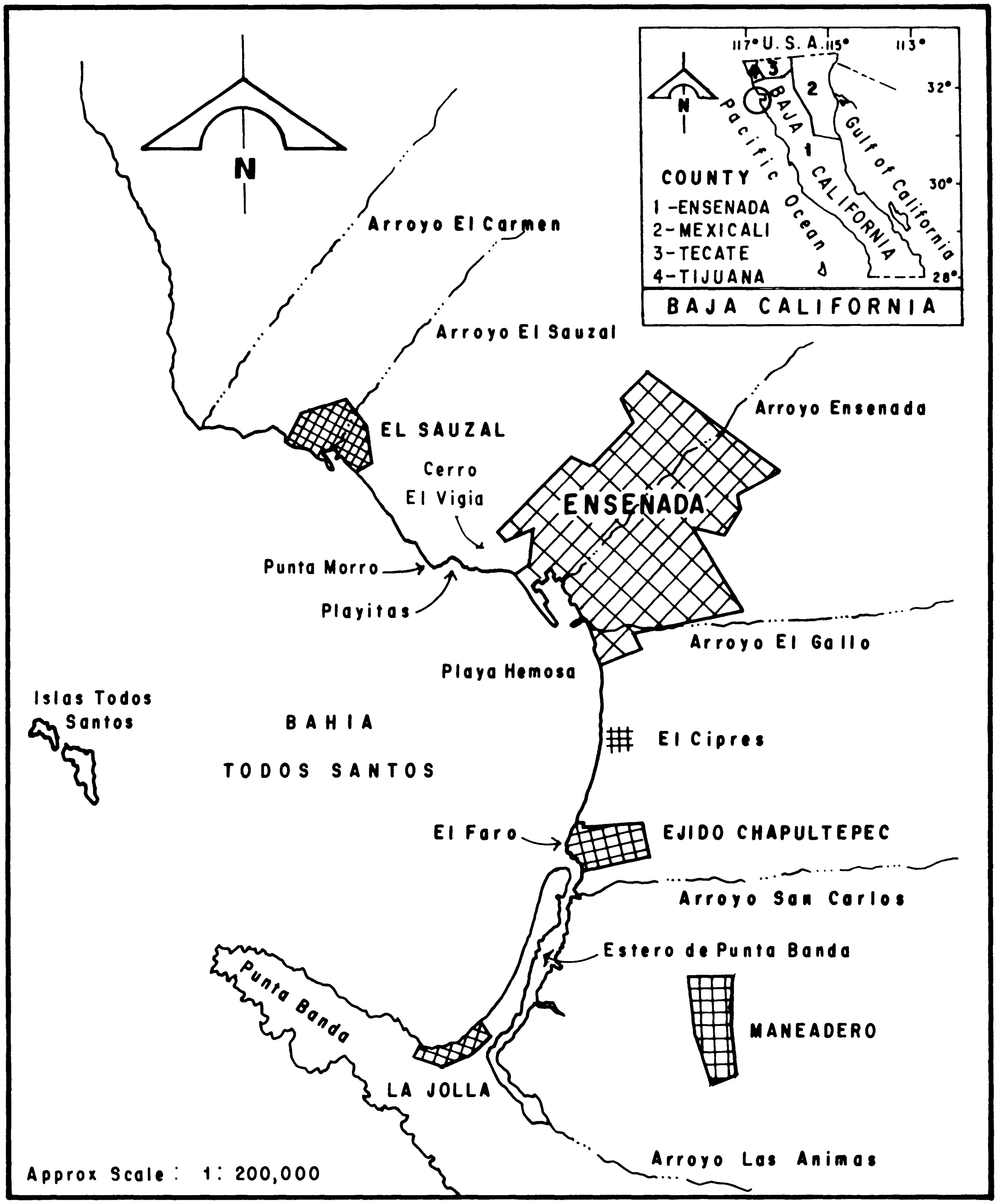

Figure 1. Location of the Bahia de Todos Santos, B. C. Major urban settlements and significant coastal features referred to in the text. In the insert map note the large shoreline extent under Ensenada County's jurisdiction.

toward commercial services and tourism activities (52%) (DDUE, 1994). Of particular interest is tourism since it has been considered a key factor in the region's economy and has received attention from federal, state and local authorities to promote it through strategies of attracting investment for coastal developments. Under these circumstances, not only the increase of urban infrastructure near or even on the coastline has been significant, but also new harbor facilities have been constructed and the existing facilities have been expanded. Two new marinas with capacity for 600 small boats are being constructed, one in the locality known as Playitas and the other just north of the BTS known as La Salina. The harbors of Ensenada and El Sauzal also have been increased in size as shown for the former in Figure 2.

General Morphological Framework

The coastal relief along the BTS consists of low mountains with some valleys and hills cut by several arroyos that flow

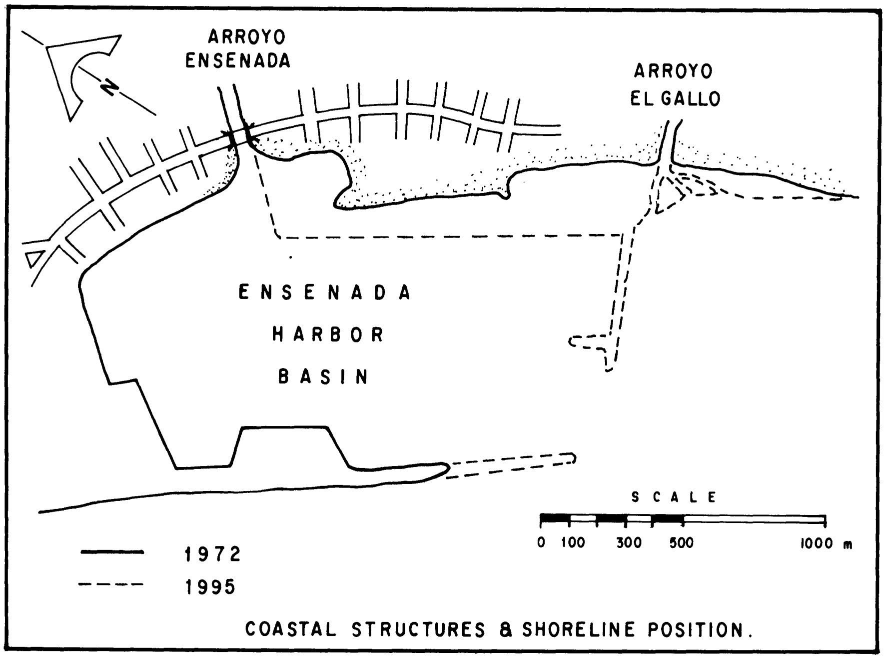

Figure 2. The lengthening of the breakwater and groin for creating a larger harbor basin produced significant shoreline changes including the loss of a beach segment and restricted sediment input to the littoral system. The cross sectional area from the tip of the groin to the tip of breakwater in 1995 is greatly reduced as compared to 1972.

only during rainy months (November through March). There are six arroyos emptying in the BTS, two of them within the Ensenada harbor and two in the interior of the coastal lagoon known as Estero de Punta Banda (Figure 1). The Arroyo Ensenada has particular significance since it cuts the city in two sections. To prevent flooding of the city, the Emilio Lopez Zamora dam was built in 1979, serving as a complementary source of water for the city (GOMEZ-ARIAS, 1995). It is of prime importance to point out that, as with many other dams of the world, this one has restricted the amount of sediment supply to the littoral system of the bay and severe erosion has taken place along several segments of the only sandy beach in the bay's interior.

The main morphological features along the 39 km of the BTS shoreline are cliffs, with or without rocky beaches at their feet, sandy beaches, dunes and the Estero de Punta Banda lagoon (Figure 3). Most cliffs are composed of sedimentary material relatively well consolidated, while those composed of hard rock are massive and are found in the northern limit of the main urban settlement of the city (Cerro el Vigia) and the Peninsula de Punta Banda which constitutes the southern limit of the BTS (Figure 1). On the margins of both types of cliffs buildings for recreational and urban housing are present.

The most significant sandy beach along BTS comprises a 17 km stretch from Ensenada to the base of the Punta Banda headland (Figure 3). Beach width is about 100 m, although in the upcurrent side of the groin closing the harbor it increases up to 150 m (Figure 2). The beach is underlain in some areas by gravel deposits which are uncovered during severe wave conditions. Recreational use of the beach is limited to central and southern portions because sewage disposal occurs in the northern reach. Due to construction and expansion of the Ensenada harbor, about 1.5 km of sandy beach has been lost permanently in this area (Figure 2).

From aerial photographs of the early 1970's, the field dunes were well developed (4–7 m high) from the south margin of Arroyo el Gallo to El Faro (nearly 6 km long and about 100 m width) and on the sand spit (3.6 km long and up to 400 m width) (Figure 3). Urban growth and tourism development along the beaches have significantly reduced the presence of dunes (Figure 4). As of 1993 dunes about 5 m high are present from south of Playa Hermosa to just north of El Faro (3.5 km) and on the northern portion of the sand spit (2.4 km). The width of the field dunes is about 90 m in the area to the north of the inlet, and on the sand spit the width increases up to 400 m near the tip (Figure 3). From this data it is evident that the protective capacity of the foredunes against wave action and as a reservoir of sand is very restricted.

The Estero de Punta Banda has a great variety of natural attractions for recreational purposes and ecological diversity. It has an inundation area of 26 km^2 during high tide and despite its ecological significance, it has been subjected to human interventions. Within the lagoon, the construction of a marine platform factory was enough to reduce the size of the marsh area and therefore the tidal prism (IBARRA-OBANDO and ESCOFET, 1987). In addition, on the sand spit separating the water lagoon and ocean waters urban development has been so intense that acceleration of dune erosion

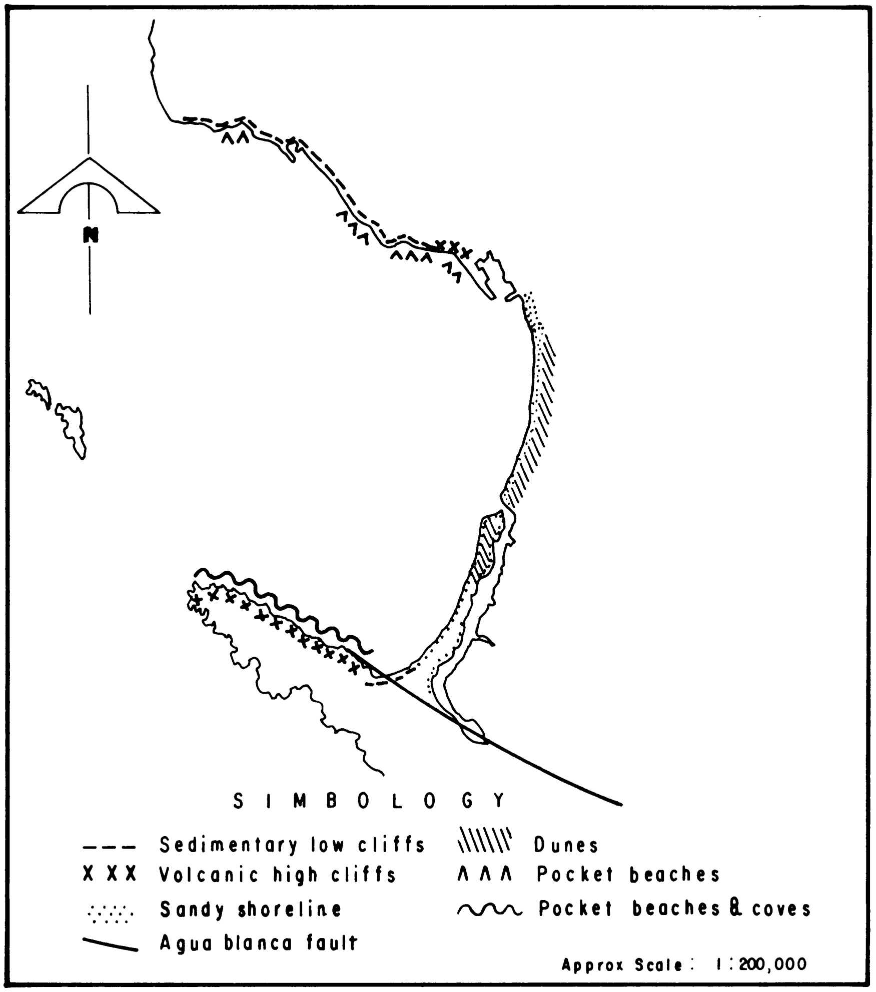

Figure 3. Morphological and geological structure of the shoreline along the Bahia de Todos Santos accounts for a range of potential erosion vulnerability: low along to Punta Banda, medium from Punta San Miguel to Cerro el Vigia, and high along the sandy beach in the central part of the bay.

and even destruction of existing dunes have occurred (GONZALEZ-YAJIMOVICH and ESCOFET, 1991) (Figure 4).

Coastal Erosion

The landward displacement of a given point between the ocean and the continent is the phenomenon known as coastal erosion. When it affects or threatens any kind of human infrastructure at that point then this natural phenomenon converts to a natural hazard.

The main factors that control the shoreline position at any time along the BTS are: (1) local coastal geology and geomorphology, (2) wave climate, (3) sea level position, (4) climate and sediment supply and (5) human intervention. To predict the occurrence of patterns of coastal erosion, first we must know how these factors operate now and in the recent past, individually or combined, and extrapolate the result to a near future.

Local Coastal Geology and Geomorphology

Tectonic processes about 5,000 years ago, horizontal block displacement through the Aqua Blanca fault were responsible for the origin of the BTS, creating a protected coast from open ocean by the massive rocky peninsula of Punta Banda and the Todos Santos Islands (CRUZ-BLANCAS, 1985; GUTIERREZ-GUTIERREZ and SUAREZ-VIDAL, 1988). Along the bay's shoreline there is a wide variety of morphological features which enable a diversity of environments to exist. These include cliffs, dunes, sand spits, sandy beaches, pocket beaches, headlands and coastal lagoons, each having their own ability to resist coastal erosion (Figure 3).

Cliffs

The conglomeratic alluvial and poorly consolidated constitution of low cliffs from Punta San Miguel to Punta Morro in the north, shows a greater potential for erosion than the

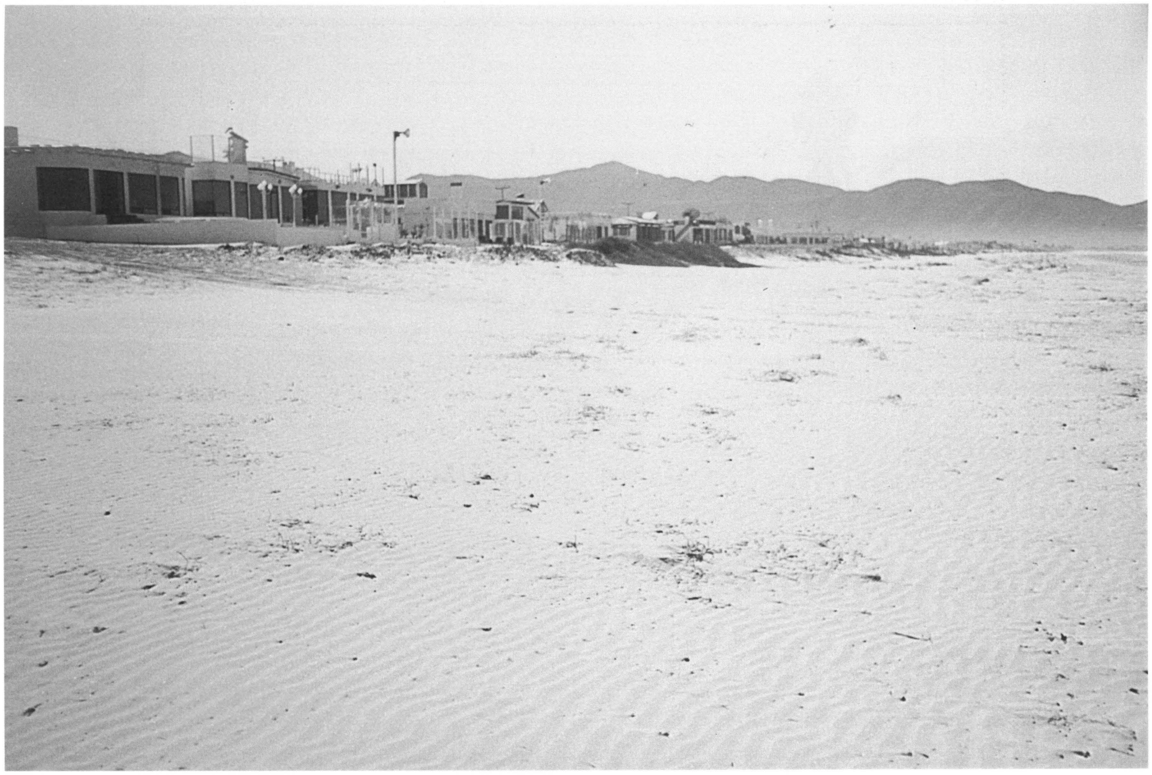

Figure 4. Dune removal to settle residential developments on the middle portion of the sand spit. Average residence height is 2.4 m and beach width from the house to high tide line is 45 m.

harder rocky constitution of higher cliffs in the Cerro el Vigia and peninsula of Punta Banda (Figure 1). Most cliffs along the shoreline show narrow, fragmented rocky and gravelled beaches that reduce cliff erosion by dissipating wave energy as it approaches the cliff base (Figure 5); however, higher waves arriving to the coast during winter storms reach the base of the cliff, eroding and removing the poorly consolidated sediment and accelerating the slumping of the cliffs.

High rates of cliff erosion by marine or subaereal processes occur along the shoreline stretch from El Sauzal to Punta Morro (Figure 1), where retreat rates have been estimated from 0.21 m/yr up to 0.7 m/yr (RAMOS-OLVERA, 1993; CRUZ-COLIN, 1994). In the last 10 years a rapid growth of tourist, industrial and housing infrastructure near or even at cliff margins has led users to adopt "protective" actions against shoreline retreat (Figure 5). For example, in a 4 km stretch of low cliffed shoreline 14 sea walls or rip rap of varying lengths have been built.

Dunes

The field dunes along the backshore act as a reservoir of sand, and they also act as a natural barrier to extreme wave events. However, most of the dunes are subjected to a continuous process of degradation and destruction by urban growth. Near Punta Banda for example, two thirds of the sand spit that encloses the lagoon have been disrupted by urbanization and most of the sand dunes have been completely destroyed (Figures 3 and 4). This has accelerated the rate of wind sand transport toward the lagoon by as much as a factor of 3 (GONZALEZ-YAJIMOVICH and ESCOFET, 1991). The loss of sand affects the reservoir function of the dunes, and increases significantly the vulnerability of the shoreline to erosion. Such processes are threatening the existence of the spit, the lagoon and the urban infrastructure.

Sand Spit

Erosional processes along the sand spit are mainly on the backshore by removal of the dunes and at its northern end which delimit the lagoon inlet. Previous studies (O'BRIEN and ZEEVAERT, 1968; and GONZALEZ-CALVILLO, 1980) show no significant erosional or depositional changes occurred during the 1960's to mid 1970's, however during the period 1978 to 1983, the occurrence of severe winter storms produced intensive erosion at the spit tip, causing the inlet width to increase from about 500 m to 1,100 m with a subsequent land loss of about 8,000 to 12,000 m^2 (CASTILLO-VALDEZ, 1995). After 16 years, it is apparent that the northern end of the sand spit is reaching the position observed in the 1970's (Figure 6).

Sandy Beaches

Sandy beaches are a very dynamic environment; the fine sand is easily moved from one place to another by winds, wave and coastal currents. Erosion processes have been ob-

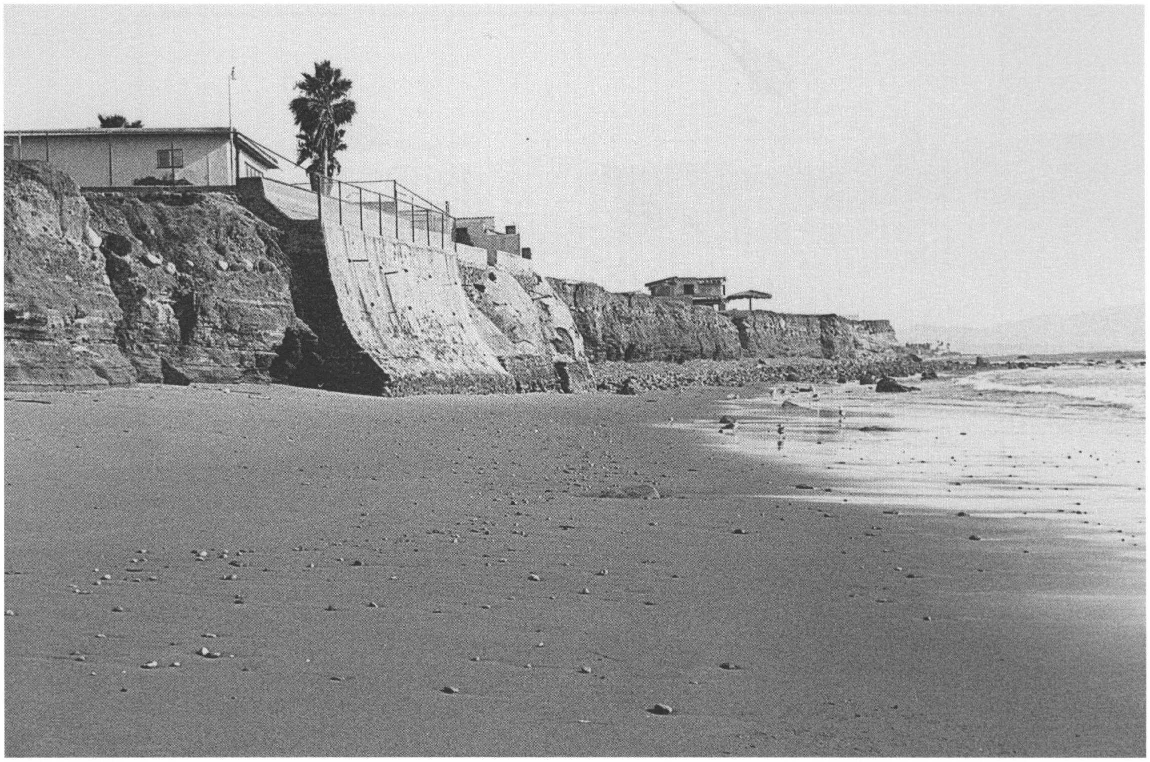

Figure 5. Two contiguous 6-m-high 21 and 23 m length sea walls near El Sauzal showing significant differences in design and construction procedures. Beach width in front of structures is 12 m to the wet area.

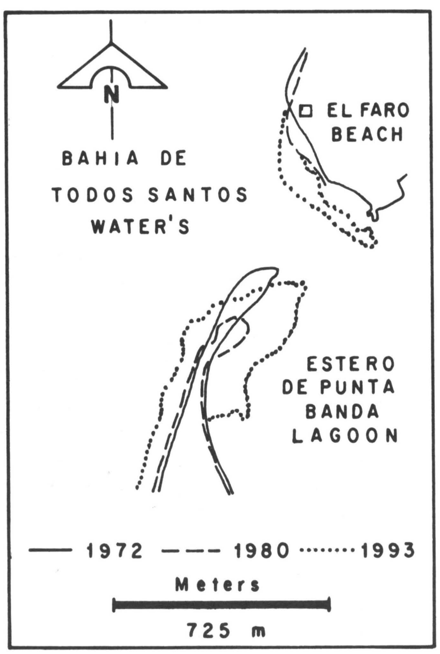

Figure 6. Significant shoreline changes at the inlet of Estero de Punta Banda lagoon were initiated during the winters from 1978 to 1983 with subsequent property loss just north of El Faro Beach.

served along the 17 km of sandy beach located at the southeastern portion of BTS (Figure 2) even though an annual retreat rate has not been established along the total length of the beach. At El Faro (Figure 1), the shoreline retreat has been estimated to be on the order of 2 to 5 m/yr during the period 1972–1989 (GUARDADO-FRANCE, 1993) (Figure 6), and several structures built on the backshore were brought down. The same effect has occurred along the beach stretch at Playa Hermosa.

Headlands and Pocket Beaches

Pocket beaches in the northern portion of the bay show very narrow sandy deposits underlain by gravel and cobble sized material which is uncovered during the winter season (Figure 5). When sandy beach is present in a more permanent fashion, they are covered during high tide allowing the waves to reach the base of the cliff. There is no evaluation of amounts of sand being transported along pocket beaches.

Coastal Lagoon

Erosional and depositional processes at the Estero de Punta Banda lagoon are not well known. It is evident that the lagoon is being filled with sediments brought by the arroyos, which discharge within the lagoon during rainy seasons (Figure 1) (IBARRA-OBANDO and ESCOFET, 1987). However, rates of sediments flux through the inlet has not been evaluated. CRUZ-COLIN (1994) estimated a yield of 63,618 m^3/yr from

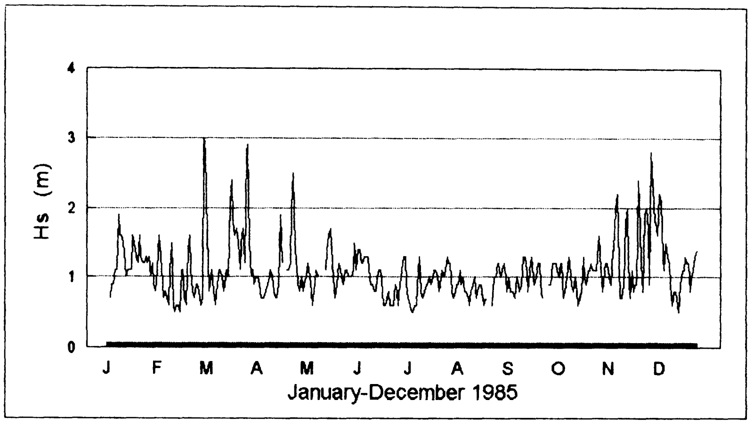

Figure 7. Pattern of high energy waves during winter and low energy waves during summer as measured at Mission Bay, U.S.A. is also observed for the Bahia de Todos Santos region.

the mouth of the lagoon to coastal areas. The most significant erosional-depositional processes occurring at the inlet mouth have been previously described by LIZARRAGA-ARCINIEGA and PEREZ-HIGUERA (1995).

Wave Climate

Waves are the single most important factor in the coastal area since they provide most of the energy to shape the shoreline. Breaking waves perform a dual function in the coastal zone as they both resuspend and temporarily transport seabed sediment and shoreline sedimentary deposits from one location to another.

Along the coasts of Baja California there are very scarce data to systematically describe the characteristics of waves arriving to the coast. The only published wave data was made by the Instituto de Investigaciones Oceanologicas, UABC, during the period of September 1986 to May 1987 (MARTINEZ-DIAZ DE LEON and NAVA-BUTTON, 1988, 1988a); from this data and those obtained since 1978 for the California coast (Coastal Data Information Program) (DOMURAT, 1981), it can be inferred that seasonal wave patterns along Southern California are similar to northwestern Baja California: during winter months (January–April) the more frequent extratropical storms produce higher waves with a greater erosive capacity than in summer (July–October). Figure 7 shows the wave energy pattern as measured off San Diego, California, and even though the pattern is similar for the coast of Baja California, the wave heights along BTS coast are lower due to refraction and protection from the Todos Santos Islands.

Erosion and redistribution of coastal sediments due to wave processes have had significant effects on the BTS coast. The 1978's extreme wave events produced the loss of sand at Playitas pocket beach (see Figure 1) and severe destruction of several houses on top of the backshore. It also produced very intensive beach erosion at the mouth of Estero de Punta Banda (LIZARRAGA and PEREZ, 1995) and just north of it (GUARDADO-FRANCE, 1993) (Figure 6). By contrast, small beach segments located at the Ensenada harbor groin have advanced seaward (LIZARRAGA-ARCINIEGA, 1976; CRUZ-FALCON and MANCILLA-PERAZA, 1991) (Figure 2). Even though there are a number of studies that have evaluated the sand volumes and their transport direction along the beach of BTS, the average annual rate of shoreline retreat has not been determined.

Sea Level Position

In addition to tides, sea level position is influenced by the occurrence of storms, tectonic processes and greenhouse effects. The intensity, duration and consecutiveness of storms can produce a significant accumulation of water over the breaker zone (storm surge), with subsequent displacement toward the beach of the breaker line, which increases vulnerability to erosion. When storm surge coincides with a high tide the increased erosion capabilities of waves are evident for relatively short periods of time. These events coincided recently along the Baja California coast during an exceptionally severe storm in January 1987, when sea level rose about 10 cm (FLICK and BADAN-DANGON, 1989); unfortunately, the evolution of concurrent beach changes along the BTS shoreline has not been documented.

The tectonic activity that generated the BTS about 5,000 years ago also was active about 1,200 years ago, when vertical displacement of coastal blocks gave rise to the 400 m deep submarine canyon between the Punta Bandas tip and Islas de Todos Santos. The resulting inundation of the coastal low lying area formed the Estero de Punta Banda lagoon (CRUZ-BLANCAS, 1985). Even though in recent years there is no apparent downmotion in the area, there are several large geological faults capable of producing significant horizontal and/or vertical motion (LEGG *et al.,* 1991).

Inundation of coastal areas by sea level rise due to the greenhouse effect will vary depending on magnitude of sea level rise and local topography; therefore, an estimation of shoreline retreat by this phenomenon presents some uncertainties. MONTOYA-TURRILLAS and GOMEZ-MORIN (1991) have studied several scenarios for shoreline shifting under varying rates of sea level rise and have concluded that for the year 2100 the worst scenario would be a 1.5 m sea level rise with a consequent shoreline retreat of about 200 m along the coastal segment from Arroyo El Gallo to just north of the mouth of the Estero de Punta Banda lagoon (Figure 1), flooding an area of about 3.5 km^2.

Climate and Sediment Supply to BTS

In the BTS the main supply of sediment is provided by cliff erosion, longshore transport of sand and arroyos. The nature of these processes makes apparent the influence of climate. The rainy season (January to April) and associated frequent winter storms in the region is the most productive period for sediment input to the coast, but the latter also produces waves with higher erosion capabilities. The easily erodible cliffed coast to the north of the bay provides an estimated 21,000 m^3/yr while the cliffs along the northeastern portion of Punta Banda peninsula provide 4,500 m^3/yr (CRUZ-COLIN, 1994) (Figure 3). It should be pointed out that sediment from the northern cliffs is distributed among the pocket beaches from Punta San Miguel to Punta Morro contributing partially to the protection of the cliff base; however, it seems apparent that this material does not reach the beach located south of Ensenada. By contrast, the supply of sediment from the cliffs at the base of Punta Banda are responsible for the growth of the sand spit adjacent to it (O'BRIEN and ZEEVAERT, 1968; PEREZ-HIGUERA and CHEE-BARRAGAN, 1984).

Along the open coast portion of the bay two arroyos, El Carmen and El Sauzal (Figure 1), contribute about 25,000 m^3/yr and apparently follow the same dispersal pattern as sediment supplied by cliffs. The arroyos draining a larger area are San Carlos and Las Animas with a combined sediment yield of 200,000 m^3/yr (CRUZ-COLIN, 1994; POU-ALBERU and POZOS-SALAZAR, 1992); however, both empty in the Estero Punta Banda lagoon (Figure 1) and their contribution to the littoral system is limited (GONZALEZ-CALVILLO, 1980).

Of particular interest is the Arroyo Ensenada from which a sediment yield of 30,000 m^3/yr is estimated. However, the construction of the Emilio Lopez Zamora dam in 1979 and the location of its deposits within the harbor of Ensenada (Figure 2), result in a significant reduction of sediment supply to the adjacent beach. GOMEZ-MORIN and LIZARRAGA-ARCINIEGA (1982) and TORRES-RODRIGUEZ (1985) estimated that the arrangement of coastal structures such as groins and the breakwater near the mouth of Arroyo Ensenada retained nearly 135,000 m^3/yr in the harbor basin, denying sediment to adjacent beaches to the south. This reduction of sand into the littoral system has resulted in a significant apparent shoreline retreat along most of the beach and has been most evident at El Faro Beach, Playa Hermosa and the mouth of Estero Punta Banda.

Human Intervention

Human activities that influence shoreline retreat are varied and complex. As a first approach, along the BTS these interventions have been exerted mainly through the construction of varied types of coastal structures and a dam. The construction of the Ensenada harbor in 1951 produced a rapid seaward advancement of about 100 m of shoreline along the beach segment immediately to the south of a pair of groins, at that time closing the harbor, and erosion to the beach of Playa Hermosa, just south of that segment (LIZARRAGA-ARCINIEGA, 1976; LIZARRAGA-ARCINIEGA and PEREZ-HIGUERA, 1995). Later, the building of the Emilio Lopez Zamora dam in 1979 and the expansion of the harbor (concluded in 1985) with a longer breakwater and longer groin to the south (from 108 hectares with 70 hectares of water and 38 hectares of land to 117 hectares with 115 hectares of water and 62 hectares of land) created a very restrictive environment for the incorporation of any sedimentary material brought around the dam through the arroyo Ensenada (Figure 2). It is hypothesized that the combined effect of these factors is responsible for the dramatic erosion observed in recent years in the area of El Faro and Mona Lisa where some residents placed a rip-rap along about 400 m of shoreline. The beach in front of this structure is exposed only during low tide (Figure 8).

The rapid urbanization in the backshore along most of the length of the beach has caused the total destruction of the dune field in most of the area. This loss leads to a more vulnerable shoreline since protection against wave action has been completely lost and transport of beach sand by wind action out of the littoral has increased significantly (GONZALEZ-YAJIMOVICH and ESCOFET, 1991).

The construction of the El Sauzal Harbor, with a protected area of 6.7 hectares, also has influenced the erosion rate of the low cliffed shoreline to the south. Continuous erosion along the shoreline has led the residents to take some protective actions, so that now 14 seawalls of different sizes and design quality have been built. Similarly, the construction of the marina at Playitas, initiated in 1994, caused the total loss of the sandy pocket beach and required emplacement of heavy riprap along an 80 m segment to protect houses on the backshore.

Along the BTS shoreline an increasing number of coastal structures have been observed. These include breakwaters, seawalls, groins and riprap constructed in order to provide sheltered areas for cargo, small boats, and protection against shoreline retreat. As of 1995, the length of coast with some kind of hard-structure protection accounts for 13% (5,289 m) of the 39 km BTS shoreline length (Table 1). Unfortunately, most of the structures have been built with a very low degree of concern, if any, for what effect they might have to downdrift shoreline segments. As was pointed out earlier, erosion rates at several specific locations have increased.

As construction of coastal facilities for tourism, residential and industrial purposes continues to grow in the area, so does the risk of permanent loss of sandy beaches. A similar pattern has occurred along the California coast where in 1971 only 26.5 miles of hard protective structures existed, while in 1989 the state's shoreline had 130 miles of some form of hard protective structures. Paradoxically, most "protected" beaches show a continuous loss of beachfront in such a way that some armored coastal segments have no beachfront at all (GRIGGS *et al.,* 1991). These conditions have considerably re-

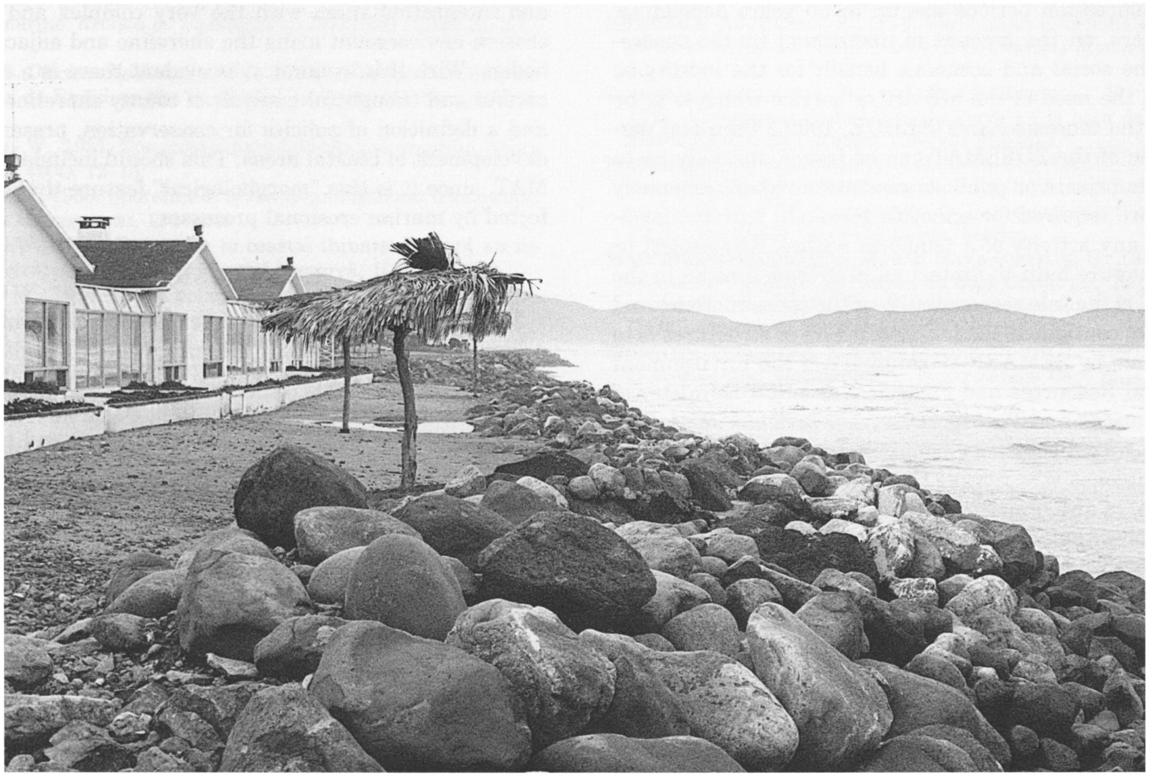

Figure 8. Side view of a 400 m long rip-rap at Mona Lisa and el Faro Beach. Along the whole length of the structure the beach is present only during low tide. Residence height from top to base is 4 m.

duced the recreational use of beaches along the California coast and have negatively affected several local economies. This lesson is relevant to BTS.

COASTAL EROSION MANAGEMENT

The management of coastal erosion can vary from "do nothing" to "protective actions". In general, "doing nothing" occurs when erosion rates are near zero, considered minimum, or do not threaten man-made infrastructure. "Protective measures" are usually developed under remedial conditions rather than preventive; that is, protective measures such as construction of sea-walls, rip-rap, etc. are implemented when destruction of property is imminent (FISCHER, 1985). It is evident that for such cases adequate planning is nil and side-effects of these protective measures are not considered.

In Mexico there is no policy whatsoever for managing shoreline erosion. The coastal strip under the potential effect of shoreline retreat is considered as a national asset within the public domain and under the sole jurisdiction of the federal government (SEDUE, 1982). This strip is known as "zona federal maritimo-terrestre" (federal maritime-continental zone, ZOFEMAT) and is defined by federal law as a strip 20 m inland from the higher high tide line (SEDUE, 1991). These portions of territory can be used by private or public

Table 1. *Coastal structures along the Bahia de Todos Santos as of 1995. Most seawalls are located from El Sauzal to Punta Morro showing variability of design and construction materials. Heavier structures are for harbors and marina facilities.*

Length (m)	Type	Materials	Locality
800	sea-walls	concrete; interlocked rocks	El Sauzal-Pta. Morro
624	breakwater	rubble-mound	El Sauzal
440	groins	rubble-mound	El Sauzal
400	breakwater	rubble-mound	Marina las Rosas
200	groin	rubble-mound	Marina las Rosas
80	rip-rap		Playitas
1,640	breakwater	rubble-mound	Ensenada
840	groin	rubble-mound	Ensenada
15	seawall	interlocked rocks	Playa Hermosa
250	rip-rap		El Faro

organizations under federal law by concession or temporal permits. Concession periods are up to 50 years depending, among others, on the amount of investment by the consessionaire, the social and economic benefit for the locality or region and the need of the activity or service which is to be offered by the consessionaire (SEDUE, 1982). Temporal permits for use of the ZOFEMAT can be issued annually up to two years to private or public organizations when temporary activities are required for scientific research, tourism development or any activity of a temporal nature. Any project or coastal structure built to protect an area from erosion in the ZOFEMAT is the sole responsibility of the consessionaire and the owner of contiguous land. Construction of structures is to be authorized by SEMARNAP (Ministry of the Environment and Natural Resources and Fisheries) and SCT (Ministry of Communications and Transport).

It is recognized that local communities in a given coastal area are the ones who receive the impacts, whether positive or negative, of any projected use or "protection" of the coastline; therefore, their involvement in these matters is critical. Further, coastal counties and communities are the most appropriate organizational level to define the type and amount of development desirable along their coastline. This very simple approach is not as clear as expected when considering the jurisdictional authorities for decisions about the coastal zone, and particularly for shoreline development (see for example FISCHER *et al.,* 1995). Very recently (June 1994), in several coastal states of Mexico, a federal-state-county agreement has been signed for the administration and coordination of the ZOFEMAT. Even though the federal government has the final authority to grant approvals and permits for use of the ZOFEMAT, the county is in a position, through a County Committee for the Administration of the ZOFEMAT (CCA), to give an opinion about proposed uses of that strip of land by any solicitor (SEDESOL, 1994).

Under state legislation for environmental protection (SAHOPE, 1992), the county has elaborated a program for urban development for the City of Ensenada (DDUE, 1994). This program recognizes that coastline retreat is a hazard, but no policies about its management are clearly stated. In addition, the territorial limits associated with coastal erosion considered in this program are confined to the shore bordering the urban area of the city, accounting for only 4% of the county's total shoreline length. Considering the state's interest in the expansion of the tourism industry as a means to increase economic and social wellbeing, it is evident that there is the need to promote ZOFEMAT as an important element of effective coastal zone management.

It is known that development and use of the shoreline varies from country to country. Demand for coastal land in developed countries is oriented to residential and recreational purposes, whereas in countries like Mexico, development is oriented to industries for the general exploitation of the coast and therefore carry a higher risk for environmental deterioration (CHACKO, 1974). These circumstances, added to the extensive coastline of the state of Baja California, pose a major task to local communities in the state. Rapid development of the BTS requires a planning framework in which coastal land-use requirements can be rationally balanced geographically. This necessitates the adaptation of activities present and integrating them with the very complex and sensitive erosion environment along the shoreline and adjacent water bodies. With this in mind, it is evident there is a need for a careful and thoughtful analysis of county shoreline planning and a definition of policies for conservation, preservation or development of coastal areas. This should include the ZOFEMAT, since it is this "morphological" feature that is first affected by marine erosional processes.

CONCLUSIONS

The actual and foreseen rapid expansion of urban and suburban areas of Ensenada, El Sauzal, Ejido Chapultepec, Maneadero, Estero de Punta Banda and La Joya has exerted a significant environmental pressure along the coastline of the BTS. Construction and expansion of harbors and marina facilities at Ensenada, El Sauzal, Playitas and El Faro have created new stretches of beach erosion, and in some localities, the acceleration of erosion rates has produced significant shoreline retreat.

Coastal erosion as a natural or man-made hazard is best recognized at local levels rather than state or federal levels. As simple as this recognition sounds, the management of coastal erosion in Mexico is only in its initial phase of conceptual, organizational and operational development. However, when one considers the amount of money put into coastal development and the potential impact on the local economy from erosion damage, it is evident that a model should be followed in which local authorities, local scientists, community leaders and coastal land owners are integrated along with major developers into a management forum for decisions about coastal area uses, including investment in coastal erosion studies in the ZOFEMAT (FISCHER, 1990). Without local input into state and federal coastal development planning, the shoreline of Ensenada County will be left to the vicissitudes of morphological processes and rampant unsustainable development patterns.

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