CALIFORNIA MARINE WATERS
AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

RECONNAISSANCE SURVEY REPORT

Mugu Lagoon to Latigo Point
Ventura and Los Angeles Counties

STATE WATER RESOURCES CONTROL BOARD
Division of Planning and Research
Surveillance and Monitoring Section

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WATER QUALITY MONITORING REPORT 79-5

ACKNOWLEDGEMENT

This State Water Resources Control Board report is based entirely on a reconnaissance survey report submitted to the Board by Dr. James G. Morin and Anne Harrington of the University of California at Los Angeles. The latter report was prepared in fulfillment of an agreement with the California Department of Fish and Game. The Department coordinated the preparation of a series of Area of Special Biological Significance survey reports for the Board under an Interagency Agreement.

ABSTRACT

The Mugu Lagoon to Latigo Point Area of Special Biological Significance (ASBS) includes the ocean waters between Latigo Point in Los Angeles County and Laguna Point in Ventura County, from the intertidal to 100 foot depth or 1,000 feet offshore, whichever is further. This ASBS is adjacent to about 24 miles of relatively straight east-west trending coastline and has a surface area of 11,710 acres. The area is contained within the approximate map coordinates 34°01' 34"-05' 40" N. Lat and 118°45' 20"-119°06' 30" W. Long.

Most of the intertidal area and much of the subtidal are sand; however, spectacular and extensive subtidal reefs are present. This area is geologically complex, consisting for the most part of Miocene age sedimentary shales, sandstones, breccias, and recent terrigenous sands. Land forms adjacent to the ASBS consist of (from west to east) an alluvial plain with a coastal lagoon, a steep mountain escarpment, and a coastal bluff with cliffs along the shoreline. Four major land vegetation types border the ASBS: salt marsh, coastal strand, coastal sage scrub, and riparian woodland.

The ASBS experiences a Mediterranean climate with seasonal winter rainfall. Winds are primarily westerly in the summer and northeasterly in the winter. Current flow into the ASBS is generally from the north and west.

The biota of this ASBS is extremely rich and diverse which reflects the variety of habitats in this area. Reconnaissance surveys indicated five major subtidal habitat types: 1) indurated rock reefs and exposed offshore kelp beds between Little Sycamore and Lechuza Point, 2) semi-protected sandstone reefs and kelp beds off Paradise Cove, 3) shallow sands (0-60 ft.) off Zuma Beach and most of the western portion of the ASBS, 4) deeper sands (60-100 ft.) that occur along most of the ASBS, and

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Findings

Laguna Point to Point Mugu

1. Access to most of this portion of the ASBS is strictly controlled by military restrictions and land ownership.

2. Mugu Lagoon opens into and discharges tidal outflow into this portion of the ASBS.

Point Dume to Little Sycamore Canyon

1. Lands adjoining the majority of this portion of the ASBS are part of Mugu State Park.

Little Sycamore Canyon to Latigo Point

1. This portion of the ASBS adjoins the areas of existing and potential coastal residential development.

2. Some residential developments in this stretch utilize septic tank disposal systems in or near the beach area.

3. Large municipal outfalls discharge treated wastewaters into Santa Monica Bay southeast of the ASBS boundary.

4. Extremely heavy recreational use is made of this portion of the ASBS.

5. The giant kelp, Macrocystis pyrifera, appears to be healthy and reproductive.

Conclusions

1. The Mugu Lagoon to Latigo Point ASBS is one of the least impacted regions on the mainland of Southern California, protected in part by steep mountainous terrain, offshore currents and State and federal land ownership.

2. Water quality protection in the ASBS appears adequate; however, potential sources of impact include outflow from Mugu Lagoon, erosion resulting from land development and leachate from septic tank leach fields.

3. The occurrance and abundance of certain organisms, such as lobster, abalone, scallops and some fishes, have been altered by harvesting; in many areas, the limited rocky intertidal zone has been severly impacted by people collecting and/or disturbing the fauna.

4. The findings of this survey suggest that consideration should be given to expansion of the seaward boundary of the ASBS to the 100 ft. isobath or 3000 ft. offshore in order to include larger portions of Dume and Mugu submarine canyons.

5. The findings of this survey suggest that populations of the important organisms in the ASBS should be surveyed periodically in identified locations in the subtidal zone to determine their relative abundance, age distribution, recruitment and their general health.

The giant kelp, Macrocystis pyrifera; surf grass, Phyllospadix torreyi; the gray tube worm, Diopatra ornata; the sand tube worm, Phragmatopoma californica; the sand dollar, Dendraster excentricus; the halibut, Paralichthys californicus, and the pismo clam, Tivela stultorum, are important organisms in this ASBS. Possible survey locations for these species include: Nicholas Canyon and Paradise Cove for the rock dwelling organisms, Zuma Beach and Mugu Barrier Beach for the sand organisms.

6. The findings of this survey suggest that the mouth of Mugu Lagoon and other locations in the ASBS should receive additional water quality monitoring to assess the potential impact of outflow from the lagoon.

7. The findings of this survey suggest that an assessment of the potential water quality-related impacts of the septic tank leach fields adjoining the ASBS is warranted.

8. This reconnaissance survey has pointed to increased urban development in the area as a potential source of water quality degrada-

tion. The soil in this area is very erodible and the terrain is steep; grading, filling and other practices could lead to increased sediment loads in the streams flowing into the ASBS.

INTRODUCTION

The California State Water Resources Control Board, under its Resolution No. 74-28, designated certain Areas of Special Biological Significance (ASBS) in the adoption of water quality control plans for the control of wastes discharged to ocean waters. The ASBS are intended to afford special protection to marine life through prohibition of waste discharges within these areas. The concept of "special biological significance" recognizes that certain biological communities, because of their value or fragility, deserve very special protection that consists of preservation and maintenance of natural water quality conditions to practicable extents (from State Water Resources Control Board's and California Regional Water Quality Control Boards' Administrative Procedures, September 24, 1970, Section XI. Miscellaneous--Revision 7, September 1, 1972).

1. Discharge of elevated temperature wastes in a manner that would alter natural water quality conditions is prohibited.

2. Discharge of discrete point source sewage or industrial process wastes in a manner that would alter natural water quality conditions is prohibited.

3. Discharge of wastes from nonpoint sources, including but not limited to storm water runoff, silt and urban runoff, will be controlled to the extent practicable. In control programs for wastes from nonpoint sources, Regional Boards will give high priority to areas tributary to ASBS.

4. The Ocean Plan, and hence the designation of Areas of Special Biological Significance, is not applicable to vessel wastes, the control of dredging or the disposal of dredging spoil.

In order for the State Water Resources Control Board to evaluate the status of protection of the Point Mugu to Latigo Point ASBS, a reconnaissance survey integrating existing information and additional field study was performed by Dr. James Morin and Anne Harrington of the University of California at Los Angeles. The survey report was one of a series prepared for the State Board under the direction of the California Department of Fish and Game and provided the information compiled in this document.

Reason for designating the Mugu Lagoon to Latigo Point ASBS: The recommendations of the Ocean Advisory Committee to the California Regional Water Quality Control Board, Los Angeles Region, state clearly the reasons why the area between Latigo Point and Laguna Point was designated an Area of Special Biological Significance:

This area represented the only remaining coastal area within the region that has not undergone extensive changes from development and/or water quality impairment. The area lies between two areas of extensive development (Los Angeles vicinity and the Ventura/Oxnard area) and, if unprotected, faces the danger of encroachment from either side. In describing this area, the Department of the Interior Bureau of Outdoor Recreation, Santa Monica Mountain Study, made the following statement in their preliminary report: "The 27-mile stretch of coastline, from the mouth of Ramirez Creek at Paradise Cove to the westernmost boundary of Point Mugu Pacific Missile Range, contains a varied and extremely rich marine and littoral biota, submarine canyons off Point Dume and the mouth of Mugu Lagoon, undisturbed sandy beaches, kelp beds and rock shores. It is the most outstanding inshore marine area left between Santa Barbara and San Clemente." In reference to the same area, Dr. Rimmon Fay in his report to Southern California Association of Governments (SCAG) entitled An Evaluation of the Health of the Benthic Marine Biota of Ventura, Los Angeles, and Orange Counties, made the following statement: "There is no area quite the equal of this stretch of coast in the whole of southern California for the diversity and productivity of the biota. It remains in essentially a native state as a remnant of what was typical of the rock shoreline of the three county coastline."

Five major habitat types are found between Arnold Road and Latigo Canyon: a barrier beach, open coast kelp beds, open coast sandy beaches, semi-protected kelp beds and submarine canyons, the combination of which is unique in all of southern California. It is the recommendation of the committee that this section of coastline be included in its entirety and not parcelled off as smaller discontiguous areas for we strongly feel that the protection of these five habitat types are represented in the following areas:

ORGANIZATION OF SURVEY

This project involved the conduct of a qualitative reconnaissance survey of the physical, chemical and biological aspects of the subtidal and intertidal areas within, and land areas adjacent to, the Mugu Lagoon to Latigo Point ASBS. Descriptions of human land/water use, actual or potential pollution threats within the ASBS, and any special water quality requirements of the biota in the ASBS were also included.

The subtidal description is based on 1) previous notes taken following scuba dives in the ASBS by Dr. James Morin, Anne Harrington (investigators) and Dr. Noel Davis, 2) portions of a manuscript in preparation for publication by the investigators, and Drs. Jon Kastendiek and Noel Davis dealing with the Zuma Beach subtidal sand community and 3) direct reconnaissance surveys by the investigators and Drs. Thomas Ronan and Noel Davis during an intensive one-week period of diving (See Fig. 1).

Dives logged off the beach within the ASBS prior to this survey (between 1970 and 1977) consisted of 1) thirty dives in the Latigo Point-Paradise Cove area, 2) eight in Dume Canyon, 3) ca. two hundred fifty at Zuma Beach (including Westward and Trancas Beaches), 4) forty nine between Lechuza Point and Little Sycamore Canyon, 5) three off Deer Canyon and 6) three between Big Sycamore Beach and Point Mugu. After each of these dives a log was made which included a description of the basic physical characteristics of the area and a list of all organisms encountered that could be identified (Appendices 2 and 4). Sometimes relative densities were also included.

During a five-day period (September 19 to 23, 1977) of sustained boat diving, a total of 76 individual dives was made. All of the major habitats within the ASBS were encompassed by these dives (Fig. 1). As standard procedure, the first dive of the day was to 90 to 100 foot depths. Subsequent dives were usually to depths less than 45 ft. During used. The species for these genera can be located by referring to the appendices.

Table 1. Shoreline Distances Within the Mugu-Latigo ASBS

Eastern Location	to Western Location	Miles	Km
I. Major Distances			
1. Total Distance:			
Latigo Pt (BM 24) [east end of ASBS]	Laguna Pt. [west end of ASBS]	23 9/10	38.5
2. Los Angeles County Distance:			
Latigo Pt. (BM 24)	Los Angeles-Ventura County Line	13 1/10	21.1
3. Ventura County Distance:			
Los Angeles-Ventura County Line	Laguna Pt.	10 4/5	17.4
II. Shorter Distances			
Latigo Pt.	Paradise Cove Pier	1 3/4	2.8
Paradise Cove Pier	Pt. Dume	2	3.2
Pt. Dume	Lechuza Pt.	4 1/5	6.8
Lechuza Pt.	Lachusa Cyn.	2	3.2
Lachusa Cyn.	San Nicholas Cyn. (Pt. Zero)	1 1/5	1.9
San Nicholas Cyn. (Pt. Zero)	Sequit Pt.	1 2/5	2.3
Sequit Pt.	Little Sycamore Cyn	1 2/5	2.3
Little Sycamore Cyn.	Deer Cyn.	1 1/2	2.4
Deer Cyn.	Big Sycamore Cyn. (BM 25)	1 9/10	3.1
Big Sycamore Cyn. (BM 25)	La Jolla Cyn.	1 1/2	2.4
La Jolla Cyn.	Pt. Mugu	1 1/2	2.4
Pt. Mugu	Opening of Mugu Lagoon	1 9/10	3.1
Opening of Mugu Lagoon	Laguna Pt.	1 1/3	2.1
III. Other Distances			
Pt. Dume	Zuma Cyn.	1 1/3	2.1
Zuma Cyn.	Trancas Cyn.	1 2/3	2.7
Sequit Pt.	Los Angeles-Ventura County Line	0.48	0.8
East end of La Jolla Beach	West end of La Jolla Beach	1 1/3	2.1
East end of Big Sycamore Beach	West end of Big Sycamore Beach	1/3	0.5

The generalized oceanic surface flow of water along the California coast is becoming understood (Fig. 4). The predominant offshore current is the slow southerly moving California Current off northern and central California. When this current reaches Point Conception it continues south well off the coast of the Southern California Bight and even beyond the outer islands. However, some of the California Current is diverted eastward at San Miguel Island. This water flows along the north coast of the northern Channel Islands and then splits into three parts. One segment continues eastward along the northern Channel Islands and escapes into the Santa Monica Basin off Anacapa Island. Another segment moves northward across the channel at about the level of Santa Barbara. As it nears the coast it divides into the other two parts: a westerly flowing current along the coast from Santa Barbara to Point Conception (thus forming a counterclockwise gyre in the Western Santa Barbara Basin) and an easterly flowing and weaker current along the coast from Santa Barbara to Port Hueneme where it also enters the Santa Monica Basin in the vicinity of the Mugu-Latigo ASBS.

The largest part of the California Current continues south well off the coast. South of the northern Channel Islands some of the California Current is deflected eastward and then northward along the Santa Cruz Basis east of the Santa Rosa-Cortez Ridge. This current is the Southern California Countercurrent. It is usually well-developed in summer and fall, but weak or absent in winter and spring. As it approaches the northern Channel Islands, one portion turns west toward the California Current, another segment flows east into the Santa Monica Basin and a small portion penetrates into the eastern Santa Barbara Basin between and mixes with the two prongs of the eastern Santa Barbara Basin Circulation. The eastern arm of the Southern California Countercurrent joins with the water flowing easterly out of the Santa Barbara Basin along its northern (mainland) side.

The combined water mass moves primarily southward off the coast from Santa Monica Bay to well beyond the Mexican Border where it finally rejoins the California Current. However, a portion of the flow forms a counterclockwise gyre in Santa Monica Bay which flows northerly and then

Tides can have major effects on the currents. In general, however, they produce an oscillatory effect in the vicinity of the ASBS, moving water and associated materials on and off shore as the tide rises and falls. Net movement along the shore is primarily created by other factors.

The ocean swell also has a major influence on local currents. Most of the time the swell and the wind lie roughly parallel and in the same direction, from the west, and hence have an additive effect. However, where the two conflict, current direction cannot always be predicted and can vary from place to place and time to time. The dominant swell pattern especially during most of the winter and spring months is westerly. During the summer and fall, however, large southerly swells generated from storms in the southern hemisphere frequently strike the shores of the ASBS. The swells tend to create more westerly moving nearshore currents.

An important shallow water current is the longshore current. Where ocean swells strike the beach at an angle, a current develops in the shallowest waters (usually to depths of no more than 20 or 30 ft.) directed away from striking waves. Thus in the ASBS, the dominant winter and spring westerly swells usually produce an eastward moving longshore current. During times of more southerly swells the longshore currents tend to move westward. These currents can be extremely swift, moving at rates approaching 30 to 40 meters per minute. Such currents usually do not persist for more than a day or two, and can reverse their flow rapidly, over a period of minutes. Tidal periodicity and bottom topography will drastically affect such currents; offshore reefs and kelp beds can strongly dampen both swell and resulting longshore currents. At Point Dume, in the vicinity of the stacks just offshore, the easterly moving offshore currents coupled with dominant easterly nearshore currents create a very strong current directed toward Santa Monica Bay.

Longshore drift carries large quantities of sediments in a predominately southerly direction. The quantity of material transported has been estimated to be about 900 yd^3/day at Point Mugu and Sequit Point and about 800 yd^3/day at Point Dume (Fay, 1972; Ingle, 1966).

Figure 5. Average monthly ocean surface temperatures at Zuma Beach (taken from SCE, 1973)

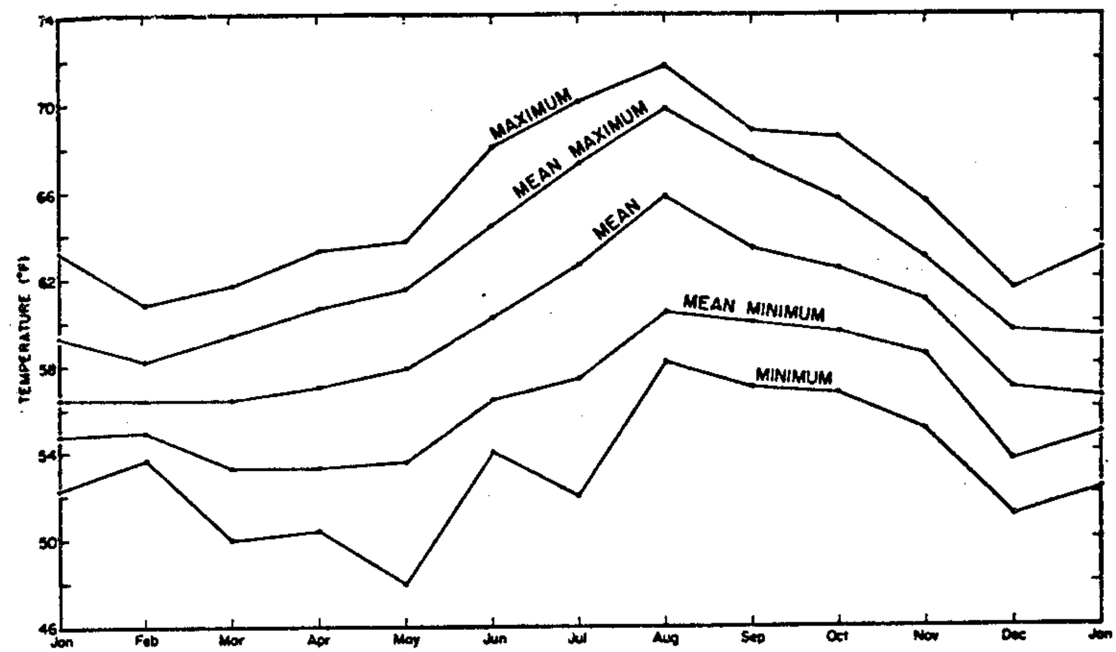

Table 2.

Seasonal Distribution of Temperature, Salinity and Density off the Mugu-Latigo ASBS (from Allan Hancock Foundation, 1965).

Season	Temperature (°C)		Salinity (‰)		Mean Density	
	Surface	60 m	Surface	90 m	Surface	60 m
January-March	14-15	12½	33.5-33.6	33.8	1.0251	1.0255
April-June	16-16½	10-11½	33.5-33.6	33.6-33.9	1.0245-1.0248	1.0256-1.0260
July-September	18-19	12	33.6	33.5	1.0243	1.0259
October-December	16½-19	13½	33.5-33.7	33.6	1.0240-1.0244	1.0252

Ripcurrents, like longshore currents, are a nearshore shallow water phenomenon. These currents are usually extremely local. They are particularly common off sand beaches during the winter and spring, when offshore sand bars are well developed. The massive amount of water from the surf which collects shoreward of the major sand bar exits from the trough as a narrow high speed current which generally runs perpendicular or obliquely to the shoreline. Once beyond the bar and surf line, these currents dissipate quickly. Their influence rarely extends more than a hundred yards from shore. Rips are particularly prominent off the exposed beach at Zuma, but they can occur off all of the other sand beaches along the ASBS.

Sea conditions within the Mugu-Latigo ASBS generally consist of a 2 to 4 foot swell, but can vary from flat calm to seas in excess of 15 to 20 feet on rare occasions. For further information on currents, refer to Emery (1960), Jones (1971), Fay (1972), SCCWRP (1975, 1976, 1977), SCE (1975).

<u>WATER COLUMN</u>: Water clarity within the Mugu-Latigo ASBS varies from zero to over one hundred feet. However, these extremes are both relatively rare and occur at most a few days a year. Visibility averages between 10 and 20 feet throughout most of the year. Maximum turbidity can be expected during the spring and early summer plankton blooms, and during winter and early spring storms. Maximum visibility tends to occur in the late summer and fall.

Visibility almost always improves away from the shoreline; it is usually 0 to 10 ft. to a water depth of about 20 feet, and then steadily improves with increasing depth to a maximum at about 35 foot depths and beyond. Seaward of the ASBS, water clarity usually exceeds 40 ft. During this survey period in September, 1977, diving conditions were better than normal, and visibilities of about 20 to 30 ft. were recorded in areas deeper than about 35 feet and ranged from zero up to about 15 ft. toward shore. Most of the turbidity resulted from surge.

The average surface temperatures within the ASBS range between 56.5 and 65.5°F (14 and 19°C) with a minimum of 48°F(9°C) recorded in May and a maximum of 72°F(22.5°C) recorded in August (Fig. 5, Table 2). There is a distinct thermocline (ca. 2-3°F) which varied in depth between 20 to 35 feet. The depth of this thermocline varied from location to location and with time. Often the thermocline breaks down and major stratification disappears during the winter and spring months as a result of mixing by storms and upwelling. In Mugu Canyon in September, three distinct thermoclines between the surface and 100 ft. were detected. These occurred at 20, 40 and 80 foot depths and each thermocline had a temperature differential of about 2°F. Average temperatures offshore from the ASBS are given in Table 2 for the surface and for 200 ft. (60 m) during the four seasons.

Salinity within the ASBS remains relatively constant throughout the year (Table 2). The maximum of about 33.7 o/oo occurs in the fall and the minimum (33.5 o/oo or less) occurs during the rainly season of winter and early spring. As there are no major drainages into the ASBS except Calleguas Creek, salinities do not drop sharply in most locations throughout the year. Calleguas Creek discharges large quantities of low salinity water into the ASBS during the rainy season. This influence is localized around the mouth of Mugu Lagoon. Temperature and salinity gradients produce an increase in sea water density with depth (Table 2).

Dissolved oxygen levels within the ASBS are adequate to support marine life. The minimum concentration reported is about 4 mg O_2/l, which is about 50% air-saturation. In the surface waters, dissolved oxygen concentrations usually vary between 100 and 140% air-saturation as a result of aeration caused by the swell and wind chop. Values are highest in the fall and winter (data from U.S. E.P.A. 1977).

Nitrate levels within the ASBS surface waters range between 0.01 and 0.16 mg/l and increase with depth. Concentrations are highest in the spring when deeper nutrient rich waters are brought to the surface by upwelling (Allan Hancock Foundation, 1965).

Trace metals probably vary considerably within the ASBS from place to place and with time as their concentrations are affected by storm runoff, lateral currents, upwelling and plankton concentrations. These metals can occur in ionic form, absorbed on particulates, bound to organics or as complexes. An indication of the levels and variability of these metals at sewage outfall locations on either side of (but not in) the ASBS is given in Table 3. Lead and mercury levels appear to be increasing in the sediments of the Southern California Bight (SCCWRP, 1975).

Topographic and Geomorphic Characteristics

SUBMARINE TOPOGRAPHY: The Mugu-Latigo ASBS extends from the intertidal zone seaward to the 100 foot contour line except at the head of Mugu Canyon, where it includes depths of at most, 125 feet (Fig. 3). The major types of substrates are shown in Figure 6. Except near the canyons, the bottom slopes off gently with a gradient of about 1.7% to 3% (Table 4) and consists primarily of medium to very fine, well sorted sand, especially below 60 ft. depths (Fig.6).

Nearshore areas, particularly between Bass Rock, just west of Deer Canyon, Lechuza Point, and between Point Dume and Latigo Point, have a variable relief where the sand is replaced by extensive rock reefs. These reefs show a high degree of variability, ranging from cobble fields on a sand base to towering and precipitous bedrock ridges and gigantic boulders up to 30-40 ft. in diameter. The soaring reefs and ridges between Bass Rock and Lechuza Point generally lie parallel to shore and consist primarily of an erosion resistant brecciated rock. The more inclined reefs between Point Dume and Latigo Point generally run perpendicular to or at an angle away from the shore and consist of a more erosive sandstone. A few small reefs of this latter type run parallel to shore off Zuma Beach. Point Dume itself is of a mixed igneous brecciated rock origin. Just off the point a few sea stacks terminate in sand.

Between Point Mugu and Deer Canyon the shallow water areas off the headlands are regularly bordered by bedrock outcroppings and boulder fields. These rocky substrates quickly give way to sand beyond a depth of no more than 10-15 feet. The more protected shallow water areas between the headlands are bordered by clean white sand beaches (La Jolla Beach and Big Sycamore Beach).

Table 3. (Taken from SCCWRP, 1975)

ESTIMATED MEAN BACKGROUND CONCENTRATIONS (mg/Dry Kg) OF TRACE METALS IN THE SEDIMENTS AROUND MAJOR OUTFALL SYSTEMS

Metal	White's Point	Santa Monica Bay	Orange County	Point Loma	Oxnard	Five-Area Mean (Nearshore Sediment Background Concentration)
Silver	0.61	0.71	1.5	0.88	1.5	1.0
Cadmium	0.42	0.22	0.53	0.48	0.20	0.37
Cobalt	9.3	5.0	-	-	-	7.2
Chromium	53	62	34	39	41	46
Copper	21	13	14	14	18	16
Iron	27,000	20,000	-	29,000	-	25,000
Mercury	0.043	0.043	0.019	0.046	0.035	0.037
Manganese	390	230	390	280	-	320
Nickel	17	15	9.4	-	-	14
Lead	6.2	6.9	10	7.5	12	8.5
Zinc	75	57	67	54	61	63

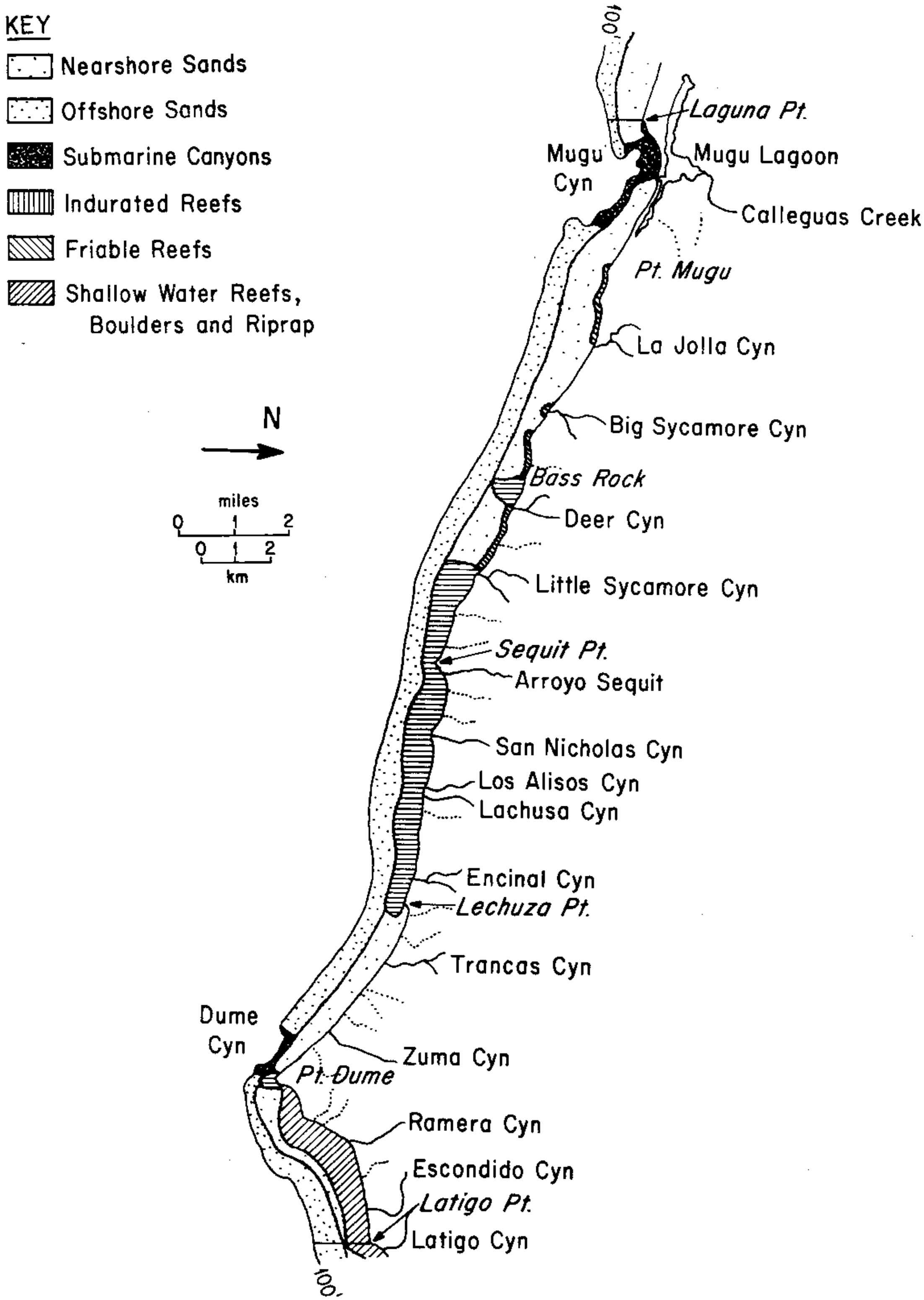

FIGURE 6

Major Types of Substrates within the Mugu-Latigo ASBS.

The generally gentle sand slope of the ASBS is interrupted at two locations by submarine canyons: Mugu Canyon to the west and Dume Canyon to the east. Both are steep walled canyons of very fine sand to mud. These canyons are primarily offshore from the ASBS. They begin at about 50 to 60 foot depths, 500 to 800 feet offshore, and rapidly descend with a slope of 8 to 33% (Table 4, Fig. 3). In the deeper parts of both canyons (beyond the ASBS) poorly described rock outcrops apparently occur (Shepard and Dill, 1966).

Beyond the boundary of the ASBS, the ocean floor continues to slope off gradually as the continental shelf. Below a depth of about 300 feet (ca. 2 to 3 miles offshore) the bottom drops off more steeply as the continental slope. The slope terminates in the enclosed Santa Monica Basin at a depth of about 1500 feet. There is a large submarine ridge about 5 miles offshore due south of La Jolla Beach which projects out from the shelf. It rises to within 250 feet of the surface.

For further information on topography see Egstrom (1974), Emery (1960), Fay (1972), and Shepard and Dill (1966).

In some areas of the ASBS, man has altered the topography. Where the roadbed of the Pacific Coast Highway lies immediately adjacent to the sea, the shoreline has frequently been augmented by riprap. Old decaying groins also occur at regular intervals between Bass Rock and Little Sycamore Canyon. The U.S. Navy has constructed a jetty and placed riprap at the head of the west branch of Mugu Canyon. Three manmade piers exist within the ASBS. Two occur at the head of Mugu Canyon where the U.S. Navy has one in a state of good repair and one that is neglected. The third is a private fishing pier and boat launch at Paradise Cove. The only other manmade structures within the ASBS are two old artificial reefs. The one off Paradise Cove was installed by Fish and Game in 1959. It is in 60 feet of water, is composed of old autos, and covers an area of about one-tenth of an acre. This reef has largely de-teriorated. The second reef, at about a 45 foot depth, is off the County Lifeuard Headquarters at Zuma Beach. It is small and composed of old toilets, bathtubs, etc. Both reefs are surrounded by sand.

Table 4. Bottom Slopes at Selected Locations within the Mugu-Latigo ASBS.

Location (east to west)	Approximate slopes in the shallower regions (ca. 10-50') and in the deeper regions (ca. 50-100;) [as %]	
	shallower regions	deeper regions
Paradise Cove	2.0	1.7
Dume Canyon	8 (at ca. 50')	12 (at ca. 100')
Zuma Beach	3.0	1.7
San Nicholas Canyon	2.0	2.0
Sequit Point	3.0	2.5
Deer Creek	2.0	2.0
La Jolla Beach	2.0	1.7
Mugu Canyon	10	16

Intertidal and Subtidal Geomorphology: The geomorphology of the intertidal and offshore rock areas is generally consistent with that of the adjacent land masses. The majority of the shoreline and subtidal zone within the ASBS consists of Quarternary terrigenous deposits of very fine to coarse sand (Table 5). The sand substrate is interrupted in numerous locations by bedrock reefs, outcrops, and rocky headlands, usually of the same composition as adjacent land formations. Thus the intertidal and subtidal reefs between Point Dume and Latigo Point are interbedded and inclined sandstone and soft shale reefs of the Modelo Formation. They extend out to a depth of 60 to 70 feet and in general run east and west. These are friable reefs which are heavily bored by marine organisms. Low reefs of similar origin occur intermittently off Zuma Beach in 45 to 60 feet of water.

Point Dume itself is made up of resistant igneous breccia and the intertidal reefs and offshore stacks are considerably different both physically and biologically from the sandstone reefs to the east of the headland. From Trancas Beach and Lechuza Point westward to Little Sycamore Canyon, the offshore reefs are extensive and complex, very much like the landward formation (the Malibu bluff coast). On these reefs, spectacular biological assemblages develop. Terrigenous sands surround all these reefs and continue offshore.

With the exception of one major outcrop between Deer Canyon and Bass Rock, there are almost no subtidal reefs between Little Sycamore Canyon and Point Mugu. Along this area, the Santa Monica Mountain escarpment apparently pluges so steeply that no folded reefs protrude above the expanses of terrigenous sand. Here bedrock or boulder fields extend at most to a depth of 10-15 feet, and again reflect the geomorphology of the adjacent coast. Off the alluvial plain at the west end of the ASBS, the substrate is sand as would be expected.

The sands which dominate the coast are usually fine to very fine and well sorted (Table 5). They give way to silts seaward beyond the boundary of the ASBS.

Land Geomorphology: There are three principal coastal divisions that border the ASBS: the Ventura-Oxnard alluvial plain, the Santa Monica Mountain escarpment, and the central Malibu bluff coast (Fig. 7).

Table 5

Characteristics of Subtidal Sands from Selected Locations Within the Mugu-Latigo ASBS.

Location (east to west)	Water Depth feet	meters	Mean Grain Size (Ø)	Grade*	Sorting*
Latigo Pt.	30	9.1	2.19	Fine Sand	Moderately Well Sorted
Paradise Cove	25	7.6	2.91	Fine Sand	Very Well Sorted
Dume Canyon	95	29.0	3.31	Very Fine Sand	Very Well Sorted
Zuma Beach	95	29.0	2.86	Fine Sand	Well Sorted
Between Los Alisos and Encinal Canyons	18	5.5	3.37	Very Fine Sand	Very Well Sorted
Between Los Alisos and Encinal Canyons	38	11.6	3.49	Very Find Sand	Very Well Sorted
Between Los Alisos and San Nicholas Canyons	25	7.6	2.13	Fine Sand	Poorly Sorted
One Half Mile West of the County Line	50	15.2	2.98	Fine Sand	Very Well Sorted
One Half Mile West of the County Line	80	24.4	3.33	Very Fine Sand	Very Well Sorted
Little Sycamore Canyon	40	12.2	1.22	Medium Sand	Moderately Well Sorted
Deer Canyon	25	7.6	0.82	Coarse Sand	Very Well Sorted
Big Sycamore Beach	30	9.1	3.38	Very Fine Sand	Very Well Sorted
LaJolla Beach	50	15.2	3.25	Very Fine Sand	Well Sorted
LaJolla Beach	80	24.4	2.97	Fine Sand	Well Sorted

Table 5 (Continued)

Location (east to west)	Water Depth feet	Water Depth meters	Mean Grain Size (Ø)	Grade*	Sorting*
One Half Mile East of Pt. Mugu	30	9.1	3.07	Very Fine Sand	Well Sorted
Pt. Mugu (in Sand Dollar Bed)	20	6.1	2.23	Fine Sand	Moderately Well Sorted
Pt. Mugu (outside Sand Dollar Bed)	25	7.6	1.32	Medium Sand	Well Sorted
Mugu Canyon	80	24.4	3.48	Very Find Sand	Very Well Sorted

*Nomenclature from Folk, R. L., Petrology of Sedimentary Rocks, 1968.

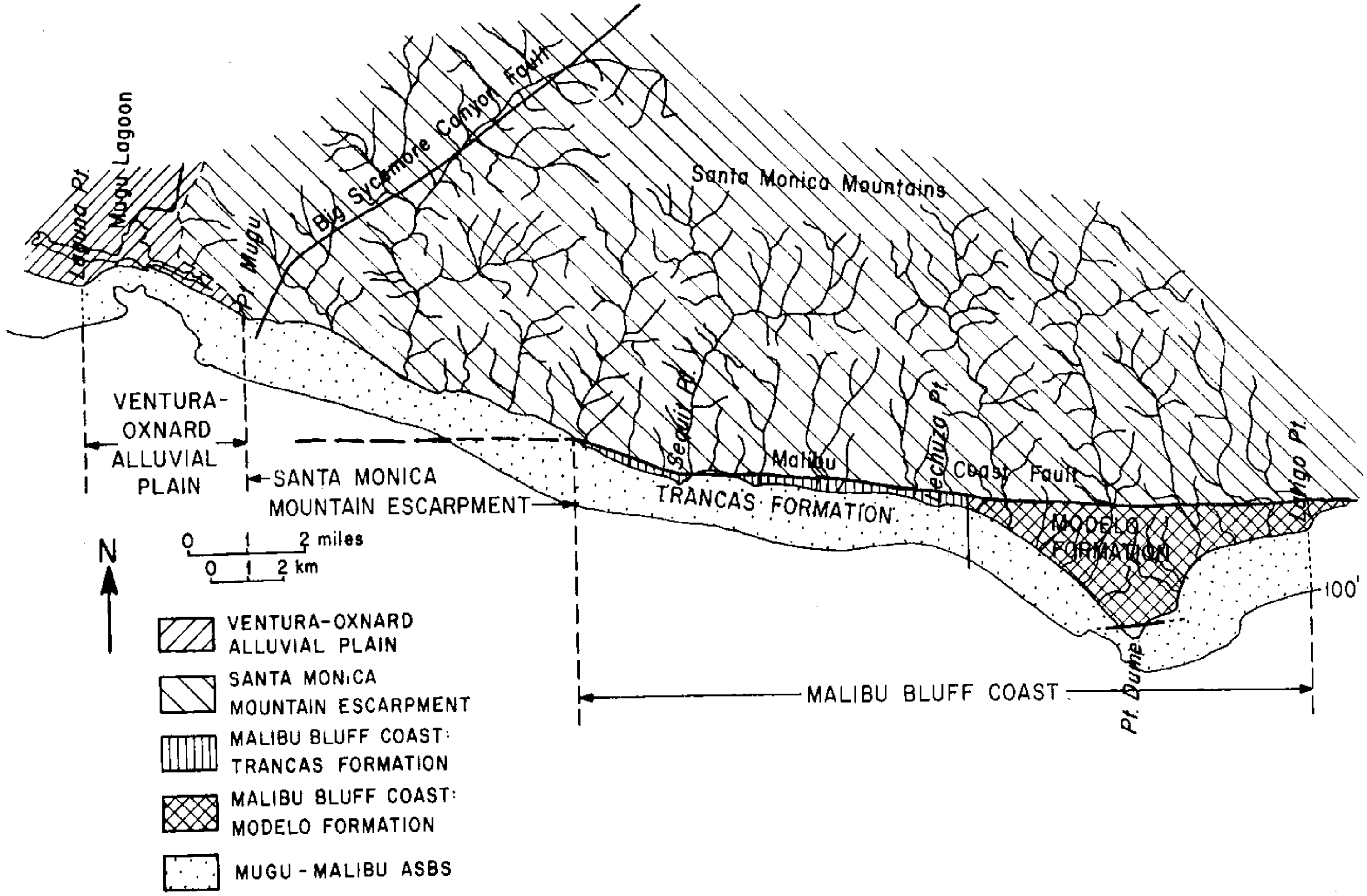

FIGURE 7

Major Geological Features and Faults in the vicinity of the Mugu-Latigo ASBS.

tura County (ca. 6 miles). This region is characterized by steep mountain slopes (usually greater than 20%) and few offshore reefs. The coastal area here is susceptible to landslides. Point Mugu is an outcrop of resistant black shale. Further to the east, more easily weathered formations of sandstone and shale can be seen as white stratified outcrops in the roadcuts along Pacific Coast Highway. These are the Big Sycamore and Nicholas Formations.

The Malibu bluff coast is triangular with its widest point at Point Dume. This region is structurally the most complex within the ASBS. The rocks are highly folded and steeply dipping so that very different rock types lie next to one another. The western part of this bluff coast from Little Sycamore Canyon to Trancas Beach is made up of older Tertiary (Miocene) erosion resistant rocks of the Trancas Formation. The spectacular white cliffs of Paradise Cove are outcrops of the Miocene age Modelo Formation which forms steep inclined bids from Zuma Beach eastward to Corral Beach (beyond the ASBS boundary). This formation is predominantly a siliceous shale and was probably formed in the deep sea. The headland at Point Dume is a highly resistant igneous breccia which has protected the softer sedimentary shale behind it from erosion. In addition to the Miocene deposits, there is an irregular veneer of Pleistocene marine terrace deposits on the bluff between the ocean and the mountains adjacent to the eastern section of the ASBS. This is a reddish, poorly stratified and sorted material, which is soft and easily dissected. It tends to form steep-sided stream gullies and sea cliffs.

There are no major watersheds along the portion of the ASBS bounded by the Santa Monica Mountains and the Malibu bluff. Instead there are about 16 small drainages which flow only during the rainy months of the year (Fig. 9).

A major east-west low angle thrust fault, the relatively young Malibu Coast Fault (Fig. 7), separates the Santa Monica Mountain escarpment from the central Malibu bluff coast. The fault generally can be traced in the central and eastern part of the land adjacent to the ASBS by the distinct change in slope between the terrace of the Malibu bluff and the rapidly rising Santa Monica Mountains behind (Fig. 3). High angle faults tend to run north from this fault into the Santa Monica Mountains. The Malibu Coast Fault runs inland from offshore at Las Flores Canyon to the east of the ASBS, and re-enters the sea at Little Sycamore Canyon within the ASBS. Many smaller faults run roughly north-south in the Santa Monica Mountains and often provide the basis of the steep-sided canyons in the area. The largest of these faults is the Sycamore Canyon Fault (Fig. 7). Additional faults may separate the Trancas and Modelo Formations at the western end of Zuma Beach and another fault may exist offshore of Point Dume, separating the Point from the Modele Formation. Seismic activity within the ASBS has been relatively infrequent. Epicenters of 6 earthquakes between 1934 and 1958 occurred within or offshore of the ASBS (Emery, 1960). No major earthquakes are known to have occurred in the area within historic times.

Further information on the geomorphology of this area can be found in Azmon (1956), Bass (1960), Campbell et al. (1970), Fay (1972), Jahns (1954), Sonneman (1956), U.S., E.P.A. (1977), Page (1963), Calif. Dept. Parks and Rec. (1977).

Climate

The temperature, humidity, precipitation, and wind characteristics for the vicinity of the Mugu-Latigo ASBS are monitored by the Pacific Missile Test Center at Pt. Mugu and are published periodically (de Violini, 1975). These data are summarized in Table 6. Southern California is characterized by a Mediterranean climate with mild temperatures and seasonal winter rainfall. Weather in this area is largely controlled by the Eastern Pacific high which is located off the coast of Northern California during the spring and summer months; this high pressure cell prevents low pressure systems from moving down the coast into southern California. The resulting summers are warm and without precipitation but moderated by prevailing westerly winds from the ocean and typical summer coastal fogs (Fig. 10). The average summer temperatures are a

Table 6. Point Mugu Surface Climatic Summary (Taken from de Violini, 1975)

Month	Temperature (°F)				Precipitation (Inches)			Humidity (Percent)			Surface Winds (Knots)			Mean Sky Cover (Tenths)
	Average		Extreme		Average Amount	Extreme		Average		Extreme	Prevailing Direction	Average Speed	Peak Gust Direction/Speed	
	Max.	Min.	Max./Year	Min./Year		Max./Year	Min./Year	Max.	Min.	Min./Year				
January	62.0	43.8	88/1965*	29/1970	2.53	11.57/1969	0.02/1948	86	47	4/1961	NE	10	ENE/45	4.1
February	62.9	44.8	89/1971	27/1971	2.02	13.85/1962	Trace/1964*	89	49	2/1955	W	9	ENE/49	4.3
March	62.3	45.1	87/1951	33/1971*	1.18	4.52/1958	0.00/1959	92	54	3/1956	W	10	W/43	4.4
April	63.5	48.0	99/1966	34/1955	0.90	4.23/1965	Trace/1973*	93	59	12/1971*	W	10	W/50	4.2
May	64.8	51.1	96/1970	39/1950	0.13	0.99/1955	Trace/1973*	93	63	8/1960	W	9	NE/39	4.8
June	67.2	54.2	100/1957	42/1971*	0.03	0.26/1963	Trace/1973*	94	67	9/1957	W	8	W/29	5.8
July	70.0	56.9	88/1960	41/1948	0.01	0.13/1969	0.00/1947	96	68	34/1960	W	7	SSE/27	5.1
August	71.7	58.0	97/1972	46/1948	0.01	0.12/1947	0.00/1971*	95	67	29/1972	W	8	W/24	5.1
September	71.8	56.7	97/1965*	39/1948	0.06	0.57/1963	0.00/1957	93	63	5/1958	W	7	NE/40	4.8
October	70.1	52.7	104/1971	33/1971	0.19	0.90/1957	Trace/1970*	91	58	7/1971*	W	7	NE/41	4.4
November	67.7	48.6	98/1966	31/1958	1.82	6.42/1965	0.00/1956	88	50	4/1961*	NE	7	SE/42	4.7
December	63.8	45.2	89/1958	28/1971	1.63	5.33/1971	0.05/1962	87	43	3/1959*	N	5	NE/44	4.0
Year	**66.5**	**50.4**	**104/10/71**	**27/2/71**	10.50	**21.87/1961-2 Season**	**4.82/1958-9 Season**	**91**	**57**	**2/2/55**	**W**	**8**	**W/50**	**4.6**

*Also occurred in earlier year or years.

NOTE: Periods of record are as follows:

Temperature: Averages, January 1947 to December 1972; Extremes, March 1946 to December 1972.

Precipitation: Averages, July 1946 to June 1973; Extremes, July 1946 to June 1973.
A trace is an amount too small to measure (< 0.01 inch).

Humidity: Averages, January 1952 to December 1972; Extremes, January 1952 to December 1972.
All months have reported 100 percent relative humidity

Surface Wind: Averages, March 1960 to December 1972; Extremes, July 1962 to December 1972.
Prevailing wind direction and average wind speed are the most frequently observed wind direction and the average speed from that direction. (In July 1962, the AN/UMQ-5 wind equipment at Point Mugu was relocated from tower locations near 90 feet AGL to the present runway location at 12 feet AGL. Surface winds reported since that date are substantially lower than those recorded in earlier years due to this relocation and are considered more representative of true surface conditions.)

Sky Cover: January 1960 to December 1969.
Zero-tenths is clear, ten-tenths is overcast.

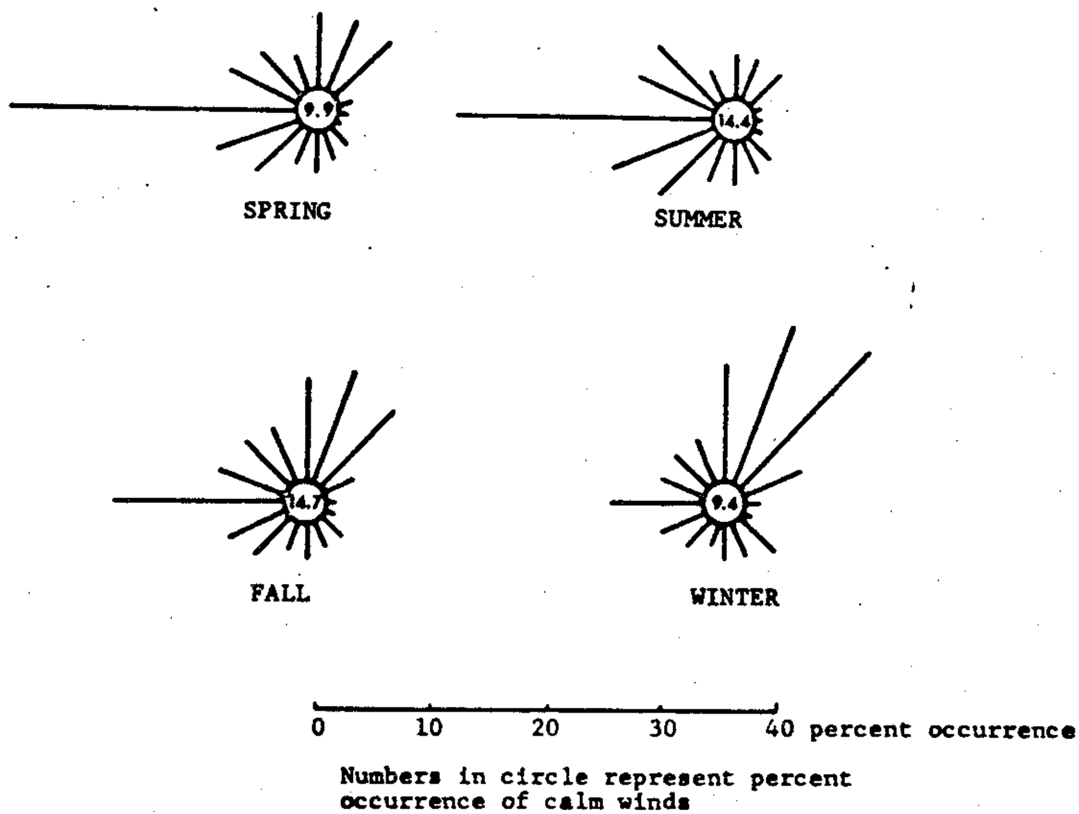

Figure 10. Seasonal Wind Roses for Pt. Mugu Naval Air Station (from SCE, 1973,1975).

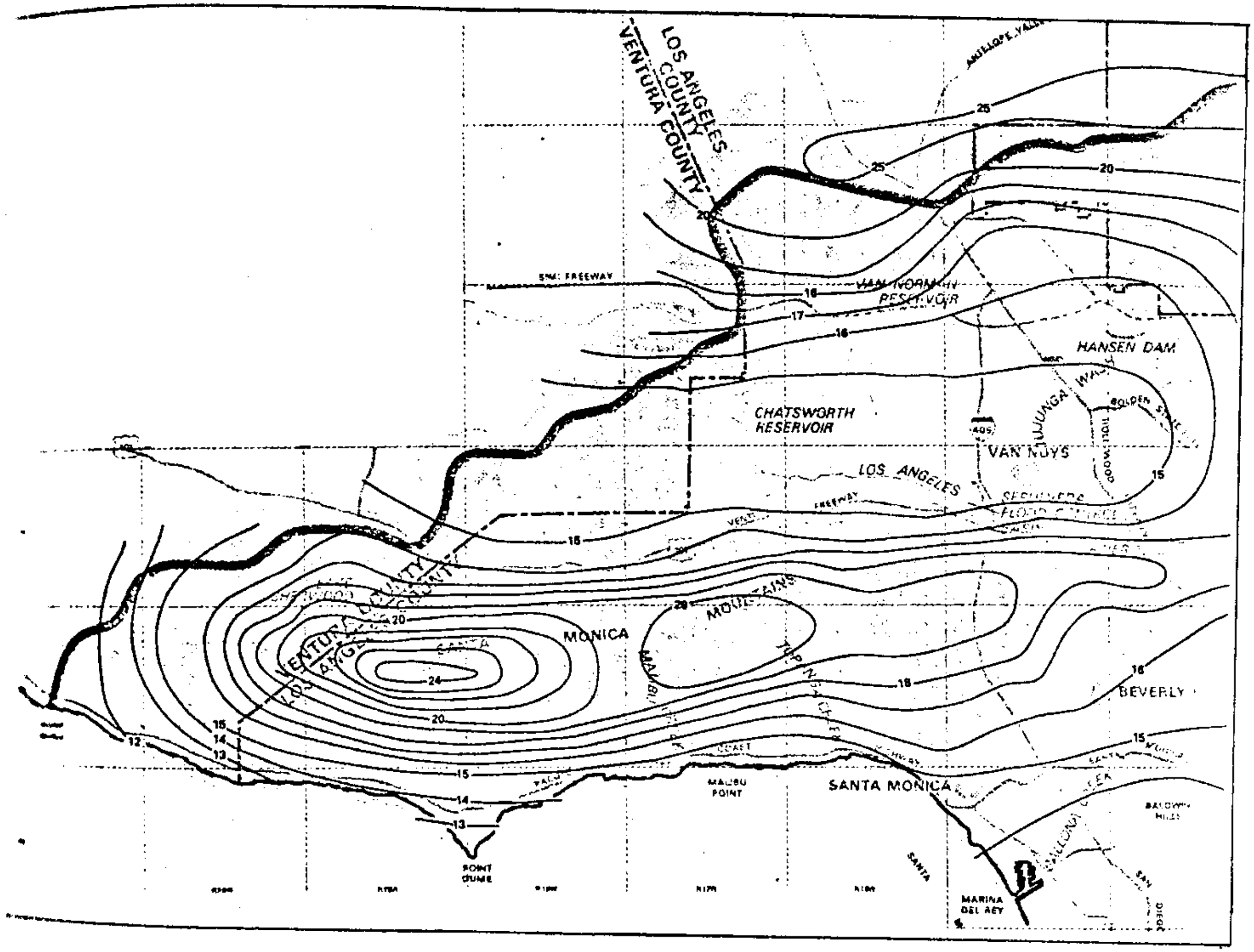

Figure 11. Annual Precipitation Contours for the Santa Monica Mountains Area (from U.S., E.P.A. 1977)

maximum of 67 to 72°F (19.5-21°C) and a minimum of 54 to 58°F (12-14.5°C) (Table 6).

In the late fall the East Pacific high weakens and moves south, allowing storm systems to move down the coast. During the winter months, winds are predominately northeasterly at Point Mugu (Fig. 10). Although this area receives 95% of its yearly rainfall at this time, the sky is clear the majority of the time and the average relative humidity is actually lower in the winter than in the spring and summer (Table 6). The average winter temperatures are a maximum of 62 to 64°F (17-18°C) and a minimum of 44 to 45°F (6.5-7.5°C) (Table 6).

The average annual precipitation (Fig. 11) is lower in the vicinity of the Mugu-Latigo ASBS (11-13 inches) than in the adjacent coastal mountains (up to an average of about 24 inches). However, there is a very large variation in precipitation from year to year as witnessed by the recent drought followed by the excessive rains (>30 inches) of 1977-78. Between 1946 and 1973 the annual rainfall varied between 4.8 inches and 22 inches at Point Mugu (Table 6).

In addition to these large scale weather patterns, there is a daily land-sea breeze cycle. During the day, cool ocean air moves onshore as air heated over the land rises; at night air tends to move from the cooler land masses toward the warmer ocean. In general the seaward nighttime flow is best developed in January (winter months) and least developed in July (summer). This seaward nighttime flow is primarily from the northeast and flows down the canyon slopes to the ocean. A more detailed account of seasonal day-night wind cycles is presented in U.S. E.P.A., (1977) and LNG Technical Report #23 (1977).

BIOLOGICAL DESCRIPTION

Subtidal Biota

The subtidal biota within the ASBS consists of a spectacular array of species, often in very high abundance (Appendices 1-4). The high diversity in this area is due in part to the varied and distinct subtidal habitats. It is one of the most diverse areas in the State from the standpoint of both number of different habitats and variety of organisms. The principal habitat types (Fig. 6) consist of: 1) highly indurated rock reefs, 2) friable rock reefs, 3) nearshore sands out to 60 ft., 4) deep sands (60-100 ft. depths), and 5) submarine canyons.

The important planktonic community of the water column is not described in this report. The microscopic organisms in this community provide most of the energy input into the benthic communities within the ASBS. The majority of the shallow coastal water benthic animals are sessile or sedentary suspension feeders which utilize this abundant phytoplankton and zooplankton as a food source. Many of the major marine animal groups are made up entirely of suspension feeding organisms. They include sponges, Porifera, hydroids, Hydrozoa, barnacles, Cirripedia, clams and mussels, Bivalvia, bryozoans, Bryozoa, tunicates, Urochordata, and many species of anemones and corals, Anthozoa, segmented worms, Annelida, brittle stars, Ophiuroidea, and sea cucumbers, Holothuroidea, (See Appendices 1-4). The presence of this mode of feeding allows increased complexity in marine food webs.

Indurated Rock Reefs: Subtidal indurated rock reefs are primarily located throughout a six-mile region in the heart of the ASBS (Fig. 6). An important aspect of these reef areas is the general heterogeneity created by enormous igneous bed rock protrusions, which produce numerous cliffs, overhangs cracks and crevices. Often large boulder fields are located at the bases of these subtidal reefs, and are punctuated by variable sized sand pockets. The major reef blocks usually run parallel to shore and are interspersed with large sand flats.

Table 7. General Characteristics of the Major Zones of a Subtidal Reef (after Pequegnat, 1963,1964,1968).

Zone	Depth (m)	Water Movement (in cm/sec)		% Biomass of Feeding Types					Relative Plankton Abundance	Number of Species		Number of Individuals (per cm^2)	Relative Size	Total Biomass (gm/m^2)
		Maximum	Average	Suspension	Carnivore	Scavenger	Detritus	Herbivore		With max. pop. in zone	In zone total			
Reef Top (I)	9.5-12.5	98	34	86	9	5	0.1	0.2	highest	131	189	2.55	smaller	2,585
Reef Side (II)	12.5-14.5	21	13	80	9	8	0.3	3	high	87	144	0.95		1,408
Reef Base (III)	14.5-16.5	9-16	7	54	14	12	3	17	lower	51	114	0.32	larger	376
Reef Fan (IV)	16.5	9-16	7	32	14	36	14	4		31	47	0.06		175

Table 8. Dominant Organisms on Rock Reefs of the Mugu-Latigo ASBS.

Region	Shallow Reefs (Midintertidal to 15')	Nearshore Reefs (15-35')	Offshore Reefs (35-65')
Upper Parts of Reef and Rocks	Mytilus californianus (California Mussel) Pollicipes polymerus Goose neck barnacle) Phyllospadix torreyi (surf grass) various foliaceous red algae (e.g. Gigantina) and articulated corallines (e.g. Corallin and Bossiella)	various foliaceous red algae (e.g. Gigartina and Prionitis and and articulated corallines (e.g. Corallina and Bossiella) Eisenia arborea and Pterygophora californica (sea palms) Cystoseira osmundacea (bladder kelp)	Macrocystis pyrifera (giant kelp) Muricea californica (rust gorgonian) Chama pellucida (jewel box clam) various foliaceous red algae (e.g. Rhodymenia) Tethya aurantia (orange puffball anemone)
Sides of Reef	Anthopleura elegantissima (aggregating green anemone) Egregia laevigata (feather boa kelp) Pisaster ochraceus (ochre star)	various encrusting sponges (e.g. Ophlitospongia, Leucosolenia and Leucetta), hydroids (e.g. Tubularia, Abietinaria, and Plumularia), encrusting bryozoans (e.g. Parasmittina, Scrupocellaria, and Celloporaria) and tunicates (e.g. Euherdamania, Trididemnum, and Aplidium) Serpulorbis squamigerus (worm snail) encrusting corraline algae (e.g. Lithothamnium)	Corynactis californica (strawberry anemone) various encrusting sponges, hydroids, encrusting bryozoans, and tunicates as in the Nearshore Reef Foliaceous or erect bryozoans (e.g. Phidolopora, Hippodiplosia, Bugula, and Diaperoecia) Pisaster giganteus (knobby blue star) Megathura crenulata (giant keyhole limpet) Hinnites multirugosus (rock scallop)

Table 8 (Continued)

Region	Shallow Reefs (Midintertidal to 15')	Nearshore Reefs (15-35')	Offshore Reefs (35-65')
Basal Part of the Reef and Surrounding Apron	*Phragmatopoma californica* (sand tube worm) various hydroids (*Obelia* sp. etc.) encrusting corallines (e.g. *Lithothamnium*)	*Diopatra ornata* (grey tube worm) *Strongylocentrotus purpuratus* (purple urchin) *Mitrella carinata* (dove snail)	*Diopatra ornata* *Strongylocentrotus franciscanus* (red urchin) *Pachycerianthus fimbriatus* (tube anemone) *Parastichopus parvimensis* (southern sea cumber) *Kelletia kelletii* (Kellet's Whelk)

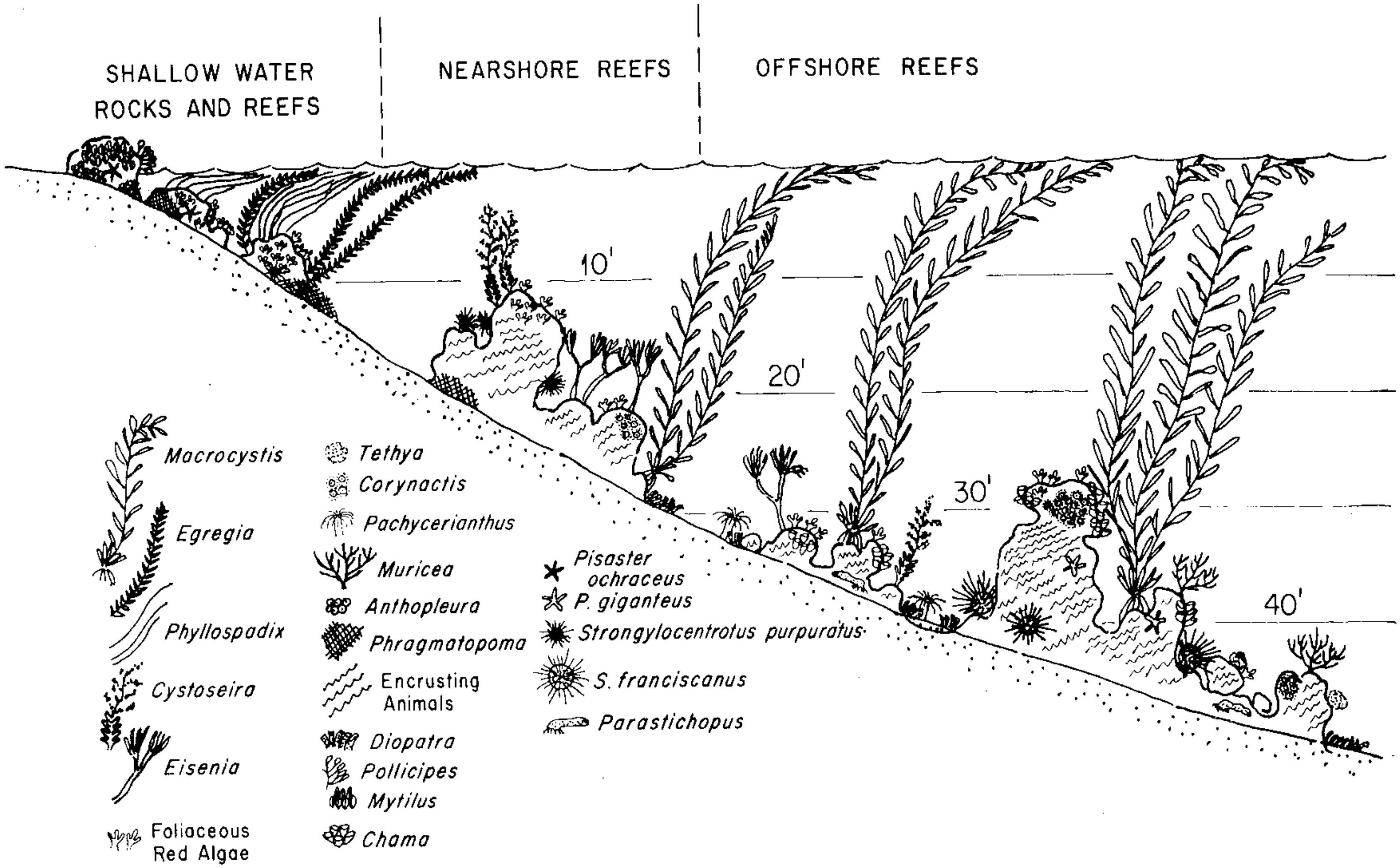

FIGURE 13

Idealized Depth Distribution Patterns of the Dominant Organisms associated with Indurated Rock Reefs within the Mugu-Latigo ASBS.

and also to cope with possible scouring by sand or floating debris such as the protective tubes of the feather duster worm, Eudistylia polymorpha.

The sand, gravel or cobble fan surrounding the reef tends to accumulate debris and rich organic material (such as fecal material) from the reef above. Attached suspension feeders have a tendency to be covered and smothered in this zone. Hence their abundance is relatively low but includes organisms such as the worm Eudistylia and the tube anemone, Pachycerianthus fimbriatus, which can cope with sediments. However, this habitat is dominated by 1) deposit feeding organisms such as terebellid worms, Neoamphitrite robusta, and the burrowing cucumber, Leptosynapta albicans, 2) carnivores, and 3) scavengers such as crabs. Diversity in species numbers, individuals and biomass per unit area are all lowest in this region (Table 7). Most organisms here are relatively motile and large.

Additional factors influence diversity and cause the species distribution and abundance to be distinct for each major reef block and subreef. These include water depth, reef contour and orientation, material at the reef base, and type and extent of algal cover. Community structure on reefs in the ASBS varies most significantly with water depth, and a fairly distinct biota is found on 1) shallow water rocks and reefs (0 to 15 ft. depth), 2) nearshore reefs (15 to 35 ft. depth) and 3) offshore reefs (35 to 65 ft depth) (Fig. 13, Table 8).

The following is a more detailed account of the distributional and interactive patterns that one sees on these three major depth distributed reef types. (Table 8, Fig. 13).

Shallow Water Rocks and Reefs: These low reefs and isolated rocks are close to shore and are strongly affected by the incoming swell, currents, sanding in, high turbidity and scour, local runoff from the land, and salinity drops from rain. This region is often a zone of rapid turnover of species, and available space for colonization is sometimes quite extensive after catastropic events such as sanding in and subsequent re-exposure of the rock. Species here tend to be either 1) tolerant to being buried by sand and/or to abrasion by sand or 2) rapid colonizers, the so-called fugitive species. Tolerant species both physical removal and potential pollutants as it has a particularly important ecological role and is not easily replaced.

The feather boa-kelp, Egregia menziesii, occurs just below the Phyllospadix in depth, to 15-20 ft., and around the bases of rocks topped by Phyllospadix. This long belt-like kelp also helps dampen the incoming swells. One obligate herbivorous limpet, Notoacmea insessa, is almost always found attached to and eating along the central rib of Egregia.

There are two principal sessile animals which extend from the low intertidal zone into this shallow subtidal area. These are the reef-forming sand tube worm, Phragmatopoma californica, and the solitary form of the green anemone, Anthopleura elegantissima. Both are exceedingly abundant in the ASBS wherever shallow subtidal rocks occur. Phragmatopoma are small suspension feeding annelids which form vast wonderfully architectured sand tube reefs composed of thousands of individuals. These worm reefs, which can be several meters long and continue from rock to rock, are found around the bases of rocks in moderate to heavy surge areas. The overall ecological importance of Phragmatopoma is unclear, but their ability to cement rocks together clearly stabilizes sediments and decreases the erosion around the rock bases. The green anemones, Anthopleura elegantissima, are found in vast clones on rock walls especially in the intertidal zone, but also as large solitary forms in the shallow subtidal area. This species is an important suspension feeder-carnivore-scavenger and probably helps remove much dead organic material from shallow water. Their longevity is not known with certainty but they probably live for many years.

Three other members of the intertidal zone also regularly occur in the shallow subtidal zone: the mussel, Mytilus californianus, the goose-neck barnacle, Pollicipes polymerus, and the sea star, Pisaster ochraceus. They are discussed in greater detail under the intertidal section below. In some protected areas black abalone, Haliotis cracherodii, occur in crevices. Lobsters frequent these regions during the summer, especially where there is surf grass.

Juvenile purple urchins are quite common in crevices and beneath rocks in this region. These herbivorous animals are claimed to have caused severe damage to kelp beds (Leighton, 1971), but their numbers and location appear to be no threat to any of the major kelp species within the ASBS. However, on some reefs the foraging heights of the urchin are quite evident. The urchins usually are situated near the base, but part way up the reef beyond their foraging range there is a distinct increase in the foliaceous plant growth, and hence a major biotic shift.

Another important organism on the sides and bases of these reefs is the sessile, suspension feeding worm snail, Serpulorbis squamigerous. This snail can form large clumps of hundreds of individuals, which often cement rocks together, thus strengthening the reef, and providing crevices and hiding places for other organisms. These reefs are the main habitat for the green abalone, Haliotis fulgens.

The sides of reefs, which are protected from sand abrasion and well-shaded, are dominated by rich encrustations of sponges, tunicates and especially bryozoans. These species usually form very thin and flat colonies which adhere closely to the rock. Presumably, the more erect and crustose forms found in deeper waters cannot survive the strong surge characteristic of this area. One exception to this trend is the club-shaped sand tunicate, Euherdmania claviformis, which commonly forms small pendulous clumps beneath overhangs. Encrusting coralline algae species are also quite abundant here where light is available and where sand scour and/or urchin grazing eliminates other encrusting forms. The bases of these nearshore reefs usually terminate in sand. Shifting sands and sand scour often provide open space on the rocks for fugitive species. Large clumps of the sand tube worm, Phragmatopoma, are also found around these reefs in water depths less than 25 ft.

The aprons around reefs in waters deeper than 25 ft., are often heavily populated by the gray tube worm, Diopatra ornata. These finger-sized worms build tough parchment-like tubes into the sand to depths of about a foot. The tops of the tubes extend several centimeters from the sand and are richly "decorated" with bits of drift kelp, surf grass, shells and rocks. The tubes are usually found in clumps or large masses.

Table 9. Principal Organisms Inhabiting Macrocystis Holdfasts, Crevices and Beneath Rock of the Deeper Reefs within the Mugu-Latigo ASBS.

I. Organisms from Macrocystis Holdfasts	II. Organisms Dwelling in Cracks and Crevices on Reef Walls	III. Organisms Found Under Rocks at the Reef Base
SURFACE:	Sargartia catalinensis (pinkish anemone)	Hymenamphiastra cyanocrypta (cobalt blue sponge)
Obelia sp. (hydroid)	Phascolosoma agassizii (peanut worm)	Obelia sp. (hydroid)
Eucopella everta (hydroid)	Chaetopterus variopedatus (parchment worm)	Plumularia sp. (hydroid)
Plumularia sp. (hydroid)	Eudistylia polymorpha (feather duster worm)	Brown Tentacled Anemone (undescribed species)
Epiactis prolifera (proliferating anemone)	Heptacarpus sp. (broken back shrimp)	Chaetopterus variopedatus (parchment worm)
Trididemnum opacum (white tunicate)	Lysmata californica (candy cane shrimp)	Neoamphitrite robusta (terebellid worm)
Pharagmatopoma californica (sand tube worm)	Panulirus interruptus (spiny lobster)	Euphrosine aurantiaca (caterpiller worm)
WITHIN:	Scyra acutifrons (masking crab)	Gammarid amphipods
Cerebratulus californiensis (nemertine)	Doriopsilla albopunctata (sea lemon)	Hapalogaster cavicauda (furry crab)
Chaetopterus variopedatus (parchment worm)	Many nudibranchs	Porcelanid crabs (Petrolisthes and Pachycheles)
Terebellid worms	Haliotis sp. (abalones)	Paraxanthias taylori (lumpy crab)
Polynoid worms (scale worms)	Cypraea spadicea (chestnut cowry)	Pilumnus spinohirsutus (furry crab)
Syllid worms	Amphissa versicolor (variable snail)	Many nudibranchs
Nereid worms	Oceanebra lurida (orange snail)	Crepipatella lingulata (half-slipper shell)
Gammarid Amphipods	Hiatella arctica (nestling clam)	Chitons
Cirolana harfordi (isopod)	Hinnites multirugosus (rock scallop)	Chlamydoconcha orcutti (naked clam)
Alpheus dentipes (pistol shrimp)	Octopus bimaculatus (octopus)	Protothaca staminea (rock cockle)
Lima hemphilli (file scallop)	Ophiactis sp. (six armed brittle star)	Semele decisa (pink edged clam)
Octopus bimaculatus (octopus)	Cucumaria salma (sea cucumber)	Brittlestars:
Ophiothrix spiculata (red banded brittle star)		Amphipholis squamata
		Ophioderma panamense
		Ophioplocus esmarki
		Ophiopteris papillosa

(Rosenthal *et al.*, 1976), and it is the holdfast, not the fronds, which is long-lived. During the winter many of the stipes may be lost, but new ones grow up from the holdfast. The plant dies only when severe storms or organisms such as boring sphaeromatid isopods and grazing urchins cause the holdfast to lose attachment. Holdfasts within the ASBS may reach a diameter of 4 to 6 ft., but only the outer part of the holdfast contains living rhizoids. Internally, it is made up of a honeycomb of passages, accumulations of deposited material and fecal pellets, and decaying rhizoids. The open mesh form of the outer rhizoids allows ventilation of the holdfast so that innumerable organisms dwell, often imprisoned by the rhizoids, within this organic rich mound. The surface of the holdfast is usually well endowed with epiphytes such as hydroids, anemones and tunicates (Table 9), while internally there is a large diversity of worms, small arthropods (amphipods, isopods, shrimps), clams and brittle stars. These holdfasts are a truly unique, but poorly studied microhabitat containing many obligate understory species.

Rosenthal *et al.* (1976) studied a kelp bed off Del Mar, California. Most of their findings are applicable to the beds within the Mugu-Latigo ASBS, and their paper is an excellent supplement to this report. Other sources which were not referenced above but provide useful information about *Macrocystis* include Dawson, *et al.* (1960) Limbaugh (1955), Neushul and Haxo (1963), and North (1961, 1964, 1968, 1971).

Beneath the *Macrocystis* canopy there is a "shrub zone" on the tops of the offshore reefs which is made up of organisms reaching 1 to 3 feet in height. A prominent shrub member is the yellow rust gorgonian, *Muricea californica*. These large suspension feeding octocorals form colonies composed of thousands of individual polyps. The fan shaped colonies, often 2 to 3 feet in height, are generally positioned perpendicular to the prevailing surge so that feeding is maximized (Grigg. 1970). Gorgonian colonies can be very dense, up to several per square meter, and are long lived. They are subject to little predation, probably because of the toxic chemicals contained within their skeletons, although the ovulid snail, *Simnia vidleri*, and the nudibranch, *Tritonia* festiva do feed on them. Infrequently in the ASBS they are overgrown and killed by the colonial zoanthid anemone, Parazoanthus lucificum.

Other shrub members are the sea palms, Eisenia and Pterygophora, and the bladder kelp, Cystoseira. These three species are usually excluded by Macrocystis probably because of shading and therefore are most often found in open meadow-like gaps in the Macrocystis forest, around its periphery, or on outlying reefs. In deeper water below about 45 feet a large laminarian kelp, Laminaria farlowii, will often be found lying over the reef.

Along most reef tops and below the shrub zone is a distinct "turf zone" made up of encrusting and foliaceous organisms with a height of only a few inches. On the tops of the reef, this turf is mainly composed of foliaceous red algae. Some articulate corallines, very high densities of the jewel box clam, Chama pellucida, and, especially around the edges of reefs and along overhangs, large numbers of the strawberry anemone, Corynactis californica, hydroids (eg. Aglaophenia sp., Sertularella sp., Sertularia sp., etc.), and foliaceous and erect bryozoans (Bugula neritina, Hippodiplosia insculpta, Thalamoporella californica etc). The special composition and abundance varies from reef to reef depending on the degree of surge, amount of available light penetrating the Macrocystis canopy, depth, topographic heterogeneity, and the past chance settling of various animal larvae and plant spores. Plants, particularly red algae, are prominent on reef tops at all depths within the ASBS. These algae often support particular hydrozoan and bryozoan epiphytes (hydroids: Eucopella, Sertularella; bryozoans: Aetea anguina, Hippodiplosia, Membranipora tuberculata). The carnivorous sea star, Pisaster giganteus, is a conspicuous element of the turf community.

The reefs with a lower profile and gradually sloping walls have a greater abundance of motile herbivores such as the giant keyhole limpet, Megathura crenulata, red urchins, and the wavy top snail, Astraea undosa, and carnivore-scavengers such as the whelk, Kelletia kelletii, the crabs, Loxorhynchus grandis and Paguristes ulreyi, and the sea stars, Pisaster giganteus, Patiria, Henricia and Linckia columbiae. The overall effect is a decrease in the turf-like plants and many sessile invertebrates and a greater abundance of globose or lobe-like sponges (egs. Tethya aurantia, Spheciospongia confoederata, Axinella mexicanus, Titilla arb, and Ophlitospongia pennata) and tunicates (egs. Archidistoma psammion, Styela montereyensis, Aplidium spp., Pychnoclavella stanleyi,) and some of the erect and branched bryozoans (egs. Diaperoecia californica, Celleporaria brunnea and Bugula neritina) and hydroids (eg. Aglaophenia sp.). The colonial coral, Astrangia, is most abundant in these situations and may cover an area of 1 square meter or more; the northern solitary orange coral, Balanophyllia elegans, is sometimes found here also. The greatest abundance of the yellow rust gorgonian, Muricea californica, sometimes intermixed with the other two gorgonians in deeper water (M. fruticosa and Lophogorgia chilensis, often occurs on these low benches.

Any crack or crevice in this area will usually have one or more small solitary anemone species protruding from it. Common species include an undescribed brown tentacled anemone, the pinkish, Sagartia catalinensis, the brown, Cactosoma arenaria, with stubby tentacles, and the variegated and larger Anthopleura artemisia. Other crevice members which more frequently occur in vertical cracks are sometimes found here but are discussed below.

The high vertical cliffs and overhangs in these offshore reefs contain some of the most spectacular of all animal assemblages to be seen anywhere (Table 8). Plants are usually absent and are replaced by colonies and individuals of numerous species of suspension feeders, especially bryozoans, tunicates, hydroids, sponges, clams, and worms. All available space is occupied, and organisms are usually found growing on other organisms. Bryozoans or tunicates, with perhaps a half-dozen species of each, dominate. Solitary species occupy little of the available space. Two clams, jewel box, Chama, and jingle shell, Pododesmus cepio, are very abundant but obscure species found beneath these more superficial species. Vance (1978) has shown that the high rugosity of the Chama shell tends to encourage other suspension feeding organisms to settle on them. Chama often grow on top of other Chama to the point of creating four to six layers of clams. This pile on effect greatly enhances the available surface area of the reef and also provides an enormous crevice habitat for infaunal organisms (Table 9). Especially abundant in these interstices are small crustaceans (gammarid amphipods, isopods, pistol shrimp) and free living polychaete annelids (scale worms, nereids, syllids etc.).

Encrusting, erect and branching bryozoans (egs. encrusting: Parasmittina californica, Rhynchozoon rostratum, Scrupocellaria sp., Lichenopora novae-zelandiae; erect: Phidolopora pacifica, Diaperoecia, Hippodiplosia, Celleporaria; branching: Bugula californica, B. neritina, crisiids) abound throughout these cliffs as do the encrusting, lobe-like and club-like tunicates (egs. encrusting and lobe-like: Trididemnum, Aplidium spp., Didemnum spp.; club-like Clavelina huntsmani, Euherdmania, solitary: Pyura hasutor and some Styela spp.). Sponges on these vertical walls are flat-lobed or tubular. They include the calcareous sponges, Leucetta losangelensis, Leucandra heathi, Leucilla nuttingi and Leucosolenia sp. and the demosphonges, Microciona sp. (red), Haliclona permollis (purple), Halichondria sp., (brown), Dysidea amblia (gray), Verongia aurea (yellow), Anaata spongigartina (maroon), Cliona celata (yellow, bores into clam shells and other calcareous material), and others. Hydroids usually found here include Eudendrium ramosum, Tubularia sp. (both usually near the top), Hydractinia sp., Antennella avalonia (along the top of the cliff edge), Clytia hendersoni, Plumularia spp. and others.

Large aggregations of the thin orange-crowned white tubed serpulid worm, Salmacina tribranchiata, with hundreds of individuals, are regularly encountered on the walls. Solitary individuals of barnacle species (Balanus tintinnabulum and B. trigonus), and polychaete worms (particularly seruplids like Spirorbis, Hydroides and Spirobranchus spinosus) are commonly found attached to any hard substrate including clams, other tubes, and bryozoans on these walls.

Few creeping or motile species can maintain their positions here so predator abundance is low. Exceptions include the sea star, Pisaster giganteus, some of the carnivorous snails like Ceratostoma nuttalli, Maxwellia and Oceanebra spp. and many nudibranch species. A prominent nudibranch is the brilliant orange and purple eolid, Flabellinopsis iodinea, which feeds specfcically on the hydroid Eudendrium ramosum found on most exposed cliffs. The nudibranch's vivid coloring is a warning to potential predators of its distastefulness. Another conspicuous nudibranch is the large orange and black sponge-eating dorid, Anisodoris nobilis, which produce a noxious chemical when disturbed. Most of these predators, however, are more abundant near crevices where there is some protection from the surge.

Within crevices and amongst the Chama, a different microhabitat allows for the existence of another cadre of suspension feeders (Table 9). Most prominent among these filtering organisms are the feather duster worm, Eudistylia, with its variable colored tentacles, the rock scallop, Hinnites multirugosus, with its distinctive red, tan or green-black mantle and numerous "shiny eyes", and the salmon cucumber, Cucumaria salma with its well camouflaged mottled black and white tentacles. In general, these suspension feeders are larger and usually solitary compared to their more exposed rock wall competitors. It is within the crevices, too, that other feeding types maintain themselves in these high relief areas. The herbivorous pink abalone, Haliotis corrugata, and red urchins as well as several carnivores such as the spiny lobster, Panulirus, the octopus, and the chestnut cowry, Cypraea spadicea are regularly found in crevices and/or caves. In smaller cracks or further back in crevices the omnivorous shrimps, Heptacarpus spp., Lysmata californica and Pandalus gurneyi, can be seen. Still further back or in tighter cracks amphipods, isopods, peanut worms, polychaete worms, small snails and small crabs occur in abundance. The exact constituents of all of these reef side communities is rarely the same, but the general trends, as outlined above, are consistent.

In the rocks and boulders around the base of the reef, debris and deposited material accumulate so that fewer suspension feeders but more deposit feeders and predators occur (Table 8). Drift algae is the major food source for the red urchin, Strongylocentrotus franciscanus, and the red and white abalones, Haliotis rufescens and H. sorensoni, respectively. The red urchins have their maximum abundances (up to 3 - $4/m^2$) in this lower part of the reef although they will be found in protected areas higher up on the reef or closer to shore. Their depth distribution is broad, from the lowest intertidal zone where they are rare, to 25 to 40 feet where they are maximally abundant. They can be found to about 60 feet depth. The population densities of red urchins is generally fairly high in the ASBS and they have been harvested to a limited degree. Unlike the purple urchin, larvae of these urchins are known to recruit specifically under the adults and the juveniles grow up under the protective spines of the adults until they are about 4 cm in diameter (Tegner and Dayton 1977). At this stage, they leave the adults and become vulnerable to predation from both fish (sheephead especially) and sea stars, Dermasterias imbricata and Astrometis sertulifera, both of which are relatively uncommon in the ASBS. Thus the continued presence of red urchins, S. franciscanus, is probably more dependent on a large population of adults than are purple urchins, S. purpuratus. In areas surveyed there was little evidence that red urchins have a major impact on the Macrocystis or other kelp stands. Most of their food appears to be foliaceous red and drift algae. In some areas where urchins abound, their grazing has reduced the surrounding biota to mostly encrusting coralline algae and bryozoans.

Deposited microscopic debris and fecal material are consumed by the "vacuum cleaner of the sea", the southern sea cucumber, Parastichopus parvimensis, and terebellid worms such as Neoamphitrite. In low surge areas Parastichopus is very common ($2\text{-}4/m^2$) and is an important and conspicuous member of the community.

Predators are most abundant here and include the snails Kelletia and Conus californicus, most of the rock dwelling sea stars, and most of the ambushing types of fishes. Also common at the reef base are carnivore-scavengers such as hermit crabs, Paguristes and Pagurus spp, other crabs, Cancer spp, Loxorhynchus grandis, and the bat star, Patiria, all of which help eliminate dead and drift material. Periodically over the years, divers have observed very peculiar one or two meter diameter concentrations of the large furry hermit crab, (Paguristes), at the base of a reef or in a pocket. The hermit crabs may be piled five or six deep and number in the hundreds. The significance of these concentrations is unknown.

Suspension feeders most prevalent in this area are larger and usually extend higher off the substrate than those on the reef sides. They include the gorgonians, white rust gorgonian, Muricea fruticosa, and pink gorgonian, Lophogorgia chilensis, the colonial coral, Astrangia, the larger red anemone, Tealia (an undescribed species), sometimes the worm snail, Serpulorbis squamigerus, and the parchment tube worm, Chaetopterus variopedatus. Frequently one finds the large brown lumpy bryozoan, Antropora tincta, growing on Kelletia snails.

Gaps under rocks are another major microhabitat around the bases of the offshore reefs, particularly where there are well developed boulder fields so that boulders lie on one another and not in sand (Table 9). Here, protected from larger predatory crustaceans, sea stars, snails and fishes, one encounters large numbers of detrital feeding amphipods, isopods, cumaceans and ostracods. Other common underrock crustaceans include the porcelanid crabs, Petrolisthes cinctipes and Pachycheles rudis, the furry anomuran crab, Hapalogaster cavicauda, the pistol shrimp, Alpheus californica, and the brachyuran crabs, Paraxanthias taylori and Pilumnus spinohirsutus. Most conspicuous, however, are the large photophobic brittle stars, Ophiopteris papillosa, Ophioplocus esmarki, Ophioderma panamense, and the smaller cosmopolitan, Amphipholis squamata. All of them are apparently deposit feeder-scavenger-carnivores. A very peculiar member of this microhabitat is the small white naked clam, Chlamydoconcha orcutti, which resembles a nudibranch more than a clam. It is a poorly known, but not uncommon species within the ASBS. Finally, beneath rocks there are some sessile suspension feeders, particularly where there is enough space for water to circulate freely. These include the cobalt blue sponge, Hymenamphiastra cyanocrypta, usually under rocks but sometimes exposed, encrusting bryozoans, some hydroids like Obelia spp. and Plumularia spp. the underscribed "brown tentacles anemone", the very common half slipper shell, Crepipatella lingulata and the clams Protothaca staminea and Semele decisa.

The basal fan surrounding the reef represents a gradient in organisms between strict sand dwellers and the more typical rock dwellers. Along the sand-rock interface there are two prominent and important species which show their maximum densities here. These are the gray sand worm, Diopatra ornata, and the tube anemone, Pachycerianthus fimbriatus. The densely packed Diopatra tubes around the bases of reefs and within sand pockets in the reef can exceed 1,000 tubes per square meter. They live for well over one year (Emerson, 1975). These dense populations of deposit feeder-scavengers help consume much of the detrital materials from the reef, substantially stabilize the sand around the reefs, and reduce sand abrasion to other organisms in the vicinity. The consistently high numbers of Diopatra are an indication of the abundance of drift debris and decaying organics which are constantly supplied from the reefs above. For further details see Emerson (1975). Within the deeper Diopatra beds there are usually substantial numbers of the large tube anemone, Pachycerianthus. This suspension-deposit feeder can reach densities of up to 100 per square meter in certain Diopatra sand patches.

Most of the motile predators and scavengers found at the base of the reef frequently wander out into this surrounding fan region. The cucumber Parastichopus the snails Kelletia and Conus and the sea stars Patiria and Pisaster giganteus are particularly prone to foraging out on the surrounding sand fringe.

The above distribution patterns are characteristic of the three primary indurated offshore reefs: Point Dume, Lechuza Point to Little Sycamore Canyon, and Deer Canyon. The major biotic variations which occur on these reefs are dictated by the general reef profiles. Locations that show very high relief (up to 20 ft.) with numerous precipitous cliffs are found scattered throughout the three areas, but are most prominent at 1) Point Dume, 2) areas just west of Lechuza Point, and 3) areas just west of the County Line (Harrison's Reef). Low (1 to 5 foot) to medium (10 foot or less) reef profiles are common throughout the Lechuza Point to Little Sycamore area. Boulder fields also sporadically occur within this area (expecially between Encinal and San

Nicholas Canyons) and are common at Deer Canyon. Deer Canyon also has substantial low to medium height reefs but few high reefs. The abundance of low bench-like reefs near Deer Canyon probably accounts for the greater prevalence of sponges there than in the other areas. The Harrison's Reef area appears to have a relatively greater abundance of tunicates (about 10% more) and fewer bryozoans (about 10% less) than surrounding areas. Point Dume has mostly high cliffs (stacks and ridges) surrounded by small boulder fields.

Friable rock Reefs. Well developed sandstone reefs occur in the Paradise Cove area between Point Dume and Latigo Point. These reefs are among the most impressive subtidal sandstone outcrops along the California coast. They are part of the Modelo formation, and quite distinct from the more resistant graywacke at the tip of Point Dume. The sandstone reefs of Paradise Cove are a moderately dipping (ca. 25%) series of very soft shales interbedded between harder sandstone. The tilted angle of these reefs produces two principal profiles: a low inclined side generally facing shoreward and a steep inclined side facing more seaward (Fig. 15). These reefs run mostly east-west with their steep sides facing south, and generally extend from the intertidal zone to depths greater than 50 feet. The overall east-west trend of the reefs can be seen from the surrounding cliffs, as indicated by the parallel lines of Macrocystis beds which run along the back sides and tops of the subtidal ridges (Fig. 21). The reefs are separated by areas of open sand. The substrate heterogeneity results in high species diversity.

Beacuse of the protection afforded by Point Dume, the usual westerly swell is somewhat reduced compared to the rest of the ASBS. The lower wave surge, while still prominent, allows rock dwelling organisms and kelp beds to exist somewhat closer to shore than in comparable areas further to the west in the ASBS. This area has the same overall biological trends discussed for indurated rocks with Phyllospadix occurring in the shallowest subtidal zone, followed next by Egregia, then Macrocystis and shrub plants in the deeper parts. However, the depth distribution is much compressed shoreward such that even Macrocystis and Phyllospadix overlap. The shallowest reefs are richly

Further up on these gradual slopes there are more low and lobed sponges, tunicates and encrusting bryozoans. There are very few erect turf forms, except near the tops of the reefs, probably because of periodic sand burial or the presence of the purple urchin, Strongylocentrotus purpuratus. Where rock heterogeneity provides protection, urchins are a significant species in this area. Boring clams, Penitella, Parapholas and Platyodon, occur regularly throughout these slopes.

Along the ridge tops, these reefs have lush growths of foliaceous red algae and articulated corallines. Here, surge tends to be strongest as this is the shallowest and most exposed part of the reef. The area is generally sufficiently distant from the sand so that abrasion is not a factor and high surge does not allow grazing urchins to flourish.

The precipitous seaward facing side of these reefs is very different in character from the low inclined side. This side contains a series of variable sized clefts that run horizontally along the cliff face paralled to one another (Fig. 15). In these areas, the crevices slope downward into the cliff face at the same angle as the inclination of the bedding. Each cleft is protected not only by the lip of the reef above but also by each cleft just above and below it. The height, depth and relative location of each of these clefts determines the type of community to be expected in this microhabitat. Narrow clefts will house sipunculids, Phascolosoma agassizii, small snails, Oceanebra spp., Maxwellia, Pteropurpura festiva, nudibranchs, Anisodoris, Laila cockerelli, nestling clams, Hiatella arctica, and shrimp, Alpheus Betaeus, while slightly larger crevices frequently contain the feather duster worm, Eudistylia, cone snails, Conus, the salmon cucumber, Cucumaria salma, and especially the common chestnut cowry, Cypraea. Middle-sized gaps a few inches high will often contain purple urchins, particularly lower down on the reef. Still larger crevices and cave-like areas are ideal habitat for abalone, greens, Haliotis fulgens, in shallower water, both reds, H. rufescens, and pinks, H. corrugata, in the middle depths, and whites, H. sorensoni, in deeper water. However, our observations indicate that abalone are not now common in this area.

The spiny lobster, Panulirus, occurs in shallow water amongst the crevices in the eel grass in summer and in deeper water in the winter. Although habitat appears ideal, lobsters are not common at present. The larger crevices are also used by moray eels, Gymnothorax mordax.

Erect suspension feeders proliferate on the shaded projections between the crevices and below the top of the ridges. These species tend to be the same ones found on vertical cliffs in the indurated reef areas, but the areas inhabited are not so extensive and are broken up by the horizontal cracks. Bryozoans are by far the dominant group here. The coral-like bryozoan, Diaperoecia, forms miniature heads which may be 5 to 6 inches in diameter. The delicate little crisiid bryozoans abound. Numerous others include the lace bryozoan, Phidolopora, the cornflake bryozoan, Hippodiplosia, and the bushy bryozoan, Bugula neritina and B. californica. These areas have some species of tunicates (especially Trididemnum, Pyura, Aplidium spp. and Euherdmania), but they are relatively insignificant compared to bryozoans. There are fewer hydroids and sponges on these projections than on vertical cliffs to the west. Toward the base of this steep, cleft indented face, the erect and branching bryozoans give way to more encrusting forms and encrusting coralline algae. This change may be the result of decreased surge, increased scour, and/or increased grazing pressure, especially by purple urchins. Where sand pockets occur at the base of the reefs below 25 feet, they are almost always densely packed with gray tube worms, Diopatra. Densities reach at least 1000 tubes per square meter in some areas.

If a reef ends on another gently sloping reef without much sand deposited at its base there are usually substantial numbers of purple urchins (up to about 20-25/m^2). Higher on the reef where water movement is strong, urchins generally are tucked into hemispherical impressions that they have eroded into the reef; they do not appear to graze as much and probably rely more heavily on drift algae. However, in deeper waters of 25 to 30 feet, they actively graze and the surrounding areas are mostly open patches of thin encrusting bryozoans, coralline algae, the colonial coral Astrangia and an occasional kelp such as the shrubs Pterygophora, Eisenia, Cystoseira, or the giant kelp, Macrocystis.

Below 20 feet, both red and purple urchins occur. In general, the larger red urchins are more prevalent toward the base of the steep faces, while the purple urchins occur further out on the gentle slope or further up on the steep slope. At about 25-30 feet, their numbers are approximately equal. Below about 30 feet, the purple urchin becomes less common and the small (ca. 1-2 in. diameter) delicate tan and white sand urchins, Lytechinus, become fairly abundant, although the red urchins also persist.

As the reefs go deeper, the biotic trends are repeated: 1) a gentle slope with thin encrusting species, many urchins and numerous clams bored into the reef; 2) a reef ridge top with well-developed growths of foliaceous red algae; 3) a steep face with numerous horizontal clefts containing crevice dwelling organisms (Table 9) and bryozoan turf on the preminances; and 4) a base with Diopatra in sand pockets and urchins on the rocks. The boring clams, Penitella, with their purple siphons, and Parapholas with their gray siphons, will sometimes also be found in the steep faces as well as the gentle slopes. The sheepcrab, Loxorhynchus grandis, is occasionally found at any depth within this area. Giant kelp plants occur only infrequently on the deeper reefs. The sea stars, Pisaster giganteus, and Dermasterias, and especially the batstar, Patiria, and the whelk, Kelletia kelletii, are quite common throughout the deeper regions. Gorgonians are quite sparse throughout the area. Particularly among the foliaceous red algae along the ridges, the sea hare, Aplysia californica, occurs with reasonable frequency.

The reefs at the eastern end of the ASBS (Latigo Point) are also composed of this same Modelo sandstone but are relatively flat and broken into large flat topped benches and boulders only a few feet high. Sand pockets regularly occur within the reef area. Urchins are relatively sparse here, probably because of the steep angles of the rocks and the low density of turf plants. Macrocystis is common, with large holdfasts (to 6 feet in diameter); but shrub plants are not common. However, the yellow rust gorgonian, Muricea californica, is exceedingly dense and large (up to 35 in. high), with young colonies common. Much of the remaining space is dominated by the usual erect bryozoans, tunicates, hydroids (especially Hydractinia sp. and Plumularia spp.), and the colonial coral, Astrangia. The under rock and crevice microhabitats also contain typical species (see Table 9). The sand pockets and sand periphery around these Latigo Point reefs have substantial populations of the gray tube worm, Diopatra.

Finally, there are a few small sandstone reefs in about 35-45 feet of water off Zuma Beach, but they are very sparse.

Rock and Kelp Associated Fishes: The fishes have not been discussed to this point because of their distinctive modes of foraging for food. Many fishes tend to hover and drift about the reef and are not restricted to a special region, while others remain in one spot for long periods of time.

Discussion of the fishes will focus on three basis aspects of their biology: 1) their method of feeding, 2) their principal foraging position and location, and 3) their time of foraging (Table 10). There are three major modes of feeding by fishes in the ASBS: 1) ambushing, stalking and hunting fishes, 2) picking and crusing fishes, and 3) planktivorous fishes. Foraging position and location is defined according to: water depth (very shallow, 0-10 ft., nearshore, 5-25 ft., offshore, 25-65 ft., or deep water, 65 ft.), substrate type (rock, sand, kelp etc.), and position (hovering about the substrate, perching on the substrate, hiding within the substrate, hanging high in the water column, or rapidly swimming). Finally most fishes can be classed either as diurnally or nocturnally active. These divisions are based on the investigator's observations, those of Hobson (pers. com.; Hobson and Chess, 1976), and those of North and Hubbs (1968).

Ambushing, Stalking, and Hunting Fishes: The largest number of fishes in the ASBS forage on motile prey. In rocky regions most of these fishes rest motionless on the bottom and ambush their prey. The common medium to large fishes (1 to 3 feet) of this type within the ASBS which eat other fishes and decapod crustaceans include the cabezon, Scorpaenichthys marmoratus, the scorpionfish, Scorpaena guttata, most of the bottom dwelling rockfishes including the gopher, Sebastes carnatus;

Table 10 (Continued)

LOCATION	FEEDING TYPE: Hunt, stalk, or ambush small (S) or large (L) prey usually off the bottom	Pick or crush prey on bottom (includes Herbivores)	Planktivorous by day (D) or night (N)
II. Offshore: 1. On the bottom or in kelp in *Macrocystis*-reefs	*Oxylebius pictus* (S) (painted greenling Cottids (S) Clinids (S) Blennies (S) *Coryphopterus nicholsii* (black-eyed goby) *Gibbonsia* sp. (S) *Scorpaena guttata* (L) *Scorpaenichthys marmoratus* (L) (cabezon) *Sebastes carnatus* (L) (gopher rockfish) *S. chrysomelas* (L) (black and yellow rockfish) *S. rastrelliger* (L) (grass rockfish) *S. serriceps* (L) (treefish) *Heterostichus rostratus* (giant kelpfish)		
2. Near the bottom or kelp but not on the bottom	*Sebastes atrovirens* (kelp rockfish) *S. serranoides* (L) (olive rockfish) *Paralabrax clathratus* (L) (kelp bass)	*Brachyistius frenatus* (kelp perch *Damalichthys vacca* (pile perch) *Embiotoca jacksoni* (black perch) *Hypsurus caryi* (rainbow perch)	*Chromis punctipinnis* (D) (blacksmith) Atherinids (N) *Hyperprosopon argenteum* (N) *Sebastes mystinus* (D) (blue rockfish)

Table 10 Continued

LOCATION	FEEDING TYPE		
	Hunt, stalk, or ambush small (S) or large (L) prey usually off the bottom	Pick or crush prey on bottom (includes herbivores)	Planktivorous by day (D) or night (N)
II. Offshore: 2. Near the bottom or kelp but not on the bottom (Continued)		Phanerodon furcatus (white perch) Rhacochilus toxotes (rubberlip perch) Roncador stearnsii (spotfin croaker) Medialuna californiensis (half-moon) Girella nigricans (opaleye) Hypsypops rubicund (garibaldi) Oxyjulis californica (señorita) Halichoeres semicinctus (rock wrasse) Pimelometopon pulchrum (Sheephead)	
3. Open water	Sarda chilensis (L) (Bonito) Trachurus symmetricus (L) (Jack mackerel) Sphyraena argentea (L) (barracuda)		Engraulis mordax (N) (anchovy)

black and yellow, S. chrysomelas; grass, S. rastrellinger; and treefish, S. serriceps, and the lingcod, Ophiodon elongatus. All of these fishes, except the lingcod, are relatively common throughout the nearshore and offshore reefs within the ASBS, particularly amongst large crevices or in open low surge areas. The treefish favors deeper crevices and caves more than the other species. The scorpionfish forages in shallower waters than most of the others and is frequently encountered in surf grass beds. The California halibut, Paralicthys californicus, is an ambusher found nearly hidden in the sand often around the base of rocks.

Small fishes (ca. 2 to 8 inches) which utilize this ambushing strategy feed mainly on small crustaceans and worms and are exceedingly common and diverse in all rocky habitats within the ASBS from the shallowest rocks to the deepest reefs. The commonest group are the sculpins or cottids (family Cottidae) which are difficult to detect and identify in the field. A few such as the lavender sculpin, Leiocottus hirundo and the staghorn sculpin, Leptocottus armatus, are somewhat larger (8 to 12 inches) and readily identifiable. The lavender sculpin is most frequently encountered in the nearshore and shallow offshore reefs in mixed sand-rock areas. During the surveys, it was most common in the friable reef areas of Paradise Cove and Latigo Point. The staghorn sculpin is largely a sand dweller. The blennies (family Blennidae) pricklebacks (Stichaeidae) clinids (Clinidae) and Gobies (Gobiidae) can all generally be included as ambushers and tend to be small. Blennies, such as Hypsoblennius sp., and clinids, such as Neoclinus blanchardi, are seen mostly in small sheltered retreats such as empty rock scallops and jewel box shells or in large dead barnacle shells. Another clinid, the small kelpfish, Gibbonsia spp., is encountered stalking prey at all depths and amongst the foliaceous red and coralline algae turf and also in surf grass beds. The black-eyes goby, Coryphopterus nicholsii, is a very common constituent of all the nearshore and offshore reefs, but only at the sand-rock interface where a crevice leads directly onto sand. This goby is sand colored and blends into the background, even when fully exposed. The painted greenling, Oxylebius pictus, is a small to medium-sized fish which sits high amongst the reddish colored algal occasionally sighted within the boundaries of the ASBS. The common blue shark almost certainly occurs regularly in the waters of the ASBS.

Picking and Crushing Fishes: Another large group of fishes feed by picking their prey items directly off the substrate. Food material varies from benthic crustaceans and worms to plants, sedentary or sessile suspension feeders, and attached herbivores. In general, picking, crushing, or rasping types of fish forage actively just off the substrate. They primarily use their pectoral fins for locomotion which gives them maximum maneuverability over very short distances. As a group they generally have powerful jaws for crushing. The most conspicuous members of this group are the surfperches, the wrasses, the garibaldi, opaleye and halfmoon. The croakers also fit into this pattern but they occur most frequently over sand.

Perhaps the most common of the surfperches in the ASBS is the black surfperch, Embiotoca jacksoni, which occurs in reef areas at all depths. This species typically pick at the bottom while they drift over it at an angle. The rainbow perch, Hypsurus caryi, is also common but seems to prefer flatter rock areas and boulder fields. The pile perch, Damalichthys vacca, and white perch, Phanerodon furcatus, often occur in loose mixed schools, and pick over the bottom in kelp beds. The big rubber-lipped surf perch, Rhacochilus toxotes, gets quite large (12 to 24 inches), has very powerful jaws, and apparently forages mainly at night (Ebling, pers. comm.). The other common surfperch here is the kelp surfperch, Brachyistius frenatus, a small, kelp colored fish. This species feeds by picking crustaceans and other prey directly off the kelp. Two other species of small surfperches are typically found among nearshore rocks. The solitary dwarfperch, Micrometrus minimus, is most frequently encountered just above and foraging on surf grass. The shiner perch, Cymatogaster aggregata, in common in areas where large boulders project from the water and there is a lot of turbulence. The spotfin croaker, Roncador stearnsii, a large fish, sometimes occurs in the deeper reefs as well as over sand and picks along the bottom.

The wrasses are a very important and common group of pickers and crushers. Most abundant is the small cigar-shaped senorita, Oxyjulis

The opaleye, Girella nigricans, a large stout fish with a blunt head, is a reasonably common member of the shallow and nearshore reef communities and somewhat less common on the outer reefs. They are essentially herbivorous, feeding on the kelp, foliaceous red algae and undoubtedly many of the animals growing on these plants. They are most common where algal or surf grass growth is luxuriant. They forage from the reef, particularly the tops, well up into the kelp, and are in constant motion. Another fish which has habits somewhat like the opaleye, but is more omnivorous, is the halfmoon, Medialuna californiensis. This moderate sized, steel grey fish is often seen well off the bottom, usually under the kelp canopy. The halfmoon forages mostly on kelp organisms and probably the kelp as well. The species is most prevalent on the offshore and deeper nearshore reefs.

Other important bottom foragers around reefs are the swell shark Cephaloscyllium ventriosum, and the horn shark, Heterodontus francisci. They apparently primarily feed on nocturnally active benthic crabs, some molluscs and fishes. Both species are present but not especially common within the ASBS.

Planktivorous Fishes: There are relatively few planktivorous fish species within the ASBS, but they occur in significant numbers. The two most prevalent species by day are the blacksmith and the silversides. The blacksmith, Chromis punctipinnis, is a small (about 3 to 6 inch), blue-black fish which is abundant under the kelp canopy and around its fringes in all of the reef regions where kelp is well developed. It is found hanging nearly motionless in the water column, and feeds on small zooplankters. They are a very conspicuous member of the reef community. At night they go into crevices in the reef. The blacksmith becomes less common further north along the coast and its ecological replacement seems to be the blue rockfish, Sebastes mystinus. The coloration and habits of these two species are very similar; only their shapes are distinctive. The blue rockfish does occur within the ASBS but it is not very common.

Ranging further away from the kelp, and from the surf line outward, silversides (atherinids) are common planktivores. These are strictly pelagic fishes which occur near the sea surface in loose schools and are in constant motion. They are silvery in color and include three virtually indistinguishable species including the grunion, Leuresthes tenuis. Their distribution overlaps with the blacksmith only around the preiphery of the kelp bed. They appear to be nocturnal foragers and spread out in more open areas at night.

The anchovy, Engraulis mordax, another pelagic species which occurs still further out away from the reefs, but sometimes migrates into nearshore waters. This species forms enormous schools and is one of the principal prey of the pelagic hunting fishes such as jack mackeral.

The walleye surfperch, Hyperprosopon argenteum, and the silver surfperch, H. ellipticum, are nocturnal planktivores. At night they fan out individually over the reef and sand and forage on the larger nocturnal demersal plankton, especially on those occurring near the bottom. In some locations they are very common. The only other common nocturnal planktivore is the kelp rockfish, Sebastes atrovirens, which feeds on a wide size range of prey and is perhaps best considered a nocturnal ambusher. A more elaborate treatment of most of these species and a few other planktivorous local fishes can be found in Hobson and Chess (1976).

Nearshore Sands (0 to 60 ft. in depth): Three vast areas of nearshore sands are located within the ASBS (Fig. 6). The eastermost section is Zuma Beach (including Trancas and Westward Beaches), which lies immediately west of Point Dume and extends for a little more than four miles. The second sand area extends for about 1-1/3 miles between Little Sycamore Canyon and Deer Canyon, and is bordered shoreward by broken shallow rocks and reefs. The westernmost section extends from Bass Rock to Mugu Canyon, a distance of about 6 miles, and includes the Mugu Lagoon barrier beach. Between Bass Rock and Point Mugu much of this nearshore sand region is bounded shoreward by shallow rocks and riprap except for Big Sycamore and La Jolla Beaches (Fig. 6).

The physical factor which probably has the greatest influence on the biota of the nearshore sands is the ocean swell and its accompanying wave surge. The effect of the surge decreases as the water depth in-

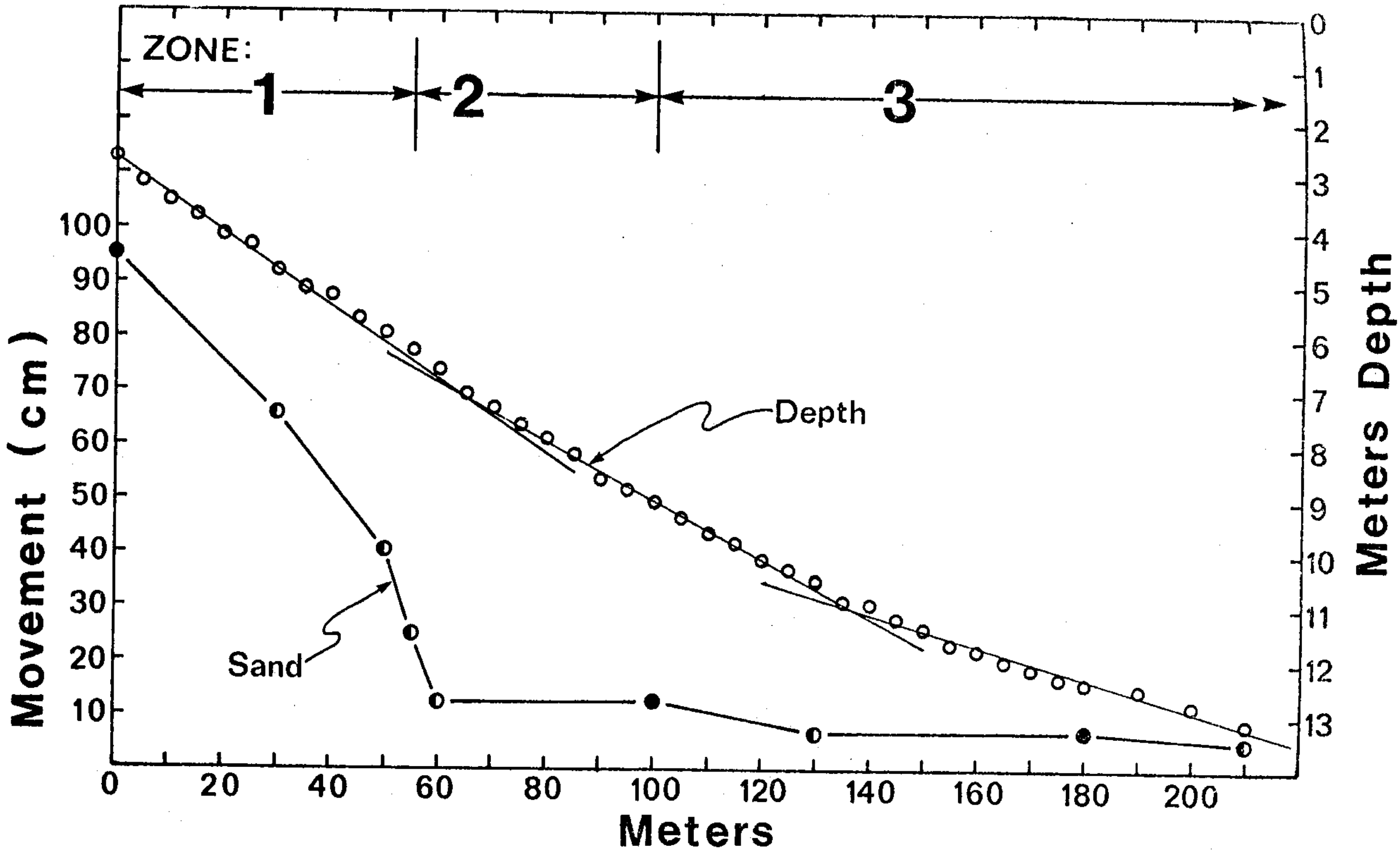

Figure 17. Depth Profile, Maximum Recorded Sand Movements and Biological Zones along the Zuma Beach Subtidal Study Transects (Taken from Morin et al. 1978). (Note these transects begin about 50 meters from shore in about 3 meters (10') depth of water.

Figure 18. Idealized Section of the Nearshore Sand Bottom off Zuma Beach Showing the Three Main Biological Zones.

Key		Major Zone
	Sea Pansy (*Renilla kollikeri*)	1, 3
	Sea Pen (*Stylatula elongata*)	3
	Gray Tube Worm (*Diopatra ornata*)	3
	Spiny Sand Crab (*Blepharipoda occidentalis*)	1
	Purple Crab (*Cancer gracilis*)	1-3
	Elbow Crab (*Hetero crypta occidentalis*)	3
	Purple Olive Snail (*Olivella biplicata*)	1
	Carpenter's Turrid (*Megasurcula carpenteriana*)	3
	High Moon Snail (*Polinices altus*)	3
	Pansy Nudibranch (*Armina californica*)	3
	Pismo Clam (*Tivela stultorum*) [side view]	1
	Pismo Clam (*Tivela stultorum*) [surface view]	1
	Sand Dollars (*Dendraster excentricus*)	2
	Shallow Sand Star (*Astropecten armatus*)	2, 3
	Deep Sand Star (*Astropecten verrilli*)	3
	Pink Star (*Pisaster brevispinas*)	2

FIGURE 18

Figure 19. The distribution of the abundant benthic invertebrates are presented as the percent occurrence plotted against position along the Zuma Beach transect. The abscissa is marked in intervals of 10 percentage points. The percent distributions are read as the number of intervals to either the left or right of the central vertical line representing individual species. The ordinate is marked in 10 meter intervals. The long transect length results from the overlapping of two transects. Both winter (clear area) and summer (cross-hatched) distributions are given. The animals represented are: De, Dendraster excentricus; Se, Stylatula elongata; Rk, Renilla kollikeri; Arc, Armina californica; Asc, Astropecten verrilli; Ob, Olivella biplicata; Asa, Astropecten armatus; Ts, Tivela stultorum; and Mc, Megasurcula cerpenteriana. The distribution of Polinices altus is very similar to that of Astropecten verrilli, and the distribution of Luidia foliolata is very similar to that of Megasurcula. Note the zonal array of peak abundances and the seasonal shifts in the shoreward limits of the distributions. Note that this graph does not represent relative abundance (taken from Kastendiek, 1975).

Table 11. (Taken from Kastendiek, 1975)

The abundance and occurrence of the animals at Zuma Beach. The 15 most abundant animals are listed and their densities within various regions of the study area (zones) are tabled. Seasonal peaks in abundance and diurnal peaks of occurrence, if they occur, are designated. F=fall, Sp=spring, D=day, and N=night.

		Densities (per sq. meter)				
Species	Phylum	Zone I	Zone II	Zone III	Season	Day-Night
Dendraster excentricus	Echino.	3.55	to 1100	-	-	-
Renilla kollikeri	Coel.	11.74	-	0.87	F	-
Diopatra ornata	Annel.	-	4.40	1.84	-	-
Tivela stultorum	Mollus.	1.04	-	-	-	-
Stylatula elongata	Coel.	-	-	1.35	-	N
Astropecten californicus	Echino.	-	-	0.77	-	-
Armina californica	Moll.	0.65	-	0.25	F	D
Olivella biplicata	Moll.	0.54	-	-	-	-
Cancer gracilis	Arth.	0.11	0.18	0.09	-	N
Astropecten armatus	Echin.	-	-	0.13	-	-
Polinices altus	Moll.	-	-	0.10	-	N
Megasurcula carpenteriana	Moll.	-	-	0.10	-	-
Luidia foliolata	Echino.	-	-	0.05	-	-

like appearance of the outside edge is maintained. The sand dollars move primarily in the inclined position and the whole outer seaward edge may move up to 3 meters per day. Although generally unaffected by surge, the outer edge can be significantly altered by heavy surf. With the subsidence of large swells the seaward edge resumes its former position.

On the other hand, the shoreward (inner) edge of the sand dollar bed moves along a shore-sea axis far less than the seaward edge during a season. The net movement is less than 15 meters per year. Its position tends to be quite variable within this range and shows no seasonal consistency. However, because of its proximity to the surf zone, the prevailing surge conditions influence the position of this shoreward edge dramatically by scattering the sand dollars shoreward or burying them during heavy surf. The identity of the edge recovers within a few days after the subsidence of heavy surf.

As a result of the yearly contraction and expansion of its outer edge, there is a fluctuation in the densities of the sand dollars at any one position within the bed. At the outer edge, the highest maximum densities are recorded during the summer (up to $1,100/m^2$) and the lowest during the winter (about $500-600/m^2$). Another spatial characteristic of the summer bed is the presence of large open patches of sand. Although these patches may occur throughout the year, they are larger and more numerous during the summer.

Certain organisms are usually associated with sand dollars. The broken back shrimp, Heptacarpus sp., is frequently found between the sand dollars throughout the bed. The sand barnacle, Balanus pacificus, fouls living sand dollars. This barnacle also can be found wherever there is solid substrate available in the sand (e.g. small rocks, dead clam shells, crab carapaces, etc.), but they occur predominately on sand dollars. About 0.2% of the Dendraster has barnacles growing on them, usually the barnacles are positioned on the sand dollar aborally and opposite the anus. The number of fouled sand dollars is highest near shore in Zone 1 where the sand dollar densities are low. Balcis rutila, a tiny ectoparasitic eulimid gastropod, is commonly found attached to it is always common. Diopatra form fence-like regular foot-long rows of several dozen individual tubes parallel to shore and the ripple marks. The end of each row is about a foot from the next parallel and perpendicular row.

The majority of the organisms associated with this zone are consistently found seaward of 9m (30 ft.) depth and most show an increasing occurrence to a peak density in the depth range of 10.5 - 12m (35-40 ft.). These include the dominant species, the sea pen, Stylatula, and the slender sand star, Astropecten verrilli, the moon snail, Polinices altus, the carpenter's turrid, Megasurcula carpenteriana, probably the snails, Terebra pedroana, and Ophiodermella ophioderma, the limp sand star, Luidia foliolata and the elbow crab, Heterocrypta occidentalis. Heterocrypta is most prevalent in the spring.

Most of the crabs and fishes show a fairly even distribution within the study area. These animals occur in relatively low densities and exhibit a high degree of motility, distinct nocturnal activities, and wariness of divers. Hence it was difficult to collect a sufficient number of observations within the one-meter-wide transects to accurately describe their distributions. However, the following animals appear to be distributed throughout the study area in all zones: the purple crab, Cancer gracilis, and the ornate crab, Randillia ornata, the thornback ray, Platyrhinoidis triseriata, the speckled sanddab, Citharichthys stigmaeus, the C-O turbot, Pleuronichthys coenosus, the diamond turbot, Hypopsetta guttulata, and the halibut, Paralichthys californicus. The sheep crab, Loxorhynchus grandis is most abundant within the sand dollar bed, especially in the spring. The hermit crab, Isocheles pilosus, appears to be most abundant in the vicinity of the outside edge of the sand dollar bed. During the spring there occurs an influx of large gravid Cancer crabs. Summer is characterized by the presence of two species of fishes throughout the region, the halibut, Paralichthys californicus, and the lizard fish, Synodus lucioceps. Both are often very common. Paralabrax clathratus, the kelp bass, is seasonally common over the sand dollar bed during the late fall, winter and early spring. Several other animals which are less common but seasonal in their occurrence are listed in Appendix 4.

The fish within the study site can generally be divided into three primary classes with respect to diel activity: those observed only during the night, only during the day, and during both the night and day. Nocturnally active fishes include the thornback ray, Platyrhinoidis, the shovelnose guitarfish, Thinobatos productus, the staghorn sculpin, Leptocottus armatus, the cusk eel, Chilara taylori, and the scorpionfish, Scorpaena guttata. These species lie quiescent and well buried within the sand during the day and are therefore difficult to detect. All are very active and obvious at night. During the day the walleye surfperch, Hyperprosopon argenteum occurs in small schools well off the bottom near the surf line. At night they move close to the bottom and spread out as solitary individuals throughout the study area. They are nocturnal feeders (Hobson and Chess, 1976).

Along the sand bottom within the study area there are relatively few strictly diurnal fishes. These include the white surfperch, Phanerodon furcatus, and the pile surfperch, Damalichthys vacca, usually encountered in large mixed schools moving over the bottom actively "picking" at the sand. The kelp bass, Paralabrax clathratus, is occasionally encountered near the bottom during the day in the winter and spring.

As a group, the flatfishes, including the speckled sanddab, Citharichthys stigmaeus, the C-O turbot, Pleuronichthys coenosus, and the diamond turbot, Hypopsetta guttulata, do not vary much in occurrence with respect to the time of day. However, the two turbots appear to be completely uncovered and active at night, but quiescent and partly buried during the day. There is no apparent change in numbers or activity of speckled sanddabs between day and night; this species is always common and active.

There appear to be no strictly diurnal crustaceans within the study area. However, the hermit crabs, Isocheles pilosus, Paguristes ulreyi and Pagurus ochotensis, the sheepcrab, Loxorhychus, and the elbow crab, Heterocrypta, appear active regardless of the light levels. However, there is a massive increase in the numbers of other crustaceans evident at night. The purple crab, Cancer gracilis, the ornate crab, Randallia, and the swimming crab, Portunus xantussi, are strongly nocturnal and are buried during daylight hours. The crabs, Cancer antennarius, C. anthonyi and C. productus also show a similar pattern, as does the spiny sand crab, Blepharipoda and the sand shrimp, Crangon nigricauda. During the day, these crustaceans may sometimes be seen out foraging, especially if there is a heavy cloud cover or the water is very turbid so that the relative light level is low.

Both the numbers of individual animals and the number of species are greater at night than during the day. The sources of the nocturnal animals can be either deeper water, the substrate of the area itself, or the surf zone. No measurements of the possible increase in potential prey items, which probably underlies this day-night phenomenon, have been made, although the numbers of small crustaceans (amphipods, isopods, cumaceans and mysids) all increase perceptibly at night.

In addition to seasonal, diel, and weather related alterations in population disposition and abundance, dramatic differences in the number of exposed organisms often occur under seemingly identical circumstances of light, surge, tide, temperature and water clarity. For example, during a series of dives, the total number of sea pens observed varied from 1 1/5 per m^2 to none. Conditions were apparently similar in all cases, yet many of the sea pens were not present above the sand and were presumably pulled into the sand. Similar differences have been noted for sea pansies, pismo clams, olive snails, pansy nudibranchs and sand stars, all of which are capable of pulling or burrowing into the sand. Therefore, changes in density from one time to another may be more apparent than real.

Since commencement of the survey, long term changes in the population sizes of some of the animals within the study area have occurred. The most dramatic non-cyclic variations that occurred repeatedly over more than one season were the successful spatfalls (larval sets) of sea pansies, Renilla, and sea pens, Stylatula. These organisms release their gametes in the summer and the first small juveniles can be detected on the bottom in September.

A second, but more continuous change has been observed in the overall decrease in the numbers of gastropods and crabs encountered at

Zuma Beach during the study period. This drop has been especially evident in the crabs, Loxorhynchus grandis, Cancer gracilis, and other Cancer species; the three hermit crabs, the elbow crab, the ornate crab, and the snails: Polinices lewisii, Megasurcula carpenteriana, Terebra pedroana, Nassarius fossatus, and Cancellaria cooperi. However, since the winter of 1974-75 there has been a dramatic increase in the number of crabs observed. These include Loxorhynchus grandis, Cancer gracilis, and Randallia ornata.

Over the entire period of the study, there has been a gradual decrease in the overall density of the sand dollar population along the transects. The population is of one age class and the decrease appears to be from attrition without recruitment. On the other hand, the brittle star, Amphiodia occidentalis, has increased in overall abundance from uncommon at the commencement of the study to common in Zone 3 at the present time.

The other nearshore sand bottoms in the ASBS show a similar overall pattern. The sand dollar, sea pansy, sea pen and sand star populations in general resemble those of Zuma Beach in relative numbers, densities, and distribution. However, a few variations do occur. At La Jolla Beach, the width of the sand dollar bed is much broader than in all of the surrounding areas. The bed is situated between depths of 15 and 40 feet, a distance of approximately one-quarter mile. The slope of the bottom off La Jolla Beach is extremely shallow, about 1.7%, and accounts for the wide sand dollar bed. There is a distinct outer edge to the sand dollar bed, but within the bed there are very large open patches except toward the shoreward margin. In the outer sections there are huge lens-like areas with high densities of sand dollars. Many dead sand dollar tests are in evidence and they provide a substrate for algae, mainly two stringy reds, Neoaghardiella baileyi and Gracilaria sjoestedii, and the sea lettuce, Ulva angusta. The parasitic snail Balcis was abundant on sand dollars on the outer edges of the bed during

Many of the western nearshore sand areas are bounded by stretches of very shallow beach rock or riprap (Fig. 6). The sand bottom usually commences at about 10 feet in depth, continues uninterrupted seaward and otherwise has the appearance of the Zuma Beach area. However, the surveys observed enormous numbers of fishes congregated around these shallow rock areas. This was particularly true in the area between Point Mugu and La Jolla Canyon. The principal fishes observed near these rocks were huge tight-packed schools of queenfish, Seriphus politus, and large numbers of walleye and silver surfperches, Hyperprosopon argenteum and H. ellipticum, all of which are nocturnal plankton feeders offshore (see Hobson and Chess, 1976). Presumably these fish school near shore under the protection of these rocks and then move out over the sand at night to forage. The large numbers of fishes indicate that the demersal plankton productivity of the surrounding sands must be very high.

Also present amongst these rocks are other surfperches such as the pile perch, Damalichthys, the black perch, Embiotoca jacksoni, the white perch, Phanerodon, the rainbow perch, Hypsurus, the rubberlip, Rhacochilus, the shiner perch, Cymatogaster, and the dwarf perch, Micrometrus. The survey showed their distribution was similar to that seen in the shallow rocks and reefs discussed above. Opaleye and senoritas were also seen. During the survey, halibut were consistently present in the sand at the base of these rocks below these abundant fish populations.

The rocks themselves support a biota typical of the shallow rocks discussed above: surfgrass, feather boa kelp, some sand tube worms, Phragmatopoma, mussels, gooseneck barnacles, aggregating green anemones and many fugitive species like green algae, Ulva, foliaceous red algae and many hydroids and barnacles.

Where rock outcrops occur in offshore areas the sand community within about 200 feet of the rocks can show some modification. Sea pens, Stylatula, some worms, and sand stars often show reduced numbers compared to uninterrupted sand areas, probably because of the foraging activities of rock associated fishes such as sheephead and some of the surfperches (Davis, 1978).

The eel grass, Zostera marina, occurs in about 35-45 feet of water on sand bottoms off of some of the more extensive reefs in the vicinity of Lechuza Point and Los Alisos Canyon. The bed at Lechuza Point has remained there for several years and is fairly large (2-5 meters wide x ca. 40 meters long).

Another variation in the nearshore sand areas occurs in the pismo clam populations (Figs. 21-23). They generally are most abundant off the Mugu Lagoon barrier beach, but are quite common all along this region. Ormond Beach, about 4 miles west of the ASBS, has been extensively studied because of the Ormond Beach Generating Station. A study by the Intersea Research Corporation showed that the sand-mud bottom in 10-40 foot depths off Ormond Beach was moderately rich in species numbers, but low in number of individuals (IRC, 1971). The sanddab, Citharichthys stigmaeus, and the surfperch, Hyperprosopon anale, were the most abundant fishes and 11 of the 31 species of fishes caught contributed over 95% of the total number.

Offshore Sands: In general, the very fine sand bottoms (Table 5) beyond about 60 foot depth are similar throughout the ASBS. They are dominated by infaunal worms and clams, with the windmill worms, Laonice foliata, gray tube worms, Diopatra ornata, horse clam, Tresus nuttalli, and geoduck, Panopea generosa, being the most conspicuous. The slender sand star, Astropecten verrilli, is the dominant invertebrate forager in the region. Densities of animals in these deeper regions are usually low compared to the nearshore sand bottoms; for the most part, plants are absent.

Deposit feeding annelid worms live in movable, semi-permanent burrows, and their presence is indicated by fecal mounds on top of the sand. These species are common but live far down in the sand and are difficult to sample adequately. Tube dwelling annelids are a common and important constituent of this community. Most common (several/m^2) is the siponid polychaete, the windmill worm, Laonice sp., which builds sand imbedded parchment tubes about 1/8 in. in diameter and 2-3 in. high. Around the mouth of the tube are peculiar long thin extensions which give the tube the appearance of a windmill. Also common is the ubiqitous gray tube worm, Diopatra ornata, which is much larger than the windmill worm. Densities of Diopatra are patchy, but reach 1 to 2/m^2, nowhere near their huge numbers around reefs. These worms are important,

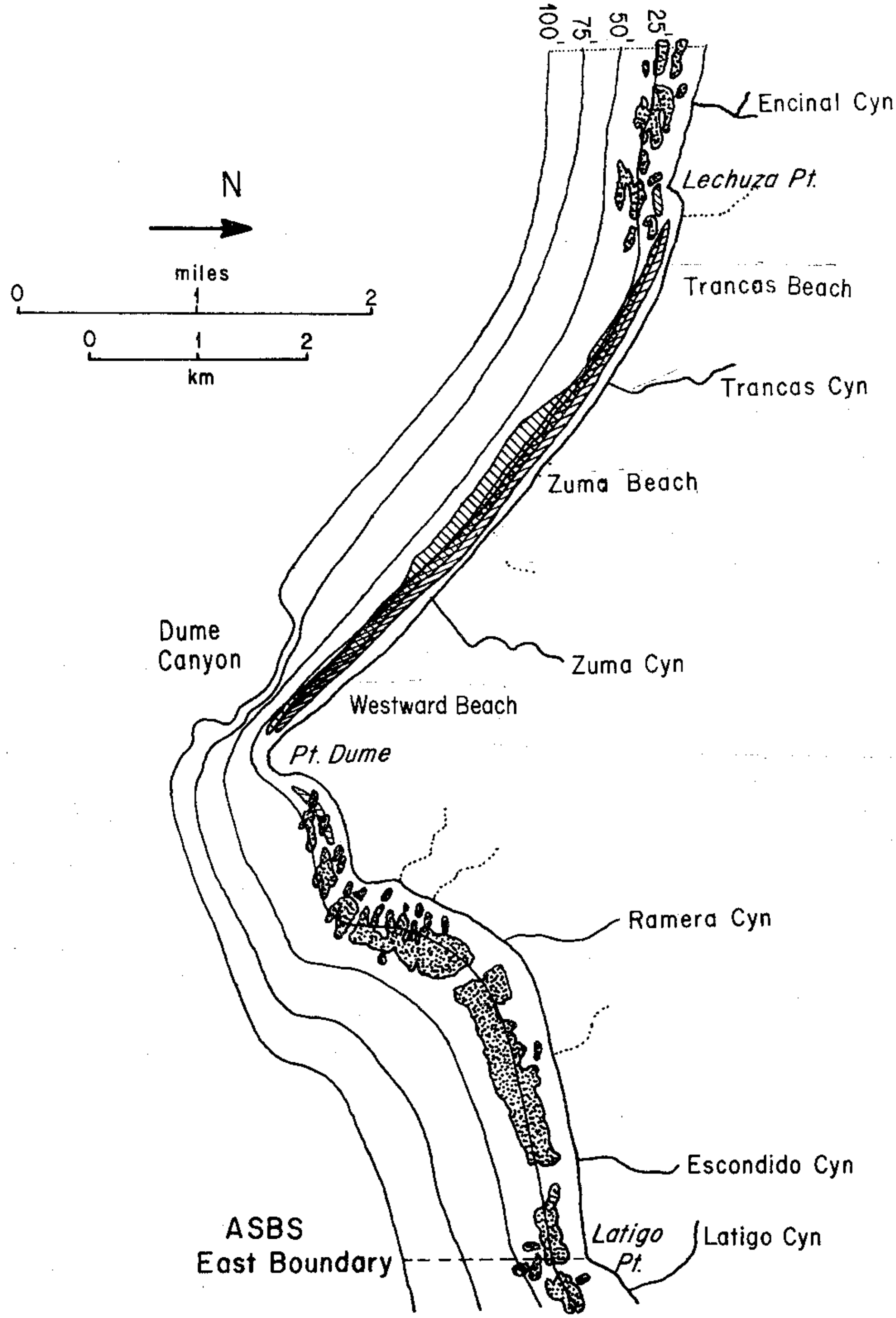

FIGURE 21

Approximate Distribution of the Giant Kelp (Macrocystis), Pismo Clams (Tivela), and Sand Dollars (Dendraster) in the Eastern Part of the Mugu-Latigo ASBS.

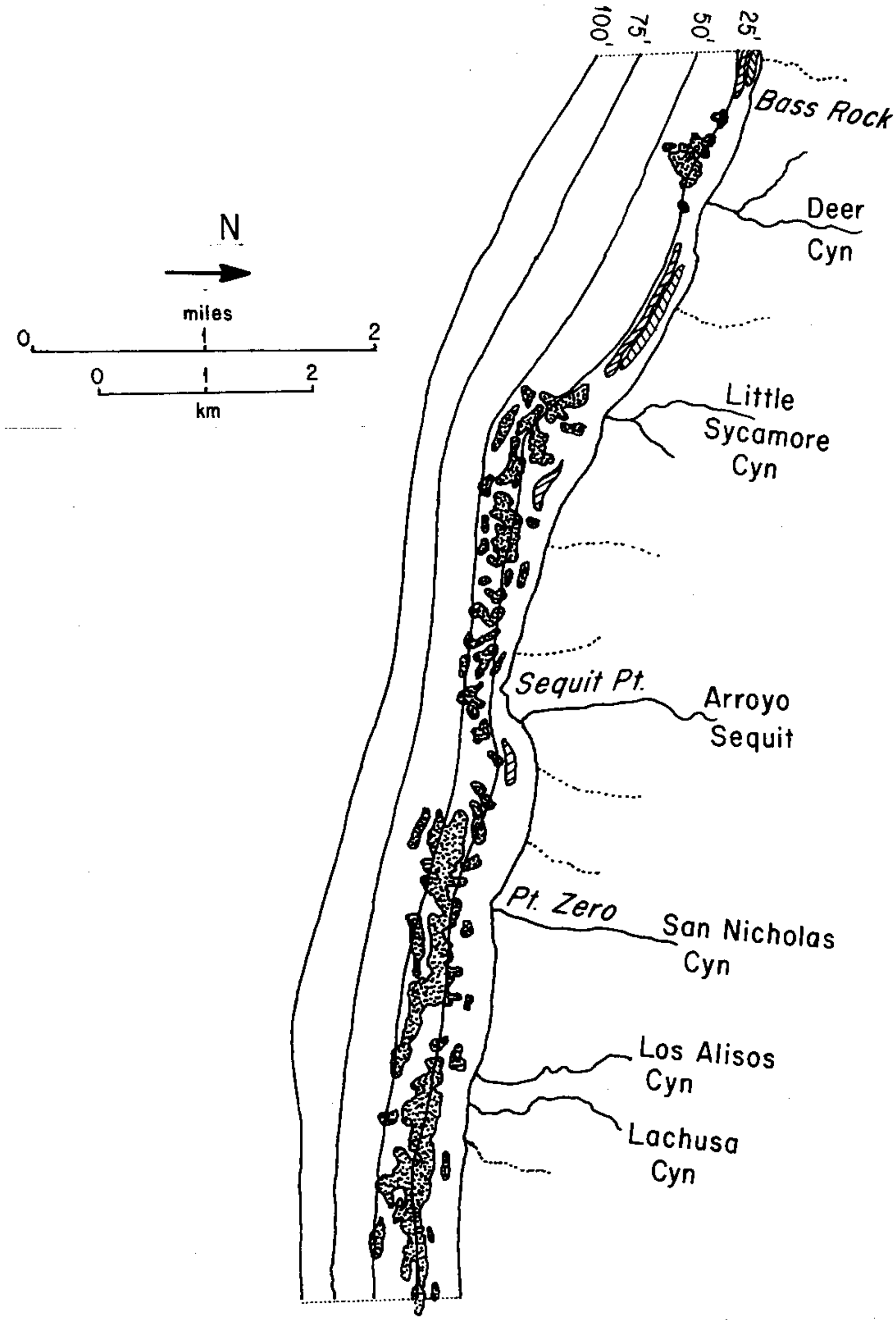

FIGURE 22

Approximate Distribution of the Giant Kelp (Macrocystis), Pismo Clams (Tivela), and Sand Dollars (Dendraster) in the Central Part of the Mugu-Latigo ASBS.

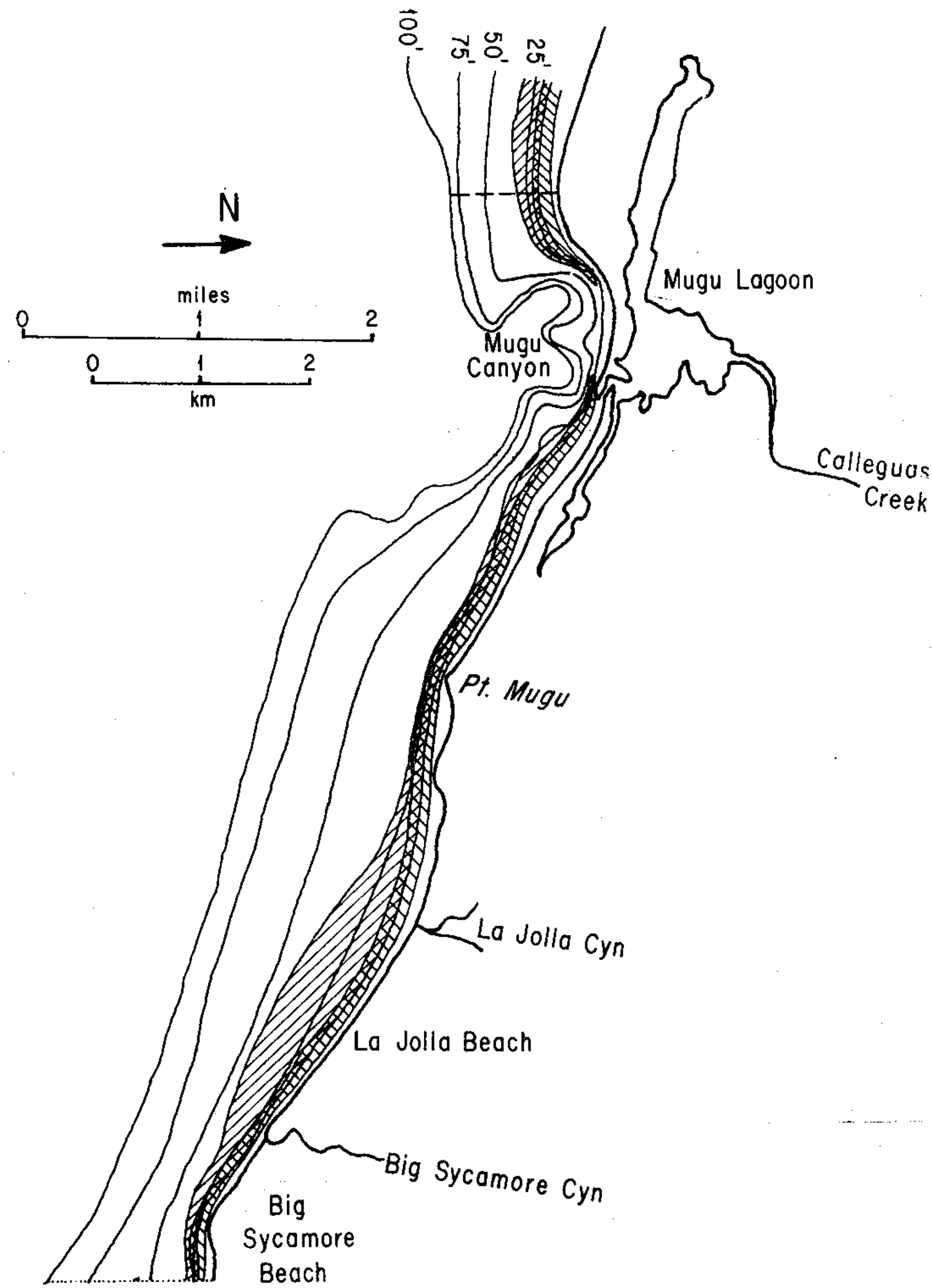

FIGURE 23

Approximate Distribution of the Pismo Clams (Tivela) and Sand Dollars (Dendraster) in the Western Part of the Mugu-Latigo ASBS.

however, because they provide one of the few solid substrates in the region. Thus, nearly every tube seems to provide substrate for deeper water species of hydroids (2 species of Plumularia) or the branching bryozoan, Thalamoporella sp. This bryozoan also commonly occurs drifting free on the bottom. Another tube worm which is also present, but in low numbers, is the soda straw worm, Spiochaetopterus costarum. Terebellids (species unidentified) are present and spread their tentacles out on the sand surfaces to deposit feed.

Bivalves, while inconspicuous to the diving observer from above, are a common and important group of infaunal organisms. The tellinid bivalve (surface deposit feeders) appear to be quite abundant as judged from the number of valves to Tellina spp. and Macoma spp. observed. The suspension feeding razor clams, Tagelus californianus, horseclams, Tresus nuttallii, and geoducks, Panopea generosa, are also fairly common. The large siphons of the latter two species are especially conspicuous as they project out of these relatively featureless plains. Their densities are generally much less than $1/5m^2$, however.

Other infaunal or attached species which project above the substrate include the leathery gooseneck barnacle, Scalpellum osseum, which is common and grows in small clumps on the sediment, usually attached to some object. The sand brittle star, Amphiodia occidentalis, is relatively common in some areas in the offshore sands. Their cryptically colored arms are often seen extending several inches above the sand. The tube anemone, Pachycerianthus fimbriatus, and the sea pens, Stylatula elongatus, Stylatula sp. and Virgularia sp. also project from the sand sporadically throughout these regions. Their numbers are not high.

Regularly occurring grazing and predatory organisms in these offshore regions include the conspicuous and abundant slender sand star, Astropecten verrilli. These carnivores are generalists, feeding mainly on snails, crustaceans, and probably drift material (Davis, 1978). Their densities usually average 1 to $2/m^2$ so that they must be considered a dominant in this habitat. The more flexible sand star, Luidia, is also regularly seen (averaging about $1/5m^2$). Crabs that are usually encountered include the wide ranging large cancer crabs, the elbow crab, Heterocrypta, and the deeper water crab, Mursia gaudichaudii. Hermit crabs, Pagurus spp., are also occasionally encountered. A number of snail species occur here with regularity and include Kellet's whelk, Kelletia, which is more common in reefs, the turrids Megasurcula carpenteriana (the shallower water species) and M. stearnsiana (the deeper water species), the small olive snail, Olivella baetica, the turrid Terebra pedroana, the parasitic snail, Balcis sp., which occurs on the slender sand star, Astropecten, and the common high moon snail, Polinices altus. Finally the small white and tan grazing sand urchin, Lytechinus is common in sparse patches, particularly where quantities of drift algae and other material are present.

Bottom fishes are not very common on offshore sands within the ASBS. Most frequently encountered are small sanddabs, Citharichthys sordidus and C. stigmaeus. Other flat fishes that also occur here are the turbots, Pleuronichthys coenosus and P. verticalis, and the big mouthed sole, Hippoglossina stomata. The lizard fish, Synodus lucioceps, was usually seen at least once or twice on each survey dive. This fish appears to be seasonally common in summer and fall. Bat ray holes, 1 to 2 feet across and 6 to 8 inches deep, usually occur in about $1/20m^2$ densities in these regions. These holes are dug by the rays as they forage for clams, and their depressions usually remain for extended periods of months and collect a lot of drift material.

Organisms which forage just off the bottom include crustaceans, squid and fish. Mysids (oppossum shrimp) of an unknown species are exceedingly common and form patchy "clouds" of small cryptically colored individuals just above the substrate. Periodically common over this bottom is the local squid, Loligo opalescens. Their eggs, which are attached to the bottom, were common in some areas during the survey. The pile surfperches, Damalichthys vacca, and the white surfperch, Phanerodon furcatus, are occasionally observed as large mixed schools foraging over the bottom. One school of spotfin croakers, Roncador stearnsii, and one of the jack mackerel, Trachurus symmetricus, was encountered on the offshore sands.

Beyond the ASBS, and mostly on soft substrates, the Bureau of Land Management's Southern California Baseline Study has an intensive sampling program off Point Dume (BLM 1978). They have 60 stations between 41 and 855 meters depth (outside of the ASBS). They have found this sampling area to be high in species richness and population densities compared to other areas within the Southern California Bight.

Submarine Canyons: There are two submarine canyons within the Mugu-Latigo ASBS: Dume Canyon and Mugu Canyon (Fig. 3). These canyons are composed of steeply sloping (8-16%) very fine sands (Table 5). They have a distinct lip usually at about 50-60 ft. depth, where there is a very noticeable change in the substrate slope from less than 5% to 10% or more. Both canyons have rocky components in their deeper regions (Shepard and Dill, 1966) but not within the ASBS.

Dume Canyon borders the eastern end of Zuma Beach. The rim or lip of the canyon here is generally dominated by dense beds of the gray tube worm, Diopatra. Above the lip in less than 50 ft. of water, the benthic community appears similar to other sand bottoms within the ASBS at that depth. There are relatively fewer Diopatra shallower than 50 ft. compared with the lip region. Maximum Diopatra densities (dozens/m^2) occur at about 60 to 65 ft. depth, and this species drops out almost entirely below 80 ft. This Diopatra zone (50 to 80 ft.) has the greatest diversity and numbers of organisms compared to deeper areas. The clumps of Diopatra tubes probably help stabilize this area. The bryozoan, Thalamoporella sp., is abundant on the Diopatra tubes. Also present on these tubes are crisiid bryozoans as well as the corn flake bryozoan, Hippodiplosia and Celleporaria. Regularly occurring in this zone are the horse clam, Tresus, geoduck, Panopea, and razor clam, Tagelus, the sand brittle star, Amphiodia, the moon snail, Polinices altus, the carpenter's turrid snail, Megasurcula carpenteriana, and hermit crabs, Pagurus spp. Also seen in this region are species which are more frequently encountered on reefs or shallower waters, including the bat star, Patiria - quite common, the cancer crab, Cancer productus, and the sea slugs, Flabellinopsis - iodine nudibranch, sea hare, Aplysia, and navanax, Chelidonura inermis. The interesting infaunal heart urchin, Lovenia, was encountered several times during the survey dives on the sand surface.

The sea pens, Stylatula elongata, but especially Stylatula sp. and Virgularia sp. occur in both the Diopatra lip zone and deeper water. None of the sea pens are common in either region. The slender sand star, Astropecten verrilli is a dominant in both regions and generally shows densities estimated at 1 to $2/5m^2$.

The deeper zone below 80 ft. also contains many of the other constituents found in the offshore sand areas. Common are the windmill worm, Laonice, and the black-tentacled terebellid. Others include the long-noded hydroid, Plumularia sp., the cone snail, Conus, the Kellett's whelk, Kellettia, the ornate crab, Randallia, the limp sand star, Luidia, densities of ca. $1/5m^2$, and the lizard fish, Synodus. Some species such as the long noded sertularian hydroid, Sertularia sp., and the large sea slug, Pleurobranchea, were observed only in the canyon. Stearns' turrid, Megasurcula stearnsiana, is much more common in the deeper parts of the canyon than elsewhere in the ASBS.

Based on a single dive, the area of Mugu Canyon which was examined was very peculiar. The west wall of the west branch was found to be quite barren of organisms. It was extremely steep (>10%) with a series of 8 step-like slump blocks between 100 ft. and the lip at 50 ft. Each slump had a steep step about 6 feet high and ca. 30% slope and then a sump region 10-15 feet long. The region is obviously quite unstable, which probably explains why there were relatively few organisms observed. In the sumps rafted material had collected, including logs, cans, drift kelp, dead sand dollars and pismo clams. There was some evidence of infaunal annelid activity and a few horse clam, Tresus, siphons were seen. The deep dwelling long noded hydroid, Plumularia, with numerous skeleton shrimp, (caprellids) were evident below 50 ft. Other usual offshore soft substrate organisms were uncommon, but a few gray tube worms, Diopatra, slender sand stars, Astropecten verrilli, lizard fish, Synodus, and sanddabs, Citharichthys sp., were seen below 60 ft. Above the lip at about 50 ft., the sand became firmer and more stable and the number of organisms increased. Diopatra were fairly prevalent ($2-3/m^2$)

between 25 and 50 ft depths; in shallower water they dropped out completely. In about 25 ft. of water, juvenile sea pansies, Renilla, were abundant (200/m^2 in places), as was the small furry sand anemone (Zaolutus - 300-500/m^2). A very few sand dollars (1-2/m^2) were found at this depth, and only two pismo clams were detected. Tiny Renilla were recent settlers and were probably doomed since, as they grew, they would be displaced into offshore canyon regions where they probably could not survive. The low numbers of sand dollars and pismo clams also suggests the instability of this region. The survey did not look at other parts of the canyon to see if it resembled Dume Canyon, although it is expected that it does in many locations.

In general, both canyons exhibit considerable biological overlap with the offshore sand areas. They tend to have deeper water (>100 ft.) representatives in water less than 100 ft. deep within them, probably because of the steepness of the contours in these regions (Appendix 3). The canyons do appear to be biologically distinct from other areas and warrant more intensive study.

Northern and Southern Elements (Table 12, Appendix 1 and 3). The Mugu-Latigo ASBS is a prime region which, while not necessarily unique in its overall biological constituency, is representative of the diverse communities found along the shallow subtidal shorelines of the Southern California Bight. Each reef has unique species compositions, distributional patterns, and abundances. The majority of the species found here occur widely throughout southern California, and their ranges extend to central and northern California, and Baja California. The biota are not sufficiently well known to determine whether there might, in fact, be locally endemic species within the ASBS.

However, the Mugu-Latigo ASBS does contain a mix of some northern and southern species which are nearing the end of their distributions in about this region. Thus unique overlapping does occur here. The organisms listed in Table 12 generally represent the northern or southern limits where these species occur with regular frequency, but exceptions of distributions always occur, particularly where regions of upwelling occur to the south (egs. Point Loma, Punta Banda).

Table 12. (Continued)

Species at or relatively near their southern end of their range (Northern Species)	Species at or relatively near their northern end of their range (Southern Species)
Crustaceans:	
Pandalus gurneyi	Hemisquilla stylifera
Hapalogaster cavicauda	Balanus aquila
	Cancer anthonyi
	Lysmata californica
	Panulirus interruptus
Molluscs:	
Acmaea mitra	Astraea undosa
Astraea gibberosa	Haliotis corrugata
Calliostoma annulatum	Haliotis fulgens
Calliostoma canalic latum	Haliotis sorensoni
Clinocardium nuttallii	Norrisia norrisi
	Cypraea spadicea
	Serpulorbis squamigerus
	Kelletia kelletii
	Maxwellia gemma
	Crassispira semiiflata
	Pteropurpura festiva
	Pteropurpura trialata
	Terebra pedroana
	Chlamydoconcha orcutti
	Semele decisa
	Trachycardium quadragenarium

Table 12 (Continued)

Species at or relatively near their southern end of their range (Northern Species)	Species at or relatively near their northern end of their range (Southern Species)
Echinoderms:	
Dermasterias imbricata	Astropectern armatus
Orthasterias koehleri	Luidia foliolata
Pycnopodia helianthoides	Astrometis sertulifera
Eupentacta quinquesemita	Linckia columbiae
Lissothuria nutriens	Ophioderma panamense
Cucumaria piperata	Ophiopsila californica
	Centrostephanus coronatus
	Cucumaria salma
	Parastichopus parvimensis
Bryozoans and Brachiopods:	
	Antropora tincta
	Lichenopora novae-zelandiae
	Thalamoporella californica
	Glottidia albida
Fishes:	
Sebastes atrovirens	Cephaloscyllium uter
Sebastes carnatus	Heterodontus francisci
Sebastes caurinus	Platyrhinoidis triseriata
Sebastes chrysomelas	Rhinobatos productus
Sebastes dallii	Scorpaena guttata
Sebastes mystinus	Sebastes serriceps
Hexagrammos decagrammus	Leiocottus hirundo
Embiotoca lateralis	Leptocottus armatus
Ophiodon elongatus	Paralabrax clathratus

Table 12 (Continued)

Species at or relatively near their southern end of their range (Northern Species)	Species at or relatively near their northern end of their range (Southern Species)
Fishes (Continued):	
	Paralabrax nebulifer
	Cheilotrema saturnum
	Menticirrhus undulatus
	Roncador stearnsii
	Amphistichus argenteus
	Embiotoca jacksoni
	Chromis punctipinnis
	Halichoeres semicinctus
	Hypsypops rubicundus
	Pimelometopon pulchrum
	Lythrypnus zebra
	Girella nigricans
	Paralichthys californicus
	Synodus lucioceps
	Gymnothorax mordax

Rocky Intertidal Zone: The intertidal boulders and reefs to the east of and not including Point Dume consist of friable rock. Reefs and boulders west of and including Point Dume are of indurated rock and the most conspicuous formations occur from east to west as follows: Point Dume, Lechuza Point, Point Zero, Sequit Point, Point Mugu and large wave cut benches between Little Sycamore Canyon and Point Mugu. In general, these formations consist of huge bed rock reefs of graywacke which project seaward perpendicular to the sand beach. Very few loose boulders or rocks that can be turned occur around them. Cobble and boulder fields in the intertidal zone are relatively scarce and usually not extensive, but occur at Little Sycamore Canyon, Arroyo Sequit, and a few other small locations. All of these cobble areas are well imbedded in sand. Friable sandstone reefs, usually terminating in sand, are intertidal extensions of the subtidal inclined reefs, and occur regularly between Point Dume and Paradise Cove and at Latigo Point.

All of the rocky headlands have a similar flora and fauna and will be treated together (Table 13, and Appendix 5). Zonation is distinct on large rocks. This discussion follows the general zonation scheme of Ricketts *et al*. (1968) (Table 13). In the uppermost (splash) zone (Zone 1), the herbivorous periwinkle, *Littorina planaxis*, is found at the highest reaches, the herbivorous limpets, *Collisella digitalis* and *C. scabra*, and the suspension feeding barnacle, *Chthamalus fissus*, become plentiful in the lower part of this zone (5.0 to 6.0 ft. above MLLW). The herbivores, usually most abundant near crevices, feed on a microscopic film of blue-green algae which grows over these rocks. The scavenger-herbivore isopod, *Ligia occidentalis*, is another member of this high intertidal zone. It is especially common on the large boulders at Point Dume and Point Mugu. All of these organisms are well adapted to withstand desiccation and extreme temperatures.

In the high intertidal (Zone 2), the above two species of limpets become less restricted to cracks and share the available open space with several other limpets, *Collisella conus*, *C. strigatella*, and the owl limpet, *Lottia gigantea*. *Lottia* is a large territorial limpet of the lower part of this zone, usually occurring just above and often tucked

Table 13 (Continued)

Zone 3 (Continued)

Gigartina leptorhynchos (foliaceous red algae)

Mopalia muscosa (mossy chiton)

Acanthina spirata (toothed whelk)

Nucella (=Thais) emarginata (dog whelk)

Pagurus samuelis (hermit crab)

Zone 4 (Low Intertidal) [-1.6 to 0.0 ft below MLLW)

Phragmatopoma californica (sand tube worm)

Phyllospadix torreyi (surf grass)

Egregia menziesii (feather-boa kelp)

Prionitis sp. (foliaceous red algae)

Pseudochama exogyra (reversed chama)

Serpulorbis squamigerus (worm snail)

Penitella penita (flat-tipped piddock or boring clam)

Pisaster ochraceus (ochre star)

Euherdmania claviformis (sand club anemone) up against the mussel beds. Its conspicuous territories, usually about 1 to 2 sq. ft., are on tops or sides of rock, and are maintained by the Lottia actively eliminating newly settled barnacles, mussels, etc. and driving out any invading herbivores (Stimpson, 1973). The barnacle, Balanus glandula out-competes the higher dwelling Chthamalus in this region and much of the most exposed vertical and horizontal rock is covered by large numbers of them packed in side by side. Larvae selectively settle around adult barnacles. The obviously different size classes from spot to spot on a rock indicate the periodic recruitment which occurs throughout the year. Balanus extends down into the middle intertidal zone where it is mostly found on mussels.

Any region in this zone which is periodically left clean of organisms by sanding in and then scouring out or other destructive events is usually first colonized by the fugitive algae sea lettuce, Ulva. Ulva was particularly common on high intertidal rocks during our surveys in early 1978 after the devastating winter storms which eliminated most of the grazing populations. As limpets and barnacles recruit, the area covered by Ulva will shrink. However, Ulva generally remains around the sand scoured bases of the high intertidal rocks. The ridges and peaks in this zone usually are populated by the large red barnacle, Tetraclita squamosa. This barnacle extends down into the middle intertidal zone where this species frequently occurs on mussels. The gray-green chiton, Nuttalina fluxa, occurs around ledges and in small scars on the walls and tops of softer rocks. The alga, Ralfsia sporadically occurs on exposed walls in this zone in brown-black patches a few inches across, which resemble patches of tar. The herbivorous black turban snail, Tegula funebralis, is most prevalent at low tide in the protection of crevices or mussels in the lowest part of the high intertidal zone. This region and the middle intertidal zone is well patrolled by the swift scavenger-carnivore, the lined shore crab, Pachygrapsus crassipes. These medium sized crabs are most abundant where crevices for hiding are readily available.

The middle intertidal (zone 3) in most rock areas is completely dominated by three suspension feeders: 1) the mussel, Mytilus space within the midintertidal zone is occupied by algae. Areas which are relatively free of grazers and suspension feeders mostly have good growth of foliaceous red alalgae, especially Gigartina leptorhynchos, and articulated corallines, Corallina spp. and Bossiella orbigniana. These areas usually occur as patches surrounded by the suspension feeders or as a zone below the usual limits of the mussels or anemones. Areas inhabited by grazers or which experience a lot of abrasion are more likely to be covered by encrusting corallines, Lithothamnium or Lithophyllum spp. The primary grazers in the middle intertidal are the same as those limpets and snails found in the high intertidal plus the mossy chiton, Mopalia muscosa. This chiton is very inconspicuous because it almost always has foliaceous red algae growing on its valves and resembles the surrounding algal turf. It is most common on horizontal surfaces where algae is present.

The barnacles on the mussels and the mussels themselves provide a major source of food for two common predatory snails in this zone: the dogwhelk, Nucella (=Thais) emarginata, and the toothed whelk, Acantina spirata. Throughout this zone and lower, particularly in and around small pools and pockets, the hermit crab, Pagurus samuelis, which is a scavenger, can be found. This species usually occupies shells of the black turban snail, Tegula, or the purple olive snail, Olivella, depending on which shells are most abundant in the area.

The biota of the low intertidal zone 4 (-1.6 to 0.0 ft. below MLLW) are practically indistinguishable from that on shallow subtidal rocks and reefs discussed above. All of the dominant suspension feeders and primary producers in this zone have their maximum abundances in the shallow subtidal zone but extend into the low intertidal area. These include the sandtube worm, Phragmatopoma, the worm snail, Serpulorbis, the sand club tunicate, Euherdmania, the surf grass, Phyllospadix, the feather-boa kelp, Egregia, and the foliaceous red alga, Prionitis. The major organisms which appear to have their maximum abundances within this zone are the reversed chama clam, Pseudochama exogrya, and the ochre star, Pisaster ochraceus. Both of these extend into the shallow subtidal zone, however. The biota of the low intertidal and shallow occurrence in Appendix 5. Note the extensive overlap of species which occur in both the intertidal (Appendix 5) and subtidal (Appendix 1) zones.

Sandy Intertidal Zone: Within the ASBS the majority of the intertidal zone (ca. 80% or more) is made up of soft substrates. As opposed to the subtidal zone, most of these soft intertidal substrates house relatively few organisms (Appendix 6). Extensive movement of sand precludes organisms from readily living in this area. The more exposed beaches such as those off the Mugu Lagoon barrier beach, La Jolla Beach, Big Sycamore Beach and Zuma Beach are particularly barren. Here, in the middle intertidal zone, one might occasionally find the bloodworm, Euzonus mucronata, and the isopod, Excirolana chiltoni. In the surf line, patches of the sand crab, Emerita analoga, also occur periodically, especially in the summer and fall. The more southern bean clam, Donax gouldii, is found here on rare occasions. The common subtidal species, the spiny sand crab, Blepharipoda, the pismo clam, Tivela, and the purple olive snail, Olivella, sometimes are found in these high energy locations in lowest intertidal zone. Otherwise, the sandy intertidal zone is barren of macroscopic fauna.

The more protected beaches behind kelp beds and headlands have a larger number of sand associated intertidal organisms, but still few compared to the rocks. The portion of Paradise Cove which is well-protected by Point Dume shows the greatest diversity and abundance in the ASBS (see Patterson, 1974, Straughan, 1977). All of the 18 organisms listed in Appendix 6, except for Nerindes acuta, Donax and Tivela have been encountered in the Paradise Cove area, while only those mentioned in the paragraph above (plus Hemipodus borealis and Nerindes) were encountered at the high energy Zuma Beach. Especially abundant at Paradise Code are the blood worm, Euzonus, the sand crab, Emerita, and the purple olive snail, Olivella. They often occur in distinct patches. The beach hoppers, Orchestoidea spp., can be locally abundant any place where rafted kelp accumulates on the beach for any length of time. These species are important as decomposers of this deposited material. These decomposers do not generally occur along Zuma Beach because it is groomed daily by Los Angeles County.

The major fish which occurs on these soft substrate intertidal regions is the grunion, which run at high tide in spring and summer. Grunion runs occasionally occur along the Mugu Lagoon barrier beach, La Jolla and Big Sycamore Beaches, and Zuma Beach. The California corbina, Menticirrhus undulatus forages in the surfline within the ASBS and feeds primarily on the sand crab, Emerita.

The intertidal and subtidal areas of Mugu Lagoon are not part of the ASBS, but the lagoon does have common species which do not occur frequently within the ASBS itself. A number of studies have been done within the lagoon and should be consulted for further information: MacDonald, 1976; MacGinitie and MacGinitie, 1969; Miller, 1977; Straughan, 1977; Warme, 1971. Fishes commonly encountered and breeding within the lagoon are: the spiny dogfish, Squalus acanthias, the round sting ray, Urolophus halleri, and the shovelnose guitarfish, Rhinobatos productus.

Aquatic Birds and Mammals

Numerous aquatic birds are associated with the ASBS, especially along the coastal strand, and in the adjacent Mugu Lagoon. Mugu Lagoon is an integral part of the Pacific Flyway. Over 205 species have been reported in the Pacific Missile Test Center area, including five endangered species (MacDonald, 1976). A list of aquatic birds known to occur over or along the ASBS is given in Appendix 7.

The California sea lion, Zalophus californica, and the harbor seal, Phoca vitulina, regularly occur within the ASBS and are known to haul out at Point Dume and Point Zero. The grey whale, Eschrichtius robustus, occurs within the ASBS between November and March during their annual migration along the coast. They often travel adjacent to and within the kelp beds. Whales have been observed over the sand dollar bed in about 30 feet of water at Zuma Beach and in the surfline at Point Dume.