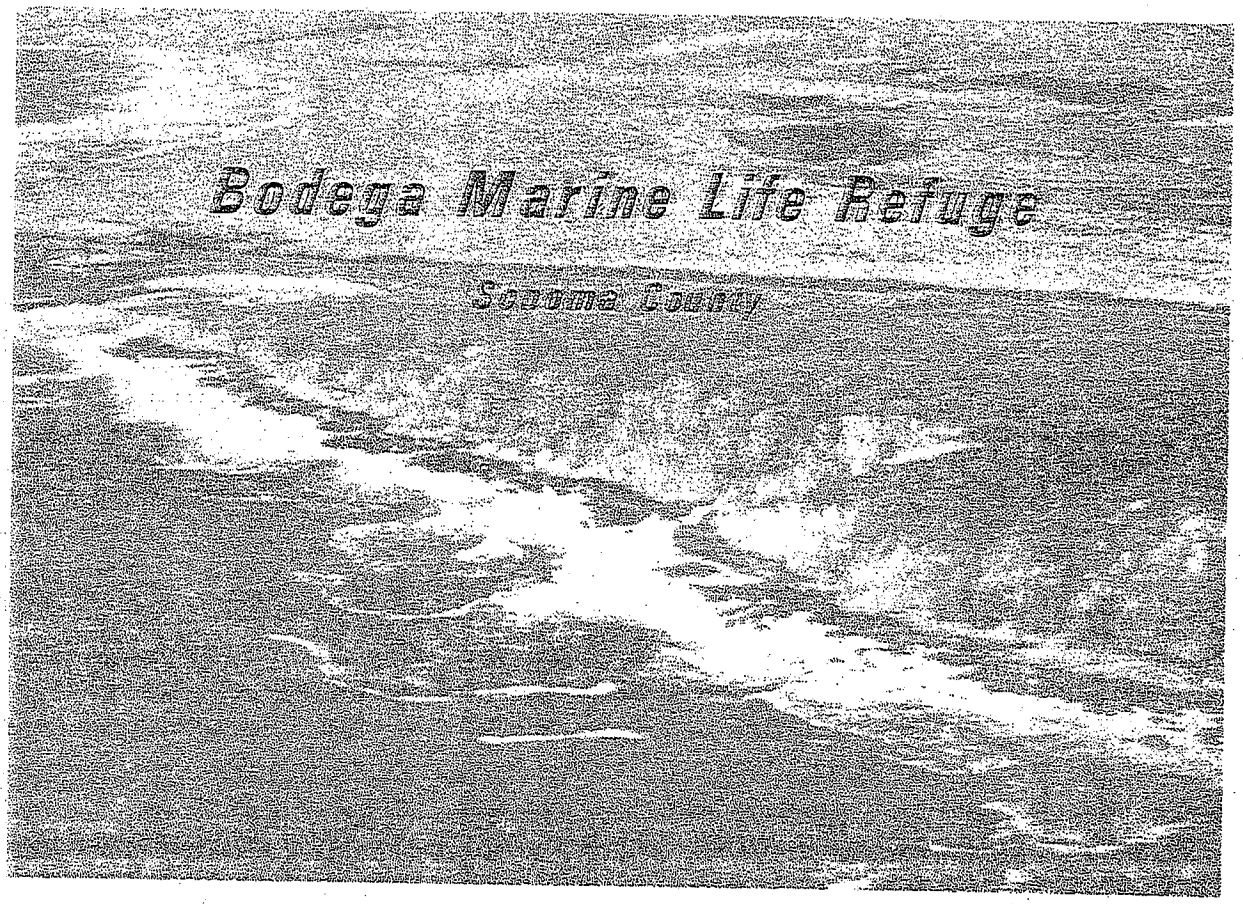
California Marine Waters
Areas of Special Biological Significance
Reconnaissance Survey Report

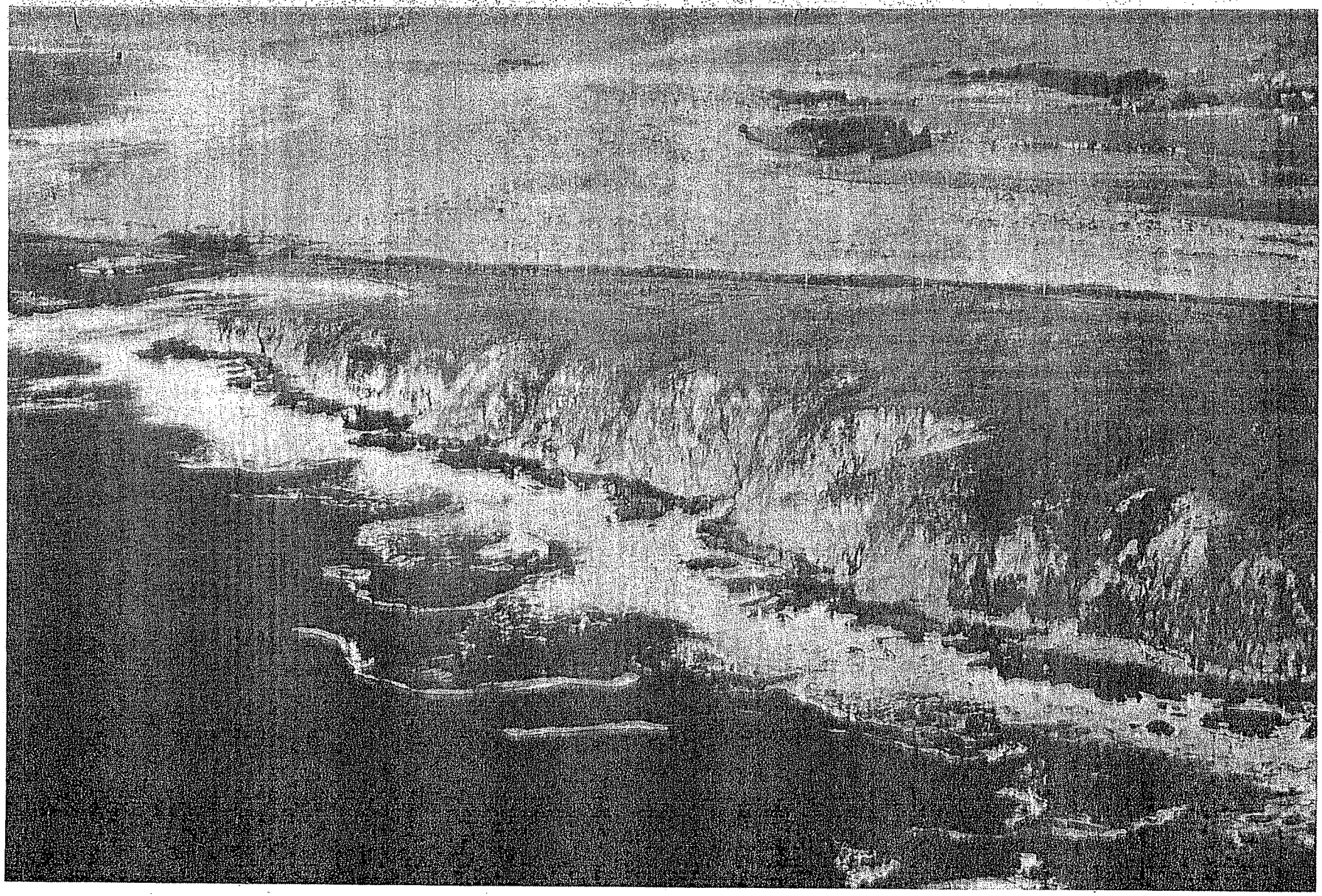


CALIFORNIA STATE WATER RESOURCES CONTROL BOARD
DIVISION OF PLANNING AND RESEARCH
SURVEILLANCE AND MONITORING SECTION

June 1979

WATER QUALITY MONITORING REPORT NO. 79-16

Cover Photograph: Bodega Marine Life Refuge Area of Special Biological Significance



Bodega Marine Life Refuge Area of Special Biological Significance

STATE WATER RESOURCES CONTROL BOARD

AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

Designated March 21, 1974, April 18, 1974, and June 19, 1975

1. Pygmy Forest Ecological Staircase
2. Del Mar Landing Ecological Reserve
3. Gerstle Cove
4. Bodega Marine Life Refuge
5. Kelp Beds at Saunders Reef
6. Kelp Beds at Trinidad Head
7. Kings Range National Conservation Area
8. Redwoods National Park
9. James V. Fitzgerald Marine Reserve
10. Farallon Island
11. Duxbury Reef Reserve and Extension
12. Point Reyes Headland Reserve and Extension
13. Double Point
14. Bird Rock
15. Ano Nuevo Point and Island
16. Point Lobos Ecological Reserve
17. San Miguel, Santa Rosa, and Santa Cruz Islands
18. Julia Pfeiffer Burns Underwater Park
19. Pacific Grove Marine Gardens Fish Refuge and Hopkins Marine Life Refuge
20. Ocean Area Surrounding the Mouth of Salmon Creek
21. San Nicolas Island and Begg Rock
22. Santa Barbara Island, Santa Barbara County and Anacapa Island
23. San Clemente Island
24. Mugu Lagoon to Latigo Point
25. Santa Catalina Island — Subarea One, Isthmus Cove to Catalina Head
26. Santa Catalina Island — Subarea Two, North End of Little Harbor to Ben Weston Point
27. Santa Catalina Island — Subarea Three, Farnsworth Bank Ecological Reserve
28. Santa Catalina Island — Subarea Four, Binnacle Rock to Jewfish Point
29. San Diego—La Jolla Ecological Reserve
30. Heisler Park Ecological Reserve
31. San Diego Marine Life Refuge
32. Newport Beach Marine Life Refuge
33. Irvine Coast Marine Life Refuge
34. Carmel Bay

CALIFORNIA MARINE WATERS
AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

RECONNAISSANCE SURVEY REPORT

BODEGA MARINE LIFE REFUGE
SONOMA COUNTY

STATE WATER RESOURCES CONTROL BOARD

DIVISION OF PLANNING AND RESEARCH

SURVEILLANCE AND MONITORING SECTION

JUNE 1979
WATER QUALITY MONITORING REPORT 79-16

ACKNOWLEDGEMENTS

This State Water Resources Control Board Report is based on a reconnaissance survey report submitted by Dr. Donn A. Ristau, Chris Tarp, and Dr. Cadet Hand of the University of California, Berkeley, in August, 1977.

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The latter report was prepared in fulfillment of an agreement with the California Department of Fish and Game, which has coordinated the preparation of a series of Area of Special Biological Significance Survey Reports for the Board under an Interagency Agreement.

ABSTRACT

The Bodega Marine Life Refuge Area of Special Biological Significance (ASBS) is located near Bodega Head (38°19' N LAT, 123°04' W LONG), approximately 1.7 miles (2.8 km) from the town of Bodega Bay in Sonoma County. About 200 acres (77 ha) of water are included along the 1.8 mile (2.9 km) stretch of shoreline comprising the ASBS.

Bodega Head is mainly a granitic peninsula approximately 1.9 miles (3.1 km) long and 0.5 miles (0.8 km) wide. It is connected to the mainland by a dune-covered stretch that marks the San Andreas Fault zone. The mainland adjacent to Bodega Head is composed of sandstone, shale, chert and conglomerate of the Franciscan Formation. Bodega Head is covered primarily by a coastal grassland-type community consisting of polypody fern, sea pink, lupine, fiddleneck, Italian ryegrass, bull thistle and miner's lettuce. The sand dune area supports dense-to-sparse growths of beach grass, sea rocket, ice plant, lupine, coyote bush, mock heather, beach strawberry, sand verbena and silver beach weed. The climate of the Head is cool Mediterranean, with cool, wet winters and dry, but foggy summers.

The water of the Area can be characterized as a coastal water mass in a transitional zone. The southward-flowing California Current carries northern Pacific and Arctic waters to the area. During the fall, the northward-flowing Davidson Current sweeps the area with warmer water of lower salinity. Mean surface water temperatures usually vary between 57.6°F and 46.4°F (14.2° and 8.8°C). Salinities typically range around 33 to 34°/oo. Water transparency is generally low with 3 to 7 feet (1 to 2 m) vertical visibility, due to the intense wave and swell conditions. Three-fourths of the waves enter the Area from the northwest with heights in excess of 23 ft. (7m) during periods of winter storm activity.

The intertidal zone is composed largely of granitic rock bisected by a number of deep and sheer-walled surge channels. On the extreme northern end of the ASBS, the beach is composed of fine sand and, near the southern portion of the Area, a prominent cove exists with a coarse sand beach. Due to the diversity of intertidal habitat types, a rich fauna and algal flora characterize the ASBS. Conspicuous in the area are the starfish-mussel-barnacle assemblage and the surf grasses, Phyllospadix spp.

Subtidally, granitic rock accounts for an estimated 80 percent of the substrate in the entire Area. Unstable homogenous sandy areas and sand-filled channels account for the remaining 20 percent of the subtidal substrate. Except for surge channels, the bottom topography is fairly uniform near Horseshoe Cove but much more rugged in the northern portion. In waters less than about 23 ft. (7m) deep, algae and vascular marine plants are the dominant competitors for the rocky substrate. In deeper waters, encrusting coralline algae covers large areas of the granitic rock. An extensive species list is contained in the appendix. Marine mammals and birds that inhabit or frequent the area are also discussed.

The prime use of the Area is for scientific study initiated largely out of the Bodega Marine Laboratory of the University of California. Numerous field courses and special studies are carried out in the area. Some recreational seashore activities undoubtedly result from visitors to adjacent public areas.

Water quality threats to the Area are considered minimal at this time. Large spillage of petroleum either in shipping corridors offshore of the ASBS or within Bodega Bay could cause serious problems. Animal grazing on the coastal mountains also could create siltation problems via Salmon Creek.

Unique features of the Area include: 1) Bodega Head is the northern-most exposure of granitic rock along the California coast; 2) it is a transition zone between temperate zone species and typically boreal fauna; and, 3) it is designated "type" locality for several newly described marine species.

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Findings

1. The environment of Bodega Marine Life Refuge ASBS can be classified as pristine and relatively unimpacted by human activity.

2. The limited access and prior status as a marine life refuge are largely responsible for the pristine nature of the area.

3. The marine biota of the ASBS are quite diverse and the area represents an exceptional study site for academic investigations.

4. The existing water quality analysis programs that monitor the area (State and Federal Mussel Watch and Bodega Marine Laboratory's program) are providing valuable baseline information with respect to a wide range of potential pollutants.

Conclusions

1. The Bodega Marine Refuge should retain its designation as an ASBS.

2. The designation of the area as an ASBS will further supplement the environmental protection of the area.

3. The ASBS is unique, in part because of the lack of impact in the area and also with respect to its geologic setting. The ASBS has also recently become important because of the designation of certain portions as the "type" locality for some newly described species.

4. The major foreseeable threat to the character and quality of the ASBS probably lies with increased urban development in the vicinity of Bodega Bay. The effects on the ASBS of increased land use adjacent to the ASBS are impossible to predict; however, it is not known whether the existing buffers that currently protect the area will continue to remain effective.

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 Board's Administrative Procedures, September 24, 1970, Section XI. Miscellaneous--Revision 7, September 1, 1972).

Specifically, the following restrictions apply to ASBS in the implementation of this policy.

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 Bodega Marine Life Refuge ASBS, a reconnaissance survey integrating existing information and additional field study was performed. This 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.

The Bodega Marine Laboratory (BML) welcomed the opportunity to include its ocean fronting area as an ASBS. The Bodega Marine Life Refuge typifies the diverse fauna and flora of Central California and its prior designation as the Bodega Marine Life Refuge (BMLR) had already protected it from the general human pressures common to much of California's shoreline.

Because the University controls access to its ocean property, and because the BMLR also provides protection, the designation of this area as an ASBS seemed well warranted. The goals of Bodega Marine Laboratory, in part, require the preservation of local marine resources for both education and research uses. Concomitant with this goal is the necessity that the flora and fauna be present in as natural and undisturbed a condition as possible. These conditions were well on their way to being established when the area was considered for ASBS status.

The ASBS differs from much of the other nearby coastal marine areas in that its primary substrate is granitic. This, added to its relatively pristine biota, made it a particularly attractive candidate as an ASBS. The added protection given it by this designation helps to guarantee the continued protection of this relatively unique piece of shoreline.

ORGANIZATION OF SURVEY

Techniques used in the development of the floral and faunal lists of this report were based in part on the analysis of existing data and by the generation of new information through field surveys of this area.

Underwater reconnaissance surveys of the ASBS (see Fig. 1) were accomplished by SCUBA diving during 11 days between August 1, 1977 and November 20, 1977. Approximately 38 total hours were logged in the collection of subtidal data. Over 100 additional hours of subtidal research time in the area has been compiled by the various contributing specialists during prior investigations. Data from this previous work has been used in completing the subtidal biota lists. Species identifications for the subtidal list were based in part upon field identifications of morphologically reliable forms, in part on laboratory examinations of collected material and in part on the comparison of collected material with previously identified specimens in the synoptic collection of BML.

The intertidal lists are the result of approximately 40 trips to the ASBS intertidal region during minus tides between the period June 1975 to March 1978.

PHYSICAL AND CHEMICAL DESCRIPTION

Location and Size

The Area of Special Biological Significance (ASBS) is located on Bodega Head (38°19' north latitude, 123°04' west longitude), approximately 1.7 mi. (2.8 km) from the town of Bodega Bay, in Sonoma County, California. The ASBS includes the coastline from 462 yards (420 m) south of Horseshoe Cove to 264 yards (240 m) northeast of Mussel Point (see Fig. 1). Approximately 200 acres (77 ha) of water area are contained in the 1.8 mi. (2.9 km) stretch of shoreline that comprises the ASBS.

The official boundary description, as stated in the California State Water Resources Control Board publication Areas of Special Biological Significance (1976), is as follows:

> "Ocean waters within that portion of District 10 consisting of that certain parcel of land bounded by the line of mean high tide of the Pacific Ocean lying between the northern boundary extended northwesterly and the southern boundary extended southwesterly of the lands of the Regents of the University of California according to the final order of condemnation in Case No. 47,617 in the Superior Court of the State of California in and for the County of Sonoma, recorded in Book 1930, at pages 656 and 659, inclusive, Office Records, Sonoma County, California, and extending into and including the state waters of the Pacific Ocean from the line of mean high tide."

Bodega Head is mainly a granitic peninsula approximately 1.9 mi. (3.1 km) long and 0.5 mi. (0.8 km) wide. It is connected to the mainland by a dune-covered stretch of land that marks the zone of the San Andreas Fault (see Fig. 2). The fault zone in this area is 1.5 mi. (2.4 km) wide. Although lateral movement of 7 to 10 ft. (2 to 3 m) occurred in the area as a result of the 1906 San Francisco Earthquake, relatively little move-

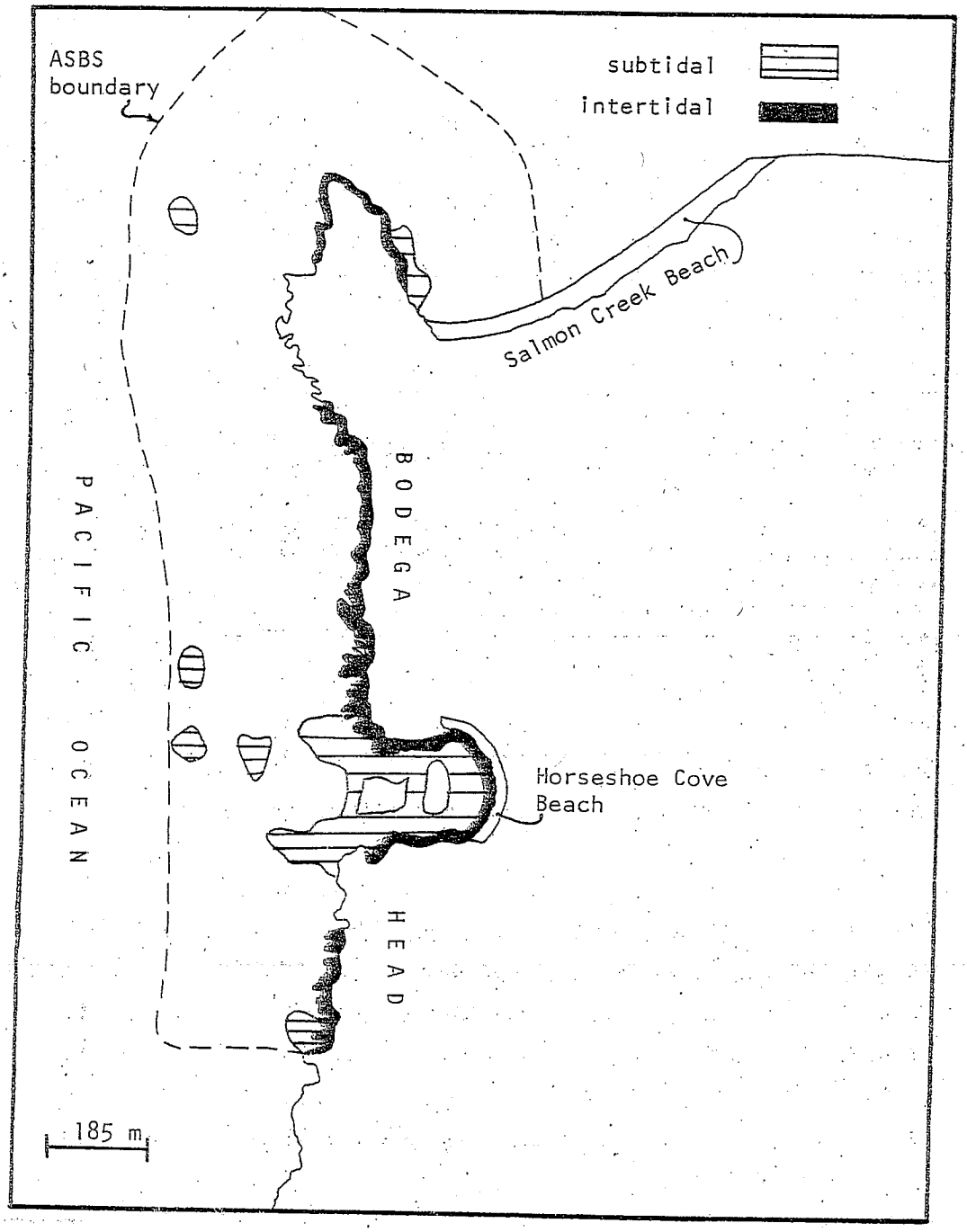

FIGURE 1: Extent of the Bodega Marine Life Refuge ASBS of Sonoma County and Areas Surveyed

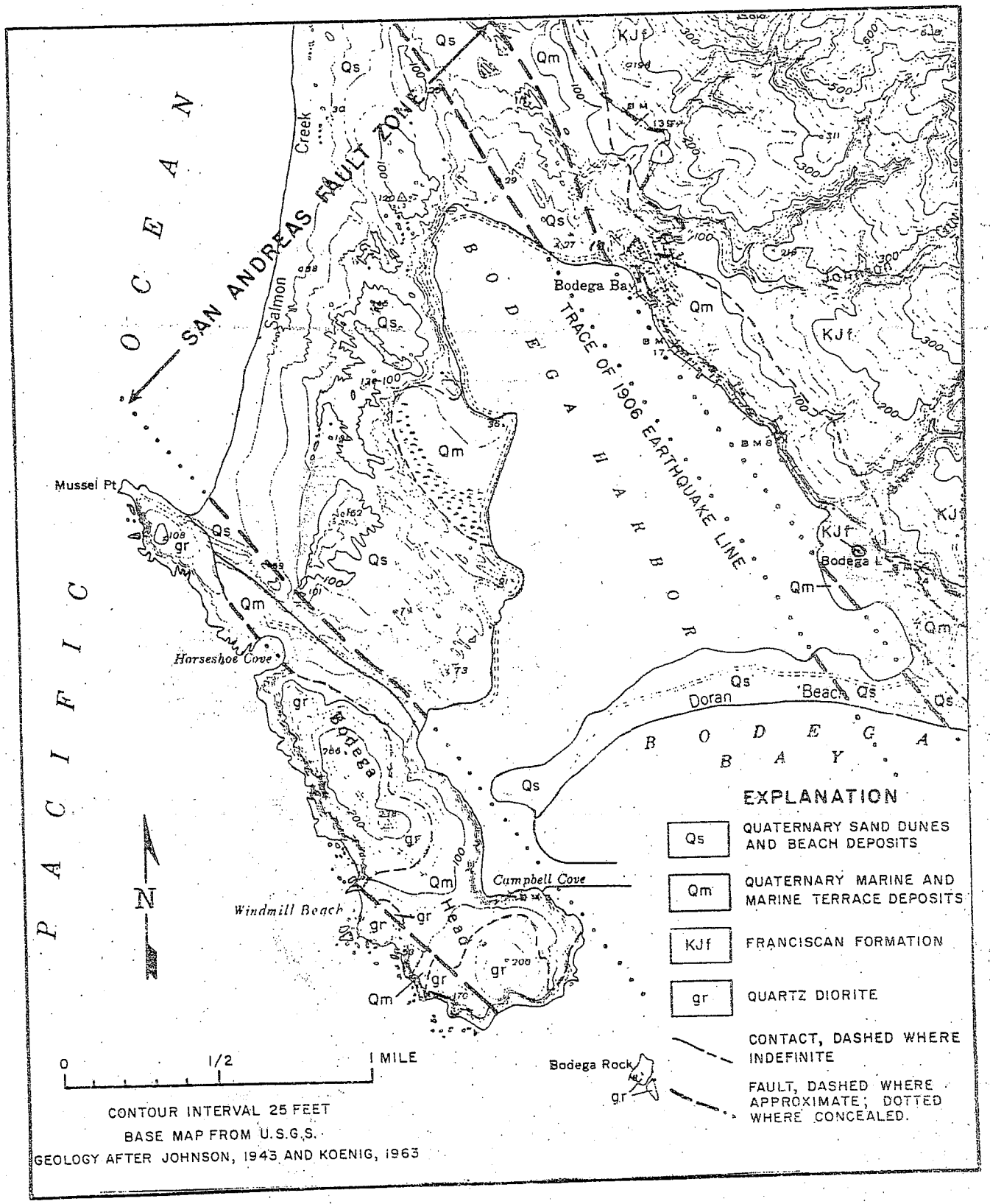

FIGURE 2: GEOLOGIC MAP OF BODEGA HEAD, SONOMA COUNTY, SHOWING SAN ANDREAS FAULT ZONE. From Koenig 1963.

ment has been detected along this portion of the fault zone within the past 70 years.

Nearshore Waters

Bodega Head is subjected to intense wave activity. The average daily wave height for the area is approximately 8.2 ft. (2.5 m) (Ristau 1977). During periods of winter storm activity, waves with heights of 16 to 23 ft. (5 to 7 m) are not uncommon, and waves up to 33 ft.(10 m) high have been observed occasionally in the area. The presence of a subtidal sill across the mouth of Horseshoe Cove at about 20 ft. (6 m) depth tends to reduce the intensity of wave action in the cove. Waves, however, do enter the cove and are frequently 5 to 7 ft. (1.5 to 2.0 m) high. Wave activity is usually more pronounced on the northwest side of the cove. Seventy five percent (75%) of the swells in the Bodega Head area approach from a northwest or west-northwest direction and have periods of 8 to 12 seconds (MacFarlane 1971). Waves with a 10 second period generally have deep-water wavelengths of 260 ft. (80 m) and subsequently begin to feel wavebase at depths of approximately 100 ft. (30m). Thus, bottom material 1100 yards (1000 m) offshore may be affected by the majority of waves striking Bodega Head. Winds in the area are generally out of the northwest and average 8 to 10 mph. Storm-induced winds normally approach from the southwest or southeast and commonly have velocities of 40 mph. Because of the prominent wave and wind activity, the water in the ASBS is normally very turbid. Visibility (measured in a vertical direction) is usually only 3 to 7 ft. (1 to 2 m). Days when the visibility may reach 33 to 39 ft. (10 to 12 m) are rare and generally occur during fall months.

Coastal current velocities and directions are largely influenced by local wave activity. The prevailing current direction along Bodega Head is from north to south. However, depending upon the size and direction of swell, localized gyres may develop off certain areas of Horseshoe Cove. Hamby (1964) has suggested that a northward-flowing longshore current

may also exist off Bodega Head. Longshore current velocities are usually in the range of 0.25 to 1.0 knots.

As a result of the generally poor visibility, strong currents, and large predators that may frequent the area, skin and SCUBA diving and other water activities in the ASBS may be rather treacherous. Diving in the ASBS is restricted and requires a University of California research certification.

The seawater of the area can be characterized as a coastal water mass in a transitional area (Davis 1972). The coastal water is apparently influenced by the subarctic Pacific and Eastern North Pacific Central water masses, which are carried into the area by the southward flowing California current (Sverdrup et al. 1942). Salinities in the area are generally constant and range from $33^{o}/oo$ to $34^{o}/oo$ throughout the year. Periods of maximum temperature generally occur during the months of August and September. Periods of minimum temperature occur during March, April or May, depending upon the occurrence of localized upwelling. Upwelling in the area results from strong northwest or northeast winds, which displace coastal surface water offshore and drive deeper, nurtient-rich water to the surface. The Davidson Current, a northward-flowing, warm, low-salinity current, is usually evident off this area during the fall months of October and November.

The tides in the area are semi-diurnal (two high and two low tides per day). Tidal heights for 1977 ranged between a maximum of 6.8 ft. (2.1 m) and a minimum of -1.8 ft. (-0.55 m).

The waters of the ASBS may be influenced in the winter by sediment and fresh water from the Russian River which empties into the ocean about 9 mi. (15 km) north of the area. The Russian River has a drainage basin of about 1,486 square mi. (3,850 square km) and the average annual runoff has been estimated at 1,510,000 acre-feet (1,863 cubic hectometers) (Standing et al. 1975). Other drainages near Bodega Head (Salmon Creek, American Creek, Stemple Creek) drain small areas of predominantly undeveloped grazing land and probably have little effect on the coastal waters of the

ASBS, except during periods of intense rainfall. Salmon Creek drains an area of 35 square miles (90 square km) and has its mouth 2.3 mi. (3.7 km) north of Mussel Point. American Creek (Estero Americano in its lower reaches) lies 2.9 mi. (4.6 km) to the southeast of Bodega Head and drains an area of 37 square miles (97 square km). Further south, and also emptying into Bodega Bay, is Stemple Creek (Estero de San Antonio), which has a 54 square mile (140 square km) watershed. There are no major drainage outlets within the ASBS itself.

The BML takes water from Horseshoe Cove to operate its study facilities. After use, the water is discharged in and near the Cove. Figure 3 shows the locations of the intake and discharge structures, and also shows locations where water quality monitoring is performed.

Sampling stations are located 110 yards (100 m) north of the BML seawater return, in the mixing zone of the discharge, and 110 yards (100 m) south of the discharge. Data from daily and weekly sampling were tabulated into monthly averages for several water quality parameters. Figure 4 demonstrates that, during 1977, the pH within the mixing zone was generally lower than at the other two sampling points; mixing zone pH ranged from about 8.05 to about 8.18. The pH of the North station averaged higher than in the mixing zone; North stations pH ranged from about 8.05 to about 8.25. The South station had the highest average pH of the stations mentioned; there the pH range was about 8.06 to about 8.28.

Figure 5 shows average nonfilterable residue data for the three stations. Interestingly, the mixing zone residues were generally lower at the other two stations. Lower dissolved solids concentrations in the mixing zone implies that the BML discharge may not be quite as saline as the surrounding ocean waters.

Figure 6 presents organic nitrogen data. The mixing zone generally had the highest organic nitrogen of the three stations. This is an indication that algae concentrations in the BML discharge may be generally somewhat higher than in the surrounding waters.

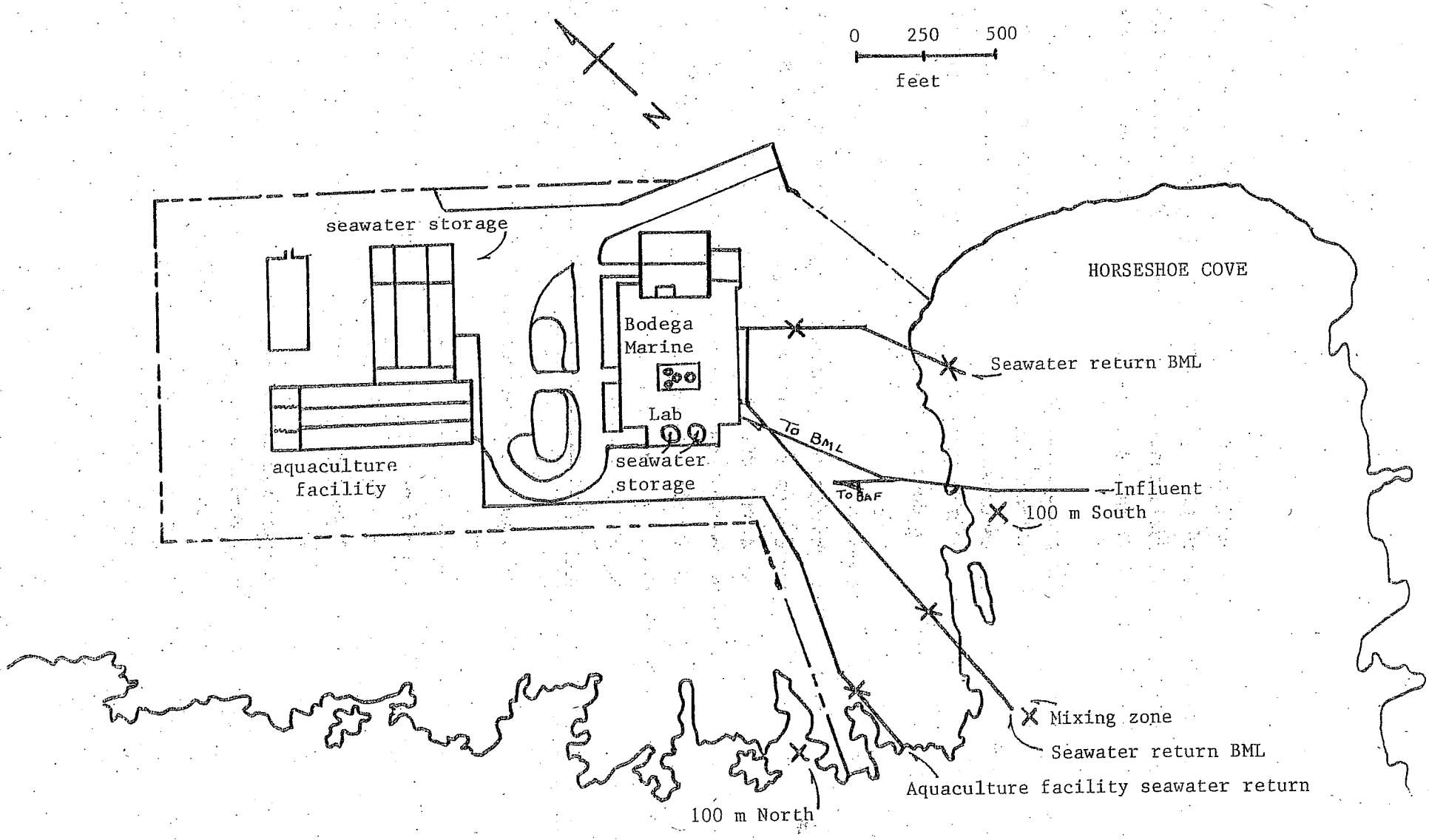

FIGURE 3: Locations of Bodega Marine Lab and Aquaculture Facility Showing Discharge Sites and Sampling Locations ×

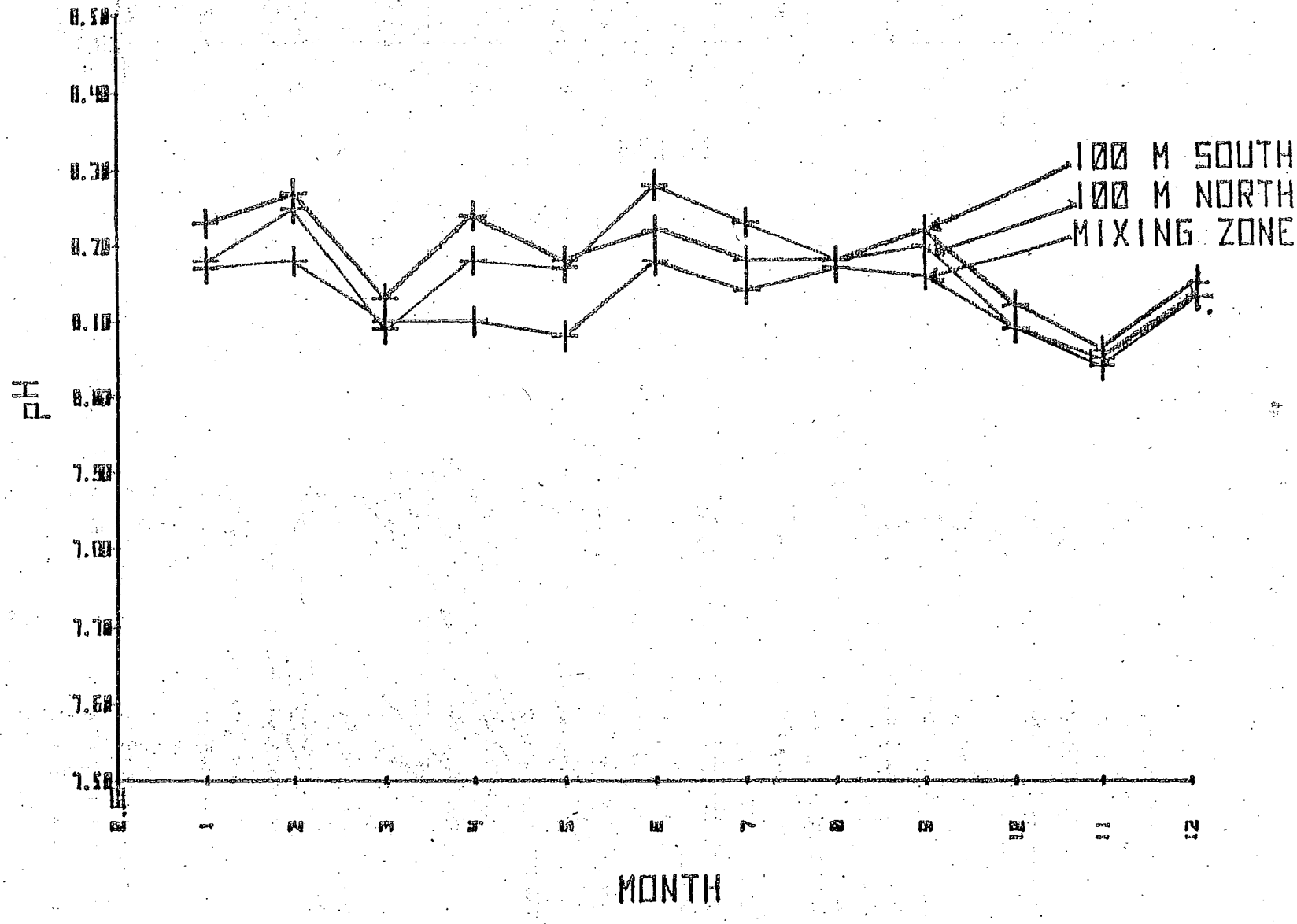

FIGURE 4: Receiving waters monthly mean pH for calendar year 1977. Samples were taken 100m north and 100m south of the Marine Lab's seawater discharge mixing zone.

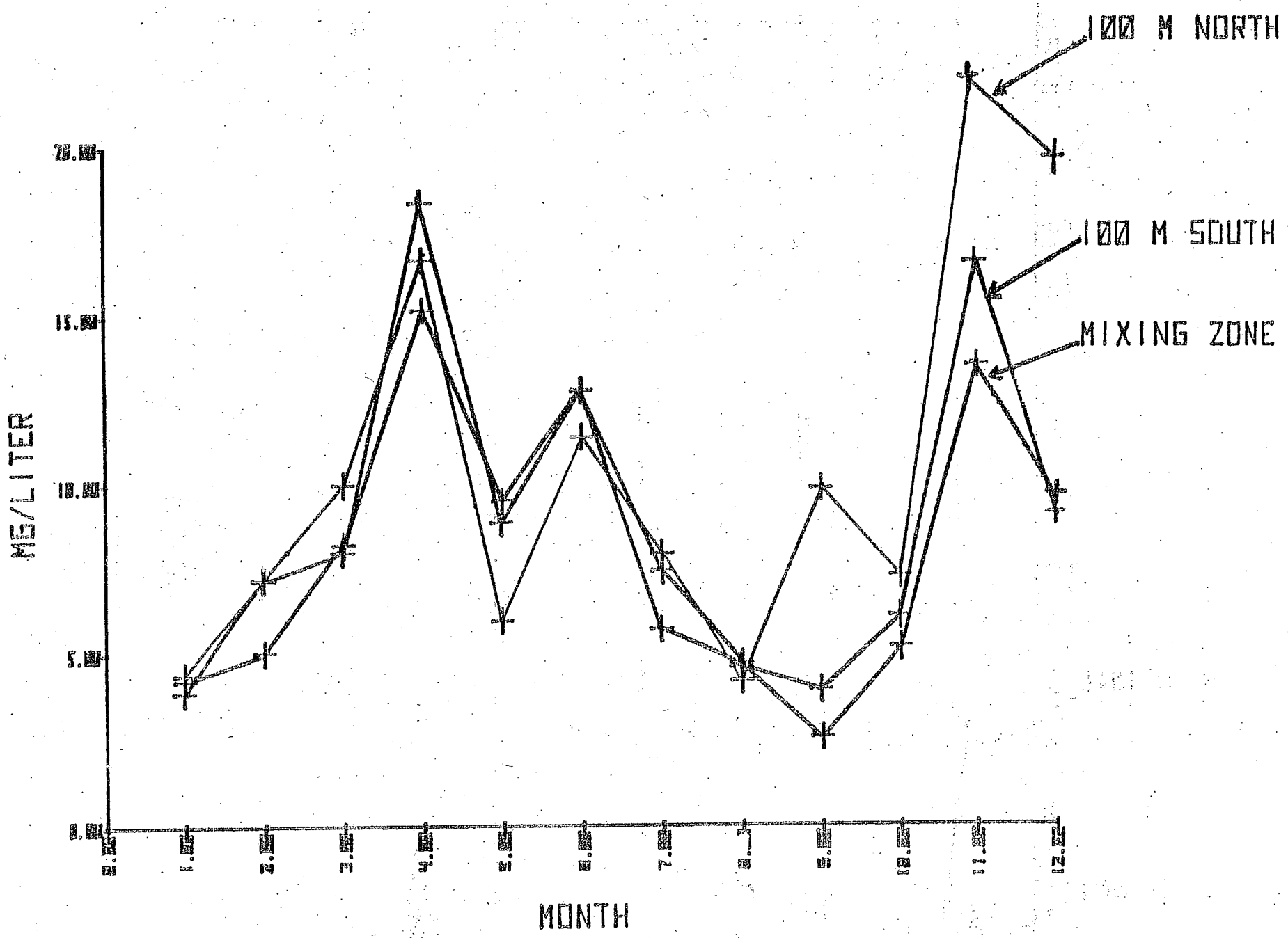

FIGURE 5: Receiving waters monthly mean nonfilterable residue for calendar year 1977. Samples were taken 100m north and 100m south of the Marine Lab's seawater discharge mixing zone.

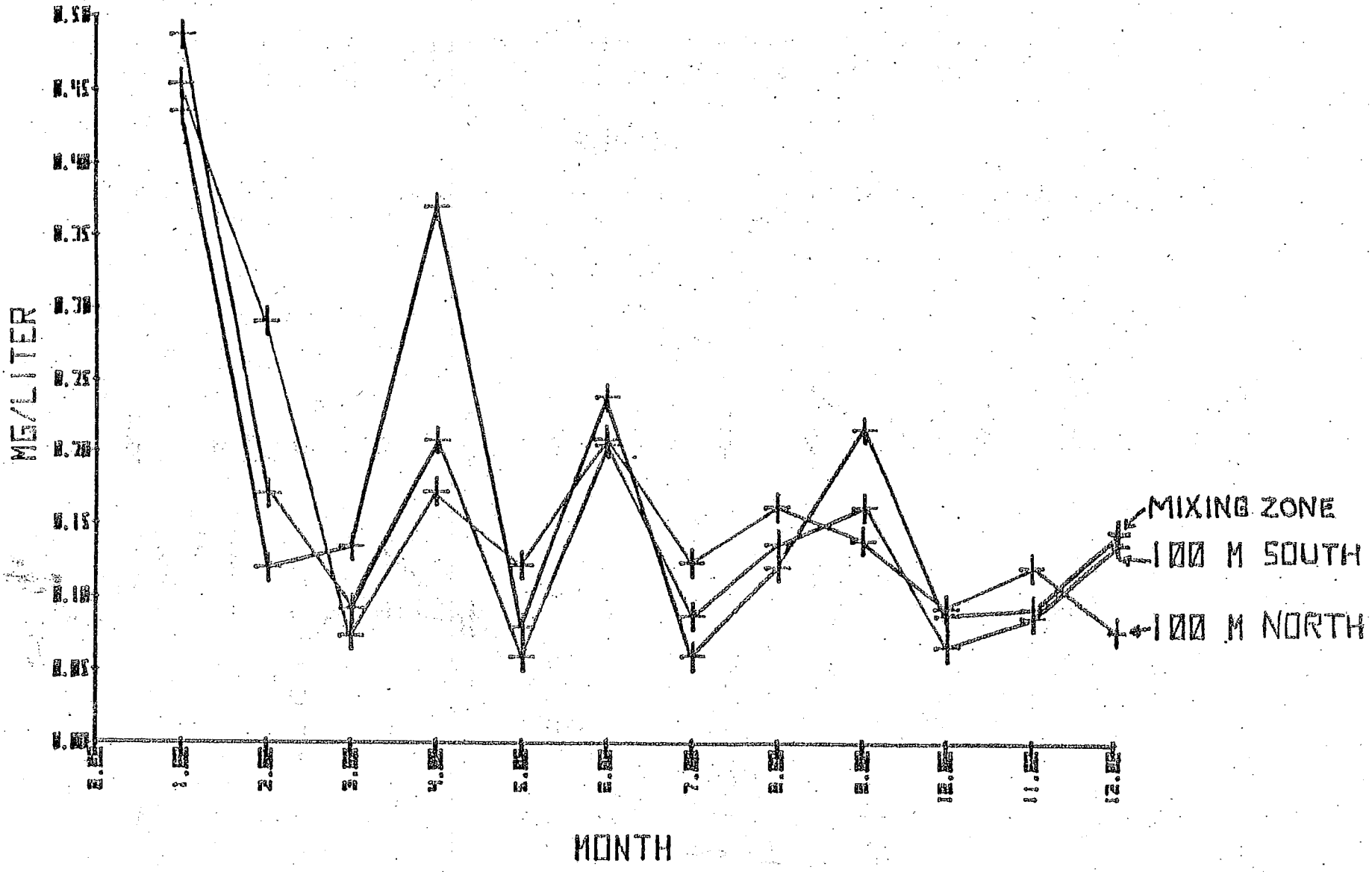

FIGURE 6: Receiving waters monthly mean organic nitrogen for calendar year 1977. Samples were taken 100m north and 100m south of the Marine Lab's seawater discharge mixing zone.

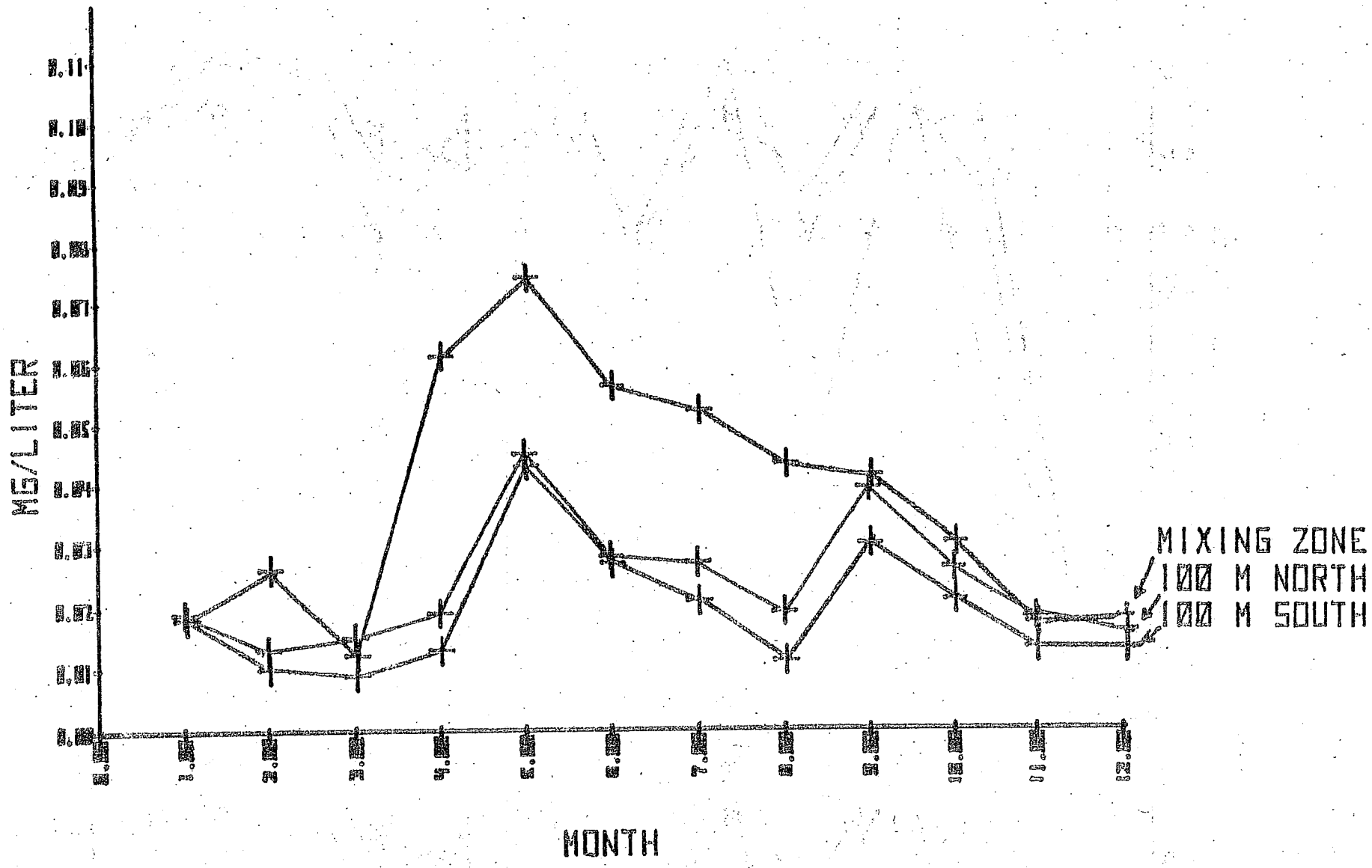

FIGURE 7: Receiving waters monthly mean ammonia nitrogen (NH_3NH_4+-N) for calendar year 1977. Samples were taken 100m north and 100m south of the Marine Lab's discharge mixing zone.

Ammonia Nitrogen data presented in Figure 7 indicate that, between March and September 1977, the mixing zone had considerably higher ammonia concentrations than did the other stations. Similarly, nitrate nitrogen concentrations were generally higher in the mixing zone (Figure 8). These data imply that the nutrient content of the BML discharge is higher than in surrounding waters.

Figure 9 demonstrates that, until June 1977, mixing zone temperatures were generally about 1.5°F (0.8°C) higher than at the other stations. Presumably the BML discharge is warmer than the receiving waters. For further information, see Barbour et al. 1973.

Topographic and Geomorphic Characteristics

The mainland adjacent to Bodega Head is composed of sandstone, shale, chert and conglomerate of the Franciscan Formation (Koenig 1963). These rocks form part of the Coast Range foothills and rise to an elevation of approximately 700 ft. (213 m) in the area near Bodega Bay. Portions of these foothills are being developed as sites for single-family residences. The undeveloped sections support coastal grasslands and are grazed by livestock.

The granitic rock of Bodega Head is quartz diorite (granodiorite), an intrusive igneous rock composed largely of plagioclase feldspar, quartz, hornblende and biotite. In composition and appearance, the granodiorite of Bodega Head is similar to the granitic rocks of Point Reyes, Tomales Point and the Farallon Islands (Koenig 1963). These rocks are all considered to be part of the Coast Range Batholith and have been potassium/argon dated at 80 to 90 million years old (Koenig 1963). Structurally, Bodega Head appears to be an extension of the Point Reyes granitic block and represents the northern-most exposure of granitic rock, west of the San Andreas Fault, along the California coastline. The granodiorite of Bodega Head is highly sheared and faulted, cut by two major sets of joints and intruded by pegmatite, aplite, and lamprophyre dikes (Koenig 1963). The maximum elevation of Bodega Head, 266 feet (81m), is located near the southern limit of the ASBS.

Quaternary marine terraces overlie portions of the Bodega Head granodiorite. These deposits consist of sands, silts, gravels and minor

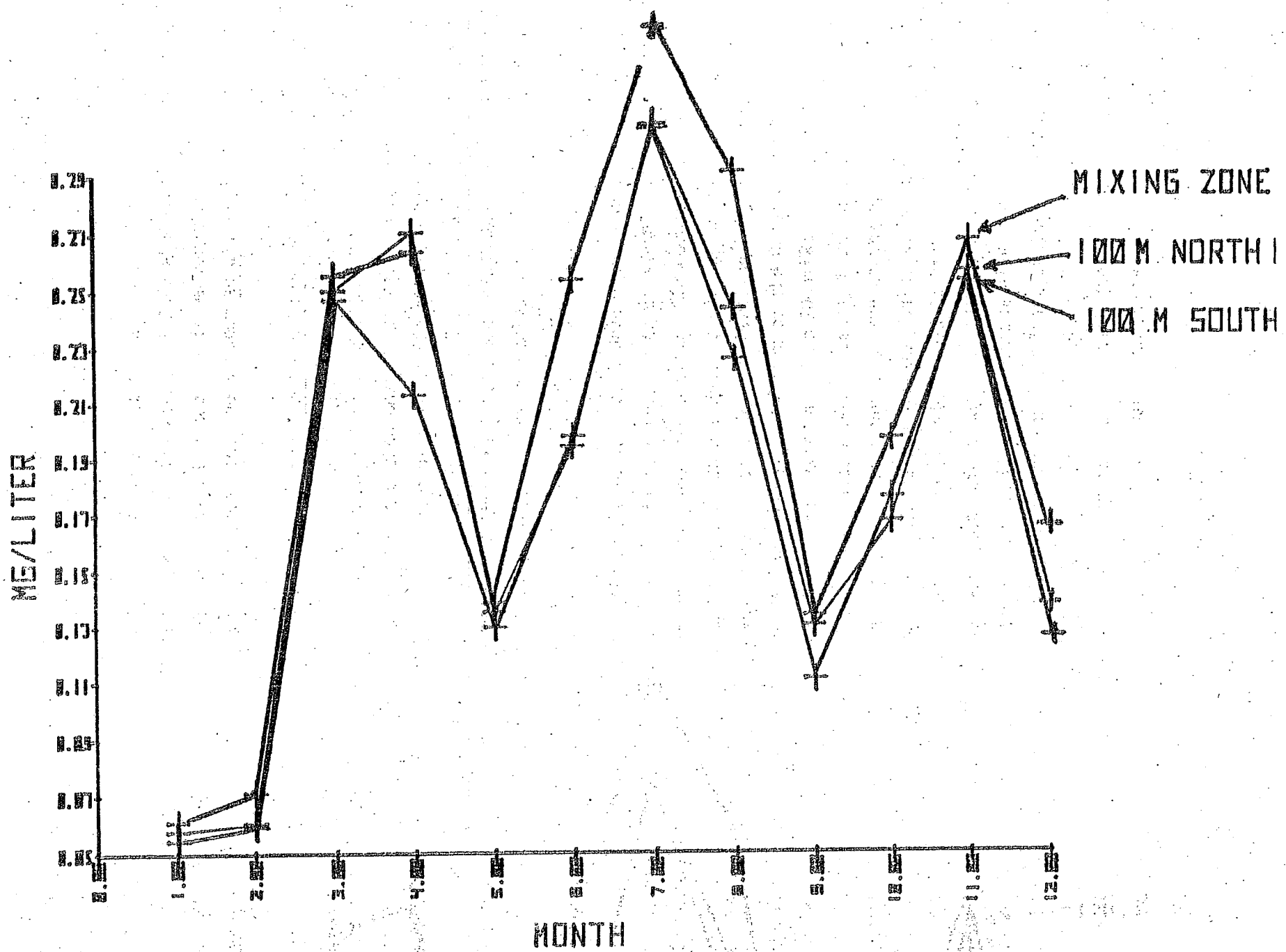

FIGURE 8: Receiving waters monthly mean nitrate nitrogen (NO_3-N) for calendar year 1977. Samples were taken 100m north and 100m south of the Marine Lab's seawater discharge mixing zone.

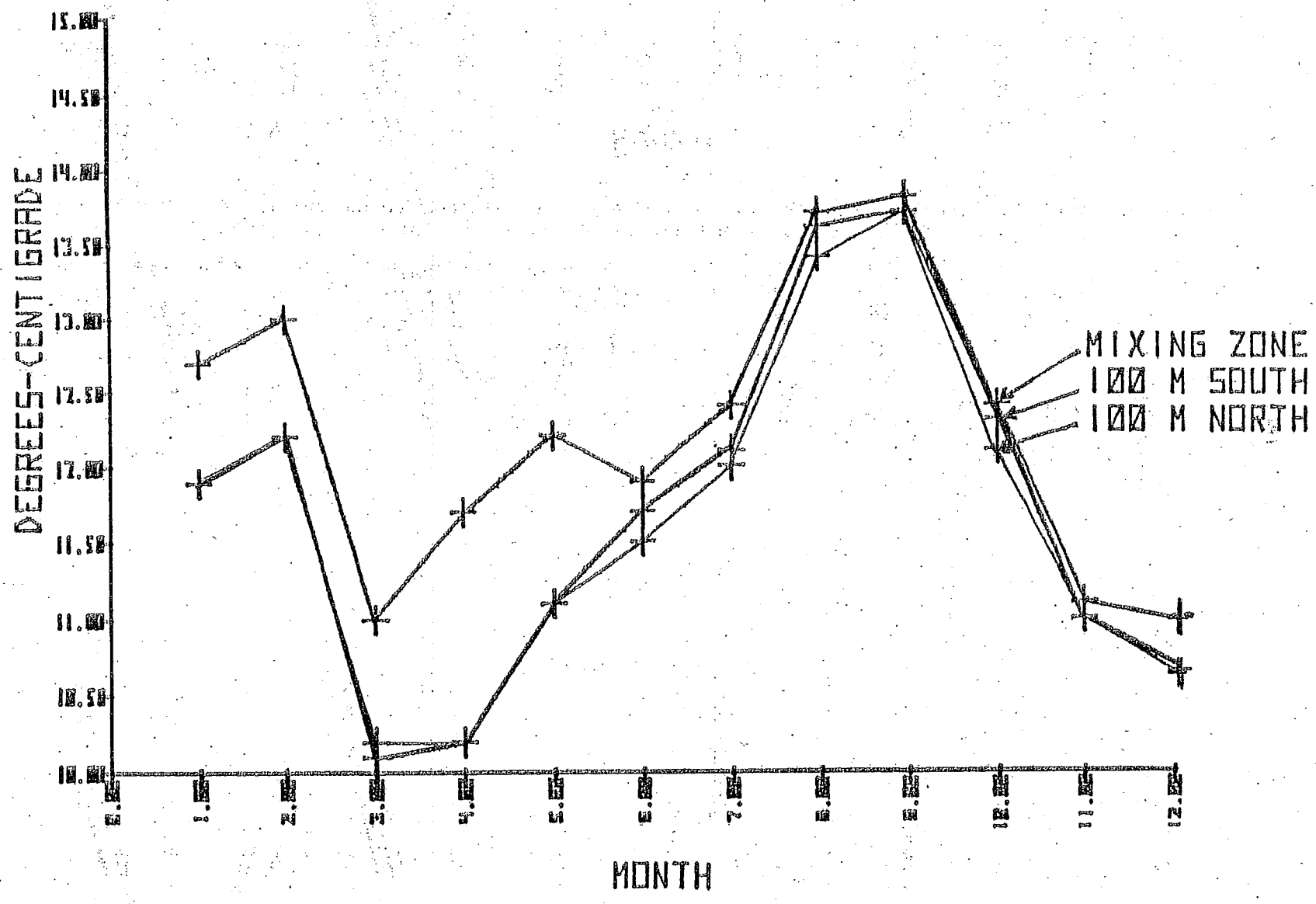

FIGURE 9: Receiving waters monthly mean temperature for calendar year 1977. Samples were taken 100m north and 100m south of the Marine Lab's seawater discharge mixing zone.

amounts of clay. The Quaternary deposits are considered to have been laid down on a shallow submarine surface, and the thickest sedimentary exposure on the Head measures about 128 ft. (39 m) (Koenig 1963).

Horseshoe Cove is one of the more prominent features of the Bodega Head Peninsula. The cove marks an area where the granitic basement rocks have been breached. The occurrence of a major zone of weakness, produced by faulting and jointing, may offer one explanation as to the origin of breaching in this area.

The northwest and southeast sides of Horseshoe Cove consist of granitic rocks that have been partially terraced by wave activity. The northeast end of the cove terminates as a sandy pocket beach, which is bounded by a 10 to 16 ft. (3 to 5 m) high cliff of slightly tilted Quaternary marine sediments. The sand of the pocket beach is a bimodal mixture of a coarse-grained fraction (-0.77 phi), derived from the granitic rocks of the Head, and a fine-grained fraction (2.52 phi), derived from mainland Franciscan material (MacFarlane 1971). The cove is approximately 460 ft. (140 m) wide and reaches a maximum depth of 30 ft. (9 m) near its mouth on the southeast side. Portions of the bottom of the inner cove area are entirely sandy, while the remaining inner areas and the central and outer areas of the cove are floored by granitic rock and occasional sand patches. The intertidal and subtidal granitic rock of the ASBS is dissected by numerous surge channels which predominately follow the major trends of jointing. Surge channels in intertidal and shallow subtidal areas at depths up to 15 ft. (5 m) are commonly floored with either medium to coarse-grained sand or granitic cobbles. A fine to medium-grained sand usually floors the surge channels and larger joints in the deeper offshore areas where depths range from 15 to 40 ft. (5 to 13 m). The intertidal and subtidal substrate of the section of Salmon Creek each included in the ASBS has been mapped as a fine sand (Welday and Williams 1975).

Granitic rock accounts for an estimated 80% of the subtidal substrate in the entire area. Unstable, homogeneous sandy areas and sand-filled channels account for the remaining 20% of the subtidal substrate. The rock-to-sand ratio for intertidal areas is estimated at 9 to 1.

Except for the surge channels, the bottom topography near Horseshoe Cove is fairly uniform. It appears that this area, to at least 1,000 ft. (300 m) offshore, was terraced by wave action during a lower stand of sea level. Vertical topographical relief in the area is usually on the order of 3 to 7 ft. (1 to 2 m). The intertidal and subtidal topography near the northern portion of the ASBS (west of Mussel Point) is much more rugged than the area near the cove; in the northern portion, well-defined, wave-cut features are not as evident. Subtidal topography west of Mussel Point consists of ridges and channels that often have 10 to 15 ft. (3 to 5 m) of vertical relief. The lack of wave-cut features in this area suggests that this portion of Bodega Head may be tectonically more active than the area near Horseshoe Cove. Figure 10 shows a generalized distribution of subtidal sediment and rock in the ASBS.

Sand distribution in the area appears to be in a continual state of flux. Maximum sand abundance on Horseshoe Cove beach and in shallow subtidal areas normally occurs during the months of July and August; minimum sand cover usually occurs in January or February. The annual deposition/erosion cycle in the shallow subtidal areas of Horseshoe Cove usually shows a variation of 3 to 5 ft. (1.0 to 1.5 m) in sand height. Superimposed on the annual cycle are minor, short-term fluctuations in sand height that generally range from 12 to 28 inches (0.3 to 0.7 m). The short-term fluctuations may be due to several factors such as local swell intensity, and direction of swell, and tidal range. These short-term sand movements, together with periodic annual movements, markedly affect the nature and degree of exposed subtidal and intertidal substrate.

Climate

The climate of the Bodega Head area is considered to be cool Mediterranean, typified by cool, wet winters and dry, foggy summers (Barbour et al. 1973). September is usually the warmest month, with a mean temperature of 62.6°F (17°C). December is usually the coldest month with a mean temperature of 50.9°F (10.5°C). Annual temperatures generally range from 40.1°F to 76.1°F (4.5°C to 24.5°C). Snow and frost occur infrequently. Fog is seasonal, occurring on approximately 10% of

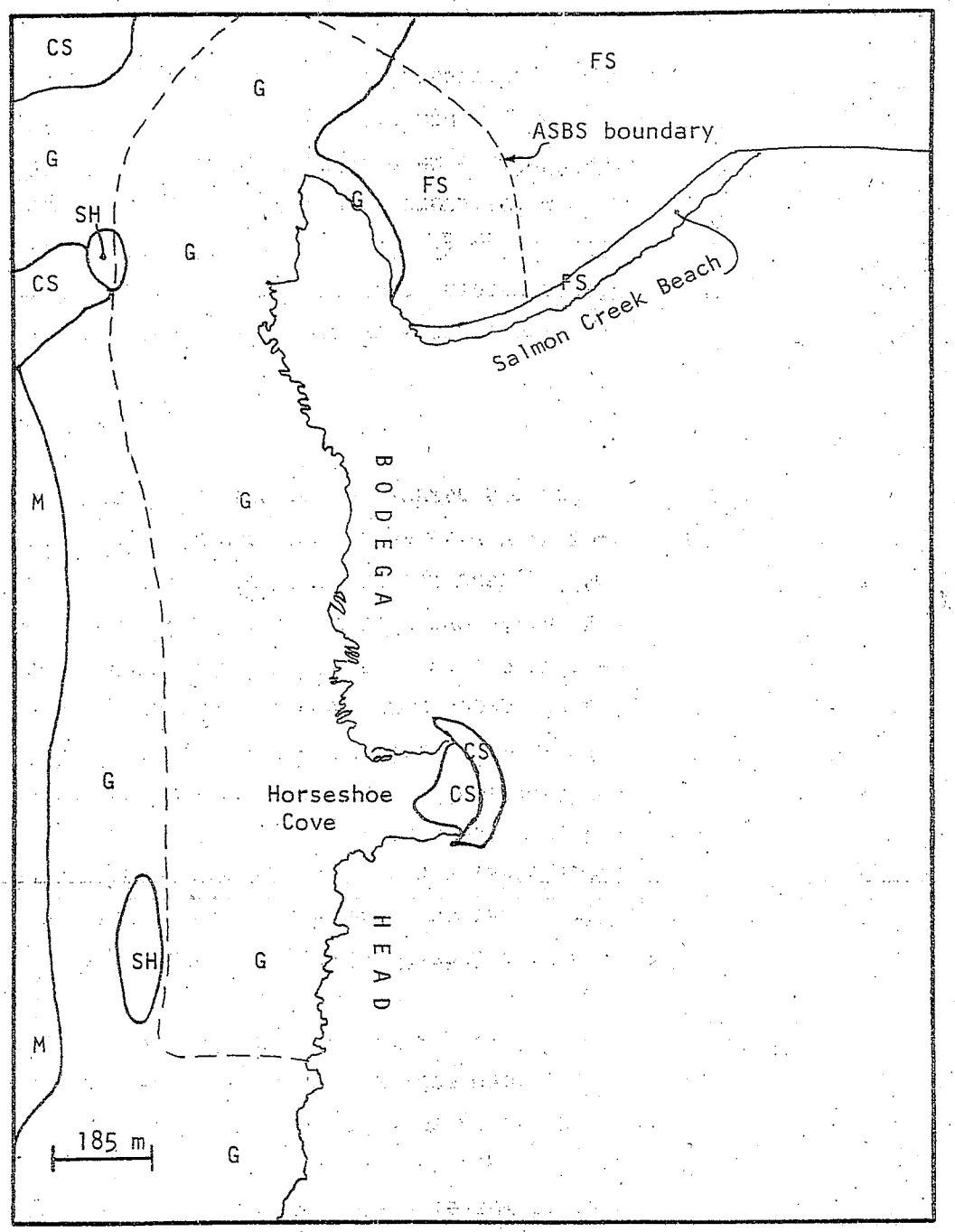

FIGURE 10 SEDIMENT AND ROCK DISTRIBUTIONS AROUND HORSESHOE COVE. From Welday and Williams 1975.

SH: shell material CS: coarse sand

G: granite M: mud FS: fine sand

the winter days and 80% of the summer days. Rainfall averages 32 inches (80 cm) a year; 90% of this precipitation occurs between October and April.

BIOLOGICAL DESCRIPTION

Subtidal Biota

The biota of the shallow subtidal zone is dominated by individuals from 12 groups (12 phyla*). The shallow subtidal zone is considered to include depths ranging from 1 to 40 ft. (0.3 to 13 m). The dominant groups are comprised of the marine plants (Divisions Chlorophyta, Phaeophyta, Rhodophyta and Tracheophyta), sponges (Porifera), Cnidaria, Ectoprocta, segmented worms (Annelida), Mollusca, Arthropoda, spiny-skinned animals (Echinodermata), sea squirts (Chordata), fishes (Chordata), birds (Chordata) and marine mammals (Chordata). Mammals and birds have been included as members of the subtidal and intertidal communities because of their utilization of these areas in foraging, nesting, resting, or migrating activities. A brief ecological discussion of each of these groups will be presented.

Most plants and animals of the major groups are characteristic of rocky areas and appear to represent the dominant competitors for substrate and resources in the area. The biota of the sand bottom areas of the subtidal zone is generally sparse, especially in Horseshoe Cove, because of the unstable and transitory nature of the sand substrate.

The pelagic (non-attached) component of the subtidal fauna has been difficult to comprehensively define because many pelagic individuals are seasonal in occurrence or are difficult to observe because of their mobility. Pelagic larvae from most local species are commonly present in the ASBS, but are not readily observable. Very little information concerning the larval component of this area is available, although some data are presented by Hand (1966). Observable members of the pelagic component consist primarily of cnidarians, fish, birds and mammals.

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*Note: The Divisions of the marine plants are considered equivalent to the level of Phylum.

In terms of community structure, species relationships, and interdependence, it is conceivable that the smaller or occasionally-occurring species may be as important in regulating the community balance as the larger or more common species. For this reason, the floral and faunal lists presented are intended to be as detailed as possible and not necessarily restricted to the common larger forms. Although the microfloral and macrofaunal components of the shallow subtidal zone undoubtedly play a significant role in developing and maintaining the energetics of the community, a study of these micro-organisms is beyond the scope of this investigation and, therefore, they have not been included in the biota list.

Data on composition and distribution of the subtidal biota are scarce, as very little previous research has been done on this area. A few of the major groups from the area (marine plants, sponges, moss animals, fishes) have recently been extensively studied, and the distribution of species from these groups is fairly well established. However, other common, community-dominant groups of the area, especially the sea squirts and to some extent the cnidarians, have not been studied in any detail. The species lists presented for such groups predominantly consist of the better known forms; it should be noted that extensive and taxonomic and distributional studies are needed.

Species abundance ratings in the biota list have generally been given as either "common" or "occasional". In the Marine Mammals list, the term "rare" is used in addition; and in the list of birds, abundance is shown as either "common" or "uncommon", consistent with usual bird distributional categories. Rarely occurring subtidal species have been considered as occasional in occurrence. Abundance ratings are qualitative, and based in part upon the contributing specialist's familiarity with the species in this area. Seasonally occurring forms have been most difficult to rate because of their abundance fluctuations throughout the year. Abundance ratings for seasonal species relate to peak periods of occurrence (Appendix 1).

As well as seasonal changes in abundance, long-term fluctuations in species composition may occur in the area. These fluctuations may be cyclical or non-cyclical and brought about by natural alterations in the character of the localized water mass, by changes in substrate availability, or by changes in competitive interactions. Minor, long-term compositional fluctuations have been noted in the sponges, (Porifera), and presumably may occur in other groups.

All species listed were not necessarily noted during the short investigative period of this report (August 1977 to November 1977). The biota list contains species that have been previously observed or are known to reside in the ASBS (Appendix 2).

While some of the listed species may be small, occur in semi-cryptic environments, or occur rarely, the majority of species are observable during reconnaissance SCUBA diving investigations.

Marine Plants: Marine plants (both algae and rooted plants) are prominent members of the ASBS subtidal community. This autotrophic group appears to represent the dominant competitor for rock substrate in shallow subtidal areas of 1 to 20 ft. (0.3 to 6 m). Although the diversity of plant species decreases markedly below the 25 ft. (7.6 m) depth, encrusting coralline algae still covers large areas of granitic bedrock in the deeper regions of the ASBS.

Factors affecting the distribution of subtidal algae are not as obvious as those determining intertidal zonation. In comparison to the intertidal environment, subtidal habitats experience only small fluctuations in environmental conditions. Among the parameters which are generally thought to be important determinants of subtidal algal distributions, and which are relevant to the portions of Bodega Head involved in this study, are: variation in light quality and intensity with depth; type and stability of substrate; wave exposure; and predation.

Light intensity decreases with depth because of scattering and absorption by the water and by suspended organic and inorganic materials

in the water. The nearshore waters of Bodega Head are commonly clouded with suspended material. This turbidity results in poor light penetration, which is in turn reflected in a small algal standing crop. The greatest standing crops found during this survey were shallower than 20 ft. (-6 m). Suitable substrates deeper than 33 ft. (10 m) are only sparsely occupied. Variation in the spectral composition of light with depth is also often cited as a controlling factor of algal zonation. Generally, green and brown algae occur in greatest abundance in the intertidal and shallow subtidal zones. The red algae, which are better adapted to utilize longer wavelengths of light, are more commonly found in deeper water or shaded shallow areas, where shorter wave length light is lacking.

Types of substrata are important to marine plant growth. Solid rock usually offers greatest growth potential. Sandy or silty areas are less favorable to growth because sediment substrates generally are not stable. The sediment in these areas may be brought into suspension during periods of high wave action, resulting in the abrasion of the algae. In the absence of extreme wave surge activity, boulders or cobble-bottoms may provide favorable habitats for plant colonization.

In areas subject to extreme exposure and wave shock, only the most robust forms of plant cover can exist; typically, these would include the brown algae or the phanerogram, Phyllospadix scouleri. Wave and surge action may also reduce algal growth in these areas through the movement of boulders and cobbles and through abrasion by suspended material.

Aggregations of algal predators (i.e. the giant red urchin, Strongylocentrotus franciscanus) may reduce large areas of suitable plant substrate to virtually barren zones. Evidence of predation is occasionally observed through the ASBS.

Porifera: Porifera, the sponges, are well represented in the ASBS at Bodega Head. Fifty-two species, from the two classes Demospongiae and Calcispongiae, are known to occur near Horseshoe Cove. Members of the Demospongiae comprise 94% of this fauna. The sponges represent a

major component of the invertebrate fauna in the area and, together with algae and sea squirts, are dominant competitors for rock or shell substrate.

Individuals or colonies of sponges are generally epibenthic, sessile filter feeders, feeding on bacteria or microscopic detrital material. Substrate availability, oceanographic conditions and competition probably are the major factors controlling the distribution and abundance of this group. Substrates utilized by sponges include rock, shell and plant material.

As with some other sessile invertebrates, species diversity of the group usually decreases with an increase in turbidity or sediment deposition. Some sponges are morphologically adapted to inhabit areas near sediment/rock interfaces, however, most species live in areas where there is a lessened threat of burial or fouling by sediment (i.e., on vertical rock faces, in high energy regimes, or in cryptic environments). Species diversity of the group in the ASBS generally increases with an increase in vertical topographical relief. Sponge distributions in the ASBS are often patchy, and the fauna below 25 to 30 ft. (8 to 9 m) is slightly different in composition and abundance from that of the shallower subtidal areas.

Cnidaria: The cnidarians represent a morphologically diverse group of organisms and members from the three classes Hydrozoa, Anthozoa, and Scyphozoa which are common to the ASBS. While not especially dominant in terms of covering large areas of substrate, some members of the phylum (most notably the giant green anemone, Anthopleura xanthogrammica) are very common in rocky, shallow subtidal areas.

Members of the group are generally considered to be predatory. However, the majority are "passive" predators, in that they depend upon water currents to supply them with a wide array of food items. The parameters which appear to be important to the success of the sessile members of the phylum include exposure and availability of dependable currents and availability of appropriate substrate. Both rock and shell

material are frequently colonized by hydrozoans and sea anemones. Algal substrates generally appear to be more commonly inhabited by hydrozoans than by the sea anemones.

Hydrozoans display the greatest polymorphism in the phylum; commonly, the hydrozoans alternate generations between attached, sessile polyps and pelagic medusoid forms. Polyp stages of varied forms and structures are the most readily observable and are frequently encountered subtidally. Most local hydroids possess flexible, chitonous skeletons, although one species of "hydrocoral" with a calcareous skeleton occasionally occurs in the deeper regions of the ASBS. Taxonomically, the hydrozoans pose severe problems in their identification and many of the characters used to classify them have been found to vary markedly with changes in environmental conditions and/or developmental stages. For this reason, only the most well known species have been included in the biota list.

Anthozoans comprise the largest class of cnidarians and locally are represented by a number of sea anemones, a solitary stony coral, and an alcyonarian. Members of this class lack pelagic medusoid stages, although extensive dispersal may still result from the planktonic larval stage.

The Scyphozoa predominantly consist of the jellyfish and seasonally may be present in large numbers in the ASBS.

Bryozoa (Ectoprocta): The Bryozoa comprise a diverse group of some 4,000 described living species and are common elements of marine and freshwater communities where firm substrates are present for colonization. Most species are found in moderately agitated, well oxygenated waters of normal marine salinity. These aniamals flourish in the relatively shallow waters of the continental shelf, 30 to 230 ft. (10 to 70 m) deep.

Bryozoans are ciliary suspension feeders which extract diatoms and other phytoplanktonic algae, protozoans, and organic detritus from the water. Although individuals are small, usually less than 0.04 inches (1 mm), their colonies of calcium carbonate ($CaCO_3$) or thickened cuticle

are constructed so that they may be several tenths of a yard across. Competition for substrate, along with sedimentation, are key factors in controlling their distribution. Diverse associations of species are generally restricted to clear, non-turbid waters where sedimentation is low. With increasing sedimentation, the diversity of encrusting species declines relative to erect forms. Although there are a few encrusting species tolerant to sedimentation, these species generally do not compete successfully against sponges and sea squirts. Substrates utilized by bryozoans include rocks, mollusc shells or crab carapaces, and algae.

Annelida: The Annelida, or segmented worms, are a large and diverse phylum consisting of some 8,700 described species. The majority of marine species fall within the class of the bristle worms (Polychaeta), which consists of some 5,300 known species. This diversity is not often apparent to the casual observer because of the cryptic or infaunal habitats of the majority of species. The polychaetes show an impressive range or morphological diversity, which matches the equally impressive range of life modes that characterize the group. Such diversity makes for difficulty in generalizing about the ecology and distribution of the segmented worms. The bristle worms (Polychaeta) have achieved a wide habitat distribution and although their greatest diversity is found in areas of soft, sandy or muddy bottoms, they are well represented in rocky intertidal and subtidal areas.

The bristle worms are usually divided into two sub-classes, based upon their mobility during life. The Errantia, or free-moving bristle worms, are characterized by numerous, generally similar segments, each bearing paired appendages. Errant bristle worm species are primarily swimmers, crawlers or burrowers. The second sub-class of bristle worms are the Sedentaria, or sedentary forms, which inhabit permanent burrows or tubes. In these species, the body segmentation is less pronounced and there is usually some regional differentation of the body. These sessile forms are usually adapted for suspension feeding or indirect deposit feeding. In the ASBS, the sedentary bristle worms are those most frequently noticed, although their distributions are patchy. Occasionally, certain species are present in such abundance that large areas of the substrate, 10 square feet (1 m^2) or more, are covered with their tubes.

Mollusca: The phylum Mollusca is well represented in the ASBS. Four classes of molluscs are present: the snails and slugs, (Gastropoda); clams and oysters, (Bivalvia); chitons (Polyplacophora); and octopuses and squids (Cephalopoda). The snails and slugs are the most abundant and diverse class of molluscs in the area.

The snails and slugs are broken into the sub-classes Prosobranchia, Opisthobranchia, and Pulmonata. The few pulmonates that may occasionally occur subtidally are found in holes, caves or kelp holdfasts, and therefore are not readily observable.

Prosobranchs and opisthobranchs are common to the area. Prosobranchs are found on rocks, algae, or sandy bottoms. Opisthobranchs are generally found on sponges, bryozoans or hydroids. The Prosobranchia consist of three orders: Archaeogastropoda, Mesogastropoda, and Neogastropoda. Archaeogastropods include the abalone, keyhole limpets, true limpets and top and turban snails. These animals primarily feed on algae, although a few feed on sponges.

Mesogastropods are able to inhabit sandy and muddy substrates, although many are often found on rocks as well. This group contains mostly herbivores, but also includes muco- and ciliary feeders (slipper shells), ectoparasites (wentletraps) and carnivores (moon snails).

The neogastropods are the most highly evolved of the Prosobranchs, and are entirely carnivorous. Examples of this order are found in both rocky and sandy areas of the ASBS.

The opisthobranchs are easily the most conspicuous and abundant of the snails and slugs at Bodega Head. These belong almost entirely to the order Nudibranchia, which in turn is subdivided into two groups; dorids and eolids. Dorids feed primarily on sponges and bryozoans, and the eolids feed mostly on hydroids. The brillant colors exhibited by the nudibranchs make these animals conspicuous and the group may be very numerous at times.

Bivalves, being mostly infaunal filter feeders, are generally not seen by divers. However, the rock scallop and jingle shell are occasionally seen attached to rocks in semi-cryptic areas.

The Pacific coast of North America possesses the world's most diverse chiton fauna. This is reflected by the abundance and diversity of chiton species found in the ASBS. Chitons are almost all herbivores except for the carnivorous chiton, Placiphorella velata, which is rare at Bodega Head. Most of the chitons listed may not be readily observable because of their small size or their habit of living beneath rocks. Several of the species, however, do reach considerable size.

The only cephalopod likely to be observed in the area is the octopus, Octopus dofleini martini. This species is generally nocturnal in nature, emerging at night to feed on crabs and shrimp; thus most divers are not likely to encounter this animal.

Arthropoda: In the ASBS, the dominant class of arthropods are the Crustacea. This class comprises a large group of marine invertebrates and plays an important role in the subtidal community. The two most important groups of Crustacea in the area are the barnacles (Cirripedia) and the crabs and shrimp (Decapoda). The water lice (Isopoda) and salt water fleas (Amphipoda), while being common and including a large number of species, are small and difficult to observe in the field. Water lice (Isopods) are generally benthic, cryptic individuals. Salt water fleas (Amphipods) are often found on algae, sea grasses, sponges, hydroids and bryozoans and may be herbivores, carnivores or scavengers.

Barnacles are more abundant intertidally but a few species of Balanus are found subtidally, attached to rock or shell substrates.

Most other observable crustaceans in the ASBS are the free living crabs and shrimp (Decapoda). These are primarily nocturnal animals, but can often be seen during the day in crevices and hidden among algae. A few species, like the decorator and hermit crabs, live in exposed areas but protect themselves by means of camouflage or by inhabiting vacant mollusc shells.

Anomuran and brachyuran crabs are the most diverse crustaceans in the area. Depending upon the species, these crabs may be herbivores, omnivores or carnivores. Reproduction is sexual and females brood eggs which hatch into pelagic larvae. Individual species often show seasonality in breeding, but one or more species will be reproducing at almost any time during the year.

Only a few species of shrimps are seen in the ASBS and they are usually colored to match the sea grass or kelp on which they live. Occasionally, large schools of the small, shrimp-like mysids, oppossum shrimp, are seen in the water column in the area.

Echinodermata: Echinoderms, while not especially diverse in the area, are numerous and occupy several important niches in the local subtidal community. Most forms are generally sedentary or slow moving animals that may be filter feeders, grazers, scavengers or predators.

Four classes of echinoderms occur locally: the brittle stars (Ophiuroidea), sea urchins and sand dollars (Echinoidea), sea cucumbers (Holothuroidea) and the starfish (Asteroidea). The brittle stars are small animals which commonly live under rocks or buried in the sediment, and thus are not often observed by divers. Unlike most other echinoderms, this group can move about quite rapidly. Brittle stars may be suspension feeders, detritus feeders or ciliary feeders.

Echinoids are represented in the ASBS by two species of sea urchins and one species of sand dollar. Most echinoids are omnivorous grazers and scavengers that scrape algae and encrusting animals from rocks. Some forms may also remove drifting algae from the water with their extended tube feet. Subtidal sea urchins may grow to very considerable sizes of over 8 inches (20 cm) in diameter and large groups of individuals, covering 150 square ft. (15 m^2) or more, are occasionally found in the ASBS. Occurrences of such abundance markedly affect the nature and degree of exposed substrate around these animals.

Holothuroids differ from other echinoderms in having soft bodies and worm-like shapes; these characteristics have earned them the name of sea cucumbers. Sea cucumbers are occasionally found partially buried, with plume-like tentacles extended, as they filter out particulate organic food material. Members of this group locally range in size from less than 0.4 inches (1 cm) to over 12 inches (30 cm) long.

The most diverse local echinoderm class is the starfish (Asteroidea). These animals have a distinctive appearance and are frequently found in a wide variety of areas. They may be active predators, herbivores, scavengers or filter feeders.

Sea Squirts (Chordata): Of all the invertebrates in the ASBS, sea squirts are probably the most frequently encountered. Individuals or colonies are sessile, muco-ciliary filter feeders, feeding on suspended detrital material and microplankton. A few species occur as solitary individuals, but the majority are colonial, of social and compound forms; they are often so variable in size, shape and color that it is necessary to confirm species identifications by examining their internal anatomy. In external morphology, some compound forms show a remarkable resemblance to sponges, making field distinctions sometimes difficult.

Sea squirts are especially abundant on the sides and undersides of rocks, but also commonly inhabit shell and algal substrates. Most members of the group are hermaphroditic. Eggs are brooded and pelagic tadpole larvae are released; these metamorphose into adult forms, which can be thin encrustations, amorphous, gelatinous or sand encrusted masses, or well defined erect individuals.

Although the group is ubiquitous, the list of species from this area is relatively small when compared to other ecologically similar groups (i.e. sponges). As the sea squirts have not been studied to any great extent in the ASBS, detailed taxonomic and distributional studies would presumably confirm the existence of many more species, some of which would probably be new.

Fishes (Chordata): Fish are difficult to observe in the ASBS at Bodega Head, primarily because of the poor visability of the water and because the fish are widely dispersed. Many of the fishes are found inshore seasonally, either for purposes of feeding or breeding. Bottom fishes and various rockfishes are seen most often because they are not easily frightened when approached. Other fish that are seasonally common to the area, such as surfperches, may be difficult to observe because they remain at the fringe of the diver's range of vision. Consequently, a diver in this area is likely to observe few fishes relative to such other locales as Monterey.

The species list in the appendix has been drawn from 10 years diving experience in the area, and from data obtained using a twenty-five foot otter trawl at depths of 39 to 82 ft. (12 to 25 m) near Bodega Head.

This area has been noted for the seasonal presence of the white shark, Carcharodon carcharias; this large predator may be relatively common in areas just south of Bodega Head at Bodega Rock and Tomales Bay. Another potentially dangerous fish, the wolf eel, Anarrichthys ocellatus, is also known to occur in the ASBS.

Birds (Chordata): Birds comprise the most conspicuous group of animals occurring within the ASBS, in that many individuals are easily visible from land during all seasons and tidal conditions. Bird populations within the area are seasonal; heaviest use occurs during spring and fall migrations, and in winter. During the summer, most of the listed species are nesting elsewhere.

A few species nest close to the intertidal zone, and are present as year-round residents. The black oystercatcher, the largest shore-bird occurring on the ASBS, probably nests on rocks just above the reach of the waves. A much smaller shorebird, the snowy plover, is a potential nester on the upper areas of the two beaches within the ASBS. Among seabirds, pelagic cormorants nest in scattered colonies of up to 30 nests at several sites along the sea cliffs. This species builds nests on rock shelves along the cliff faces above the surf. Although most colonial

nesting seabirds are highly traditional in choice of colony site in successive years, the pelagic cormorants of Bodega Head often change colony location annually, choosing each year only a few of the many available cliffs. One other seabird, the pigeon guillemot, probably nests occasionally in crevices in the cliffs of Bodega Head.

The largest seabird breeding colony in the immediate vicinity is just outside the ASBS, on Bodega Rock. Here several hundred Brandt's coromorants, a larger species which typically selects flat areas on islands for colony sites, nest each year. Individuals of this species forage within the ASBS regularly. A few western gulls nest on Bodega Rock, and black oystercatcher nests are likely here also.

Of the 59 other species occurring somewhat regularly within the ASBS, the great majority nest outside of California, with many species migrating annually to the Arctic to breed. Small numbers of some of these species, often immature birds, remain here throughout the summer.

Most of the species seen regularly along Bodega Head are typical of other rocky headland and sandy beach areas of northern and central California. This area does, however, present a very rich and diverse example of the coastal avifauna and is esteemed by California birders. In fact, one species of shorebird occurring regularly in the ASBS is seldom seen anywhere south of Bodega Head--the rock sandpiper, which nests in Alaska and winters along the coast from Alaska to Northern California. Individuals of this species forage on the rocks with flocks of black turnstones and surfbirds each winter.

In the rocky intertidal zone, several species of shorebirds (especially black turnstones, surfbirds, rock sandpipers, black oystercatchers, willets, and whimbrels) prey on water lice, salt water fleas, and other small crustaceans. Bristle worms, a variety of small molluscs, and occasionaly representatives of other invertebrate taxa are also preyed upon. Gulls feed on crabs, starfish, Pisaster ochraceus, and sea urchins. On the sandy beach, sanderlings and marbled godwits probe for water lice, Excirolana, salt water fleas, Orchestoidea and Paraphoxus, the sandcrab,

Emerita analoga, and adult and larval insects. Seabirds which capture food near the water surface (pelicans, phalaropes, terns and gulls) or dive beneath the surface (loons, grebes, cormorants, sea ducks, and alcids) forage on zooplankton, squid and fish, as well as molluscs and crustaceans taken from the seafloor. Aside from this general information, the diets of most seabird species in habitats comparable to the ASBS are not well known; it is, however, clear that birds are important predators of many of the fish and invertebrates inhabiting the area.

Marine Mammals (Chordata): Although a large number of the 111 described species of marine mammals at some time undoubtedly enter the waters adjacent to or in the ASBS, only those which have been personally sighted by the authors are discussed or listed.

Members of this group are predominantly carnivorous and represent the upper end of the marine food chain in the ASBS. The two orders of marine animals found locally are the seals and sea lions (Pinnipedia) and the dolphins, porpoises and whales (Cetacea); the seals and sea lions are the most easily observed and abundant.

Of the three families of Pinnipedia, two are represented in the ASBS. the Otariidae and Phocidae. The former are commonly known as the walking seals and the latter are known as the crawling seals. Two species of crawling seals have been observed in the area: the elephant seal, Mirounga angustirostris and the harbor seal, Phoca vitulina. Mirounga, the largest of all seals, is usually rare in the ASBS, being commonly found to the south between December and March in island rookeries off Mexico. Although the total California population of Mirounga is thought to be considerably greater than that of Phoca, over 10,000 versus less than 2,000, Phoca is much more readily sighted in the ASBS. It is not unusual to see several individuals of this species on any particular day, and individuals appear to maintain favorite hauling places within the ASBS. Sizable resident populations of harbor seal, P. vitulina, occur on nearby Bodega Rock and in Tomales Bay.

Walking seals are locally represented by the Stellar sea lion, Eumetopias jubata and the California sea lion, Zalophus californianus. The latter are seasonal in occurrence, leaving this area in June and July to breed primarily on offshore islands from the Santa Barbara Channel Islands south into Mexico. The Stellar sea lion frequents the same areas around the ASBS as the California sea lion. However, its breeding grounds extend from the Channel Islands northward to the Pribilof Islands, with breeding also taking place in June and early July.

The cetaceans are divided into two suborders; the toothed whales, (Odontoceti), and the baleen whales, (Mysticeti). Only two species of baleen whales have been observed in the realm of the ASBS; the fin-backed whale, Balaenoptera physalus, and the gray whale, Eschrictius gibbosus. Only one specimen of the fin-backed whale has been seen; that particular animal was over 65 ft. (20 m) long and was washed ashore dead into Horseshoe Cove in December 1969. The gray whale is commonly seen passing by the ASBS during its southerly migration which begins in late November and continues into February. The bulk of the herd normally passes in late December, and it is not unusual to see as many as 50 to 75 animals a day. The northern migration starts as early as late February for some individuals and extends into May and June for females with newborn young. Females and calves often hug the coastline, entering bays and inlets as they progress north to the Bering Sea. Because of this, many sightings have occurred within the confines of Horseshoe Cove in the ASBS.

Members of the toothed whales have been observed within the ASBS and its immediate vicinity in greater diversity than the baleen whales. Unfortunately, only one species has been found alive: the northern right whale dolphin, Lissodelphis borealis. Less than a dozen specimens of this species have been found along the California coast. The individual from this area was beached at the base of Mussel Point and subsequently died after being transported to the California Academy of Science. Dead beached animals of other species of the toothed whales found along the shore of the ASBS have been identified as Risso's dolphin, Grampus griseus, Pacific striped or white-sided dolphin, Lagenorhyneus obliquidens, killer whale or orca, Orcinus orca, Dall porpoise, Phocoenoides dalli, and the porpoise, Phocoena vomerina.

Intertidal Biota

The intertidal region of the ASBS has primarily rocky substrate. The rocky intertidal zone consists almost entirely of a weathered quartz diorite (i.e. decomposed granite). The exceptions to this are the sandy beaches at the head of Horseshoe Cove, and the several hundred feet of Salmon Creek Beach included within the ASBS. The sediment of the sandy beach of Horseshoe Cove is of larger grain size than that of Salmon Creek Beach.

The intertidal zone of the ASBS is a mixture of exposed and protected outer coast, as used in Ricketts and Calvin (1968). Those regions exposed directly to the Pacific include most of the ASBS, except for Horseshoe Cove, its sandy beach, and possibly Mussel Point, located near the northern boundary of the ASBS. Waves impinging upon the ASBS are large, due in part to the prevailing northwesterly winds and, at least in the winter, from large swells running from low pressure areas in the northwest.

The rocky shores within Horseshoe Cove, especially the north shore, experience waves of slightly less intensity due to the orientation of the cove; at Mussel Point wave intensity is decreased due to the presence of some offshore rocks.

It is not uncommon during the winter for spray to break over the crests of the bluffs facing the ocean, or for chunks of the cliff at the head of Horseshoe Cove to collapse due to erosion caused by wave battering.

Although qualitative differences in wave intensity between the outer coast and the shore of Horseshoe Cove are apparent, there are no substantial differences between the flora and fauna of these two regions of the ASBS.

Through geological time, waves have cut away the cliffs near sea level, producing an intertidal shelf region of variable width. These platforms are found along the entire frontage of the ASBS.

The shelf region is cut throughout by fissures and surge channels and pockmarked with pools. All this results in a region with a high degree of three dimensional complexity, allowing habitat for an amazingly diverse assemblage of plants and animals.

A rich fauna and equally rich algal flora characterize the ASBS intertidal region (Figure 11). The algal flora of this area has been well treated by Johansen (1966). The species list, Appendix 3, is taken from Johansen, Abbott and Hollenberg, 1976, and includes two species of vascular plants common to the ASBS intertidal region: the surfgrasses, Phyllospadix torreyi and P. scouleri. The surfgrass, Phyllospadix torreyi is characteristic of tidepool habitats, while the especially common surfgrass, P. scouleri, grows on exposed rocks at zero tide level and below.

For each species listed in Appendix 3, a statement of abundance is included: U (rare - seen only once or twice), O (occasional), or C (common - encountered often). Likewise, the intertidal zone where the animal is found is listed: H (high), M (mid), or L (low), according to the scheme outlined in Ricketts and Calvin (1968). Finally, the substrate where the animal is usually found is listed: rocks, pools, sandy beach, epizooic (dwelling on animals), and epiphytic (living on plants). See Appendix 1.

No comments on the seasonality of these animals have been included, because such data are lacking for the vast majority of intertidal animals. Some, such as hydroids, bryozoans and sea squirts, go through pronounced yearly cycles, with the result that they might be conspicuous at certain times of the year, and be almost absent at other times. Usually, though, some representatives of each of these species can be found throughout the year, and through successive years.

Other animals, especially the nudibranchs, are more ephemeral. Species may appear for several weeks one year, and not be seen again for years.

Many other animals live for more than one year and go through no major fluctuations in density (i.e. sponges, anemones, snails and seastars).

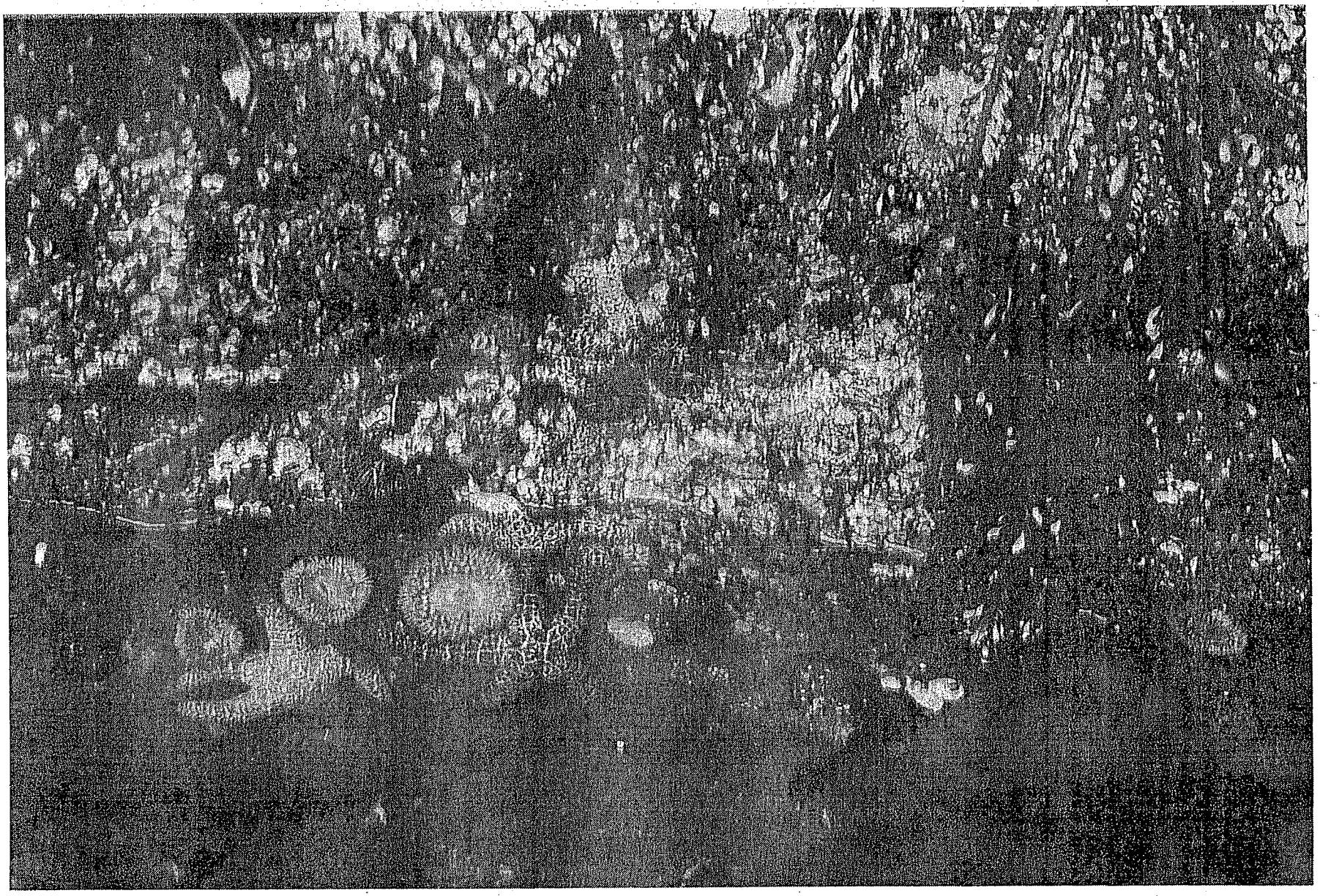

Figure 11: ASBS Intertidal biota of rich fauna and equally rich algal flora showing starfish, sea anemone and kelp.

Porifera: Sponges (Porifera) are common representatives of the low intertidal zone in the ASBS. Species from the two classes Demonspongiae and Calcispongiae, are found in this region, generally on hard substrate. Sponges, along with bryozoans and sea squirts, are spatial dominants in low intertidal habitats of crevices, caves, and overhangs.

Species diversity of sponges increases with decreasing tidal exposure. More species are present subtidally than intertidally.

Cnidaria: The phylum Cnidaria includes jellyfish, sea anemones, and hydroids. Representatives of the three classes of Cnidarians: Scyphozoa, Hydrozoa, and Anthozoa, all occur within the boundaries of the ASBS.

Scyphozoans, or the true jellyfish, appear washed up on the sand beaches in great numbers at certain times of the year. Although the vast majority of jellyfish are pelagic (free floating), there is a group of sessile jellyfish called the Stauromedusae that are rarely found within the ASBS, but are usually found on algae or surfgrass Phyllospadix.

Hydroids are forms where both a polyp and a medusoid stage may be present in one life cycle. Because the medusa stage is pelagic, the polyp stage is more readily observed within the ASBS. A rich fauna of hydroids is known from this region with more species being discovered. A complication in the identification of hydroid polyps results from the uncertainty of their systematics.

Hydroids are usually found within the low intertidal zone, although the by-the-wind-sailor, Vellela vellela, a pelagic form, washes up in large numbers in the spring.

A hydrocoral, Stylantheca porphyra, is rarely found in the lowest reaches of the intertidal on rocky substrate.

Sea anemones are commonly found intertidally within the ASBS. Several anemone species are common. The anemone, Anthopleura elegantissima,

forms huge clonal masses blanketing the upper mid zone, while the solitary giant, green anemone, Anthopleura xanthogrammica, is common in pools and in surge channels below mussel beds.

A solitary stony coral, Balanophyllia elegans, is occasionally seen in the lower intertidal zone.

Platyhelminthes: The flatworms (Platyhelminthes) are small, flattened carnivorous worms that are commonly found gliding along the underside of rocks in the mid and low intertidal zones of the ASBS. Because of their bland coloration and cryptic habits, they are easily overlooked. Taxonomic difficulties preclude all but the most simple identifications.

Nemertea: Ribbon worms (Nemerteans) are also common inhabitants of the ASBS. Although their species diversity is not great, some species like the Amphiporus spp. are present in large numbers in mussel beds where they prey upon the bristle worms.

Sipuncula: The peanut worms (Sipuncula) are represented by two species within the ASBS. One of these peanut worms, Phascalosoma agassizi, is an exceedingly common member of the community of animals living within the three-dimensional habitat of the mussel bed.

Annelida: The Annelids are segmented worms of diverse body form and habitat. One class, the bristle worms (Polychaeta), is very abundant in all tidal levels within the ASBS. Most noticeable are sedentary tube-dwelling forms that include species that form large aggregations (Phragmatopoma californica, Dodecaceria fewkesi). Other tube-dwelling worms often encountered are worms that live in lime tubes (Serpula). Close rleatives, forms allied with the genus Spirorbis, form small, coiled tubes on mussels, coralline algae, shells and rocks. The taxomony of the genus Spirorbis is confused; however, there seem to be as many as 10 recognizable species within the ASBS. The species list in Appendix 3 makes no attempt to distinguish between species.

More mobile bristle worms are also common within the ASBS. Their cryptic nature makes it hard for the casual observer to see them in great numbers, but in some situations, nereid bristle worms, Nereis vexillosa, are very common in mussel beds.

Other bristle worms are abundant within the holdfasts of the surf-grass, Phyllospadix.

Arthropoda: The joint-legged animals (Arthropods) are another group of segmented organisms that are exceedingly abundant within the ASBS.

The Class Crustacea contains many common forms. Several species of barnacles are very common within the ASBS intertidal zone. The acorn barnacles, Balanus glandula and Chthamalus dalli, are spatial dominants in the high zone, and can occur at densities as high as several thousand per square meter. Several other species of acorn barnacles, Balanus, can also be found in the intertidal zone.

Water lice (Isopods) are also present within the ASBS. Perhaps the most common are species of rocklouses, Ligia, that scurry about in the splash zone. The water louse, Cirolana, is common within mussel beds.

Salt water fleas (Amphipods) reach great abundances at all intertidal levels. Because of the difficulties they pose for the non-expert, no attempt has been made to identify them. They are common in nearly all habitats of the intertidal region. One group of salt walter fleas, the beach hoppers, are common members of the sandy beach community. Others, such as the skeleton shrimp or caprellids, can often be found on algae, hydroids and bryozoans.

Crabs and shrimp belonging to the Order Decapoda are also quite common intertidally. Crabs of the genera Pachygrapsus and Hemigrapsus are abundant in crevices and beneath rocks in the high and mid zones. Cancer crabs, Cancer spp., are found beneath rocks at the lower tidal levels.

Hermit crabs, Pagurus spp., can be found in any tidepool, while porcelain crabs, Petrolisthes, are abundant in mussel beds. Sand crabs, Emerita analoga, are sometimes plentiful on Salmon Creek Beach. Other crabs are frequently encountered, while shrimp are sometimes seen in low zone tidepools.

Insects are an often overlooked component of the intertidal biota. Fly larvae are important herbivores in certain high intertidal situations, while rove beetles, Family Staphylinidae, are characteristic predators in the drift community of sandy beaches.

Mollusca: Molluscs are another phylum common within the ASBS. Four classes of molluscs are seen: the octopods and squids, Cephalopoda; the chitons, Polyplacophora; the snails and slugs, Gastropoda; and the clams and mussels, Bivalvia.

The only common cephalopod found within the ASBS is the octopus, Octopus dofleini martini. Octopods are crevice dwellers, and are nocturnal predators. For these reasons, they are not often encountered, although they are probably reasonably common.

The chiton fauna within the ASBS is a rich one. Most chitons are herbivores, and are found at all intertidal zones excepting the highest. The gumboot chiton, Cryptochiton stelleri, is sometimes seen in protected spots; the chiton, Katharina tunicata, and the chiton species of Mopalia are also common.

Various snails and slugs (gastropods) are conspicuous members of the ASBS intertidal biota. The snails, or prosobranchs, are exceedingly common at all tidal levels. In the high intertidal "splash zone, the two periwinkles, Littorina planaxis and L. scutulata, are common, and along with barnacles, are often the most conspicuous animals present.

Found slightly lower in the intertidal zone, and extending into the subtidal zone, are limpets, which are snails with uncoiled cap-shaped shells. Locally, there are three genera of limpets found intertidally;

especially common are species of Collisella and Notoacmea. Where they are found, limpets are often the most abundant snail present. They dwell in a variety of habitats, and some live specifically on other snails, or on one species of alga or marine plant.

Other important snails that are common within the intertidal zone are the whelk, Nucella emarginata. and the black turban snail, Tegula funebralis. The whelk preys upon barnacles, and is responsible for a considerable fraction of the mortality in the acorn barnacles, Balanus and Chthamalus. The turban snail is a herbivore found in high zone pools and mid-intertidally.

Abalones, Haliotis spp., are sometimes encountered in crevices in the low intertidal zone, but are more abundant subtidally.

The pulmonates, another group of gastropods, are occasionally seen. They are crevice dwellers, also found in caves and algal holdfasts. Thus they are not very conspicuous.

The sea slugs, or opisthobranchs, are the final group of gastropods found within the ASBS. Most belong to the order Nudibranchia, and despite their seasonality, are obvious members of the intertidal biota. Sea slugs (Nudibranchs) are found mostly in the low intertidal zone, dwelling on a variety of prey items, including sponges, hydroids, bryozoans, sea squirts, and algae.

The diversity of another molluscan class, the clams and mussels (Bivalvia), is not great within the ASBS, but one species, the California mussel, Mytilus californianus, is easily the most conspicuous organism in the mid and high zone of wave-swept regions. It is probably the dominant biomass among the molluscs. Within the ASBS, mussels form large beds, often more than a foot thick, and spreading over several feet of vertical tidal height. Mussel beds serve as shelter for a variety of other organisms including worms, and various arthropods. The mussel, Mytilus, in turn, is the prey of the ochre star, Pisaster ochraceus.

Ectoprocta (Bryozoa): Bryozoans, often referred to as Ectoprocts, are a group of small colonial animals of great diversity within the ASBS. Along with sponges and sea squirts, bryozoans are spatial dominants in cryptic, dimly-lit habitats of the lower intertidal region. Bryozoans also utilize shells, crabs, and algae as substrate.

Echinodermata: Echinoderms are a common and ecologically important group within the ASBS. Four classes of echinoderms occur locally: the starfish (Asteroidea), the brittle stars (Ophiuroidea), the urchins (Echinoidea), and the sea cucumbers (Holothuroidea).

Ten species of starfish have been found intertidally in the ASBS. The ochre star, Pisaster ochraceus, is by far the most common. It is a conspicuous predator upon mussels and barnacles in the mid and low zone. It is thought that starfish predation serves to control the lower boundary of mussel beds. Other common starfish include Leptasterias spp., the batstar, Patiria miniata, and the leather star, Dermasterias imbricata. The many-armed starfish, Pycnopodia helianthoides, is a voracious predator that is occasionally seen.

Brittle stars are probably abundant within the ASBS, but are not seen very often due to their habitat. They live in sediment at the bases of boulders and are difficult to collect.

Echinoids are represented by the purple sea urchin, Strongylocentrotus purpuratus. Urchins are found in pools and on intertidal platforms where they graze on drifting and attached algae.

There are several species of sea cucumbers found in the ASBS. The most common of these is a small black form found in mussel beds, Cucumaria pseudocurata.

Chordata: Sea squirts, (Ascidians), are suspension feeding tunicates that either occur singly or colonially. Sea squirts are common in the lower intertidal region, especially beneath ledges and in crevices. They bear a strong superficial resemblance to sponges.

The most common solitary sea squirt is Styela montereyensis, while some common colonial forms include species of the genera Aplidium, Archidistoma, and Didemnum.

Fish are also seen intertidally in the ASBS, primarily within pools. Some are probably stranded with the falling tide, and others, especially sculpins of the cottid family, are characteristically intertidal.

Land Vegetation

Two major plant communities (see Barbour et al. 1973 and Standing et al. 1975) are found in proximity to the ASBS. The granitic bedrock and marine sediments of Bodega Head are covered primarily by a grassland-type community. Most of the plants in the Bodega Head grassland are annuals; about one third (1/3) of them have been introduced from European areas within the past 200 years. The dominant forms of the grassland area include: sea pink, polypody fern, lupine, fiddleneck, Italian ryegrass, bull thistle and miner's lettuce.

The sand dune area to the northeast of Bodega Head contains another distinctive plant community. The foredune area near Salmon Creek Beach is densely covered with beach grass, sea rocket and ice plant. These plants have been introduced and planted several times in an attempt to stabilize dune migration and prevent erosion. The area between the foredunes and the hinddunes is largely windswept and barren, although some beach grass and a few perennial herbs are present. The hinddune area (between Salmon Creek Beach and the harbor) shows an increase in plant diversity, with the more common forms consisting of beach grass, bush lupine, coyote bush and mock heather. Perennial herbs in this area include silver beach weed, beach dandelion, sand verbena, beach strawberry and western thistle.

Unique Components

There are no marine plants or animals in the area of Bodega Head known to be unique to that area. Likewise, no endangered or unique spe-

cies utilize the ASBS as a restricted breeding ground. The uniqueness of this area largely results from the protected status the ASBS has received as a marine life refuge. The flora and fauna of the area are prime examples of pristine, rocky, wave-swept intertidal and subtidal environments.

The fact that Bodega Head is California's northernmost exposure of coastal granitic rock is another factor contributing to the unique character of the area. Although comparative data are sparse, it is conceivable that marine biotas from other exposed north coast areas may be composed differently from those in which sedimentary or metamorphic rocks comprise the intertidal and subtidal substrate. Bodega Head is also interesting in that portions of its fauna appear to indicate that the area is a transition zone between temperate area species (as in Monterey) and forms representative of a more boreal fauna, as found in the northern sections of the state.

Evidence pointing to the lack of human impact in the ASBS is apparent when comparisons of individuals and "population" sizes of the red abalone, Haliotis rufescens, are made between Horseshoe Cove and Windmill Cove which is just south of the southern limit of the ASBS. This abalone species is extremely abundant subtidally at Horseshoe Cove, and large individuals commonly occur intertidally. At Windmill Cove, however, intertidal abalone are scarce and the subtidal portion of the population is noticeably reduced in size and abundance.

One final point depicts the importance of the ASBS in terms of taxonomic study. Portions of the marine preserve in and near Horseshoe Cove, have been designated as the type locality for several newly described species: the shrimp, Crangon handi (see Kuris and Carlton 1977), the demosponges, Adocia dubia and Leucophloeus actites (Ristau, in press) and a species of the clam, Tetilla (Ristau, in prep.). Although these species are not restricted to this area, the importance of the ASBS is enhanced because of this type locality designation.

LAND AND WATER USE DESCRIPTIONS

Marine Resource Harvesting

No major resource harvesting activities occur within the limits of the ASBS. Commercial fishing boats normally fish several miles or more away from the ASBS. Sport fisherman in charter boats and private boats likewise normally work well outside the area of the preserve. Rarely, small private boats have been noted bottom fishing near the outer limits of the ASBS, but their influence on the biota of the area is considered negligible. For a more detailed analysis of commercial fishing activities centered in the Bodega Bay area, see Standing et al. (1975).

Municipal and Industrial Activities

There are no major municipalities within 1 mile (1.6 km) of the ASBS. Bodega Bay, a small, unincorporated town of some 800 people lies 1.7 miles (2.8 km) east of the ASBS. The only major industry of the area consists of a small commercial fishing fleet that works out of Bodega Harbor. This "industrial" activity does not appear to affect the ASBS, and it is not expected to expand to a point where it potentially could impact the area. No other industry is at present expected to be developed in the vicinity.

Agribusiness

Portions of the grasslands of the Coast Range foothills above Bodega Bay are lightly grazed by cattle and sheep. Ranches in the area are small and therefore not considered to have any substantial effect on the marine waters of Bodega Harbor, Bodega Bay, or Bodega Head.

Designated Open Space and Recreational Use

The ASBS is bordered to the northeast and southeast by portions of Sonoma Coast State Park (Salmon Creek Beach, Bodega Dunes and Windmill Beach area). Westside Park and Doran Park, both County Parks, are located to the east of the ASBS. Peak usage for these areas, approximately 60% of the yearly total, occurs between the months of June and September.

During the past year, the number of visitors to these areas has been as follows (R. Grace, State Park Ranger and C. Prouty, County Parks Regional Office, personal communication):

Salmon Creek Beach (40 acres, day use)	- 176,000 people
Bodega Dunes (1,100 acres, 98 campsites)	- 85,000 people
Windmill Beach area (350 acres, day use)	- 76,000 people
Westside Park (25 acres, day use, 47 campsites, boat launching facilities)	- 47,000 people
Doran Park (120 acres, day use, 139 campsites, limited boat launching)	- 164,000 people

Although a large number of people utilize the State and County Park areas around the ASBS, very few of these people (approximately 100 per year) enter onto the Bodega Marine Reserve. The impact on the ASBS by park visitors is not considered significant.

One other section of land, between the property of the Marine Laboratory and Westside Park, has been identified in the Coastal Master Plan as property that should be preserved as open space. This parcel consists of a freshwater marsh located on private property and is on the State Lands Acquisition List.

Two major private marinas exist in Bodega Harbor and have docking facilities for some 210 boats. They are predominantly used by commercial fishermen. A third marina, to be located near Westside Park, is currently in the planning stage. Other recreational activities occurring adjacent to the ASBS include nature study, camping, hiking, photography and painting (see Standing et al. 1975).

Transportation Corridors

According to a Coast Guard spokesman (personal communication) the main shipping lanes for smaller ships and barges lie approximately 4 miles (6.5 km) offshore from Bodega Head. Larger ships generally navigate areas 6 to 8 miles (10 to 13 km) from the coast.

Scientific and Educational Use

Bodega Marine Laboratory's functions are primarily oriented toward scientific research, university teaching and public service. Much of the research and teaching at the Laboratory has utilized the area within the ASBS, and focused on marine aspects of biology, ecology and geology. In the past several years, the amount of research in the applied marine sciences of sea water conversion, marine pollution, and mariculture has increased significantly. To date, research accomplished at the Laboratory has generated 21 doctoral dissertations, five master's theses, about 150 scientific articles and books and numerous student research reports. Annually, approximately 100 university students are enrolled in either 6 or 10 week-long courses at BML. These students utilize the ASBS in their formal field work as well as in independent study projects.

Although the Laboratory is primarily associated with the University of California, Berkeley and Davis campuses, many other colleges and universities in Northern and Central California use the Laboratory and the area for field trips and research purposes (see Standing et al. 1975). In addition, classes from primary and secondary schools commonly use the Laboratory and surrounding area for field trips.

ACTUAL OR POTENTIAL POLLUTION THREATS

There is, at present, one point source of discharge entering into the waters of the ASBS. This discharge consists of the effluent of the Marine Laboratory's Seawater Circulation System.

Potential point sources of pollution that conceivably could affect the ASBS include the discharge of municipal domestic wastes, harbor dredging and vessel discharge. Potential non-point sources of pollution include agricultural wastes, oil spills and land development.

The municipal domestic wastes of Bodega Bay and the Bodega Harbor subdivision are transported through a district sewer system to an advanced secondary treatment plant located on the east side of Bodega Harbor. The treated effluent, currently at a volume of 80,000 to 100,000 gallons per day, is used to irrigate "open space" in the Coast Range foothills and a golf course in the Bodega Harbor subdivision. According to Standing et al. (1975), this effluent is not expected to cause problems for the fish and wildlife resources of the harbor; presumably, it would have a negligible effect on the biota of the ASBS.

The county parks in the area of Bodega Bay currently use septic systems for waste disposal. However, there are plans to join these parks into the existing sewer system within a few years (C. Prouty, personal communication). At present there are no indications that leaching from the county park's system is affecting the ASBS.

Waste disposal in the state park areas is accomplished by either chemical sanitary facilities or septic systems. As with the county parks, there are no indications that the waste disposal methods of the state parks are affecting the ASBS.

Dredging activities occur infrequently in Bodega Harbor and are controlled by the Army Corps of Engineers. The harbor channel has been

dredged three times since 1943, the last time being in 1968. Portions of the dredge spoils from work in 1943 and 1948 were deposited in the outer Bodega Bay area. Spoils from more recent work (1961, 1968) were deposited at Westside Park, Doran Park and Beach, and the airport site (see Standing et al. 1975). The existing airport spoil site has been recommended as the disposal site for future dredging activities (the harbor channel and the proposed marina at Spud Point) and it is not considered that subsequent dredging will threaten the biota of the ASBS.

Considering that major transportation corridors are located over 5 mi. (8 km) from the ASBS, discharge from ships is not a particularly significant problem in this area. Small amounts of petroleum hydrocarbons are probably discharged from private and commercial fishing boats, but their impact on the area is apparently negligible.

Several unpredictable non-point sources of pollution such as agricultural wastes, oil spills and sedimentation conceivably could affect the ASBS as a result of catastrophic circumstances. Major flooding of the drainages to the north and south of the ASBS could introduce large quantities of agricultural toxicants, sewage or sediment into local marine waters. Oil spillage could result from a variety of shipping accidents. Major local earthquake activity could also affect the water quality of the ASBS. Massive landsliding, resulting from earthquake shaking, could introduce significant amounts of easily erodible and suspendible sediment into the ocean waters around the ASBS. Lateral crustal movements along local segments of the San Andreas fault likewise might affect water conditions and substrates in the area by altering existing currents and changing sediment depositional patterns.

Although the waters and shoreline of the ASBS are, at present, virtually unimpacted by human activity, one potential non-point source of pollution, land development, could occur to the extent that its effects are felt in this area. Population growth in the Bodega Bay area has generally been slow; approximately 800 people are residents of the immediate area. However, if the subdivision southeast of town is fully completed, a population increase of nearly 5,400 people is expected, and an eventual popula-

tion of 9,000 people in the area has been estimated (see Standing et al. 1975). Such growth can cause problems with increased sedimentation due to construction activitiy with waste disposal and with environmental disturbance from large numbers of people using limited recreational areas. With adequate planning, the problems of sedimentation and waste disposal probably can be circumvented. However, the problems of increased land use by both residents and tourists, and their potential effect on the ASBS, cannot be predicted. It is not known whether the present buffers that now afford some protection to the ASBS (limited access and hazardous water conditions) will continue to remain effective with a large influx of people into the vicinity.

SPECIAL WATER QUALITY REQUIREMENTS

The waters of the ASBS are presently being monitored in compliance with the California Regional Water Quality Control Board North Coast Region's Order No. 76-140, NPDES CA 0024066.

In addition, marine animals from portions of the ASBS are being periodically analyzed as part of the Federal and State Mussel Watch Programs. The federal program includes monitoring for transuranic pollutants, trace metals, chlorinated hydrocarbons, petroleum hydrocarbons, and biogenic hydrocarbons and also involves performance of histopathological examinations. The state program monitors trace metals, pesticides, and petroleum hydrocarbons.

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APPENDIX 1

Key to Symbols in Subtidal Biota List

C: common

O: occasional

R: rare (Marine Mammals list)

(S): seasonal - populations may disappear completely for several months, or become markedly reduced in size.

?Genus species: generic placement questionable

Genus ?species: species identification questionable

Wrack: specimen found washed ashore at Horseshoe Cove - presumed to occur within the ASBS.

epiphytic: found growing on plants

epizooic: found growing on animals

-: data not available

Key to Symbols in Aves Fauna List

C: common - present throughout most of season

U: uncommon or rare - present in very low numbers or sporadically

RS: rocky shore

SB: sandy beach

OW: ocean water

*: probably nests on or near the ASBS

APPENDIX 2

Subtidal Biota List

	Abundance	Substrate
Marine Plants		
Chlorophyta		
Class: Chlorophyceae		
Enteromorpha prolifera	0	rock
Spongomorpha coalita	0	rock
Urospora penicilliformis	—	—
Codium fragile	0	rock
Collinsiella tuberculata	0	rock
Phaeophyta		
Class: Phaeophyceae		
Ectocarpus dimorphus	0	epiphytic
Desmarestia herbacea	0	rock
Desmarestia munda	0	rock
Laminaria ephemera	0	rock
Laminaria dentigera	0	rock
Laminaria farlowii	C	rock
Costaria costata	C	rock
Alaria marginata	C	rock
Egregia menziesii	C	rock
Lessoniopsis littoralis	0	rock
Macrocystis integrifolia	0	rock
Pelvetia fastigiata	C	rock
Cystoseira osmundacea	C	rock
Rhodophyta		
Class: Florideophyceae		
Smithora naiadum	C	epiphytic
Porphyrella gardneri	0	epiphytic
Gelidium coulteri	C	rock
Gelidium pusillum	0	rock
Farlowia compressa	0	rock

Marine Plants	Abundance	Substrate
Rhodophyta		
Class: Florideophyceae, continued		
Farlowia mollis	O	rock
Dilsea californica	C	rock
Crytosiphonia woodii	O	rock
Pikea robusta	O	rock
Constantinea simplex	O	rock
Lithothamnium pacificum	C	rock
Lithothamnium phymatodoum	C	rock
Melobesia marginata	C	epiphytic
Melobesia mediocris	C	epiphytic
Hydrolithon decipiens	C	rock
Corallina frondescens	O	rock
Corallina officinalis chilensis	C	rock
Corallina vancouveriensis	C	rock
Chiharaea bodegensis	O	rock
Bossiella californica	O	rock
Bossiella orbigniana orbigniana	C	rock
Bossiella plumosa	C	rock
Calliarthron tuberculosum	C	rock
Gloiosiphonia verticillaris	O	rock
Endocladia muricata	O	rock
Halymenia californica	C	rock
Halymenia coccinea	O	rock
Cryptonemia ovalifolia	O	rock
Prionitis cornea	O	rock
Prionitis filiformis	C	rock
Prionitis lanceolata	C	rock
Prionitis lyallii	C	rock
Callophyllis crenulata	O	rock
Callophyllis flabellulata	C	rock
Callophyllis obtusifolia	O	rock
Callophyllis pinnata	C	rock
Callophyllis violacea	O	rock

Marine Plants	Abundance	Substrate
Rhodophyta		
Class: Florideophyceae, continued		
Schizymenia pacifica	O	rock
Opuntiella californica	O	rock
Plocamium cartilagineum	C	rock
Plocamium oregonum	O	rock
Plocamiocolax pulvinata	O	rock
Gracilariopsis sjoestedtii	O	wrack
Ahnfeltia gigartinoides	O	rock
Ahnfeltia plicata	O	wrack
Gymnogongrus leptophyllus	O	sand/rock interface
Gymnogongrus platyphyllus	O	rock
Stenogramme interrupta	O	rock
Gigartina corymbifera	C	rock
Gigartina exasperata	C	rock
Gigartina harveyana	O	rock
Gigartina volans	C	wrack
Iridaea cordata splendens	C	rock
Iridaea lineare	C	rock
Rhodymenia pacifica	O	rock
Rhodymenia palmata mollis	O	rock
Gastroclonium coulteri	O	rock
Microcladia coulteri	O	wrack
Ptilota filicina	O	rock
Delesseria decipiens	O	rock
Phycodrys setchellii	C	rock
Hymenena cuneifolia	C	rock
Hymenena flabelligera	C	rock
Cryptopleura lobulifera	O	wrack
Botryoglossum farlowianum anomalum	C	rock
Polysiphonia paniculata	O	rock
Pterosiphonia bipinnata	O	rock
Pterosiphonia dendroidea	O	rock
Pterochondria woodii woodii	O	epiphytic

Marine Plants	Abundance	Substrate
Rhodophyta		
Class: Florideophyceae, continued		
Amplisiphonia pacifica	O	rock
Laurencia spectabilis spectabilis	C	rock
Odonthalia floccosa	C	rock
Tracheophyta		
Class: Angiospermae		
Phyllospadix scouleri	C	rock and sand/rock interface
Phyllospadix torreyi	O	rock and sand/rock interface

Note: This list is limited to large macroscopic algae or those smaller species that were very abundant and conspicuous. Many of the smaller, less conspicuous algae that occur as crusts, endophytes, epiphytes, and parasites were omitted. For further reference see Johansen (1966) and Abbott and Hollenberg (1976).

	Abundance	Substrate
Porifera		
Class: Demospongiae		
Acarnus erithacus	C	rock
Adocia dubia*	O	rock
?Anaata spongigartina	C	rock
Antho lithophoenix	C	rock/shell
Aplysilla glacialis	O	rock
Aplysilla polyraphis	O	rock
Axinella ?vermiculata	O	rock
Axocielita originalis	C	rock/shell
Cliona ?celata californiana	C	rock/shell
Halichondria panicea	C	rock/algae
Haliclona permollis	O	rock/shell
Hymendectyon lyoni	O	rock/shell
Isodictya quatsinoensis	C	rock/algae
Leptoclathria asodes	O	rock
Leucophloeus actites*	O	rock/algae
Lissodendoryx firma	C	rock/algae
Lissodendoryx topsenti	C	rock
Microciona microjoanna	O	rock
Microciona parthena	O	rock
Mycale ?lobata	O	rock/algae
Mycale macginitiei	O	rock
Mycale psila	C	rock
Mycale richardsoni	O	rock/algae
Myxilla agennes	O	rock
Myxilla incrustans	O	rock/shell
Ophlitaspongia pennata	O	rock/shell
?Pachychalina lunisimilis	O	rock
Plocamia karykina	C	rock/shell
Polymastia pachymastia	C	rock
Prianos problematicus	O	rock
Reniera sp. A	C	rock
Sigmadocia edaphus	O	rock

Porifera	Abundance	Substrate
Class: Demospongiae, continued		
Sigmadocia sp.	O	rock
Spongia idia	O	rock
Stelletta clarella	O	rock
Suberites sp.	C	rock
Tedania fragilis	O	rock
?Tedanione obscurata	C	rock/algae
Tethya aurantia californiana	C	rock
Tetilla sp.**	C	epizooic
Tetilla sp. a**	C	epizooic
Xestospongia trindanea*	O	rock
Xestospongia vanilla	O	rock
Anthoarcuata graceae	O	wrack
Axinomimus tuscarus*	O	wrack
Hymedesmia brepha	O	wrack
Plocamissa igzo	O	wrack
Tedania toxicalis	O	wrack
Stylopus versicolor californiana	O	wrack
Class: Calcispongiae		
?Clathrina sp.	O (S?)	rock
Leucosolenia eleanor	C (S)	rock
Leucilla nuttingi	O (S?)	rock

Note: * refers to new species, the descriptive work is in press in the Proceedings of the Biological Society of Washington.

** refers to a complex of species whose status is questionable. The descriptive work is currently in preparation. Identifications of these forms can be found in Ristau (1977).

	Abundance	Substrate
Cnidaria		
Class: Hydrozoa		
Aglaophenia struthionides	C	rock
Aglaophenia inconspicua	O	algae
Plumularia plumularoides	C	rock
Sertularella turgida	C	rock/algae
Sertularia furcata	O	rock
Stylantheca porphyra	C	rock
Velella velella	C (S)	pelagic
Class: Anthozoa		
Anthopleura elegantissima	O	rock
Anthopleura xanthogrammica	C	rock
Cnidopus ritteri	O	rock
Tealia coriacea	C	rock
Tealia lofotensis	C	rock
Tealia sp.	O	rock
Metridium senile	O	rock
Balanophyllia elegans	C	rock
Corynactis californica	O	rock
Clavularia sp.	O	rock
Class: Scyphozoa		
Aurelia aurita	O (S)	pelagic
Pelagia noctiluca	O (S)	pelagic
Ectoprocta		
Class: Gymnolaemata		
Membranipora membranacea	C	algae
Dendrobeania lichenoides	O	rock
Scrupocellaria californica	C	rock/algae
Parasmittina collifera	C	rock
Eurystomella bilabiata	C	rock
Costazia robertsonae	C	algae
Hippothoa hyalina	C	algae

Ectoprocta	Abundance	Substrate
Class: Gymnolaemata, continued		
Microporella californica	C	rock
Microporella cribrosa	C	algae
Schizoporella errata	O	rock
Alcyonidium parasiticum	C	rock/shell
Flustrellidra corniculata	C	rock/algae
Class: Stenolaemata		
Crisia occidentalis	C	rock/algae
Diaperoecia californica	O	rock
Disporella californica	O	rock
Disporella hispida	O	rock
Oncousoecia sp.	O	rock
Annelida		
Class: Polychaeta		
Nereis latescens	O	algae/rock
Phyllochaetopterus prolifica	O	sediment
Dodecaceria fewkesi	O	rock
Sabellaria cementarium	C	rock
Phragmatopoma californica	C	rock
Eudistylia polymorpha	C	rock/ sediment
Sabella crassicornis	O	sediment
Serpula vermicularis	C	rock
Spirorbis spirillum	C	rock/algae
Salmacina tribranchiata	O	rock
Mollusca		
Class: Gastropoda		
Haliotis rufescens	C	rock
Diodora aspera	O	rock
Fissurella volcano	O	rock
Megathura crenulata	O	rock
Megatebennus bimaculatus	O	ascidians

Mollusca	Abundance	Substrate
Class: Gastropoda, continued		
Acmaea mitra	C	algae
Collisella asmi	O	shell
Collisella instabilis	O	algae
Notoacmea insessa	O	algae
Notoacmea paleacea	O	Phyllospadix
Calliostoma ligatum	O	rock/algae
Tegula funebralis	C	rock
Tegula brunnea	C	rock/algae
Lacuna marmorata	C	Phyllospadix
Epitonium tinctum	O	anemones
Hipponix cranoides	O	rock
Crepidula adunca	C	shell
Polinices lewisii	O	sediment
Lamellaria spp.	O	sponges/ ascidians
Ceratostoma foliatum	O	rock
Ocenebra interfossa	C	rock/algae
Nucella canaliculata	C	rock
Searlesia dira	O	rock/algae
Amphissa columbiana	O	rock/algae
Mitrella carinata	C	rock/algae
Mitrella aurantiaca	O	rock/algae
Nassarius mendicus	O	rock/ sediment
Olivella biplicata	O	sediment
Rostanga pulchra	C	sponges
Doriopsilla albopunctata	O	rock
Cadlina luteomarginata	C	rock
Acanthodoris nanaimoensis	O	sponges
Hopkinsia rosacea	O	hydroids
Aldisia sanguinea	C	sponges
Dirona albolineata	C	rock
Diaulula sandiegensis	C	sponges
Aegires albopunctata	O	rock

Mollusca	Abundance	Substrate
Class: Gastropoda, continued		
Laila cockerelli	O	rock
Anisodoris nobilis	C	sponges
Hermissenda crassicornis	C	rock/ sediment/ hydroids
Tritonia festiva	O	rock/ hydroids
Archidoris odhneri	C	sponges
Archidoris montereyensis	C	sponges
Coryphella trilineata	O	hydroids
Antiopella barbarensis	O	hydroids
Discodoris heathi	O	rock
Precuthona divae	O	rock/ hydroids
Trinchesia flavovulta	O	rock
Trinchesia lagunae	O	rock
Triopha carpenteri	C	rock
Triopha maculata	O	rock
Class: Polyplacophora		
Tonicella lineata	C	rock/algae
Cryptochiton stelleri	C	rock
Katharina tunicata	O	rock
Mopalia ciliata	O	rock
Mopalia hindsii	O	rock
Mopalia muscosa	O	rock
Basiliochiton heathii	O	rock
Dendrochiton thamnoporus	O	rock
Class: Bivalvia		
Hiatella artica	O	rock
Hinnites giganteus	O	rock
Pododesmus cepio	O	rock
Class: Cephalopoda		
Octopus dofleini martini	O	rock

	Abundance	Substrate
Arthropoda		
Class: Crustacea		
Balanus crenatus	C	rock
Balanus nubilus	O	rock
Acanthomysis sp.	O	
Idotea montereyensis	C	algae/ eel grass
Heptacarpus brevirostris	C	algae/ eel grass
Heptacarpus cristatus	C	algae/ eel grass
Pagurus granosimanus	O	rock
Pagurus hirsutiusculus	O	sediment/ rock
Pagurus samuelis	O	rock
Cryptolithodes sitchensis	O	rock/algae
Lopholithodes mandtii	O	rock/algae
Loxorhynchus crispatus	C	algae/rock
Mimulus foliatus	C	algae/rock
Pugettia producta	C	algae
Pugettia richii	C	algae
Scyra acutifrons	C	algae/rock
Cancer antennarius	O	rock crevice
Cancer productus	O	rock crevice
Cancer gracilis	O	sediment
Cancer magister	O	sediment
Crangon handi	O	sediment
Tecticeps convexus	O	sediment
Echinodermata		
Class: Echinoidea		
Strongylocentrotus purpuratus	C	rock
Strongylocentrotus franciscanus	C	rock
Dendraster excentricus	O	sediment

Arthropoda	Abundance	Substrate
Class: Holothuroidea		
Stichopus californicus	O	rock
Cucumaria miniata	O	rock
Cucumaria pseudocurata	C	algae
Eupentacta quinquesemita	O	rock
Class: Ophiuroidea		
Amphiodia occidentalis	O	rock
Ophionereis eurybrachyplax	O	rock
Class: Asteroidea		
Pisaster ochraceus	C	rock
Pisaster brevispinus	C	sediment
Patiria miniata	C	rock/ sediment
Dermasterias imbricata	C	rock
Henricia leviuscula	C	rock/ sponges
Pycnopodia helianthoides	C	rock/ sediment
Leptasterias hexactis	C	algae
Solaster dawsoni	O	rock/ sediment
Orthasterias koehleri	O	rock
Chordata (Tunicata)		
Class: Ascidiaceae		
Aplidium californicum	C	rock
Aplidium solidum	C	rock
Aplidium ?sp.	C	rock
Archidistoma psammion	O	rock
Archidistoma ritteri	C	rock
Boltenia villosa	O	rock/algae
Clavelina huntsmani	C (S)	rock
Cystodytes ?lobatus	O	rock/algae
Cystodytes sp.	C	rock/algae

	Abundance	Substrate
Chordata (Tunicata)		
Class: Ascidiaceae, continued		
Diplosoma macdonaldi	O	rock
Distaplia occidentalis	O	rock
Distaplia smithi	O	rock
Euherdmania claviformis	C	rock/shell
Metandrocarpa dura	O	algae
Metandrocarpa taylori	C	rock
Perophora annectens	C (S)	algae/rock
Polyclinum planum	C (S?)	rock/algae
Pyura haustor	C	rock
Styela montereyensis	C (S?)	rock/algae
Synoicum parfustis	C	rock
Synoicum pellucidum	O	rock
Trididemnum opacum	C	rock/shell
Didemnum carnulentum	C	rock/shell
Chordata (Fishes)		
Class: Chondrichthyes		
Carcharodon carcharias	O (S)	pelagic
Squatina californica	O	over sand
Torpedo californica	O	over sand
Raja inornata	O	over sand
Raja rhina	O	over sand
Class: Osteichthyes		
Porichthys notatus	O	rock/sand
Microgadus proximus	C	over sand
Genyonemus lineatus	O	over sand
Brachyistius frenatus	C (S)	algae
Cymatogaster aggregata	C (S)	over rock/ sand
Embiotoca jacksoni	C (S)	over rock
Hyperprosopon anale	C (S)	sand
Hypsurus caryi	C (S)	over rock/ sand

Chordata (Fishes)	Abundance	Substrate
Class Osteichthyes, continued		
Micrometrus minimus	O (S)	over sand
Phanerodon furcatus	C (S)	over sand/ algae
Rhacochilus toxotes	C (S)	over rock
Chilara taylori	O	over sand
Gibbonsia metzi	C	algae
Apodichthys flavidus	O	rock/algae
Anarrichthys ocellatus	O	rock
Sebastes auriculatus	C	rock
Sebastes flavidus	C	rock
Sebastes mystinus	C	rock
Sebastes caurinus	C	rock
Hexagrammos decagrammus	C	rock/algae
Hexagrammos lagocephalus	C	rock/algae
Ophiodon elongatus	C	rock
Scorpaenichthys marmoratus	C	rock
Occella verrucosa	O	rock/algae
Pallasina barbata	O	sand
Stellerina xyosterna	O	rock/algae
Odontopyxis trispinosa	O	sand
Liparis pulchellus	O	sand
Citharichthys stigmaeus	C	sand
Citharichthys sordidus	C	sand
Isopsetta isolepis	O	sand
Parophrys vetulus	O	sand
Platichthys stellatus	C	sand
Pleuronichthys decurrens	O	sand
Aulorhynchus flavidus	O	sand

Note: For a more detailed account of the fish in this area see Bane and Bane (1971).

Chordata	Abundance
Class: Vertebrata (Marine Mammals)	
Fin Whale, *Balaenoptera physalus*	R
Gray Whale, *Eschrictius gibbosus (glaucus)*	C (S)
Dall Porpoise, *Phocoenoides dalli*	R
Harbor Porpoise, *Phocoena vomerina*	O
Killer Whale, *Orcinus orca*	R
Northern Right Whale Dolphin, *Lissodelphis borealis*	R
Pacific White-sided Dolphin, *Lagenorhynchus obliquidens*	R
Risso's Dolphin, *Grampus griseus*	R
California Sea Lion, *Zalophus californianus*	C (S)
Steller Sea Lion, *Eumetopias jubatus*	C (S)
Harbor Seal, *Phoca vitulina*	C
Northern Elephant Seal, *Mirounga angustirostris*	R (S)

	Seasonal Status		
	Summer	Migration/ Winter	Habitat
Class: Aves			
Common Loon, *Gavia immer*		C	OW
Arctic Loon, *Gavia arctica*		C	OW
Red-throated Loon, *Gavia stellata*		C	OW
Red-necked Grebe, *Podiceps grisegena*		U	OW
Horned Grebe, *Podiceps auritus*		C	OW
Eared Grebe, *Podiceps nigricollis*		C	OW
Western Grebe, *Aechmophorus occidentalis*		C	OW
Brown Pelican, *Pelecanus occidentalis*	C[1]	C	RS,OW
Double-crested Cormorant, *Phalacrocorax auritus*		U	RS,OW
Brandt's Cormorant, *Phalacrocorax penicillatus*		C	RS,OW
Great Blue Heron, *Ardea herodias*		U	RS
Black Brant, *Branta bernicla nigricans*		U	OW

Chordata Class: Aves, continued	Seasonal Status Summer	Migration/ Winter	Habitat
Greater Scaup, Aythya marila		U	OW
Common Goldeneye, Bucephala clangula		U	OW
White-winged Scoter, Melanitta deglandi		C	OW
Surf Scoter, Melanitta perspicillata		C	OW
Black Scoter, Melanitta nigra		U	OW
Red-breasted Merganser, Mergus serrator		C	OW
Black Oystercatcher, Haematopus bachmani		C	RS
Snowy Plover, Charadrius alexandrinus		U	SB
Black-bellied Plover, Pluvialis squatarola		C	RS,SB
Surfbird, Aphriza virgata		C	RS,SB
Ruddy Turnstone, Arenaria interpres		U	RS,SB
Black Turnstone, Arenaria melanocephala		C	RS,SB
Whimbrel, Numenius phaeopus		C	RS,SB
Wandering Tattler, Heteroscelus incanus		C	RS
Willet, Catoptrophorus semipalmatus		C	RS,SB
Red Knot, Calidris canutus		U	RS,SB
Rock Sandpiper, Calidris ptilocnemis		C	RS
Pectoral Sandpiper, Calidris melanotos		U	SB
Baird's Sandpiper, Calidris bairdii		U	SB
Least Sandpiper, Calidris minutilla		U	SB
Dunlin, Calidris alpina		U	SB
Western Sandpiper, Calidris mauri		U	SB
Sanderling, Calidris alba		C	SB
Marbled Godwit, Limosa fedoa		C	SB
Red Phalarope, Phalaropus fulicarius		U	OW
Northern Phalarope, Lobipes lobatus		U	OW
Parasitic Jaeger, Stercorarius parasiticus		U	OW

Chordata Class: Aves, continued	Seasonal Status Summer	Migration/ Winter	Habitat
Glaucous-winged Gull, Larus glaucescens	U	C	RS,SB,OW
Western Gull, Larus occidentalis	*C	C	RS,SB,OW
Herring Gull, Larus argentatus	U	C	RS,SB,OW
Thayer's Gull, Larus thayeri		U	RS,SB,OW
California Gull, Larus californicus	U	C	RS,SB,OW
Ring-billed Gull, Larus delawarensis	U	C	RS,SB,OW
Bonaparte's Gull, Larus philadelphia		U	RS,SB,OW
Heerman's Gull, Larus heermanni	C[1]	U	RS,SB,OW
Black-legged Kittiwake, Rissa tridactyla		U	RS,SB,OW
Forster's Tern, Sterna forsteri		C	OW
Common Tern, Sterna hirundo		U	OW
Elegant Tern, Thalasseus elegans	U[1]	U	OW
Caspian Tern, Hydroprogne caspia		C	OW
Common Murre, Uria aalge	U	C	OW
Pigeon Guillemot, Cepphus columba	*C	C	RS,OW
Marbled Murrelet, Brachyramphus marmoratus		U	OW
Ancient Murrelet, Synthliboramphus antiquum		U	OW
Rhinoceros Auklet, Cerorhinca monocerata		U	OW
Belted Kingfisher, Megaceryle alcyon		U	RS,OW
Black Phoebe, Sayornis nigricans	*U	C	RS,SB
Say's Phoebe, Sayornis saya	U	C	RS,SB
Common Raven, Corvus corax	*C	C	RS,SB
Water Pipit, Anthus spinoletta		C	SB
Yellow-rumped Warbler, Dendroica coronata		C	SB
Savannah Sparrow, Passerculus sandwichensis	*C	C	RS,SB

Note: Species of accidental status or species occasionally straying into these areas are excluded.

Note[1]: Brown Pelican, Heermann's Gull, and Elegant Tern are present as migrants and wintering birds mainly from June through December. They are usually absent in late winter and spring. Many other species which arrive as migrants by early August are not listed as occurring in summer.

APPENDIX 3
Intertidal Biota List

Intertidal Marine Plants	Abundance	Substrate
Chlorophyta		
Class: Chlorophyceae		
Collinsiella tuberculata	O	rock
Prasinocladus ascus	U	rock
Bolbocoleon piliferum	U	endophytic
Endophyton ramosum	O	endophytic
Entocladia viridis	O	endophytic
Blidingia minima minima	C	rock
Enteromorpha compressa	-	-
Enteromorpha intestinalis	C	rock
Enteromorpha linza	C	rock/ epiphytic
Enteromorpha prolifera	C	rock
Ulva lobata	C	rock
Ulva californica	U	rock
Prasiola meridionalis	O	rock
Spongomorpha coalita	C	rock
Cladophora columbiana	C	rock
Urospora penicilliformis	O	rock
Derbesia marina	O	epiphytic
Codium fragile	C	rock
Codium setchellii	C	rock
Phaecophyta		
Class: Phaeophyceae		
Ectocarpus dimorphus	-	epiphytic
Ectocarpus parvus	U	epiphytic
Feldmannia cylindrica	-	epiphytic
Pilayella gardneri	O	epiphytic
Myrionema balticum	-	epiphytic
Leathesia difformis	C	rock
Cylindrocarpus rugosus	O	rock
Analipus japonicus	C	rock
Desmarestia herbacea	O	rock
Desmarestia munda	C	rock

Intertidal Marine Plants	Abundance	Substrate
Class: Phaeophyceae, continued		
Phaeostrophion irregulare	O	rock
Soranthera ulvoidea	O	epiphytic
Petalonia fascia	U	rock
Scytosiphon lomentaria	U	rock
Coilodesme californica	O	epiphytic
Costaria costata	O	rock
Hedophyllum sessile	C	rock
Laminaria ephemera	U	rock
Laminaria dentigera	C	rock
Dictyoneurum californicum	C	rock
Lessoniopsis littoralis	O	rock
Macrocystis integrifolia	U	rock
Postelsia palmaeformis	C	rock
Alaria marginata	C	rock
Pterygophora californica	C	rock
Egregia menziesii	C	rock
Fucus distichus	C	rock
Pelvetia fastigiata	O	rock
Pelvetiopsis limitata	C	rock
Cystoseira osmundacea	C	rock
Rhodophyta		
Class: Florideophyceae		
Erythrocladia subintegra	-	epiphytic
Smithora naiadum	C	epiphytic
Bangia fusco-purpurea	O	rock
Porphyra lanceolata	O	rock
Porphyra perforata	C	rock
Porphyrella gardneri	O	epiphytic
Acrochaetium subimmersum	O	endophytic
Kylinia ?arcuata	O	epiphytic
Rhodochorton purpureum	C	rock
Gumagloia andersonii	O	rock

Intertidal Marine Plants	Abundance	Substrate
Rhodophyta		
Class: Florideophyceae, continued		
Gelidium coulteri	O	rock
Gelidium purpurascens	C	-
Gelidium pusillum	O	rock
Constantinea simplex	C	rock
Cryptosiphonia woodii	C	rock
Dilsea californica	C	rock
Farlowia compressa	U	rock
Farlowia mollis	C	rock
Pikea californica	C	rock
Gloiosiphonia verticillaris	O	rock
Gloiopeltis furcata	O	rock
Endocladia muricata	C	rock
Peyssonellia pacifica	C	epiphytic/ epizooic
Rhodophysema elegans polystromatica	U	epiphytic
Hildenbrandia occidentalis	C	rock
Bossiella californica	U	rock
Bossiella orbigniana ssp. dichotoma	O	rock
Calliarthron tuberculosum	C	rock
Chiharaea bodegensis	O	rock
Corallina frondescens	C	rock
Corallina officinalis chilensis	O	rock
Corallina vancouveriensis	C	rock
Hydrolithon decipiens	C	rock
Pseudolithophyllum neofarlowii	O	rock
Lithothamnium pacificum	C	rock
Lithothamnium phymatodeum	C	rock
Melobesia marginata	C	epiphytic
Melobesia mediocris	C	epiphytic
Mesophyllum conchatum	O	parasitic
Mesophyllum lamellatum	U	rock
Clathromorphum parcum	C	parasitic

Intertidal Marine Plants	Abundance	Substrate
Rhodophyta		
Class: Florideophyceae, continued		
Neopolyporolithon reclinatum	C	parasitic
Serraticardia macmillanii	O	rock
Tenarea dispar	O	epiphytic
Cryptonemia ovalifolia	U	rock
Grateloupia ?schizophylla	C	rock
Halymenia californica	O	rock
Lobocolax deformans	C	parasitic
Prionitis cornea	U	rock
Prionitis lanceolata	C	rock
Prionitis lyallii	C	rock
Callophyllis crenulata	U	rock
Callophyllis firma	O	rock
Callophyllis flabellulata	C	rock
Callophyllis obtusifolia	O	rock
Callophyllis pinnata	C	rock
Callophyllis ?stenophylla	U	rock
Callophyllis violacea	C	rock
Erythrophyllum delesserioides	C	rock
Petrocelis franciscana	C	rock
Schizymenia pacifica	C	rock
Neoagardhiella baileyi	C	rock
Gardneriella tuberifera	O	parasitic
Plocamiocolax pulvinata	O	parasitic
Plocamium cartilagineum	C	rock
Plocamium oregonum	U	rock
Plocamium violaceum	C	rock
Gracilariopsis sjoestedtii	C	rock
Ahnfeltia gigartinoides	C	rock
Ahnfeltia plicata	C	rock
Gymnogongrus leptophyllus	O	rock
Gymnogongrus linearis	C	rock
Gymnogongrus platyphyllus	U	-

Intertidal Marine Plants	Abundance	Substrate
Rhodophyta		
Class: Florideophyceae, continued		
Stenogramme interrupta	U	rock
Gigartina agardhii	C	rock
Gigartina exasperata	C	rock
Gigartina canaliculata	O	rock
Gigartina corymbifera	C	rock
Gigartina harveyana	C	rock
Gigartina papillata	C	rock
Gigartina volans	C	rock
Iridaea cordata splendens	C	rock
Iridaea ?coriacea	O	rock
Iridaea cornucopiae	U	rock
Iridaea flaccida	C	rock
Iridaea heterocarpa	C	rock
Rhodoglossum affine	C	rock
Rhodoglossum californicum	U	rock
Rhodoglossum roseum	C	rock
Halosaccion glandiforme	C	rock
Rhodymenia pacifica	C	rock
Rhodymenia palmata mollis	C	rock
Gastroclonium coulteri	C	rock
Callithamnion acutum	O	rock
Callithamnion ?lejolisea	O	epiphytic
Callithamnion pikeanum	C	rock
Ceramium eatonianum	C	rock/ epizooic
Microcladia borealis	C	rock
Microcladia californica	O	epiphytic
Microcladia coulteri	C	epiphytic
Neoptilota densa	C	epiphytic
Neoptilota hypnoides	O	rock/ epiphytic
Ptilota filicina	C	rock
Tiffaniella snyderiae	O	rock

Intertidal Marine Plants	Abundance	Substrate
Rhodophyta		
Class: Florideophyceae, continued		
Cryptopleura lobulifera	O	rock
Cryptopleura violacea	C	rock
Delesseria decipiens	O	rock
Gonimophyllum skottsbergii	U	epiphytic
Hymenena cuneifolia	O	rock
Hymenena flabelligera	C	rock
Hymenena multiloba	C	rock
Membranoptera dimorpha	O	rock
Polyneura latissima	C	rock
Janczewskia gardneri	O	parasitic
Laurencia spectabilis spectabilis	C	rock
Odonthalia floccosa	C	rock
Odonthalia oregona	U	rock
Polysiphonia hendryi gardneri	C	rock
Polysiphonia pacifica disticha	U	rock
Polysiphonia paniculata	C	rock
Pterosiphonia bipinnata	U	rock
Pterosiphonia dendroidea	C	rock
Rhodomela larix	C	rock
Tracheophyta		
Class: Angiospermae		
Phyllospadix scouleri	C	rock
Phyllospadix torreyi	O	rock

Porifera			
Class: Demospongiae	Abundance	Zone	Substrate
Acarnus erithacus	O	L	rock
Adocia dubia	U	L	rock
Antho lithophoenix	O	L	rock/shell
Aplysilla glacialis	C	L	rock
Aplysilla polyraphis	U	L	rock

Porifera	Abundance	Zone	Substrate
Class: Demospongiae, continued			
Axinella ?vermiculata	U	L	rock
Axocielita originalis	O	L	rock
Cliona ?celata californiana	C	L	rock/shell
Halichondria panicea	C	ML	rock/algae
Haliclona permollis	C	ML	rock/shell
Higginsia ?higginissima	U	L	rock
Hymendectyon lyoni	O	L	rock/shell
Leucophloeus actites	O	L	rock/algae
Lissodendoryx firma	C	L	rock/algae
Lissodendoryx topsenti	C	L	rock
Mycale ?lobata	O	L	rock/algae
Mycale macginitiei	O	L	rock
Mycale psila	O	L	rock
Mycale richardsoni	O	L	rock/algae
Microciona microjoanna	U	L	rock
Ophlitaspongia pennata	C	L	rock/shell
?Pachychalina lunisimilis	O	L	rock
Plocamia karykina	C	L	rock/shell
Polymastia pachymastia	U	L	rock
Reniera sp. A	O	L	rock
Suberites sp.	U	L	rock
?Tedanione obscurata	O	L	rock/algae
Tetilla sp.	U	L	epizooic
Tetilla sp. a	O	L	epizooic
Xestospongia trindanea	U	L	rock
Xestospongia vanilla	C	L	rock
Class: Calcispongiae			
Leucosolenia eleanor	O	L	rock
Leucilla nuttingi	O	L	rock
Cnidaria			
Class: Scyphozoa			
unidentified Stauromedusan	U	L	epiphytic on Phyllospadix

Cnidaria	Abundance	Zone	Substrate
Class: Hydrozoa			
Garveia annulata	O	L	rock
Hydractinia sp.	O	L	rock, epiphytic
Corynid polyps	O	L	rock, epiphytic
Eudendrium californicum	O	L	rock
Leuckartiara octona	U	L	rock
Tubularia marina	O	L	rock
Campanularia urceolata	O	L	rock, epiphytic
Campanularia volubilis	O	L	rock
Phialidium sp.	O	L	rock, epiphytic
Orthopyxis spp.	O	L	epiphytic
Halecium sp.	U	L	rock, epiphytic
Aglaophenia inconspicua	O	L	epiphytic, rock
Aglaophenia latirostris	O	L	rock
Aglaophenia struthionides	C	L	rock, epiphytic
Plumularia setacea	O	L	rock
Plumularia plumularoides	O	L	epiphytic
Abietenaria amphora	O	L	rock
Abietenaria filicula	O	L	rock
Abietenaria greenei	O	L	rock
Sertularella turgida	O	L	rock
Sertularella pinnata	O	L	rock
Sertularia furcata	O	L	epiphytic
Vellela vellela	C	pelagic	washes ashore in spring
Stylantheca porphyra	U	L	rock
Class: Anthozoa			
Anthopleura artemisia	O	L	sand at bases of rocks

	Abundance	Zone	Substrate
Cnidaria			
Class: Anthozoa			
Anthopleura elegantissima	C	HML	rock
Anthopleura xanthogrammica	C	ML	rock
Cnidopus ritteri	O	L	rock
Epiactis prolifera	C	L	rock
Tealia coriacea	O	L	rock
Balanophyllia elegans	U	L	rock
Corynactis californica	U	L	rock
Clavularia sp.	U	L	rock
Platyhelminthes			
Class: Turbellaria			
Notoplana sp.	O	ML	rock
other polyclads	O	ML	rock
Nemertea			
Class: Anopla			
Tubulanus polymorphus	U	L	rock
Tubulanus sexlineatus	O	L	rock
Class: Enopla			
Amphiporus formidabilis	O	ML	rock
Amphiporus imparispinosus	C	ML	rock
Emplectonema gracile	C	ML	rock
Paranemertes peregrina	C	ML	rock
Sipuncula			
Themiste dyscritum	U	L	rock
Phascalosoma agassizi	C	ML	rock
Annelida			
Class: Polychaeta			
Arctonoe vittata	O	L	commensal
Arctonoe fragilis	O	L	commensal
Halosydna brevisetosa	C	ML	rock

Annelida	Abundance	Zone	Substrate
Class: Polychaeta, continued			
Sthenelais fusca	U	L	algal holdfasts
Eulalia aviculiseta	O	L	rock, holdfasts
Ophiodromus pugettensis	C	ML	commensal with *Patiria*
Haplosyllis spongicola	U	L	in sponges
other syllids	O	L	rock
Nereis vexillosa	C	ML	rock
Platynereis bicanaliculata	C	ML	rock, epiphytic
Lumbrineris sp.	O	L	rock
Arabella iricolor	O	ML	rock
Naineris dendritica	O	L	rock
Boccardia proboscidea	C	HM	rock
Cirriformia luxuriosa	C	HM	rock
Dodecaceria fewkesi	C	ML	rock
Phragmatopoma californica	C	ML	rock
Neoamphitrite robusta	U	ML	rock
Thelepus crispus	O	ML	rock
Chone ecaudata	C	ML	rock, holdfasts
Eudistylia polymorpha	O	L	rock
Serpula vermicularis	C	ML	rock
Spirorbis spp.	C	ML	rock, epizooic
Arthropoda			
Class: Crustacea			
Tigriopus californicus	C	H	pools
Balanus crenatus	C	ML	rock, epiphytic
Balanus glandula	C	HM	rock
Balanus nubilus	O	ML	rock
Balanus cariosus	C	M	rock

Arthropoda	Abundance	Zone	Substrate
Class: Crustacea, continued			
Chthamalus dalli	C	HM	rock
Tetraclita squamosa	U	ML	rock
Pollicipes polymerus	C	M	rock
unidentified mysids	O	ML	pools
unidentified tanaids	O	ML	rock
Idotea stenops	O	L	epiphytic
Idotea montereyensis	O	ML	rock
Idotea wosnesenskii	O	ML	rock
Cirolana harfordi	C	ML	rock
Excirolana linguifrons	O	M	sand
Ligia occidentalis	C	H	rock
Ligia pallasii	O	H	rock
Alloniscus perconvexus	C	H	sand
Orchestoidea californiana	C	H	sand
Orchestoidea corniculata	C	H	sand
Orchestia traskiana	C	H	sand
gammarid amphipods	C	HML	rock, ubiquitous
Caprella verrucosa	O	L	epizooic
Caprella gracilior	O	L	epizooic
Metacaprella kennerlyi	O	L	epizooic
Heptacarpus brevirostris	O	L	pools
Heptacarpus taylori	O	L	pools
Loxorhynchus crispatus	O	L	rock
Mimulus foliatus	U	L	rock
Pugettia producta	C	ML	rock
Cancer antennarius	C	ML	rock
Cancer productus	O	L	rock
Opisthopus transversus	U	L	commensal with Cyrptochiton
Fabia subquadrata	O	ML	parasitic in Mytilus
Hemigrapsus nudus	C	ML	rock
Pachygrapsus crassipes	C	HM	rock

Arthropoda	Abundance	Zone	Substrate
Class Crustacea, continued			
Pagurus samuelis	C	HM	pools
Pagurus granosimanus	O	HM	pools
Pagurus hirsutiusculus	C	HM	pools
Pagurus hemphilli	U	L	rock
Oedignathus inermis	U	M	rock
Pachycheles rudis	C	ML	rock
Petrolisthes cinctipes	C	ML	rock
Emerita analoga	O	ML	sand
Class: Pycnogonida			
Achelia chelata	O	L	rock, hydroids
Phoxichilidium quadridentatum	O	L	parasitic on Eudendrium
Pycnogonum stearnsi	O	ML	rock
Tanystylum californicum	O	L	found on Aglaophenia
Class: Insecta			
Chironomid larvae	O	HML	rock
Oedoparena glauca	O	M	in Balanus
Staphylinid beetles	C	H	sand
Tenebrionid beetles	O	H	sand
Circulionid beetles	O	H	sand
Salpingid beetles	O	H	sand
Class: Merostomata			
mites	C	HML	rock
Mollusca			
Class: Cephalopoda			
Octopus dofleini martini	O	L	pools
Class: Polyplacophora			
Cryptochiton stelleri	O	L	rock
Nuttalina californica	O	HM	rock
Cyanoplax hartwegii	O	ML	rock

Mollusca	Abundance	Zone	Substrate
Class: Polyplacophora, continued			
Ischnochiton radians	U	L	rock
Lepidozona cooperi	O	L	rock
Tonicella lineata	C	L	rock
Katharina tunicata	C	M	rock
Mopalia ciliata	O	ML	rock
Mopalia hindsii	O	ML	rock
Mopalia lignosa	O	ML	rock
Mopalia muscosa	C	HML	rock
Placiphorella velata	U	L	rock
Class: Gastropoda			
Haliotis cracherodii	O	L	rock
Haliotis rufescens	O	L	rock
Diodora aspera	O	L	rock
Megatebennus bimaculatus	O	L	rock, on compound ascidians
Acmaea mitra	O	L	rock
Collisella asmi	O	HML	on Tegula and other snails
Collisella digitalis	C	H	rock
Collisella instabilis	O	L	on brown alga Laminaria
Collisella limatula	O	ML	rock
Collisella pelta	C	HML	rock
Collisella scabra	C	H	rock
Collisella strigatella	O	H	rock
Notoacmea insessa	C	ML	on brown alga Egregia
Notoacmea paleacea	C	ML	on surfgrass Phyllospadix
Notoacmea persona	O	HM	rock
Notoacmea scutum	C	ML	rock
Calliostoma ligatum	O	L	rock

Mollusca	Abundance	Zone	Substrate
Class: Gastropoda, continued			
Lirularia succincta	O	L	rock
Tegula brunnea	O	L	rock
Tegula funebralis	C	HM	rock
Lacuna sp.	C	ML	on algae
Littorina planaxis	C	H	rock
Littorina scutulata	C	HM	rock
Barleeia sp.	O	L	rock
Bittium sp.	O	L	rock
Epitonium tinctum	O	ML	on anemones
Hipponix cranioides	U	M	rock
Crepidula adunca	O	ML	on snails
Crepidula nummaria	U	L	rock
Lamellaria sp.	U	L	on compound ascidians
Ceratostoma foliatum	O	L	rock
Ocenebra circumtexta	O	L	rock
Acanthina spirata	U	L	rock
Nucella canaliculata	U	L	rock
Nucella emarginata	C	ML	rock
Searlesia dira	O	L	rock
Amphissa versicolor	O	ML	rock
Mitrella carinata	C	ML	rock
Trimusculus reticulatus	U	ML	rock
Onchidella borealis	C	ML	rock
pyramidellid snails	O	ML	ectoparasitic
Aplysiopsis smithi	U	HM	pools, algae
Acanthodoris brunnea	U	L	rock
Aeolidia papillosa	O	ML	rock
Ancula pacifica	U	L	rock
Anisodoris nobilis	O	L	rock
Archidoris montereyensis	C	L	rock
Cadlina modesta	O	L	rock
Coryphella trilineata	O	L	rock
Dendronotus frondosus	U	L	rock

Mollusca	Abundance	Zone	Substrate
Class: Gastropoda, continued			
Diaulula sandiegensis	C	L	rock
Dirona picta	O	L	rock
Doriopsilla albopunctata	O	L	rock
Doto kya	O	L	rock
Hancockia californica	U	L	rock
Hermissenda crassicornis	O	L	rock
Polycera atra	U	L	rock
Rostanga pulchra	O	L	rock
Trinchesia sp.	U	L	rock
Triopha carpenteri	O	L	rock
Triopha maculata	O	L	rock
Tritonia festiva	U	L	rock
Class: Bivalvia			
Mytilus californianus	C	HML	rock
Pododesmus cepio	O	ML	rock
Hinnites giganteus	O	ML	rock
Hiatella arctica	O	L	boring in rock
Pholadidea penita	O	L	boring in rock
Protothaca staminea	O	ML	sand at bases of rock
Mytilimeria nuttalli	U	L	in compound ascidians
Ectoprocta			
Class: Gymnolaemata			
Alcyonidium polyoum	C	L	rock, epizooic, epiphytic
Flustrellidra corniculata	C	L	epiphytic
Triticella elongata	U	L	epizooic on crabs
Bugula californica	O	L	rock
Dendrobeania lichenoides	C	L	rock

Ectoprocta	Abundance	Zone	Substrate
Class: Gymnolaemata, continued			
Electra crustulenta	O	L	rock
Membranipora membranacea	O	L	epiphytic
Scrupocellaria californica	O	L	rock
Tricellaria ternata	U	L	epiphytic
Arthropoma cecili	U	L	rock
Eurystomella bilabiata	C	L	rock
Hippothoa hyalina	C	L	epiphytic
Microporella californica	O	L	rock
Class: Stenolaemata			
Crisia maxima	C	L	rock
Filicrisia geniculata	O	L	rock
Entoprocta			
Barentsia gracilis	O	L	rock
Echinodermata			
Class: Asteroidea			
Dermasterias imbricata	O	L	rock
Henricia leviuscula	O	L	rock
Patiria miniata	C	L	rock
Evasterias troschelii	U	L	rock
Leptasterias hexactis	O	L	rock
Leptasterias pusilla	O	M	rock
Pisaster brevispinus	U	L	rock
Pisaster ochraceus	C	ML	rock
Pycnopodia helianthoides	O	L	rock
Solaster dawsoni	U	L	rock
Class: Ophiuroidea			
Amphioda occidentalis	O	L	rock
Ophiothrix spiculata	O	L	rock
Class: Echinoidea			
Strongylocentrotus purpuratus	C	ML	rock, pool

Echinodermata	Abundance	Zone	Substrate
Class: Holothuroidea			
Cucumaria pseudocurata †	C	ML	rock
Cucumaria miniata †	O	L	rock
Eupentacta quinquesemita †	U	L	rock
Chordata (Tunicata)			
Class: Ascidiacea			
Aplidium californicum †	C	L	rock
Archidistoma molle †	O	L	rock
Archidistoma psammion †	O	L	rock
Archidistoma ritteri †	O	L	rock
Clavelina huntsmani †	O	L	rock
Didemnum carnulentum †	C	L	rock
Distaplia smithi †	O	L	rock
Euherdmania claviformis †	O	L	rock
Polyclinum planum †	O	L	rock
Trididemnum opacum †	O	L	rock
Botryllus sp. †	O	L	rock
Metandrocarpa taylori †	O	L	rock
Pyura haustor †	O	L	rock
Styela montereyensis †	C	L	rock
Chordata (Fishes)			
Class: Osteichthyes			
Oligocottus maculosus †	O	ML	pools
Clinocottus spp. †	O	ML	pools
Xiphister atropurpureus †	O	ML	pools
Gobiesox maeandricus †	O	ML	pools

P. O. Box 100, Sacramento, CA 95801

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARDS

NORTH COAST REGION (1)
1000 Coddingtown Center
Santa Rosa, California 95401
(707) 545–2620

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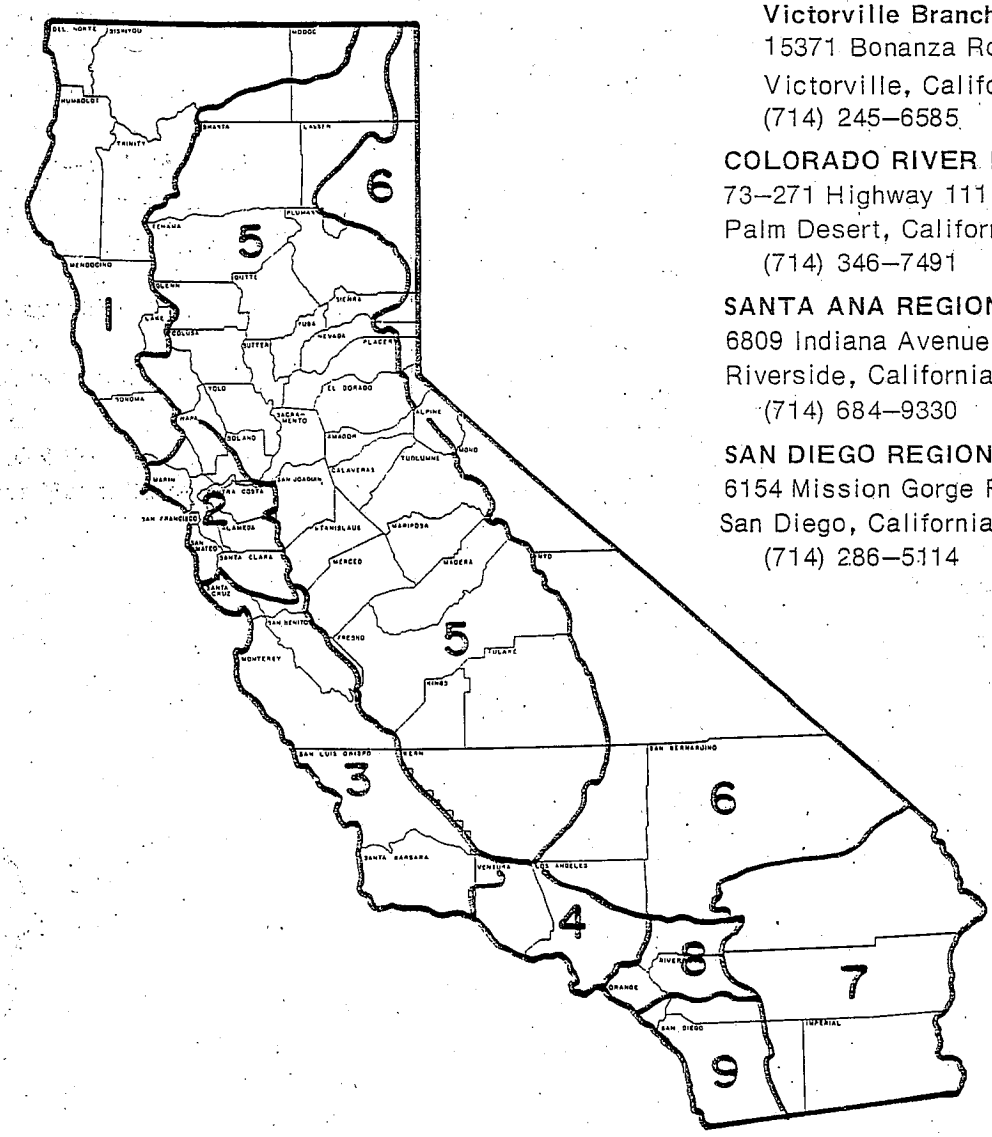
1111 Jackson Street, Room 6040
Oakland, California 94607
(415) 464–1255

CENTRAL COAST REGION (3)
1122–A Laurel Lane
San Luis Obispo, California 93401
(805) 549–3147

LOS ANGELES REGION (4)
107 South Broadway, Room 4027
Los Angeles, California 90012
(213) 620–4460



CENTRAL VALLEY REGION (5)
3201 S Street
Sacramento, California 95816
(916) 445–0270

Fresno Branch Office
3374 East Shields Avenue
Fresno, California 93726
(209) 488–5116

Redding Branch Office
1815 Sacramento Street
Redding, California 96001
(916) 442–6376

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2092 Lake Tahoe Boulevard
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South Lake Tahoe, California 95702
(916) 544–3481

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Victorville, California 92392
(714) 245–6585

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73–271 Highway 111, Suite 21
Palm Desert, California 92260
(714) 346–7491

SANTA ANA REGION (8)
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Riverside, California 92506
(714) 684–9330

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San Diego, California 92120
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