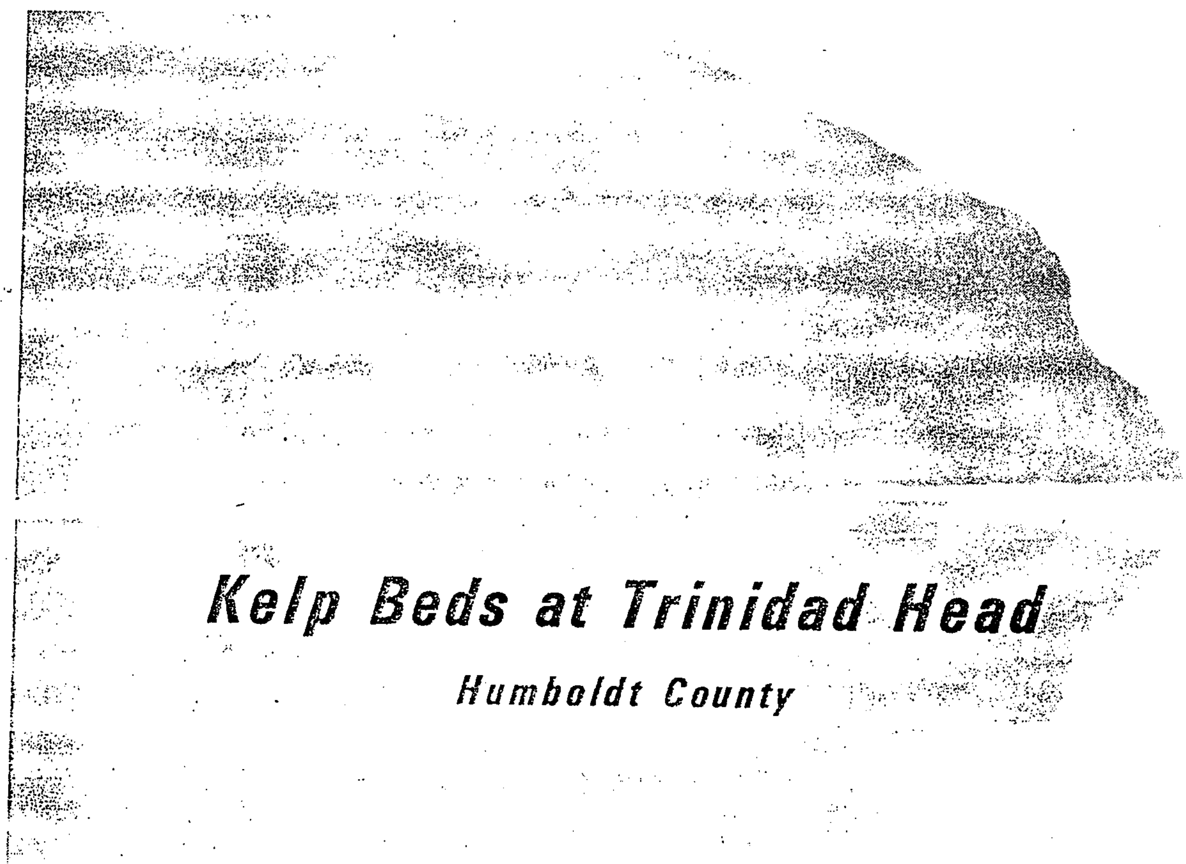
California Marine Waters
Areas of Special Biological Significance
Reconnaissance Survey Report



Kelp Beds at Trinidad Head

Humboldt County

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

DIVISION OF PLANNING AND RESEARCH

SURVEILLANCE AND MONITORING SECTION

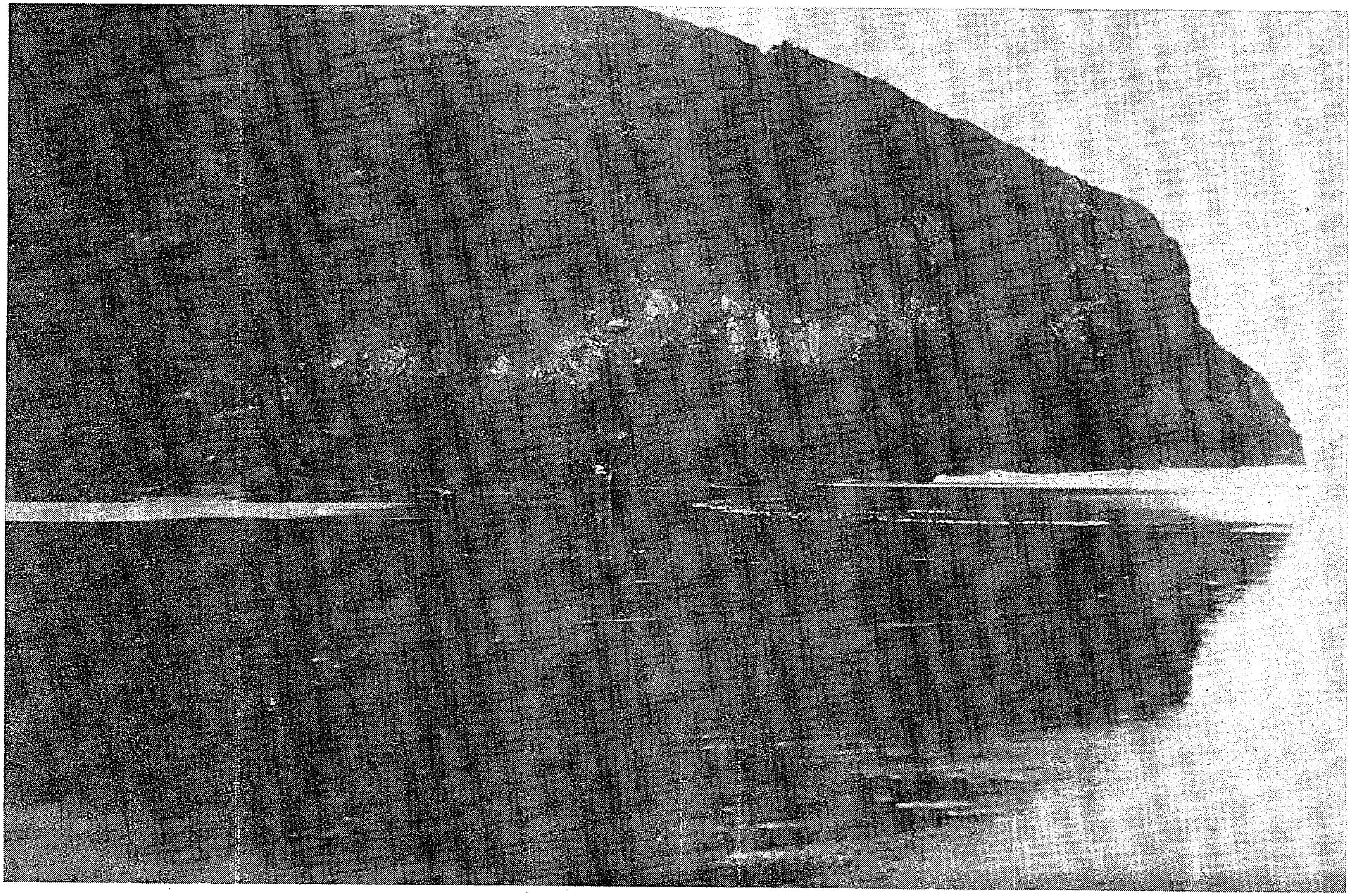
June 1979

WATER QUALITY MONITORING REPORT NO. 79-19

Cover Photograph:

Kelp Beds at Trinidad Head
Area of Special Biological Significance

Printed March 1980



Kelp Beds at Trinidad Head 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

KELP BEDS AT TRINIDAD HEAD
HUMBOLDT COUNTY

STATE WATER RESOURCES CONTROL BOARD

DIVISION OF PLANNING AND RESEARCH

SURVEILLANCE AND MONITORING SECTION

WATER QUALITY MONITORING REPORT NO. 79-19

ACKNOWLEDGEMENTS

This State Water Resources Control Board Report is based on a reconnaissance survey report submitted by Dr. Milton J. Boyd, Humboldt State University. Dr. Boyd's 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.

In addition, a macrobiological survey of Trinidad Bay and Trinidad Head Kelp Beds, conducted by Dr. John D. DeMartini, Steven Jones and Craig Seltenrich, is also included as an appendix. This survey report is based on a request by the North Coastal Zone Conservation Commission for baseline biological information to be used for constructing a management plan for Trinidad Bay.

ABSTRACT

The Kelp Beds at Trinidad Head Area of Special Biological Significance is located approximately 28 miles north of Eureka, California, and encompasses areas both north and south of Trinidad Head. The northern part of the ASBS is approximately 1.97 square miles in size and the area of the southern part is about 0.5 square miles. The northern area is fully exposed to wind and waves while the southern section is partially sheltered by Trinidad Head.

The sea bottom of both areas is a mixture of rock and sand; the source of these sediments is from adjacent cliffs, streams and nearby rivers.

Three geological components are in evidence within the ASBS: the Franciscan Formation, quaternary marine deposits, and modern beach sands. The present geological features are a result of differential weathering and erosion of the major formations.

Nearshore currents vary with the season. From February through October, a generally south-flowing nearshore current sweeps the coast, gradually establishing clockwise and counterclockwise gyres in the northwestern and southeastern portions of the ASBS, respectively. During the winter months from November to February, a current reversal occurs as a result of the predominant northward-flowing Davidson Current. This flow in turn establishes clockwise gyres in both portions of the ASBS.

The intertidal zones within the ASBS fall into four major categories: exposed sand beach; semi-exposed sand beach; fully exposed rocky intertidal; and semi-exposed rocky intertidal. Each of these habitats supports a flora and fauna influenced by the physical environment, biological interactions between species, and the activities of man. A lack of herbivore populations within the ASBS allows the growth of a diverse assemblage of intertidal algae.

The subtidal zone consists of sand-silt bottoms interspersed with a number of shear-faced sea stacks that rise nearly to or above the water surface. A variety of algae, invertebrates and fish inhabit this area.

The primary uses of the Area include commercial and sport fish boat launching and mooring, scientific study, and sport fishing. Three important commercial catches, market crab, silver salmon, and king salmon, are landed at the Trinidad Pier within the ASBS. However, fishing grounds for these species are outside the Area.

Two possible sources of water quality degradation in the ASBS include runoff via McConnahas-Mill and Mill Creeks and fish filleting offal disposal at the Trinidad Pier. Creek waters have exhibited high coliform bacterial counts in a limited number of measurements. The source and magnitude of this potential problem needs further study. Disposal of fish carcasses beneath the pier by fishermen, as observed by divers, also threatens water quality. The accumulation rate exceeds removal by scavengers so that putrefaction sets in. This situation could be resolved by a satisfactory means of fish offal disposal.

Trinidad Head ASBS is considered to be biologically special due to the diversity of habitat types, the close assemblage and association of seabirds, marine mammals, and intertidal plants and animals, and the dense beds of bull kelp, Nereocystis lutkeana.

Trinidad Head is the only major headland between Cape Mendocino and Point St. George. It appears that some species with a northerly distribution are close to their southern limit at Trinidad. A colonial tunicate, Cnemidocarpa finmarkiensis, is common at Trinidad, but is rare elsewhere in California.

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FINDINGS AND CONCLUSIONS

The two parts of the Trinidad ASBS present somewhat different management problems. Except for the collecting activities of beachcombers, the northwestern portion is not greatly affected by human activities. The offshore rocks are a haven for seabirds and marine mammals. Inshore of the larger rock islands, bull kelp, Nereocystis luetkeana, is seasonally prolific on submerged or tidally emergent rocks. As long as development in areas adjacent to this part of the ASBS is in consonance with the local plan approved by the California Coastal Commission, it appears that threats to water quality are minimal or nonexistent.

In the southeastern part of the ASBS, commercial and recreational activities are centered around Trinidad Pier and east of Little Head at a boat launching area. Disposal of fish carcasses and machine parts around the pier pose a threat to the maintenance of water quality standards. Local authorities should be encouraged to install a fish cleaning station on the pier or in the adjacent parking area to ensure the proper disposal of fish offal and carcasses. At present, there is local pressure to increase the number of seasonal mooring sites in Trinidad Bay. It seems certain that additional mooring facilities would result in more automobiles in the parking area and increased amounts of fuel and oil in waters of this part of the ASBS. The local current pattern tends to trap materials in a gyre southeast of Trinidad Head; hence, further introduction of pollutants should be avoided. Construction of a breakwater from Trinidad Head eastward would require careful study, since such a structure would tend to accentuate the "trapping" of materials in the local gyre.

Coastal bluffs overlooking the southern part of the ASBS have been designated as open space in the local general plan and in the California Coastal Plan. These cliffs are geologically unstable and unsuitable for development.

Wastewater disposal in areas adjacent to the ASBS is by septic tanks and drainage fields. Other treatment methods are not necessary at this time, and local authorities have approved a general plan which will not require other treatment methods in the near future (10-20 years).

INTRODUCTIONS

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 signficance" 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 Kelp Beds at Trinidad Head ASBS, a reconnaissance survey integrating existing information and field study was performed by Dr. Milton J. Boyd of Humboldt State University. The survey report was one of a series prepared for the State Board under the direction of the California Department of Fish and Game and provided the information compiled in this document.

Areas to the north and south of Trinidad Head were designated as Areas of Special Biological Significance because of the fluctuating presence of bull kelp, *Nereocystis luetkeana*, beds there. Kelp beds are biologically significant in providing both food and shelter for fish and invertebrates. Additionally, the beds are relatively rare along the coast of northern California and are adversely affected by thermal and waste discharges.

ORGANIZATION OF SURVEY

Beginning in August, 1977, the intertidal zones of the Trinidad Head ASBS were qualitatively surveyed and several sites that had been quantitatively surveyed in prior years were examined with particular reference to any significant changes in the physical setting or distributions of plants and animals. A photographic record of all offshore and inshore habitats surveyed was kept. Local planning documents, student theses, and published literature were used in addressing aspects of local nearshore current patterns, geological formations, and local patterns of development. The nearshore benthic habitat was not surveyed as part of this report.

Records of water temperature, salinity, and meteorological data collected by the staff of the Humboldt State University Trinidad Marine Laboratory were utilized in constructing tables and graphs of the marine and terrestrial climate. These records cover the period from January, 1973 to December, 1977.

PHYSICAL AND CHEMICAL DESCRIPTION

Location and Size

The Kelp Beds at Trinidad Head Area of Special Biological Significance is located at approximately 41°03'15" north latitude, 124°08'10" west longitude, which is 28 miles (45 km) north of Eureka, California and encompasses areas both north and south of Trinidad Head (Figure 1). The northern part of the ASBS is approximately 1.97 square miles (5.10 km^2) in size; the southern part is about 0.5 square miles (1.3 km^2) in size. The northern area is fully exposed to winds and waves, while the southern area is semi-exposed because of the sheltering effects of Trinidad Head. For a complete description of the ASBS, see the State Water Resources Control Board publication, "Areas of Special Biological Significance (1976)".

Nearshore Waters

The current patterns of the nearshore waters of the Trinidad Head ASBS are complex and variable. The two portions of the ASBS are affected quite differently by wave and wind conditions because of their differing exposure. Along the shorelines of both areas, sand and rock are intermixed and subjected to tidal variations of approximately 9.3 feet (2.8 m), dependent on the day and season. The sea bottom in both areas is a mixture of rock and sand, with much transport of sediments throughout the ASBS. In both intertidal and subtidal zones, the sediment is more coarse north of Trinidad Head than to the south, again related to the higher energy wave environment of the exposed area.

Sources of sediment are nearby streams, coastal cliff erosion, and transport from river discharges both south and north of the ASBS; the Klamath River is 34.5 miles (54.2 km) to the north, the Little River and the Mad River are 2.7 miles (4.3 km) and 8.3 miles (13.3 km) to the south respectively. The native geologic materials of the headland and its en-

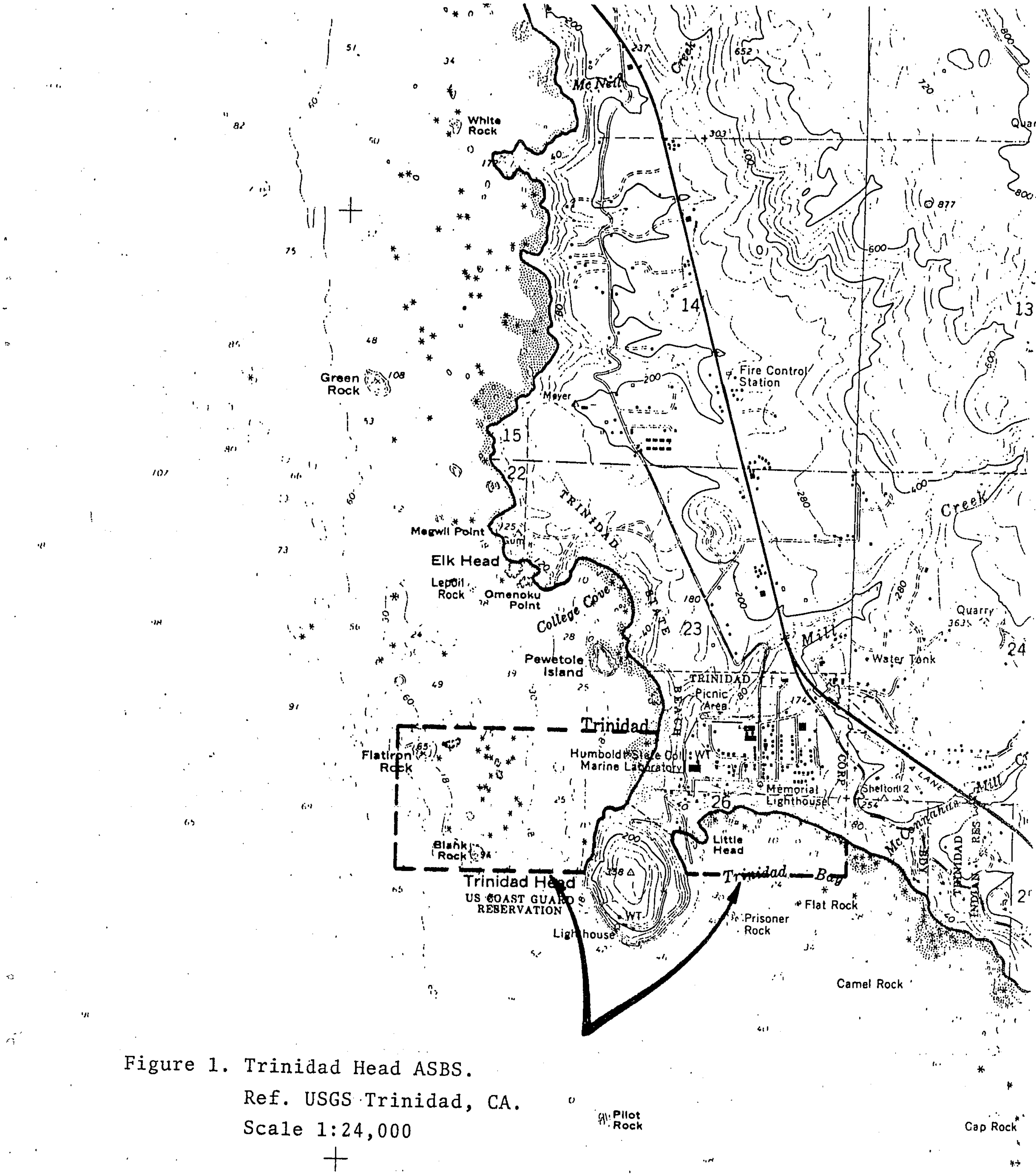


Figure 1. Trinidad Head ASBS.
Ref. USGS Trinidad, CA.
Scale 1:24,000

virons vary in age, composition, and erodibility. Erosion of cliff bases is evident both north and south of the Head, with the native materials apparently comprising the majority of fine, medium, and coarse sands along the ASBS shoreline and on the nearshore bottom.

The nearshore circulation pattern is greatly influenced by the prevailing north to south longshore drift and the interruption of this longshore drift by Trinidad Head. Beach sediments to the north of the Head are much coarser than those to the south, suggesting that finer materials eroded from the cliff bases north of the headland are transported southward, but materials eroded from the cliffs south of the Head tend to remain in a "pocket" in the immediate lee of Trinidad Head (Figures 2-4). This general pattern of circulation is modified, however, by tidal currents, the wind pattern, and upwelling in Trinidad Bay during certain times of the year.

Fluctuations in the temperature and salinity of the nearshore waters of the ASBS are relatively moderate (Figure 5). The lowest water temperatures 43°-48°F (6°-9°C), are generally recorded in late winter or early spring each year, and the highest water temperatures 53.6°-55.4°F (12°-13°C), are recorded in the late summer or early fall. The mean annual water temperature is about 50°F (10°C). Salinity varies, depending upon rainfall and runoff from surrounding streams. During periods of high rainfall in the winter, surface water salinity may drop to 20 parts per thousand for brief periods. The average annual salinity is approximately 34 parts per thousand (Figure 5). Modest seasonal changes in water temperature and salinity are typical of the nearshore zone along the northern California coast.

Topography and Geomorphology

Three geological components are in evidence in the Trinidad ASBS: the complex Franciscan Formation, Quaternary marine deposits, and modern beach sands. The present day geological picture is a result of differential weathering and erosion of the major components (Figure 6).

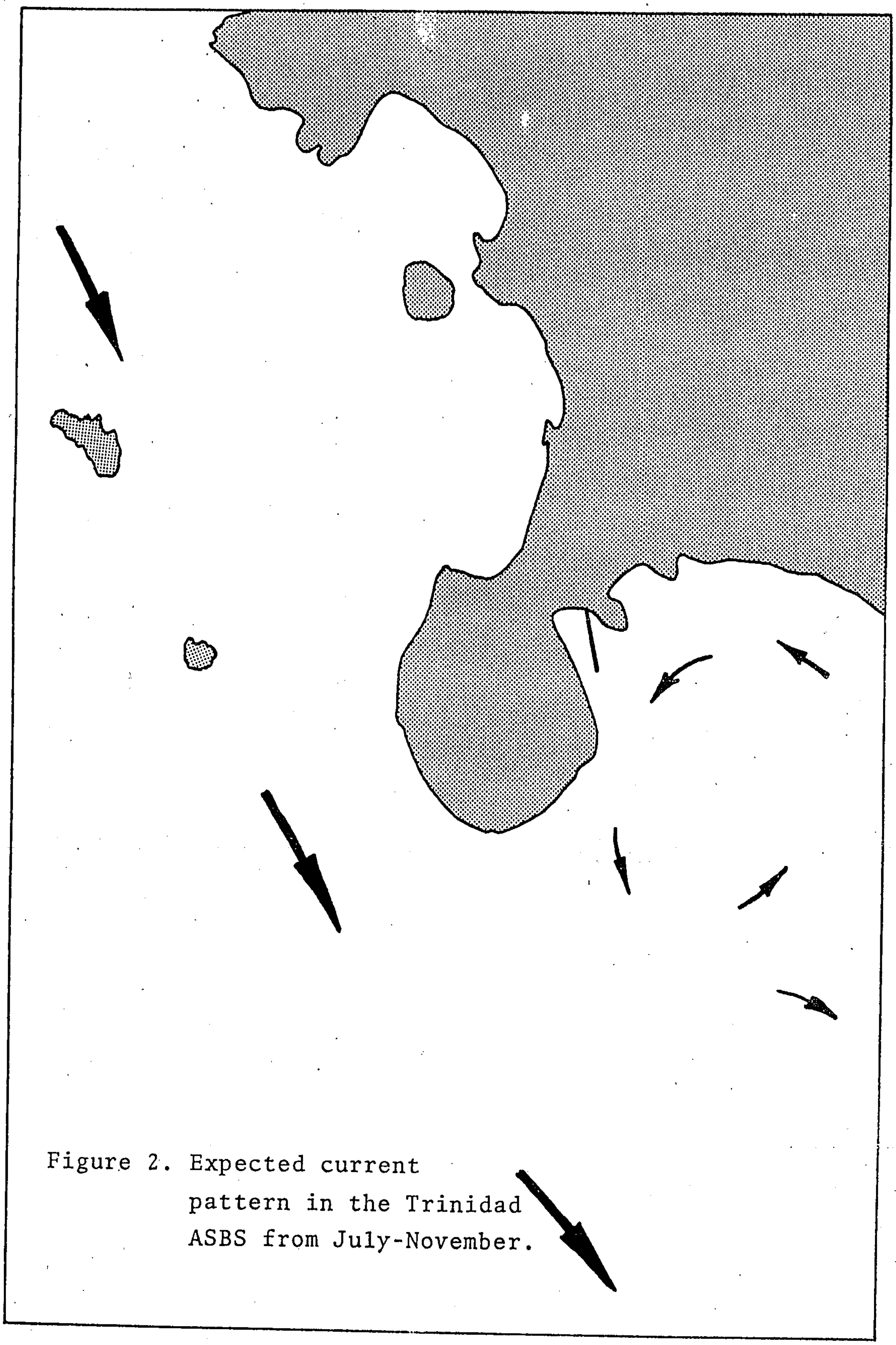


Figure 2. Expected current pattern in the Trinidad ASBS from July-November.

Figure 3. Expected current pattern in the Trinidad ASBS from November-February.

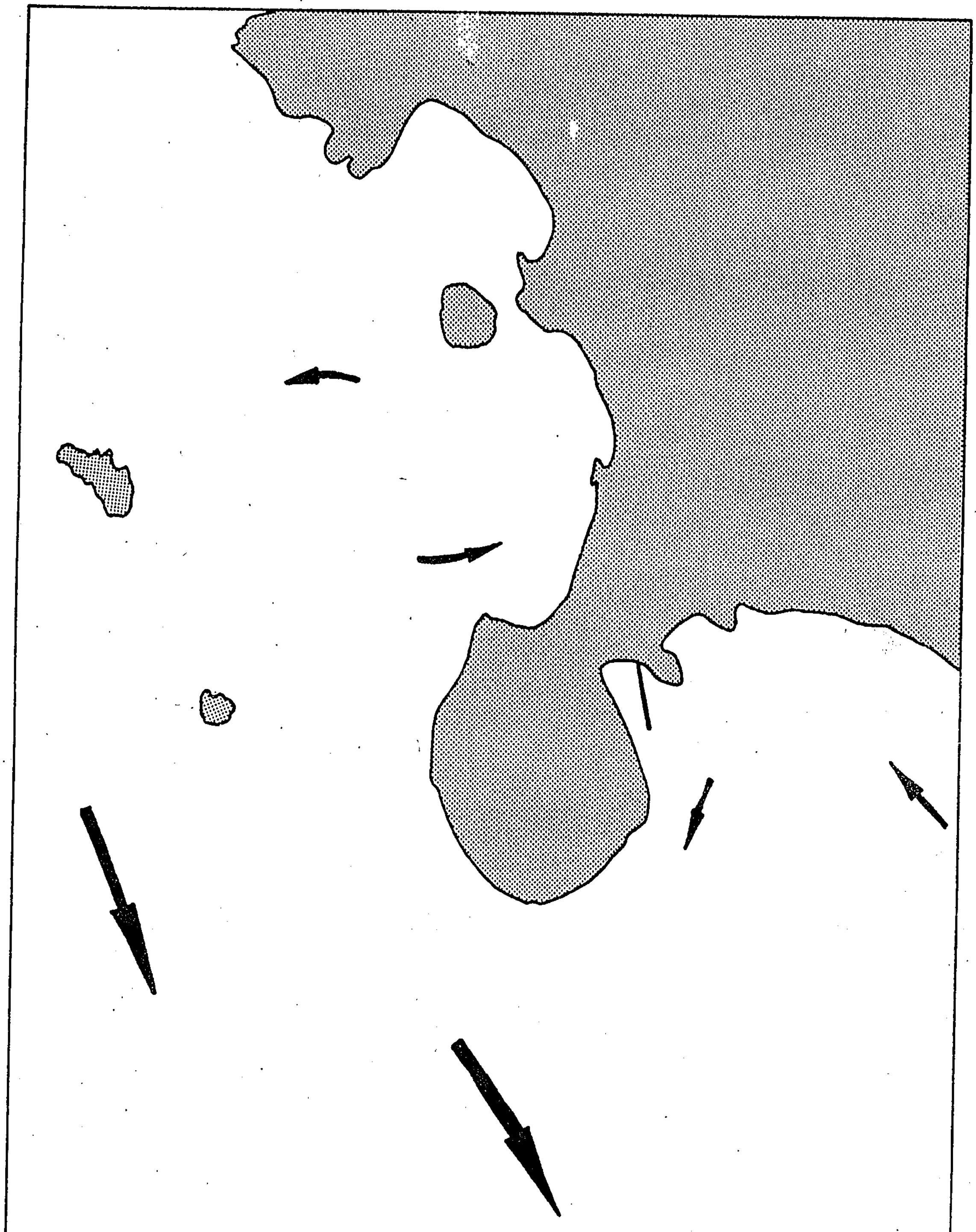


Figure 4. Expected current pattern in the Trinidad ASBS from February-July.

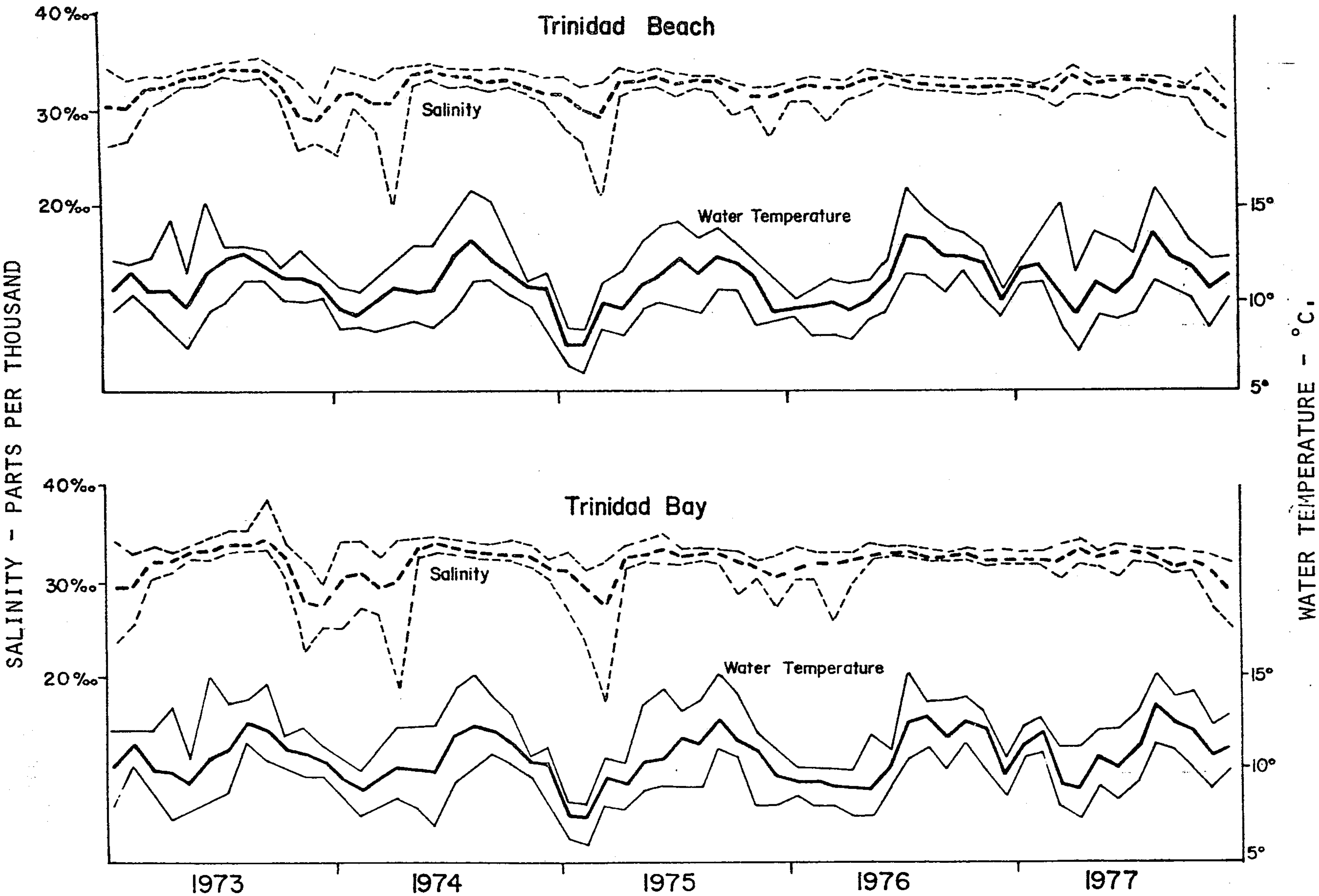


Figure 5. Water temperature and salinity of nearshore waters at two locations in the Trinidad Head ASBS. Solid line indicates mean, outer line the range of variation. Data is monthly averages.

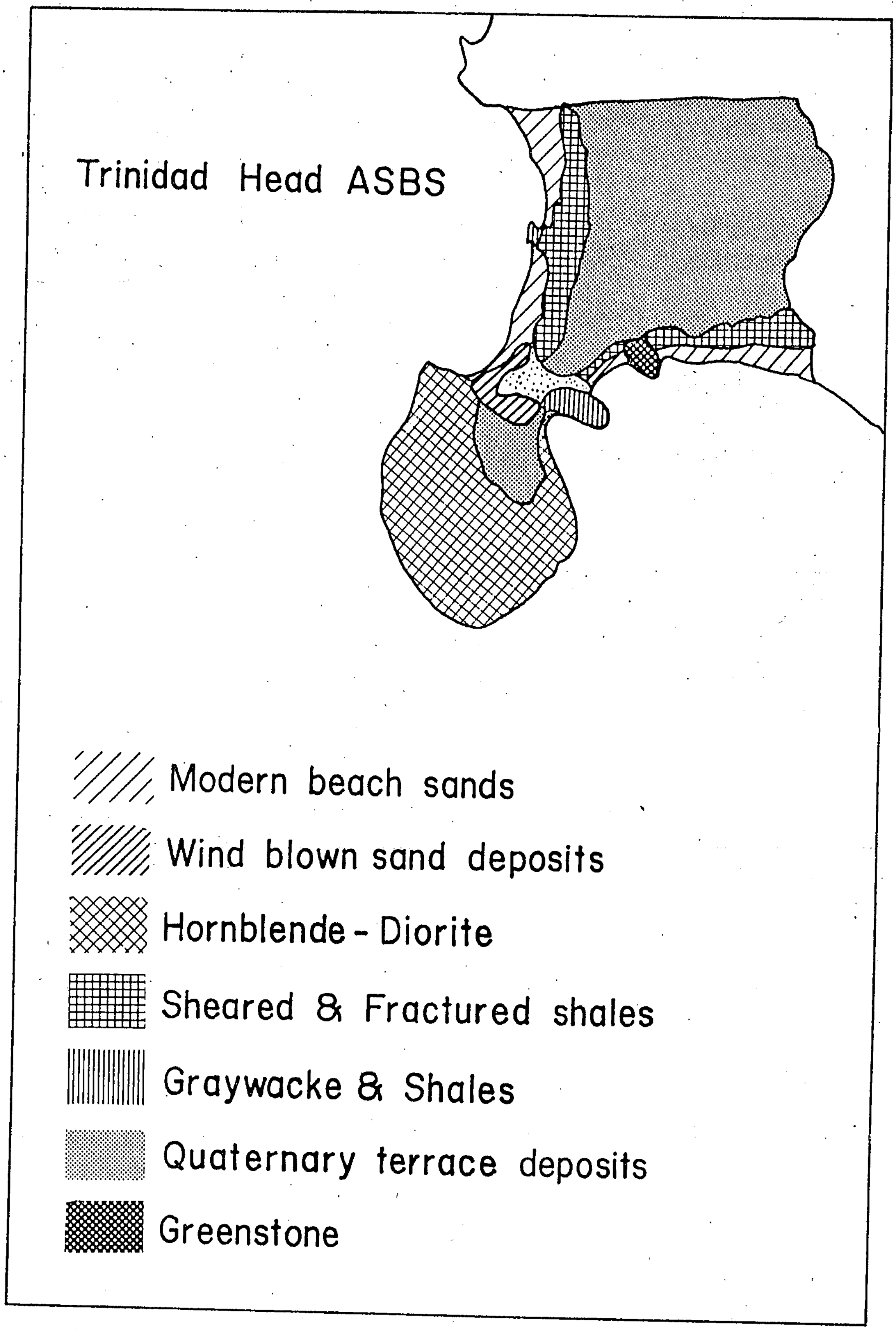


Figure 6: Geological components of the Trinidad Head ASBS.

The Franciscan Formation is geologically complex, having originated as a series of geosynclinal deposits laid down between 60-90 million years ago. Shortly after their formation, sedimentary deposits were extensively faulted, sheared, and locally metamorphosed. The Franciscan was then uplifted and eroded, followed by inundation below sea level. Most of the intertidal rocks of the ASBS show the sedimentary structure typical of Franciscan rocks. Little Head is also clearly Franciscan in origin, as are the stacks and pinnacles both north and south of Trinidad Head.

The "blue clay" at the cliff bases in both the north and south portions of the ASBS is particularly interesting as dynamic evidence of the furies to which Franciscan deposits have been subjected. The clays are called "Franciscan melange", shales that have been ground and smashed to small fragments by shearing through the ages. These highly erodible sediments present numerous problems in road building and construction throughout the northern California coastal area. More recent overlying Quaternary deposits often "slump" following exposure and erosion of the underlying Franciscan melange. Most of the more resistant intertidal rocks and stacks are recognized as "graywacke", a mineralized sandstone, by geologists. Scattered throughout the area are other resistant rocks, mainly greenstone, a metavolcanic rock, found around the base of Trinidad Pier and in the southern portion of the ASBS. Another resistant Franciscan rock type, chert, is found in the cobble field on the upper beach of the southern part of the ASBS. The chert gravels and small boulders have apparently been eroded from the Franciscan melange at the base of the cliffs.

Trinidad Head is, interestingly, not of Franciscan origin. It is a metavolcanic intrusion which apparently was formed at about the same time as Franciscan deposits were being laid down. The rocks of the Head (mainly hornblende and diorite) are more resistant to erosion than the surrounding Franciscan formation, with the resultant appearance of a promontory.

The bluffs overlooking the ASBS are Quarternary in age and were apparently deposited on top of Franciscan rocks during periods of marine inundation in the past 1-2 million years. The coast has since been uplifted and eroded. Rocks of intermediate age (older than Quaternary, but younger than the Franciscan Formation) have apparently been eroded and left no traces.

Following winter storms, erosion of the Franciscan blue clays is particularly evident and results in increased turbidity of the nearshore zone. Local planners and agencies have recognized the danger in placing structures near the present edge of the bluffs because of erosion potential. The bluffs are currently designated as open space to lessen the possibility of increased erosion and damage to property.

Climate

The local climate of the ASBS is dominated by marine factors. In the summer months, a region of high pressure lies off the coast, generating the prevailing northwesterly winds (Figure 7) and coastal fog. In winter, this high pressure zone moves southward and is replaced by a low pressure zone off the coast. Cool, moist air masses move toward the coast during winter months, and on contacting the coastal hills, are uplifted, cool, and drop their moisture as rain.

There are no rain gauge records for the immediate Trinidad area, but records of rainfall have been kept at Patrick's Point State Park, 5.7 miles (9.1 km) north of the ASBS, and Arcata Airport, 5.7 miles (9.1 km) to the south. Arcata Airport averages 121 rainy days per year and a rainfall of 46.6 inches per year (118.4 cm/yr). Patrick's Point has 116 rainy days per year and a rainfall of 70.5 inches per year (179.1 cm/yr).

The mean monthly air temperatures recorded at the Trinidad Marine Laboratory from 1973-1977 are shown in Table 1. The mean annual air temperature is 55.1°F (12.8°C) with lowest air temperatures recorded in January of each year and the highest air temperatures recorded in July.

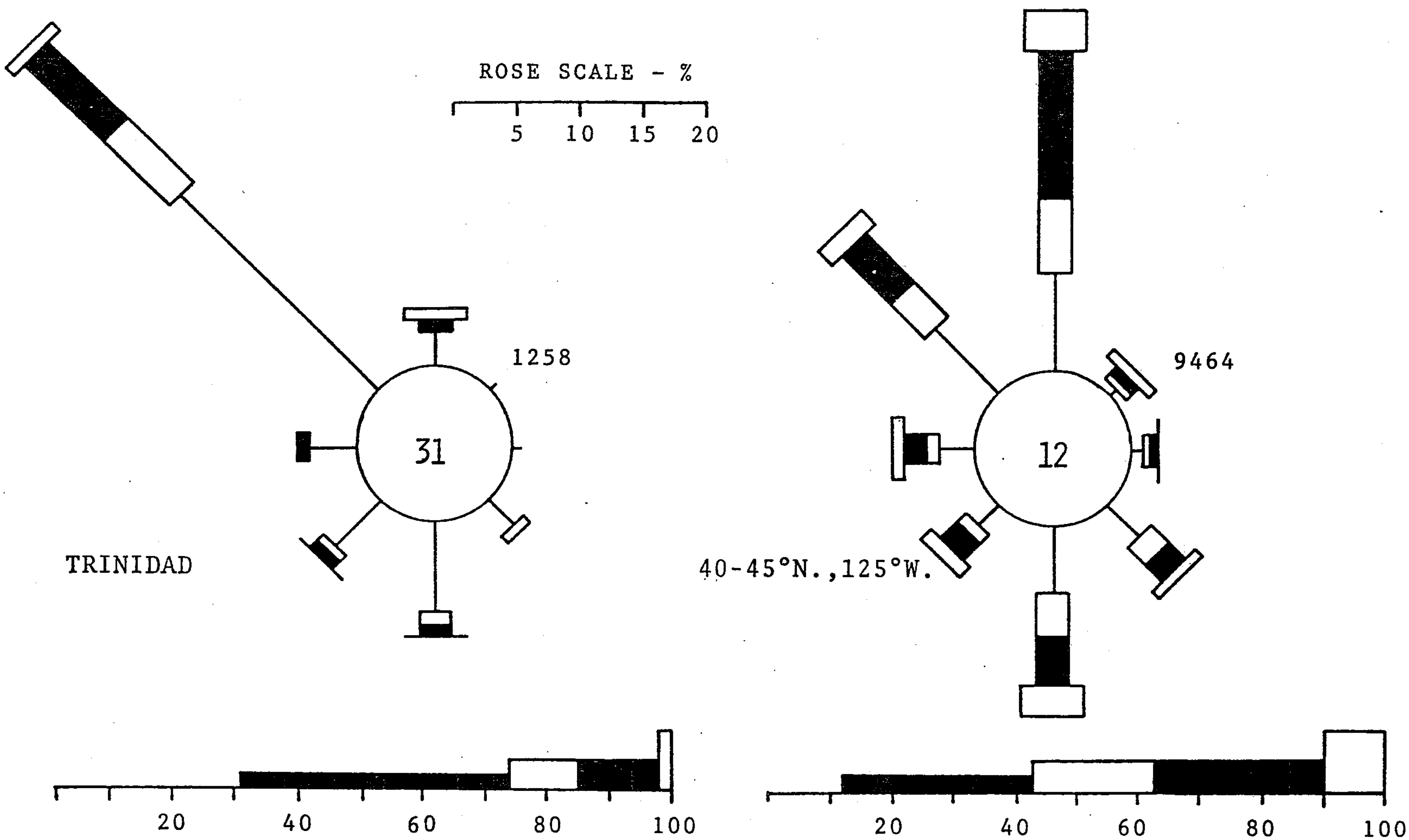


Figure 7. Wind rose composite diagram for Trinidad compared to NOAA (1977) data. Number of observations is indicated at upper right of the rose diagram.

Table 1. Monthly mean air temperatures at Trinidad, California, 1973-77.

Month	Mean Air Temperature
January	50.5°F (10.3°C)
February	51.4°F (10.8°C)
March	50.9°F (10.5°C)
April	54.0°F (12.2°C)
May	56.1°F (13.4°C)
June	57.2°F (14.0°C)
July	59.7°F (15.4°C)
August	59.4°F (15.2°C)
September	58.3°F (14.6°C)
October	57.0°F (13.9°C)
November	53.8°F (12.1°C)
December	52.9°F (11.6°C)
	[annual mean-55.1°F, 12.8°C]

BIOLOGICAL DESCRIPTION

Subtidal Biota

The subtidal zone of the southern portion of the ASBS has been investigated previously. A report on that study is presented in Appendix 4. No specific subtidal studies of the ASBS were undertaken as part of this report.

Intertidal Biota

The Trinidad ASBS intertidal zones fall into four major categories: Exposed sand beach (north part of the ASBS); Semi-exposed sand beach (south part of the ASBS); Fully exposed rocky intertidal (northwest face of Trinidad Head, Flatiron Rock, Blank Rock, numerous smaller outcrops and stacks in the northern part of the ASBS); and Semi-exposed rocky intertidal (eastern face of Trinidad Head, Little Head, smaller outcrops in the southern part of the ASBS). Each of these intertidal habitats supports a flora and fauna influenced by the physical environment, biological interactions between species in each habitat, and the commercial or recreational activities of man.

Intertidal Habitats of the North ASBS Area: The rocky intertidal zone is the most floristically and faunistically diverse habitat of the northern Trinidad Head ASBS. Environmental features of major concern are wave forces, which tend to be predominantly from the northwest, and sand movement caused by waves striking the beach adjoining Trinidad Head from the north. Because of large scale seasonal movements of sand on the beach, a very sparse macrofauna is present there. Species must withstand constant shifting of the substrate, a condition to which only a few species are adapted.

Blank Rock and Flatiron Rock lie approximately 1,600 ft. (500 m) and 3,600 ft. (1,100 m) offshore, respectively, and are somewhat isolated from the activities of man. These two islands are difficult to approach even during periods of relatively calm seas. The intertidal zone is essentially vertical and was surveyed from a boat during low tides in August 1977. The four zones of the Ricketts, Calvin, and Hedgepeth scheme of Pacific Coast zonation were clearly evident. Algae and invertebrates of highly wave-swept surfaces were particularly evident on all sides of the rocks: the seapalm, Postelsia palmaeformis; Lessoniopsis littoralis; California mussel, Mytilus californianus; gooseneck barnacle, Pollicipes polymerous; and several species of coralline algae. The ochre star, Pisaster ochraceous was more abundant than on inshore rocks, suggesting either that prey populations may be more abundant on the offshore rocks or, more likely, that collection pressure from visitors to the intertidal zone on shore is essentially absent from these offshore rocks. The vertical surfaces of both rocks were reminiscent of narrow surge channels on exposed coasts, suggesting a highly dynamic wave environment on all sides of the rocks. The intertidal zone extended 12-15 feet (4-5 m) above the low-water line, with Balanus cariosus and the acorn barnacle, B. glandula apparent on the higher mid-intertidal acres, with a scattered zone of high intertidal barnacles, Chthamalus dalli and limpets, Collisella spp. grading into barren rock surfaces with sparse lichen cover above the intertidal zone.

Both California Sea Lions and Steller Sea Lions haul out on Blank Rock and Flatiron Rock. There was no evidence of their activities affecting the intertidal zone, although increased nutrient levels from their excretions could affect the growth of attached algae and invertebrates.

The northwest face of Trinidad Head is essentially a wave-swept vertical surface. Transect studies were conducted in areas accessible from shore in April and May of 1976. They resulted in the identification of four major assemblages: 1) a low intertidal group of species, dominated numerically by sea palm, Lessoniopsis littoralis, Odonthalia spp., the giant green anemone, Anthopleura xanthogrammica, and several species of coralline algae; 2) a lower mid-interdial band of California mussel, gooseneck barnacles, scattered chitons, Katherina tunicata, ochre stars, small whelks, Nucella spp., and some yellow rockweed, Pelvetiopsis limitata;

3) a high mid-intertidal group dominated by acorn barnacles, and Balanus cariosus, and their predator Nucella emarginata; and 4) a high intertidal assemblage of Chthamalus dalli and Collisella digitalis. These four groups are typical of wave-swept vertical surfaces along the coast of northern California, and strongly resemble the vertical surfaces of the offshore rocks, except for a decreased abundance of ochre stars, which is probably the result of human collection activities.

Larger rocks and boulders within a few meters of the Head showed noticeable effects of sand scouring. These rocks have been periodically observed for the past three years during all seasons of the year. During winter months, sand surrounding the rocks is moved offshore, exposing as much as 4-6 ft. (1.3-2 m) of scoured, bare rock surface. These surfaces are colonized almost exclusively by acorn barnacles in the spring of each year, and are buried by sand accretion during summer months. The tops of boulders not buried are dominated by California mussel and several algal species including, nail brush, Endocladia muricata, iridescent seaweed, Iridaea spp., and sea palm. Smaller rocks at higher tidal levels are frequently moved by wave action and have a sparse flora and fauna. During periods of decreased wave activity in the spring and summer, smaller rocks are covered by a diatom film, scattered algae including red laver, Porphyra spp., sea lettuce, Ulva spp., and a few barnacles.

Near the northern border of the ASBS some scattered boulders, and a tall stack, project from surrounding sands. Scouring is evident around the lower margins of these boulders. As with the rocks near the northwest face of the Head, smaller boulders are periodically buried and exposed because of seasonal sand transport. These surfaces, only temporarily available for settlement, are dominated by barnacles. The major predator of these barnacles, the whelk Nucella emarginata, is extremely abundant at times, particularly spring and summer, and must have a major influence on the age structure of barnacle populations. Rock surfaces above the influence of sand transport and scour are dominated by longer-lived species, particularly the aggregating anemone, Anthopleura elegantissima, California mussels, gooseneck barnacles, and several algae. Interestingly, above these species a mixed population of barnacles occurs, suggesting that significant physiological factors (i.e. dessication) limit the upper extent of these species which appear abundantly on the newly exposed surfaces of lower, sand-scoured rocks each year.

The exposed sand beach was sampled in August, 1977, as part of this study, and has been sampled at various times during prior years. The fauna is very sparse, and is dominated numerically by several crustaceans (Appendix 1). A few sand crabs, Emerita analoga can be found in the summer months each year, with an abundance of 1 adult per 1-2 m^2. Juveniles were not collected from this beach. Haustorid amphipods, Eohaustorius spp. are sometimes encountered on the midbeach. On the low beach, mysids, Achaeomysis maculata are sporadically abundant, but are much more abundant in the surf zone adjacent to the beach. It is questionable if these animals should be characterized as sand beach inhabitants becuase of their sporadic appearance in low beach samples. Large, attached plants of any type, are absent from the beach intertidal zone, because of the lack of firm substrate on which to secure a holdfast.

Near the high tide mark on the beach, algal wrack frequently accumulates and is fed on by amphipod beach hoppers, Orchestoidea columbiana and kelp flies. Following storm waves in fall and winter, the algal wrack may be as much as one foot deep on the upper beach, with most of the algae torn from rocks offshore and to the north or south of the beach. Frequently, large algae, sea palm and L. littoralis, are still attached to a piece of rock when thrown onto the beach, indicating that the rock was fractured by waves pounding on the stipes of attached algae. Algae thrown onto the beach probably provides a major source of food for high beach amphipods and kelp flies.

Southern Part of the ASBS: Protection of intertidal zones from the full impact of waves is provided in the southern portion of the ASBS by Trinidad Head. The eastern wall of Trinidad Head itself is nearly vertical and displays a zonation pattern typical of semi-exposed surfaces. Limpets, C. digitalis and C. scabra, are scattered above a band of barnacles, C. dalli, and high zone rockweed algae. Mid-intertidal zones are dominated by acorn barnacles, and Balanus cariosus, with scattered California mussels and gooseneck barnacles. The mussels and gooseneck barnacles are not as abundant as on the eastern rock faces of the headland, indicating a somewhat less exposed situation. The lower zone is dominated by laminarian algae, including split whip, Laminaria dentigera, feather boa, Egregia menziesii, and neptune's quill, Alaria marginata; red algae, Iridaea cordata, various corallines, and surfgrass, Phyllospadix scouleri. Scattered among the holdfasts of the algae are several invertebrate species, particularly several sponges, hydroids, including Abietinaria spp., Aglaophenia spp., and Tubularia marina; a few scattered solitary corals, Balanophyllia elegans; occasional patches of the aggregating anemone, brooding anemones, Epiactis prolifera, and the striped anemone, Tealia crassicornis. Motile fauna included the chitons Katharina tunicata, Mopalia spp., Tonicella lineata in association with coralline algae; the sea stars Pisaster ochraceous, Evasterias troschelii, Henricia leviuscula and numerous smaller motile crustaceans.

A small pocket beach curves around from Trinidad Head to Little Head and is composed of coarse to medium grain sand particles. On the high beach, a few beach hoppers are supported by algal wrack and other detritus, but the infauna of the middle and low beach is sparse, probably related to sand dynamics. On the low beach, mysids are usually abundant during a receding tide. No sand crabs were found on this beach.

Near the base of Trinidad Pier, a boulder field with some rubble from the old whaling station ramp extends from the high tide mark into the sublittoral. The semi-protected nature of this habitat is particularly evident in the diverse fauna and flora attached to the boulders and rubble. Rather than list all species in the habitat, only those species which seem to be distinctive to this small area will be noted. The sea star fauna is more diverse than elsewhere in the ASBS, with the possible exception of sub-littoral areas. Eight species were encountered regularly: ochre sea star, the pink skinned, P. brevispinus, P. giganteus, the leather star, Dermasterias imbricata, the many-rayed star, Pycnopodia helianthoides, and smaller stars, Evasterias troschelii, Henricia leviuscula, and Leptasterias hexactis. The bat star, Patiria miniata has been rarely seen in the lowermost zones. The large and intertidally uncommon sun star, Solaster stimpsoni has also been collected in this boulder field.

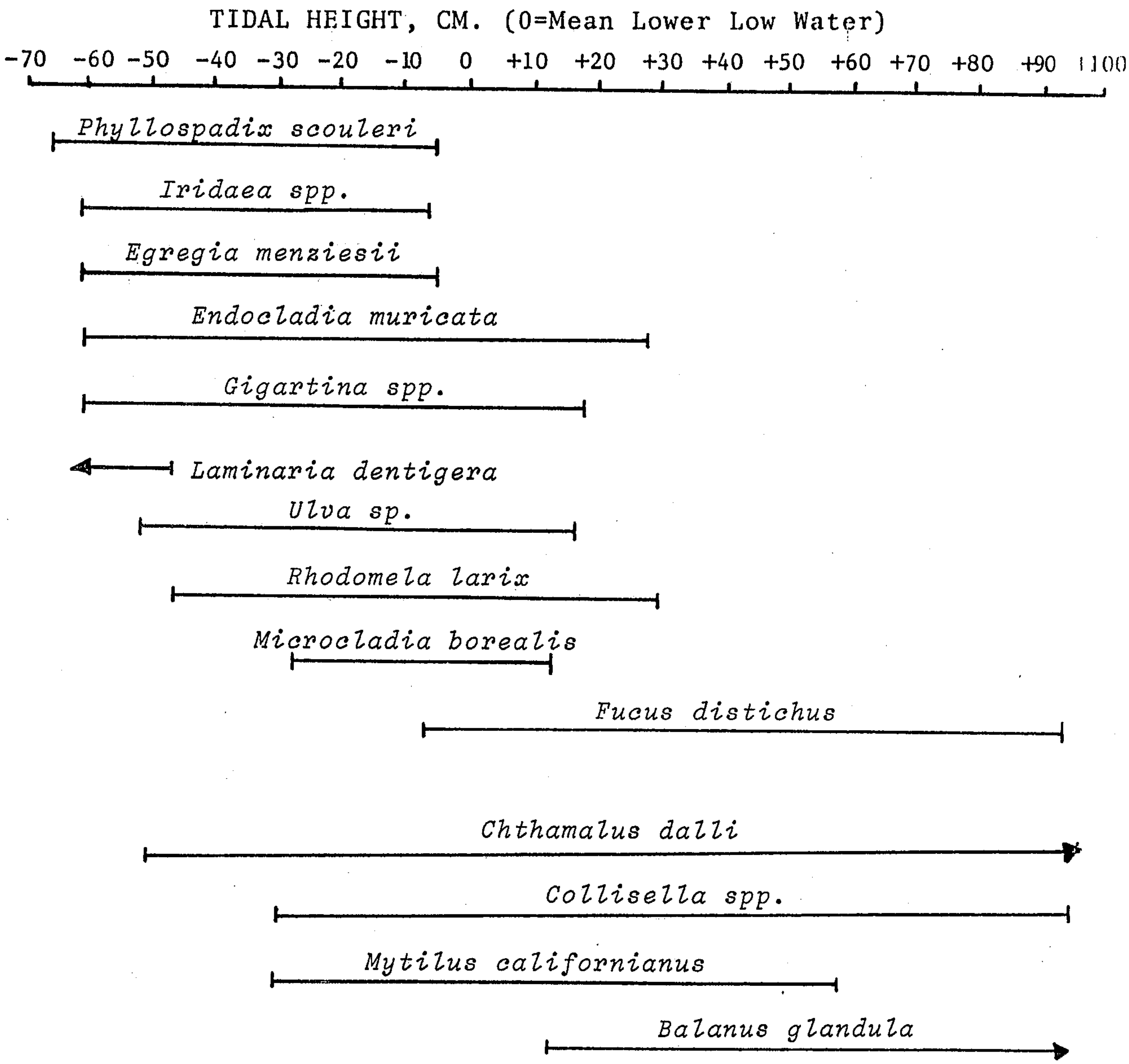
Reduced wave action allows some accumulation of sediment around the boulders, with consequent development of an infaunal assemblage. Two bivalves, the basket cockle, Clinocardium nuttalli, and the rock cockle, Protothaca staminea, are occasionally collected from the area by clammers. A diverse polychaete fauna of interest to specialists is also present as part of the infauna (see Appendix 2).

Other elements of the flora and fauna of the boulder field are fairly typical of semi-exposed rocky intertidal habitats of the northern California area. The abundance of particular species is higher than encountered in more exposed conditions, a particularly noticeable aspect seen in the lush growth of foliose red and brown algae.

To the east of Trinidad Pier, a bench formation at about the 0.0 tide level follows the contour of Little Head to its most southeasterly point. This shelf has been surveyed several times in past years and is resurveyed each year by graduate students from Humboldt State University (Table 2). Again, only some of the more distinctive elements of the biota will be mentioned here, although complete species lists have been developed for this area (Appendices 2,3).

Pools on the bench may vary in both depth and size. The largest pools are about 18 inches (50 cm) deep, 4-5 feet, (1.2-1.8 m) long, and 1-2 feet (0.3-0.6 m) wide. Hermit crabs, Pagurus spp., turban snails, Tegula funebralis, and kelp crabs, Pugettia spp.; are more abundant than elsewhere in the ASBS because of the tidepool habitats found on the bench. Scattered in the many shaded crevices of the bench are solitary corals in great abundance. Among larger boulders bordering the shelf, laminarian algae are particularly lush including split whip, chain bladder, feather boa, and neptune's quill. Surfgrass is scattered throughout the bench in small and large pools, and supports a characteristic assemblage of wormlike animals among its holdfasts: the nemertean, Carinoma mutabilis, polychaetes Schizobranchia insignis, Halosydna brevisetosa, Glycinde

Table 2. Tidal ranges of some characteristic organisms on the Tidal bench at Little Head, Trinidad Bay, California.



polygnatha, Neoamphitrite robusta, and the sipunculid Phascolosoma agassizii. The holdfasts of laminarian algae generally support somewhat less diverse, but similar, assemblages of invertebrates.

Little Head has vertical surfaces from the southeast promontory to its termination at a rail boat-launcher which parallels the northeastern face of the Head. Surge channels dissect the Head near the seaward terminus of the boat launcher and contain a diverse assemblage of hydroids, anemones, solitary corals, bryozoans, laminarian algae, and coralline algae. Higher areas of the intertidal zone are occupied by the typical barnacle, California mussel, Endocladia muricata, Chthamalus dalli assemblage.

A mixed sand beach-rocky intertidal habitat is found eastward from Little Head to the border of the ASBS. The beach is heavily used by individuals launching small boats into the surf during summer and fall months. This beach has been sampled several times, however only a few species have been found: the ubiquitous opossum shrimp, Archaeomysis maculata on the lower beach, scattered small blood worms Euzonus mucronata on the middle beach and beach hoppers, Orchestoidea spp., on the upper beach. Rocks to the east of the small beach show a typical zonation pattern for semi-exposed surfaces. The boulders are generally large and present mostly vertical surfaces. On some of the rocks, middle zones (2 and 3) are covered by clumps of the aggregating anemone, Anthopleura elegantissima with clearly defined bare areas between adjacent clones.

A sizeable boulder field lies at the eastern border of the ASBS, but the boulders are large and slope steeply into the intertidal zone. The zonation pattern on vertical rock surfaces is similar to that encountered on Little Head. Sediment does not accumulate between the closely set large boulders; hence, a significant infauna is not found in the boulder field. Around the bases of the most seaward boulders, however, a few brachiopods, Terebratalia transversa, can be seen during the lowest tides of each year. This species is apparently quite common subtidally in the ASBS.

Most of the rocks within 100 yards (300 m) of the ASBS shoreline were visited by boat in August, 1977. An unusual feature of these offshore rocks was the presence of droppings from Western Gulls, which frequently can be seen resting on the rocks. At times, the gulls have been observed feeding on sea stars, especially P. ochraceous, during low tides. The sides of the rocks apparently slope steeply into deeper surrounding waters, as bull kelp float bulbs are found within 3-6 ft. (1-2 m) of the emergent rocks during low tides.

Landside Vegetation

The coastal bluffs on Trinidad Head and overlooking the ASBS support a typical Northern Coastal Scrub plant assemblage. Common species are deer brush, Ceanothus spp., California blackberry, Rubus spp., monkey-flower, Mimulus spp., cow parsnip, Heracleum lanatum, miner's lettuce, Montia perfoliata, beach strawberry, Fragaria chiloensis, and salal, Gaultheria Shallon. Several grasses are scattered among the larger brush species, particularly Bromus sp., Deschampsia sp., and some saltgrass, Distichlis spicata. A few ferns, mostly Polypodium Scouleri, are also found along the bluffs.

On Blank Rock and on Flatiron Rock, terrestrial vegetation may be found in isolated crevices and patches. Typically, the vegetation is dominated by grasses: Bromus spp., Distichlis spicata, Poa spp.; some annual or prennial herbs are also present including Dudleya farinosa, Erodium macrophyllum, and Baeria maritima. Scattered, rather stunted ferns, Polypodium Scouleri, are found among the grasses and herbaceous species.

Bird Habitat

Numerous sea-birds nest or rest on Blank Rock or Flatiron Rock. Among birds which have been observed nesting are Brandt's Cormorants, Black Oyster-catchers, Western Gulls, Common Murres, Pigeon Guillemots, and the locally rare Tufted Puffin. There is a single record of a Fork-tailed Petrel nesting on Blank Rock, the supposed southern breeding limit of this species.

Unique Components

The diversity of intertidal habitats within the Trinidad ASBS is a distinctive feature of the area. Although no species are known to be completely unique to the ASBS, sea-birds, marine mammals, and intertidal plants and animals are rarely seen in such close association. It should be mentioned that the area has been significant in the biological history of the Pacific coast. On May 3, 1793, the sloop HMS Discovery, under the command of Captain George Vancouver, anchored in Trinidad Bay and a small party was sent ashore. In this party was Archibald Menzies, a ship's surgeon and botanist who was to make several early Pacific coast collections of both terrestrial and marine plants. Several plants bear a specific epithet derived from his name (e.g. *Egregia menziesii*, *Pseudotsuga menziesii*, and several others). Along the shore, Menzies collected the brown seaweed, *Cystoseira osmundacea*, a species which to this day is abundant around the intertidal bench on Little Head; this species was later described from Menzies' specimens by Dawson Turner, the foremost marine phycologist of that day. Trinidad remains the type locality of the species.

The Trinidad ASBS resembles closely other intertidal sites in Humboldt and Del Norte counties. Inshore waters tend to be highly turbid for most of the year because of the runoff from streams and rivers, and because waves strike an essentially exposed coastline. Even during the relatively calm seas of the summer months, upwelling in the nearshore zone contributes to increased phytoplankton productivity and decreased water clarity. Water visibility greater than 10 feet (3.2 m) is rare anywhere in the ASBS.

There is little doubt that both intertidal and subtidal attached algae are major plant material producers in the nearshore zone. In the southern part of the ASBS, bull kelp float bulbs are apparent just outside the intertidal zone. Algal herbivores seem to be sparse or absent in the area, particularly purple sea urchins, Strongylocentrotus purpuratus, and red abalone, Haliotus rufescens. A similar paucity of algal herbivores has been noted along the coast of Redwood National Park and subtidally within the Trinidad ASBS. The lack of abundant herbivore populations has been related to: 1) the presence of large amounts of silt in the water for a substantial period each year, which could foul the respiratory surfaces or structures of herbivores; or 2) a lack of suitable habitat, particularly for juveniles, within the ASBS. Whatever the reason for their scarcity, the essential absence of herbivores does result in the growth of a diverse assemblage of intertidal algae within the ASBS. Much of the algae is torn from rocks during winter storms and probably becomes part of beach or nearshore detrital food pathways, rather than being utilized directly.

Trinidad Head is the only major headland between Cape Mendocino and Point St. George. It appears that some species with a more northerly distribution are encountered close to their southern limit at Trinidad. The sea-strawberry, Gersemia rubriformis, was originally noted intertidally at Sitka, Alaska, but has recently appeared regularly at Trinidad. It apparently continues southward subtidally along the northern California coast (DeMartini, personal communication). A rather striking red colonial tunicate, Cnemidocarpa finmarkiensis, is common intertidally at Trinidad, but is considered rare elsewhere in California. Further investigations of the intertidal biota of the California coast may reveal other such anomalies in the distribution patterns of intertidal invertebrates of the Trinidad area, particularly among some of the lesser known groups (e.g. amphipods and polychaetes).

Subtidally, the dense beds of Nereocystis luetkeana at Trinidad are a distinctive feature of the biota. Although bull kelp is not rare in the rest of northern California, dense beds of this species are quite uncommon.

LAND AND WATER USE DESCRIPTION

Marine Resource Harvesting

Trinidad is a significant port for the landing of the three most important commercial marine species taken from the waters off Humboldt County: Dungeness crab, Cancer magister, King salmon, and Silver salmon. During the period from 1964-1973, 3,594,961 pounds (1,634,073 kg) of Dungeness crab were landed at Trinidad. In the same period, 1,130,141 pounds (513,700 kg) of salmon were sold to wholesalers at Trinidad. These species were not taken in the ASBS, but areas to the north and south. The crabbing areas south of Trinidad are particularly productive with ten percent of all crab landed in Humboldt County landed at Trindad. The bottom areas of the ASBS can be densely covered with Dungeness crabs at times, and are important as refuges for the crab population during periods of moulting.

No other species are landed commercially at Trinidad, but drag boats operating off Trinidad landed 1,155,913 pounds (525,415 kg) of commercial finfish at Eureka or Field's Landing in 1973. The larvae of these bottom fish have been collected regularly in the ASBS (including Starry flounder, English sole, rockfish, lingcod, and Pacific sanddab). The importance of the inshore waters as feeding grounds for the juveniles of commercially important species cannot be overemphasized.

Municipal and Industrial Activities

The Trinidad ASBS is surrounded by the City of Trinidad, a small residential and retirement community. There are 152 dwellings in the city, mostly single family units. It is anticipated that development in the city will be modest during the next ten years.

There are eight commercial establishments in the city; there are also a few craft or home-occupied enterprises. All the commercial activities within the City of Trinidad are service-oriented. About 50 percent of the local sales trade is to residents; the remainder is to tourists and commercial fishermen.

Fifteen commercial fishing boats are permanently moored at Trinidad, with an additional 400 temporary moorings placed east of Trinidad Head in May of each year to accommodate seasonal visitors. It is estimated that 600-700 boats were moored during the 1977 season. At present, the California Coastal Commission has placed an upper limit (400) on the number of moorings allowed east of Trinidad Head. The area west of the Head is unsuitable for moorings because of exposure to the predominating wind and waves.

A small marine railway parallels Little Head on the northeast side and is used for launching small recreational and pleasure craft. Operators of the facility estimate 5,000 to 6,000 boat launches and recoveries in the 1977 season. The main period of operation each year is from April 15th to September 30th, with intermittent operation at other times of the year.

Agribusiness

No agricultural enterprises border the ASBS, although a few small pastures to the north and south are utilized for cattle grazing. They are not considered significant in either size or production.

Governmental Designated Open Space

The General Plan for the City of Trinidad has designated the bluffs overlooking the ASBS as open space because of geological hazards to development. Unincorporated areas to the north and south of the ASBS have been designated as open space in the California Coastal Plan because of similar constraints.

Recreational Use

Recreational fishing is a prime source of income in the Trinidad area. Most of the commercial endeavors in the area are centered around this activity. Individuals who are not interested in fishing may beachcomb along the shoreline of the ASBS, observe activities at the pier, hike along the coastal bluffs, bird-watch, or visit the HSU Marine Laboratory. The City of Trinidad is currently studying the possibility of providing better recreational facilities to visitors (more parking, public restrooms at the pier), so additional recreational use of the area may be anticipated. At present, collecting of marine invertebrates within the ASBS is considered minimal. However, there is a noticeable difference in the abundance of some attractive animals (sea stars for example) in shoreline habitats as compared to offshore rocks. It can be anticipated that increased recreational use of the shore will result in further decreases in these easily collected species. Some efforts are being made by the California Department of Parks and Recreation and the HSU Marine Laboratory to inform visitors of the ecological consequences of uninformed "collecting".

Scientific Study Uses

The intertidal zones of the Trinidad ASBS are visited regularly by university classes at the HSU Marine Laboratory. The collecting of specimens is strongly discouraged, however. In the past five years, class members have completed various studies, among them settlement rates of plants and animals in the rocky intertidal zone, the zonation patterns of both the north and south parts of the ASBS, algae distribution patterns in the ASBS, the abundance of larval fish in intertidal habitats, and the biota of various intertidal microhabitats (algal holdfasts and rock crevices, for example). The HSU Marine Laboratory draws its sea water from the end of Trinidad Pier and regularly monitors the salinity and temperature of inshore waters at Trinidad Beach and Trinidad Bay. Meteorological observations are taken regularly by the laboratory staff and forwarded to the National Oceanographic and Atmospheric Administration, U.S. Department of Commerce.

Numerous local school groups visit the Marine Laboratory and sometimes also study the intertidal habitats of the ASBS.

Transportation Corridors

U.S. Highway 101, the major north-south transportation route for coastal northern California, lies 1/2 mile (0.8 km) to the east of the ASBS. This highway is significant in allowing easy access to the City of Trinidad, Trinidad Pier, and boat launching facilities. It can be anticipated that visitors will continue to increase in areas bordering the ASBS.

ACTUAL OR POTENTIAL POLLUTION THREATS

Point Sources

Two creeks, McConnahas Mill Creek and Mill Creek, enter the ocean immediately south and north of the ASBS. Both have been examined for coliform bacterial count. McConnahas Mill Creek had a count of 11 MPN/100 milliliter (MPN = Most Probable Number, a standard index of coliform bacterial content) and Mill Creek a count of 130-700 MPN/100 ml. Three samples have been analyzed from the cliff bases bordering the ASBS and contained 340 to greater than 1607 MPN/100 ml. The Humboldt County Health Department suggests that areas showing greater than 240 MPN/100 ml be examined for potential health hazards, but this has not yet been done in Trinidad.

Many individuals fishing from the Trinidad Pier filet their catch on the dock and throw the carcasses and offal into the water below the dock. DeMartini, et al., noted the taste of foul water in their regulators while swimming under the dock and saw moldering fish remains on the bottom. Near the foot of the dock, several old engine blocks and other machine parts have also been thrown into the water. Because the water is turbid, these manifestations of man's activities around the dock area are not visible to most observers. The intertidal zone appears free of any visible evidence of pollution.

The HSU Marine Laboratory sea-water system has its outflow near the base of the marine railway on the north side of Little Head. The outfall is a six inch (15.2 cm) pipe that lies at the surface of the sand and gravel upper beach. No evidence of pollutants emerging from the pipe was found when nearby rocks, sand and fauna were examined. All toxic materials used at the laboratory are drained into special sinks which empty into a large holding tank. This tank is periodically pumped out and the contents are disposed of on distant land fill sites. It is certainly possible, however, for an accidental spill to occur onto one of the marine laboratory water tables or into one of its tanks. Such a spill would be noticed almost immediately at the marine laboratory, however, as the system is partially recirculating. It might be possible to contain toxic materials within the laboratory system if evidence of their effects became apparent in the laboratory tanks. A large storm drain opens next to the Marine Laboratory seawater outflow. No evidence of pollution from this source was apparent in the intertidal zone. All public restroom facilities around the pier are self-contained; little pollution threat exists from this source.

Development of further parking and boating facilities in the Trinidad area, particularly around the pier, could pose additional, and unknown, hazards to the waters of the ASBS. Increased automobile traffic around the pier could lead to higher amounts of petrochemical derivatives on the ground, which would be washed into the waters of the ASBS during winter rains. If more boats are allowed to anchor in the harbor, it can be anticipated that increased amounts of oil, fuel, and other petrochemicals may be spilled into the water. It is already common to see oil and gasoline slicks around the moorings during the peak fishing season. These would almost certainly increase in frequency with further development of the moorings.

At various times in recent and past years, it has been proposed that a breakwater be extended from Trinidad Head to the vicinity of Prisoner Rock to gain additional protection from northwesterly waves and swells. As Trinidad Bay already has a small local gyre which tends to trap sediments, it seems likely that materials introduced into the harbor waters from boating and related activities would tend to remain there if a breakwater were built. A localized "pocket" of pollutants could result. There may be several design features, however, which could minimize this effect, such as a floating breakwater rather than a permanent structure. Further development of the harbor should be followed closely to protect water quality in the ASBS.

Nonpoint Sources

Wastewater disposal within areas adjacent to the ASBS is by septic tanks and associated filter fields. As far as is known, this method of disposal does not now present a significant health or environmental hazard. Increased residential or commercial development could have adverse effects, however, because of soil characteristics in the Trinidad area. The local citizenry has voiced its opposition to development which would require alternative treatment methods, i.e., a sewage treatment plant, and the California Coastal Commission has granted approval of the local General Plan which restricts development to those areas where soils are adequate for continued use of septic tanks and drainage fields. Provided further development is in agreement with this plan, no threat to water quality in the Trinidad ASBS is anticipated.

SPECIAL WATER QUALITY REQUIREMENTS

The modest commercial and residential development of the area surrounding the Trinidad ASBS has apparently had little adverse impact in nearshore waters. The high turbidity of waters in the ASBS is a natural consequence of the shoreline geology and activities in adjacent watersheds, primarily logging. It can be anticipated that the maintenance of recent stringent requirements regarding erosion following logging activities may have an effect in improving water clarity. However, the major source of suspended particulate materials in nearshore waters of the ASBS probably is the Franciscan melange (blue clay) formation at the base of the coastal bluffs. Short of stabilizing this formation (an unnatural act), turbidity will probably continue to be high as wave caused erosion continues. Fine sediments will be washed into the near-shore zone and periodically will be resuspended and transported throughout the ASBS. A fine veneer of clay particles is present both intertidally and subtidally on all but the most exposed rock surfaces.

The major threat to maintenance of the present water quality is further development of the harbor mooring facilities. Additional parking for vehicles and trailers will probably accompany increased mooring sites. Increased inputs of petrochemicals are a likely result. Intertidal and subtidal organizisms have differing, and largely unknown, sensitivities to petrochemical derivatives and degradation products. Therefore, increased petrochemical pollution could have undesirable and unpredictable effects upon the biota of the ASBS.

Continued disposal of fish carcasses and offal near the pier will also have degrading effects on water quality; this practice can be anticipated to increase if further development of visitor and boating facilities occurs. Installation of a fish cleaning station on or near the pier, with offal and carcasses collected for proper disposal, could do much to enhance water quality in the southern portion of the ASBS.

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Appendix 1

Animals of Sand Beaches in the Trinidad Head ASBS

Phylum Annelida

Class Polychaeta

Eteone dilatae Hartman, 1936
Euzonus mucronata (Treadwell, 1914)
Nephtys californiensis Hartman, 1938
Pygospio californica Hartman, 1936

Phylum Arthropoda

Class Crustacea

Archaeomysis maculata (Holmes, 1894)
Crangon nigricauda (surf zone) Stimpson, 1856
Emerita analoga (Stimpson, 1857)
Eohaustorius brevicuspus Bosworth, 1973
Eohaustorius washingtonianus (Thorsteinson, 1941)
Excirolana linguifrons (Richardson, 1899)
Orchestoidea californiana (Brandt, 1851)
Orchestoidea columbiana Bousfield, 1958
Paraphoxus sp.

Phylum Mollusca

Class Gastropoda

Olivella biplicata (Sowerby, 1825)

Phylum Nemertea

Tubulanus pellucidus (Coe, 1895)

Appendix 2

Marine Plants of the Trinidad Head ASBS

Rhodophyta:

+*Rhodomela larix* (Turner, 1819) C. Agardh, 1822
+*Polyneura latissima* (Harvey, 1862) Kylin, 1924
+*Laurencia spectabilis* Postels & Ruprecht, 1840
+*Ptilota filicina* J. Agardh, 1876
+*Odonthalia lyallii* (Harvey) J. Agardh
+*Odonthalia floccosa* (Esper, 1802) Falkenberg, 1901
+*Odonthalia oregona* Doty, 1947
+*Iridaea cordata* var. *splendens* (S&G, 1937) Abbott, 1971
+*Iridaea heterocarpa* Postels & Ruprecht, 1840
+*Neoptilota hypnoides* (Harvey, 1833) Kylin, 1956
+*Farlowia mollis* (Harvey & Bailey, 1851) Farlow & Setchell, 1901
+*Prionitis lyallii* Harvey, 1862
+*Prionitis lanceolata* (Harvey, 1833) Harvey, 1853
+*Polysiphonia* spp. (2) Greville, 1823
+*Bossiella orbigniana* ssp. *dichotoma* (Manza, 1937) Johansen, 1971
+*Bossiella chiloensis* (Decaisne, 1842) Johansen, 1971
+*Bossiella plumosa* (Manza, 1937) Silva, 1957
+*Corallina vancouveriensis* Yendo, 1902
+*Corallina officinalis* var. *chilensis* (Decaisne, 1847) Kutzing, 1858
+*Calliarthron tuberculosum* (Postels & Ruprecht, 1840) Dawson, 1964
+*Botryoglossum farlowianum* (J. Agardh, 1898) DeToni, 1900
+*Dilsea californica* (J. Agardh, 1876) Kuntze, 1891
+*Schizymenia pacifica* (Kylin, 1925) Kylin, 1932
+*Gigartina agardhii* Setchell & Gardner, 1933
+*Gigartina papillata* (C. Agardh, 1821) J. Agardh, 1846
+*Grateloupia setchellii* Kylin, 1941
+*Gymnogongrus linearis* (C. Agardh, 1822) J. Agardh, 1851
+*Pikea robusta* Abbott, 1968
+*Endocladia muricata* (Postels & Ruprecht, 1840) J. Agardh, 1847
+*Gloiopeltis furcata* (Postels & Ruprecht, 1840) J. Agardh, 1851
+*Callithamnion pikeanum* Harvey, 1853
+*Cryptosiphonia woodii* (J. Agardh, 1872) J. Agardh, 1876
+*Membranoptera dimorpha* Gardner, 1926
+*Ahnfeltia plicata* (Hudson, 1762) Fries, 1835
+*Ahnfeltia concinna* J. Agardh
+*Plocamium cartilagineum* (Linnaeus, 1753) Dixon, 1967
+*Plocamium violaceum* Farlow, 1877
+*Hymenena flabelligera* (J. Agardh, 1876) Kylin, 1924
+*Hymenena multiloba* (J. Agardh, 1876) Kylin, 1935
+*Microcladia borealis* Ruprecht, 1851
+*Porphyra perforata* J. Agardh, 1883
+*Porphyra lanceolata* Setchell & Hus, 1900
+*Porphyra smithii* Hollenberg & Abbott, 1968

Rhodophyta (continued)

- *Cryptopleura violacea* (J. Agardh, 1876) Kylin, 1924
- *Cryptopleura lobulifera* (J. Agardh, 1898) Kylin, 1924
- *Callophyllis pinnata* Setchell & Swezy, 1923
- *Erythrophyllum delesserioides* J. Agardh, 1872
- *Opuntiella californica* (Farlow, 1877) Kylin, 1925
- *Halosaccion glandiforme* (Gmelin, 1768) Ruprecht, 1851
- *Neopolyporolithon reclinatum* (Foslie, 1906) Adey & Johansen, 1972
- *Porphyropsis coccinea* (Areschoug, 1850) Rosenvinge, 1909
- *Tenarea dispar* (Foslie, 1907) Adey, 1970

Phaeophyta:

- *Leathesia nana* Setchell & Gardner, 1924
- *Leathesia difformis* (Linnaeus, 1755) Areschoug, 1847
- *Soranthera ulvoidea* Postels & Ruprecht, 1840
- *Hedophyllum sessile* (C. Agardh, 1824) Setchell, 1901
- *Egregia menziesii* (Turner, 1808) Areschoug, 1876
- *Laminaria dentigera* Kjellman, 1889
- *Laminaria sinclairii* (Harvey, 1846) Farlow, Anderson & Eaton, 1878
- *Analipus japonicus* (Harvey, 1857) Wynne, 1971
- *Pelvetiopsis limitata* Gardner, 1910
- *Alaria nana* Schrader
- *Alaria marginata* Postels & Ruprecht, 1840
- *Scytosiphon lomentaria* (Lyngbye, 1819) J. Agardh, 1848
- *Haplogloia andersonii* (Farlow, 1889) Levring, 1939
- *Lessoniopsis littoralis* (Tilden, 1900) Reinke, 1903
- *Nereocystis luetkeana* (Mertens, 1829) Postels & Ruprecht, 1840
- *Postelsia palmaeformis* Ruprecht, 1852
- *Desmarestia ligulata* (Lightfoot, 1777) Lamouroux, 1813, var. *ligulata*
- *Pterygophora californica* Ruprecht, 1852
- *Cystoseira osmundacea* (Turner, 1809) C. Agardh, 1820

Chlorophyta:

- *Spongomorpha coalita* (Ruprecht, 1851) Collins, 1909
- *Cladophora columbiana* Collins, 1903
- *Ulva* sp. Linnaeus, 1753

Pterophyta:

- *Phyllospadix scouleri* Hooker

Appendix 3

Animals of Rocky Intertidal Areas in the Trinidad ASBS

Phylum Porifera

Class Demospongiae

Cliona celata Grant, 1826, var. *californiana* de Laubenfels, 1932
Halichondria panicea (Pallas, 1766)
Haliclona sp.
Hymendectyon lyoni Bakus, 1966
Hymeniacidon ungodon de Laubenfels, 1932
Mycale macginitiei de Laubenfels, 1930
Mycale richardsoni Bakus, 1966
Ophlitaspongia pennata (Lambe, 1895)
Pachychalina lunisimilis (de Laubenfels, 1930)

Phylum Cnidaria

Class Hydrozoa

Abietinaria sp.
Aglaophenia sp.
Eudendrium californicum Torrey, 1902
Obelia geniculata (Linnaeus, 1767)
Tubularia marina (Torrey, 1902)

Class Anthozoa

Anthopleura artemisia (Pickering in Dana, 1848)
Anthopleura elegantissima (Brandt, 1835)
Anthopleura xanthogrammica (Brandt, 1835)
Balanophyllia elegans Verrill, 1864
Epiactis prolifera Verrill, 1869
Tealia crassicornis (Muller, 1776)

Phylum Nemertea

Amphiporus imparispinosus Griffin, 1898
Carinoma mutabilis Griffin, 1898
Paranemertes peregrina Coe, 1901

Phylum Annelida

Class Polychaeta

Family Ampharetidae

Ampharete sp.

Schistocomus hiltoni Chamberlin, 1919

Family Chrysopetalidae

Paleanotus bellis (Johnson, 1897)

Family Goniadidae

Glycinde polygnatha Hartman, 1950

Family Lumbrineridae

Lumbrineris sp.

Family Nereidae

Neanthes succinea (Frey & Leuckart, 1847)

Nereis vexillosa Grube, 1851

Nereis sp.

Platynereis bicanaliculata (Baird, 1863)

Family Onuphidae

Nothria elegans (Johnson, 1901)

Family Opheliidae

Armandia brevis (Moore, 1906)

Family Orbiniidae

Naineris dendritica (Kinberg, 1867)

Family Phyllodocidae

Anaitides williamsi Hartman, 1936

Eulalia aviculiseta Hartman, 1936

Family Polynoidae

Arctonoe vittata (Grube, 1855)

Halosydna brevisetosa Kinberg, 1855

Harmothoe imbricata (Linnaeus, 1767)

Family Sabellidae

Chone ecaudata (Moore, 1923)

Fabricia sp.

Pseudopotamilla sp.

Schizobranchia insignis Bush, 1904

Family Serpulidae

Serpula vermicularis Linnaeus, 1767

Family Sigalionidae

Sthenelais fusca Johnson, 1897

Family Spionidae

Boccardia proboscidea Hartman, 1940

Polydora socialis (Schmarda, 1861)

Polydora sp.

Rhyncospio arenicola Hartman, 1936

Spiophanes sp.

Family Syllidae

Autolytus sp.
Exogone lourei Berkeley & Berkeley, 1938
Sphaerosyllis sp.
Syllis elongata (Johnson, 1901)
Typosyllis alternata (Moore, 1908)
Typosyllis sp.

Family Terebellidae

Neoamphitrite robusta (Johnson, 1901)

Phylum Mollusca

Class Polyplacophora

Chaetopleura gemma Dall, 1879
Cryptochiton stelleri (Middendorff, 1846)
Cyanoplax dentiens (Gould, 1846)
Lepidozona mertensii (Middendorff, 1846)
Katharina tunicata (Wood, 1815)
Mopalia ciliata (Sowerby, 1840)
Mopalia hindsii (Reeve, 1847)
Mopalia lignosa (Gould, 1846)
Tonicella lineata (Wood, 1815)

Class Gastropoda

Subclass Prosobranchia

Acmaea mitra Rathke, 1833
Amphissa versicolor Dall, 1871
Bittium eschrichtii (Middendorff, 1849)
Calliostoma ligatum (Gould, 1849)
Ceratostoma foliatum (Gmelin, 1791)
Collisella digitalis (Rathke, 1833)
Collisella pelta (Rathke, 1833)
Collisella scabra (Gould, 1846)
Collisella strigatella (Carpenter, 1864)
Diodora aspera (Rathke, 1833)
Lacuna porrecta Carpenter, 1864
Lacuna sp.
Lamellaria sp.
Littorina scutulata Gould, 1849
Magarites pupillus (Gould, 1849)
Notoacmaea personna (Rathke, 1833)
Notoacmaea scutum (Rathke, 1833)
Nucella canaliculata (Duclos, 1832)
Nucella emarginata (Deshayes, 1839)
Nucella lamellosa (Gmelin, 1791)
Ocenebra lurida (Middendorff, 1848)
Searlesia dira (Reeve, 1846)
Tegula funebralis (A. Adams, 1855)

Subclass Opisthobranchia

Acanthodoris nanaimoensis O'Donoghue, 1921
Aeolidia papillosa (Linnaeus, 1761)
Antiopella barbarensis (Cooper, 1863)
Archidoris montereyensis (Cooper, 1862)
Coryphella pricei Mac Farland, 1966
Coryphella trilineata O'Donoghue, 1921
Dendronotus frondosus (Ascanius, 1774)
Diaulula sandiegensis (Cooper, 1862)
Dirona albolineata Cockerell and Eliot, 1905
Dirona picta Mac Farland in Cockerell and Eliot, 1905
Doto amyra Marcus, 1961
Hermissenda crassicornis (Eschscholtz, 1831)
Onchidella borealis Dall, 1871
Rostanga pulchra Mac Farland, 1905
Tritonia festiva (Stearns, 1873)

Class Bivalvia

Adula californiensis (Philippi, 1847)
Clinocardium nuttallii (Conrad, 1837)
Hinnites giganteus (Gray, 1825)
Mytilus californianus Conrad, 1837
Pododesmus cepio (Gray, 1850)
Protothaca staminea (Conrad, 1837)

Class Cephalopoda

Octopus dofleini Pickford, 1964

Phylum Brachiopoda

Terebratalia transversa (Sowerby, 1846)

Phylum Bryozoa

Bicrisia edwardsiana (d'Orbigny, 1839)
Bugula californica Robertson, 1905
Crisia occidentalis Trask, 1857
Filicrisia franciscana (Robertson, 1910)
Flustrellidra corniculata (Smith, 1871)

Phylum Arthropoda

Class Crustacea

Subclass Cirripedia

Balanus cariosus (Pallas, 1788)
Balanus crenatus Bruguiere, 1789
Balanus glandula Darwin, 1854
Balanus nubilis Darwin, 1854
Chthamalus dalli Pilsbry, 1916
Pollicipes polymerus Sowerby, 1833

Subclass Malacostraca

Order Amphipoda

Parallorchestes ochotensis (Brandt, 1851)

Order Isopoda

Gnorimosphaeroma oregonensis (Dana, 1854-1855)

Order Decapoda

Cancer antennarius Stimpson, 1856
Cancer magister Dana, 1852
Cancer productus Randall, 1839
Cryptolithodes sitchensis Brandt, 1853
Hapalogaster mertensii Brandt, 1850
Hemigrapsus nudus (Dana, 1851)
Hemigrapsus oregonensis (Dana, 1851)
Pagurus granosimanus (Stimpson, 1859)
Pagurus hirsutiusculus (Dana, 1851)
Pagurus samuelis (Stimpson, 1857)
Petrolisthes cinctipes (Randall, 1839)
Pugettia producta (Randall, 1839)
Pugettia richii Dana, 1851
Scyra acutifrons Dana, 1851

Phylum Echinodermata

Class Asteroidea

Dermasterias imbricata (Grube, 1857)
Evasterias troschelii (Stimpson, 1862)
Henricia leviuscula (Stimpson, 1857)
Leptasterias hexactis (Stimpson, 1862)
Pisaster ochraceus (Brandt, 1835)
Pycnopodia helianthoides (Brandt, 1835)
Solaster dawsoni Verrill, 1880
Solaster stimpsoni Verrill, 1878

Class Holothuroidea

Cucumaria pseudocurata Deichmann, 1938
Cucumaria miniata Brandt, 1835
Eupentacta quinquesemita (Selenka, 1867)

Class Ophiuroidea

Ophiopholis aculeata (Linnaeus, 1767)

Phylum Sipuncula

Phascolosoma agassizii Keferstein, 1867

Phylum Chordata

Class Ascidiacea

Styela montereyensis (Dall, 1872)

APPENDIX 4

A Macrobiological Survey of Trinidad Bay and Kelp Beds at Trinidad Head Area of Special Biological Significance

A MACROBIOLOGICAL SURVEY OF TRINIDAD BAY AND KELP BEDS AT TRINIDAD HEAD AREA OF SPECIAL BIOLOGICAL SIGNIFICANCE

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ABSTRACT

A subtidal macrobiological survey of Trinidad Bay and of Kelp Beds At Trinidad Head Area of Special Biological Significance was conducted from June through October 1976 and in September and October 1978. The macrobiota and their assemblages were described for the habitat types found on the major rocks and kelp beds within the Trinidad Bay and the ASBS.

General ecology is discussed including seasonal variations in biotic assemblages, and distribution of algae and macrofauna. Also, possible sources of environmental impact were identified, including the dumping of fish remains beneath the dock; metallic refuse under the dock; removal of temporary moorings from the bay; boating lanes; number of boats within the Bay; and the construction of a breakwater in the Bay.

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A MACROBIOLOGICAL SURVEY OF TRINIDAD BAY AND KELP BEDS AT TRINIDAD HEAD AREA OF SPECIAL BIOLOGICAL SIGNIFICANCE*

by

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Introduction

Trinidad Bay serves as a port for sport and commercial salmon fishing from late spring through summer. During the fishing season, the prevailing seas are generally from the northwest and Trinidad Head produces a lee for moorage. However, during periods of southerly storms, generally occurring through fall and into spring, moorage is unsafe.

In September, 1975, Mr. Jack Lahr, then Executive Director of the North Coastal Zone Conservation Commission, asked the senior author to conduct a biological survey of Trinidad Bay for producing baseline biological information to be used for constructing a management plan for Trinidad Bay. Subsequently, the senior author constructed a proposal having the following objectives:

1. To identify and to determine the distribution of the macrobiota within Trinidad Bay north of 41°03'N.
2. To identify impacted areas, if any, in the Bay.

* Edited for clarity and to conform with the ASBS report series.

3. To recommend where and what kinds of moorings would either create the least adverse ecological impact, or enhance the bottom habitat of the Bay.

4. To recommend where boat lanes may be placed to negate impacting possibly induced by water craft.

5. To make an estimate of the Bay's carrying capacity for boats consistent with maintenance of the biotic diversity and productivity of the Bay's biota.

6. To predict what kinds of biotic changes may be forthcoming, upon knowing the physical effects that could occur due to placement of a breakwater in the Bay.

Concurrently, Dr. Robert W. Thompson (Department of Oceanography, Humboldt State University) was requested to study the bathymetry and sediment distribution in Trinidad Bay. The reports were submitted to the California Coastal Commission.

In September 1978, the California Department of Fish and Game requested that the senior author review and update the original macrobiological study by meeting the following objectives:

1. To perform all field work necessary to update the original report.

2. To prepare a revised map based upon data included in the original report and upon updating with most recent, available information.

Part of Trinidad Bay contains a portion of Kelp Beds at Trinidad Head Area of Special Biological Significance (ASBS) which also includes an area west of Trinidad Head (Figure 1). A cursory survey of the western sector was also made.

Acknowledgments

Thanks to the following agencies and persons: The North Coastal Zone Conservation Commission for funding the initial biological survey; the California Department of Fish and Game for funding to update the information on the subtidal biology of the area around Trinidad Head; Dr. Theodore Kerstetter, Director of the Fred Telonicher Marine Laboratory, who offered the Laboratory's facilities; Dr. Gary Brusca (Humboldt State University) who identified the amphipod *Photis californica*; Dr. Warren J. Houck (Humboldt State University) for information on marine birds and marine mammals; Mrs. Jeanne Lauck who typed the manuscript of the original report and Mrs. Marianne Seltenrich who typed this report.

Methods and Materials

Subtidal observations were made using SCUBA. The initial survey occurred from June through October, 1976. Subsequent observations of the western sector of the ASBS and one dive in the eastern sector were performed in September and October, 1978. For the waters around Trinidad Head, excellent visibility is about 10 ft. (3 m) and often is much less, especially with depth. Often visibility was too poor for effective diving. Major rocks and kelp beds within the bay were surveyed at least once. The remainder of the bay was surveyed by running transects. Portions of the western sector of the ASBS were surveyed only once. During dives, notes were taken on an underwater slate and subsequently were typed for permanent recording. Data taken included visibility, depth, bottom type, qualitative description of the biota and specimens for identification. For partial determination of the macroinfauna of nearshore sands within the bay, cores were taken, sieved through a 0.5 mm screen and the organisms were removed for subsequent identification. Quantitative measurements of the biota were abandoned early because of the difficulties incurred by poor visibility and by the extent of the area to be surveyed. Specimens were taken to the Fred Telonicher Marine Laboratory, preserved and subsequently identified using several identification manuals (See Bibliography). A voucher collection was constructed (Appendix, Table 1). Certain rocks in the bay were uncharted. A sextant was used to locate these rocks for mapping. A map was constructed showing the ASBS and Trinidad Bay (Figure 1). Two other maps were constructed indicating major rocks and bottom types within Trinidad Bay (Figure 2) and within the western sector of the ASBS (Figure 3).

KELP BEDS AT TRINIDAD HEAD ASBS

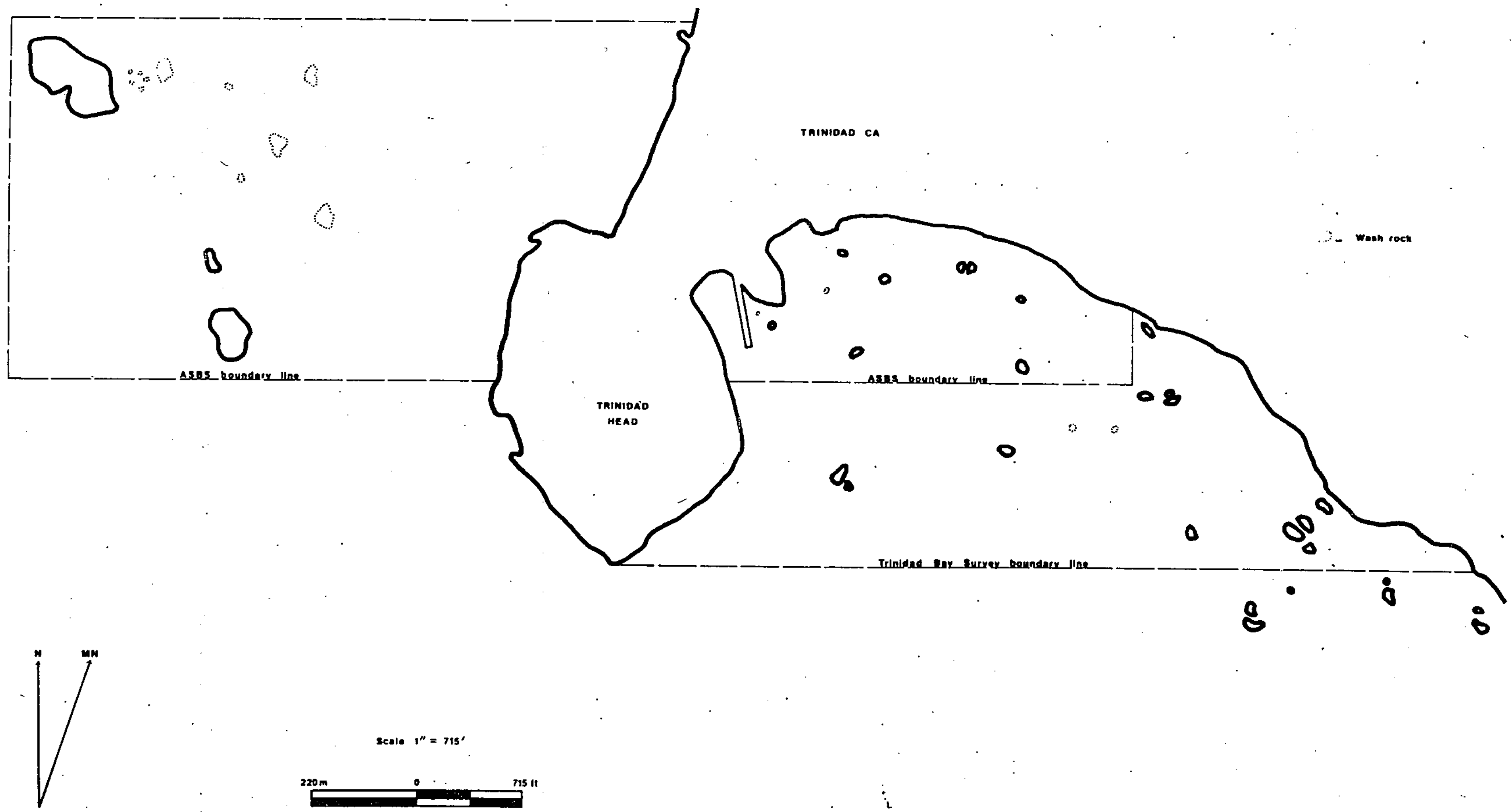

Figure 1: Map of Trinidad Bay and of Kelp Beds at Trinidad Head ASBS

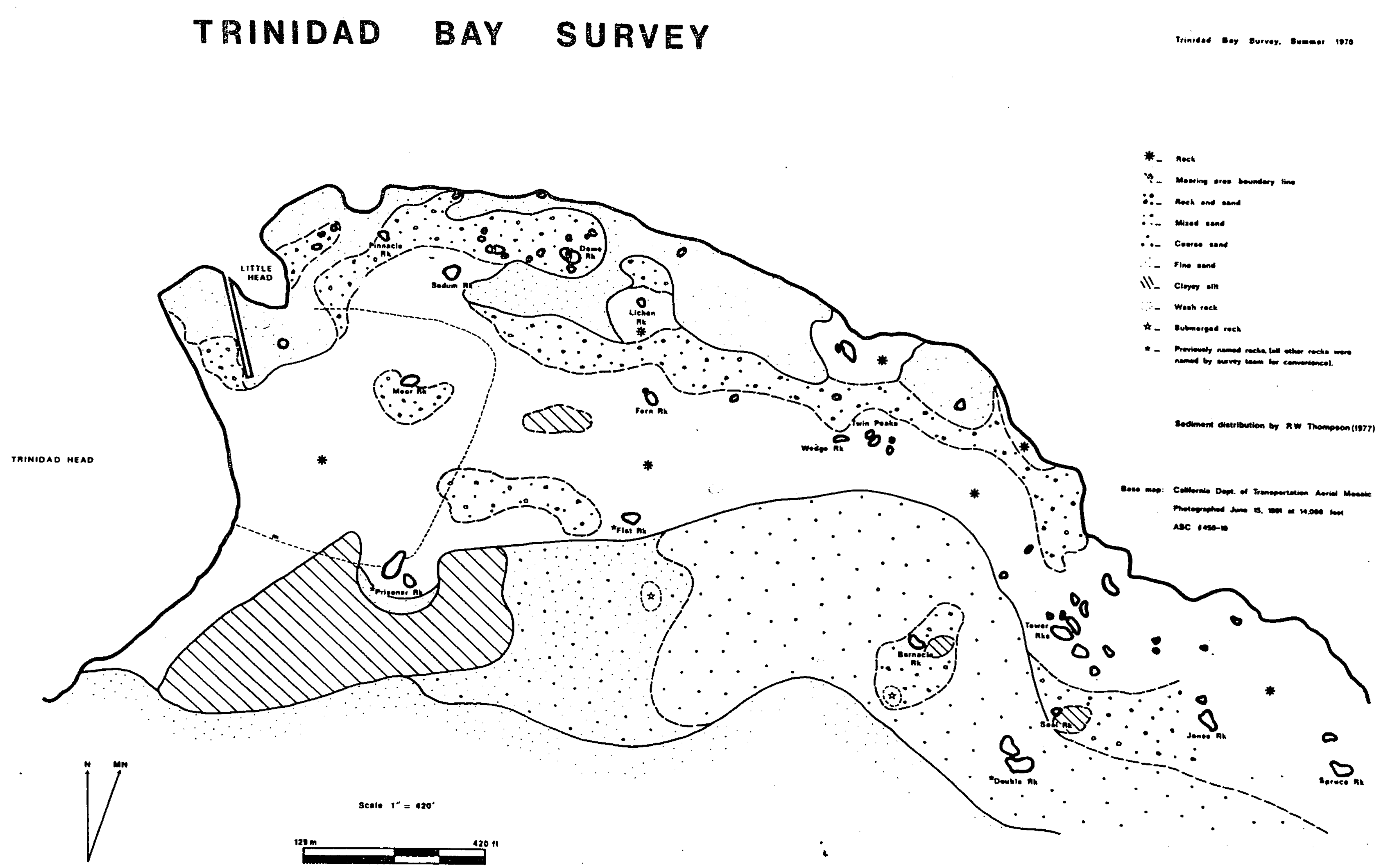

Figure 2: Map of Trinidad Bay and Incuded Eastern Sector of Kelp Beds at Trinidad Head ASBS showing major rocks and bottom types.

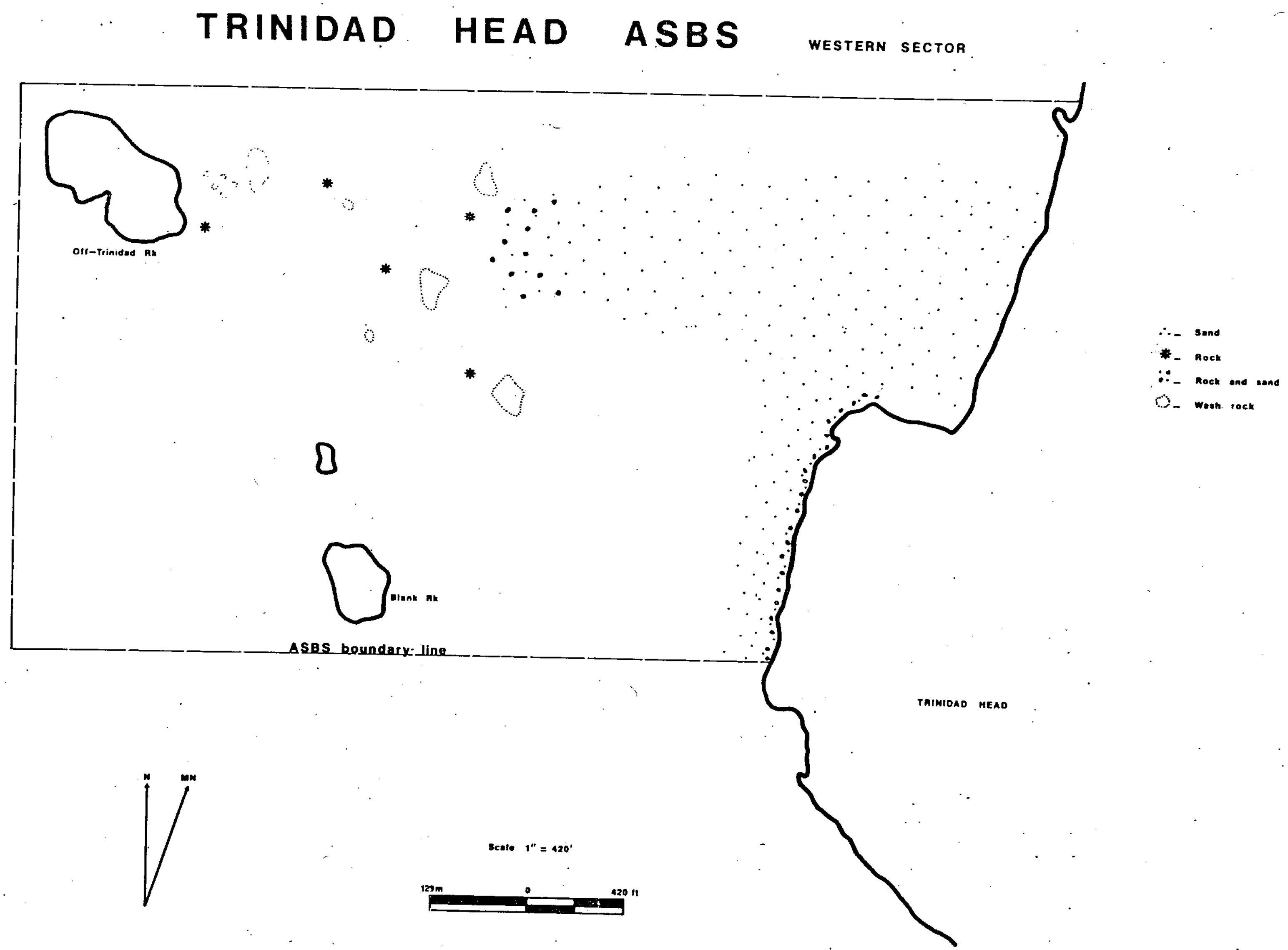

Figure 3: Map of Western Sector of Kelp Beds at Tinidad Head ASBS showing major rocks and bottom types.

In addressing practical management problems, the senior author had discussions with the following people:

1. Mr. Jack Alderson, Executive Officer, Humboldt Bay Harbor Recreation and Conservation District - During July, 1976, means of placing permanent moorings in an embayment like Trinidad Bay was discussed.

2. Mr. Jack McKellar, U.S. Army Corps of Engineers - During August, 1976, problems associated with the management of Trinidad Bay and the involvement of various civil authorities were discussed.

3. Mr. Thomas Allen, U.S. Coast Guard - Mr. McKellar and the author met with Mr. Allen in September, 1976. Mr. Allen indicated that the U.S. Coast Guard could serve as a lead agency in convening a meeting of agencies having authority over activities in Trinidad Bay.

4. Messrs. Thomas Allen, Robert Lagle (Executive Director of the North Coastal Zone Conservation Commission) and Jack McKellar - in February, 1977, a meeting was held to discuss what agencies had authority on activities performed in Trinidad Bay.

Results

The macrobiota of major rocks, of kelp beds and of major bottom types are described. The reference point for depths in the descriptions is datum, mean lower low water. Depths are recorded in both feet (ft.) and meters (m). Scientific names are either abbreviated after being used once, or written in full if abbreviating may indicate that successively named species belong to the same genus, but in fact do not. Parenthetical information applies only to the species that it follows, unless otherwise indicated. To convey a semblence of our observations, we have constructed a series of figures accompanying the text of this section. The figures should be used for imparting a "coarse-grained" image of the biota. A "fine-grained" examination was beyond the scope of this study. To determine what species are illustrated in the figures of this section, refer to Appendix - Figure 1. Also the reader should keep in mind that biotic asemblages are not static; they change temporally both qualitatively and quantitatively. The algal zone discussed below was comprised of all observed algae. Below this zone, only the crustose, red algae *Lithophyllum* sp. and *Peyssonellia hairii* were noted.

DESCRIPTIONS OF MACROBIOTIC ASSEMBLAGES

Trinidad Bay and Included Eastern Sector of Kelp Beds at Trinidad Head ASBS

South Side of Trinidad Head (Figure 4).

1. Physical Features: The substrate is rocky. Typical profiles included sheer rock faces from 9 to 45 ft. (3 to 14 m) deep. Also present were many cracks and crevices on the side and piles of boulders near the bottom. Heavy surge was common to a depth of 30 ft. (9 m), even during periods of relatively calm sea. Rock was generally clean to about 15 ft. (4 m) deep, below which occurred progressively more silt deposition to the bottom about 45 ft. (14 m) deep.

2. Biological Features: An algal zone extended to about 22 ft. (7 m) deep. The following brown algae were observed: Alaria marginata (common), Alaria nana (rare), Laminaria dentigera (common to about 10 ft. or 3 m deep), Laminaria sinclairii (extending to about 22 ft. or 7 m deep) and Lessoniopsis littoralis (dominant near datum). The following red algae were seen: Calliarthron tuberculosum, Callophyllis flabellulata and Polyneura latissima (all three scattered to about 15 ft. or 5 m deep). Below the algal zone the encrusting Lithophyllum sp. and Peyssonellia hairii extended to the bottom.

The dominant invertebrates observed within the algal zone were: the hydroids Abietinaria sp., Aglaophenia sp., Obelia sp., Plumularia sp., and Sertularella sp. (on L. sinclairii); the barnacle Balanus nubilis; and the bryozoan Tricellaria ternata. Other invertebrates noted were the hydrocoral Stylantheca porphyra, the hydroid Hydractinia sp.; the polychaete Eudistylia polymorpha; and the bryozoan Flustrellidra corniculata.

Invertebrates below the algal zone were: the sea strawberry Gersemia rubiformis; the cup coral Balanophyllia elegans; the sea anemones Anthopleura

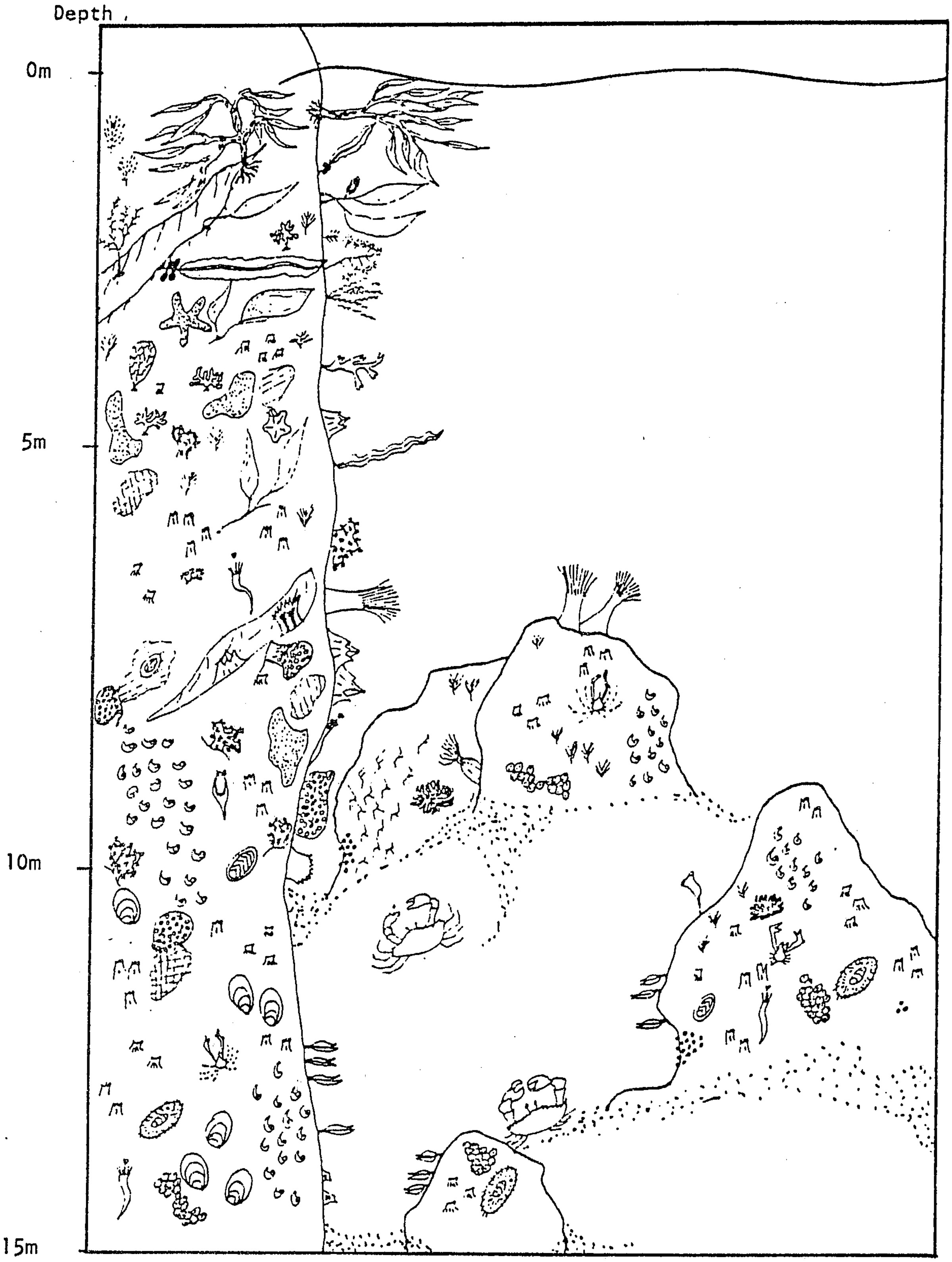

Figure 4. The macrobiota observed on and adjacent to the south side of Trinidad Head.

xanthogrammica (common in depressions), Metridium senile (common on outcrops) and Tealia lofotensis (all three occurred to about 3 ft. or 9 m deep; the polychaetes Dodecaceria concharum and Serpula vermicularis both extending from within the algal zone to about 25 ft. or 8 m deep); the lined chiton Tonicella lineata (on crustose coralline algae); the nudibranchs Hermissenda crassicornis and Tochurina tetraquetra (usually near its prey Gersemia rubiformis; the abalone jingle Pododesmus cepio (dense aggregations between 30 ft. or 9 m deep and on the bottom); the clam Entodesma saxicola; the barnacles Balanus crenatus and B. nubilis (occurring within and below the algal zone); the crabs Cancer magister (juveniles occurring by the thousands), Oregonia gracilies and Scyra acutifrons; the bryzoans Eurystomella vilabiata and Heteropora pacifica; the sea stars Dermasterias imbricata, Henricia leviuscula, Pisaster brevispinus (near the bottom) and Pisaster ochraceus (about 3 ft. or 9 m deep); and the tunicates Cnemidocarpa finmarkiensis, Perophora annectens, Pyura haustor and Styela montereyensis (very common).

Boulders were scattered below 2.5 ft. (8 m) and their habitat had a different species composition. The invertebrate fauna included the hydroid Abietinaria sp. (common on tops of scoured boulders); the polychaetes Dodecaceria concharum, Pista elongata, Serpula vermicularis and Spirorbis sp.; the chitons Lepidozona cooperi and Mopalia sp.; the crabs Cancer antennarius, C. magister (very common), Oregonia gracilis and Scyra acutifrons; the skeleton shrimp Metacaprella kennerlyi (in the largest aggregations ever seen by the author); the bryozoan H. pacifica; the branchiopod Terebratalia transversa; and the sea cucumber Cucmaria miniata (between juxtaposed boulders).

East Side of Trinidad Head (Figure 5)

1. Physical Features: During the summer, this area is protected from northwest swell and is affected only by wave chop and some surge. To about 6 ft. (2 m) deep, rocky substrates are generally either vertical or steeply inclined, especially along its southern portion. Deeper than 6 ft. (2 m), piles of boulders sloped to the bottom between about 12 to 20 ft. (4 to 6 m) deep.

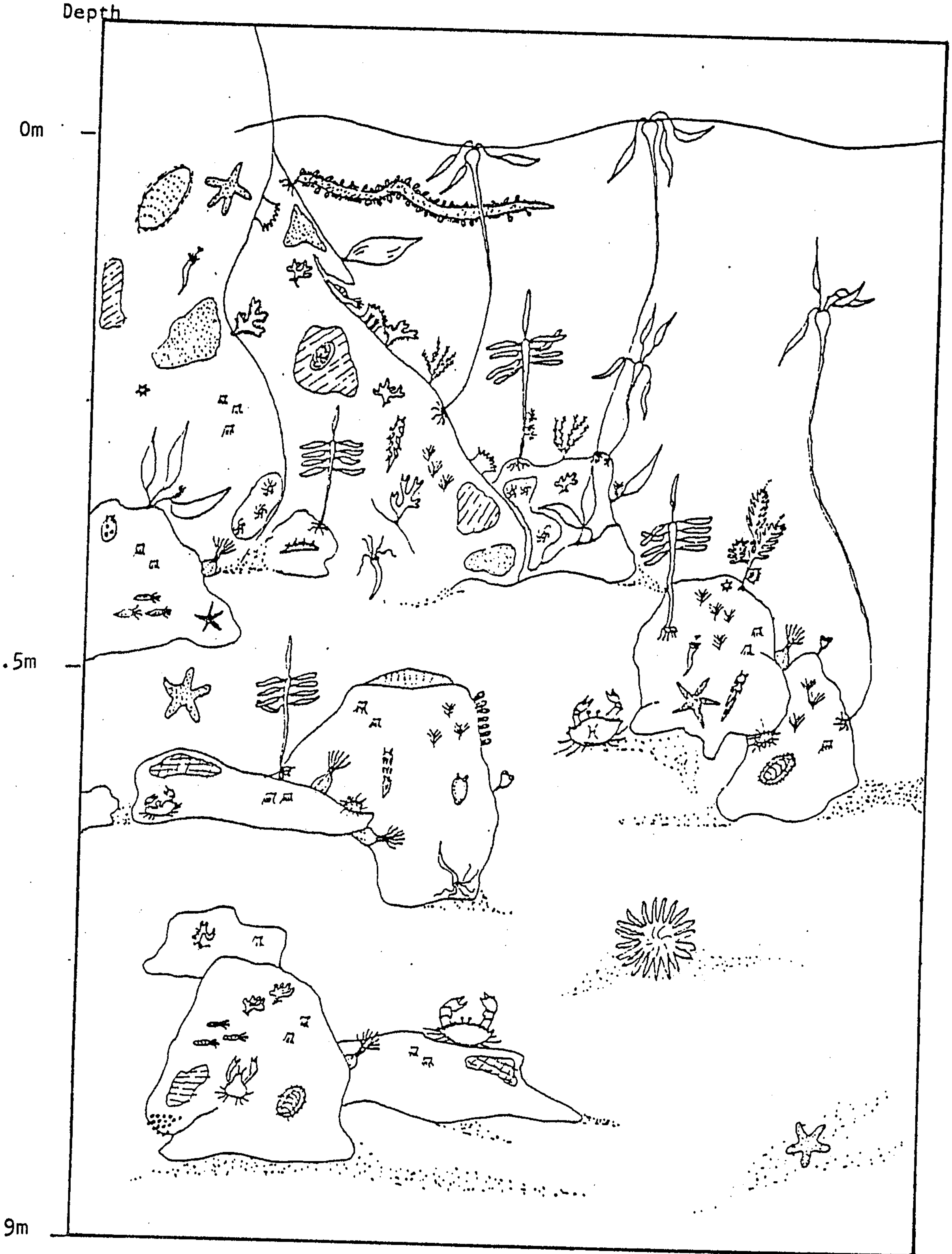

Figure 5. The macrobiota observed on and adjacent to the east side of Trinidad Head.

2. Biological Features: An algal zone extended to about 5 ft. (1.5 m) deep. Sporadic patches of the brown algae Nereocystis luetkeana to about 15 ft. (5 m) deep, and Egregia menziesii (near datum) occurred forming a canopy at or near the surface. From 3 to 6 ft. (1 to 2 m) deep, the brown alga Pterygophora californica was dominant to about 15 ft. (5 m) deep. Beneath these large kelps to about 6 ft (2 m) deep, the brown algae Cystoseira osmundacea, L. dentigera and L. sinclairii; and the red algae Botryoglossum farlowianum, C. flabellulata, Hymenena flabelligera, Iridaea splendens, Lithophyllum sp., P. hairii, Plocamium violaceum and Ptilota filicina occurred. Only the algae Lithophyllum sp. and P. hairii were seen below 15 ft. (5 m) deep. The surf grass Phyllospadix torreyi occurred on rocky prominences near datum.

The invertebrate fauna included: encrusting sponges in sheltered areas amongst boulders and crevices; the hydroids Abietinaria sp., Aglaophenia sp., Phialidium sp. and Tubularia marina, all four to about 10 ft. (3 m) deep, the cup corals B. elegans and Paracyathus stearnsi; the sea anemones A. xanthogrammica, Epiactis prolifera (on Cystoseira osmundacea), Tealia crassicornis and T. lofotensis; the zoanthid anemone Epizoanthus scotinus; the corallimorph anemone Corynactis californica (near the bottom); the polychaetes S. vermicularis (common), Thelepus crispus (common), Eudistylia sp. and Spirorbis sp.; the chitons Cryptochiton stelleri, Lepidozona mertensi, Mopalia sp., Placiphorella velata and T. lineata (on Lithophyllum sp.); the snail Ceratostoma foliatum (common in deeper portions); the nudibranchs Acanthodoris nanaimoensis, Cadlina luteomarginata, Dialula sandiegensis, Dirona albolineata (abundant), H. crassicornis (abundant) and Triopha carpenteri; the barnacle B. nubilis; the crabs C. antennarius, C. magister, Cryptolithodes sitchensis and Loxorhynchus crispatus; the skeleton shrimp M. kennerlyi; the bryozoans E. bilabiata and Parasmittina collifera, both common to about 6 ft. (2 m) deep; the sea cucumbers C. miniata (abundant between juxtaposed boulders), juvenile Eupentacta quinquesemita (sporadically abundant) and Stichopus californicus (on surfaces covered with fine sediment); the sea stars D. imbricata, Evasterias troschelii, H. leviuscula, Leptasterias hexactis, Pisaster brevispinus, P. ochraceus and Pycnopodia helianthoides; and the tunicates Clavelina huntsmani, Cnemidocarpa finmarkiensis (near the bottom), Halocynthia hilgendorfi (in crevices), Metandrocarpa taylori (in caverns) and S. montereyensis.

Prisoner Rock: This is the largest exposed rock that is completely surrounded by water in Trinidad Bay. Of the bay's southern, outer rocks, Prisoner Rock received a weaker swell than Flat and Barnacle Rocks to the east. All sides were examined and the south and north sides were diagrammed and are described.

South Side of Prisoner Rock (Figure 6)

1. Physical Features: The south side is about vertical with occasional outcroppings and ledges. To about 9 ft. (3 m) deep, the wall was smooth. Between 9 to 25 ft. (3 to 8 m) to the bottom at 42 ft. (13 m), the side was again smooth. The adjacent bottom consisted of large boulders approaching 10 ft. (3 m) around and surrounded by fine sediment.

2. Biological Features: An algal zone extended about 12 ft. (4 m) deep and contained brown alga L. dentigera and the red algae B. farlowianum, C. flabellulata and H. flabelligera. The red algae Bossiella sp. and Corallina sp. were also present, but restricted to datum and slightly below. Below 12 ft. (4 m) the algae Lithophyllum sp. and P. hairii were noted.

The dominant invertebrates of the algal zone were the hydroids Aglaophenia sp., Eudendrium californicum, Obelia sp. and Phialidium sp.; the white sea anemone M. senile; the giant acorn barnacle B. nubilis; the arborescent bryozoans Bugula californica, Crisia maxima, F. corniculata and T. ternata; and the crustose bryozoans E. bilabiata and P. collifera.

Below the algal zone the following species were common: the sea strawberry G. rubiformis, to about 30 ft. (9 m); the stony corals B. elegans and P. stearnsi, common below 30 ft. (9 m); the polychaetes D. concharum, to about 30 ft. (9 m), S. vermicularis and Spirorbis sp. (both in large

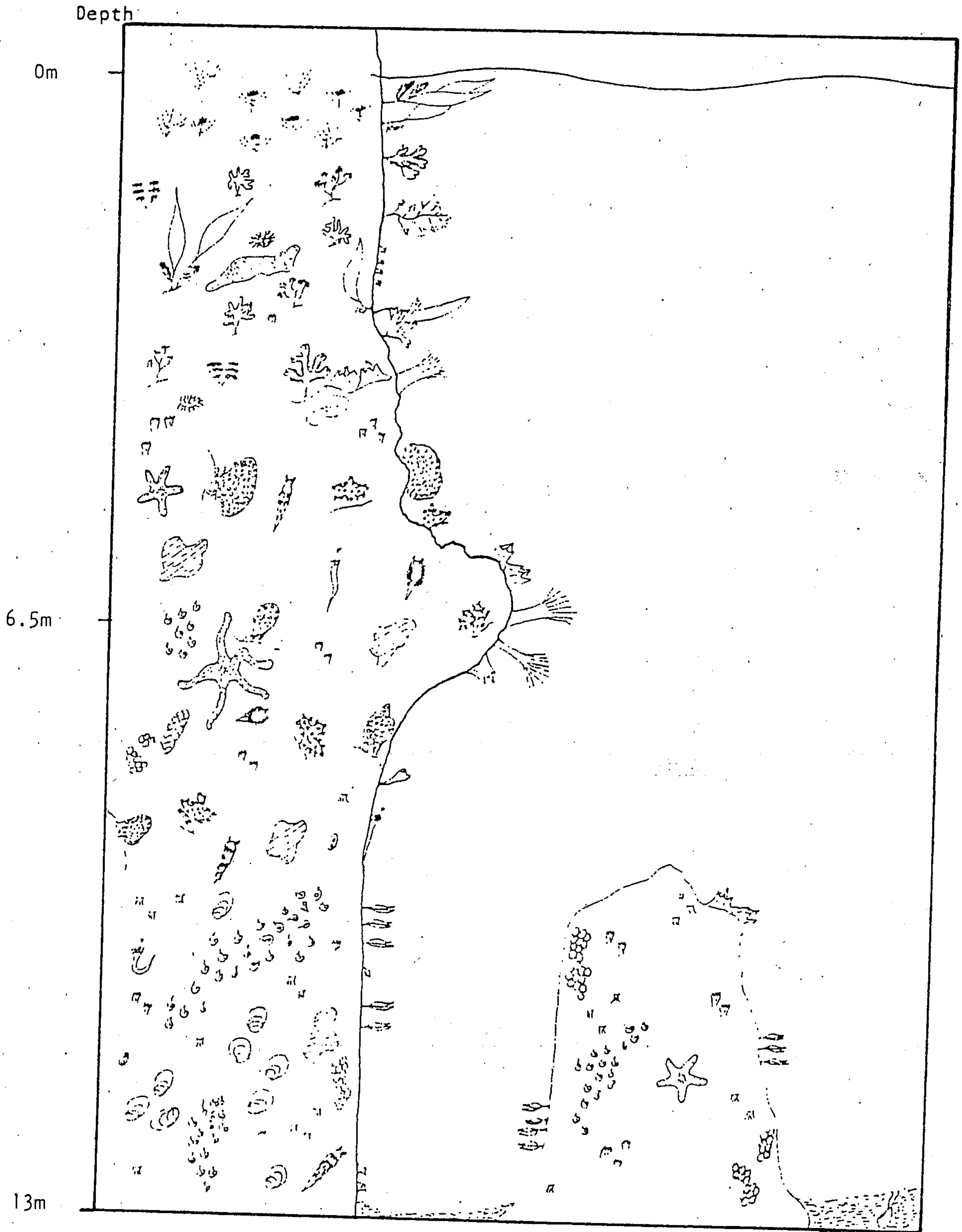

Figure 6. The macrobiota observed on and adjacent to the south side of Prisoner Rock.

aggregations); the nudibranchs h. crassicornis and T. tetraquetra; the abalone jingle P. cepio, in large aggregations below 30 ft. (9 m); the barnacle B. crenatus (dominating much of the side); the tunicates Chelyosoma productum, Cnemidocarpa finmarkiensis and S. montereyensis; and the sea stars H. leviuscula, Orthasterias koehleri (the only specimen seen during the entire study), Pisaster ochraceus, P. brevispinus, Pycnopodia helianthoides and Solaster stimpsoni.

Large boulders along the bottom of the south face bore the hydroid Abietinaria sp.; the cup coral B. elegans; aggregations of the polychaete Spirorbis sp.; the snail C. foliatum; aggregations of the barnacles B. crenatus and B. nubilis; aggregations of a caprellid amphipod; and of the brachiopod T. transversa. The surrounding sediments contained the clam Macoma inquinata.

North Side of Prisoner Rock (Figure 7)

1. Physical Features: This side of Prisoner's Rock receives no strong wave action due to northwesterly swell, but is affected by surge. This side is about vertical and smooth to about 10 ft. (3 m) deep. Topography changes abruptly between 10 to 13 ft. (3 to 4 m) depth, becoming steeply inclined to about 25 ft. (8 m) deep. Within this deep range, the rock surface is generally smooth, but it is interrupted frequently by large cracks and crevices. Below 25 ft. (8 m), the face is generally smooth and drops vertically to the bottom. The adjacent bottom consists of boulders 1 to 4 ft. (0.3 to 1 m) in diameter and surrounded by fine sediment.

2. Biological Features: The brown algae observed were all below 6 ft. (2 m) and included Desmarestia ligulata var. ligulata, N. luetkeana and P. californica, to about 20 ft. (6 m) deep. The red algae were common to about 6 ft. (2 m) deep and included Bossiella sp. Botryoglossum farlowianum, Callophyllis flabellulata, Corallina sp., H. flabelligera and P. latissima.

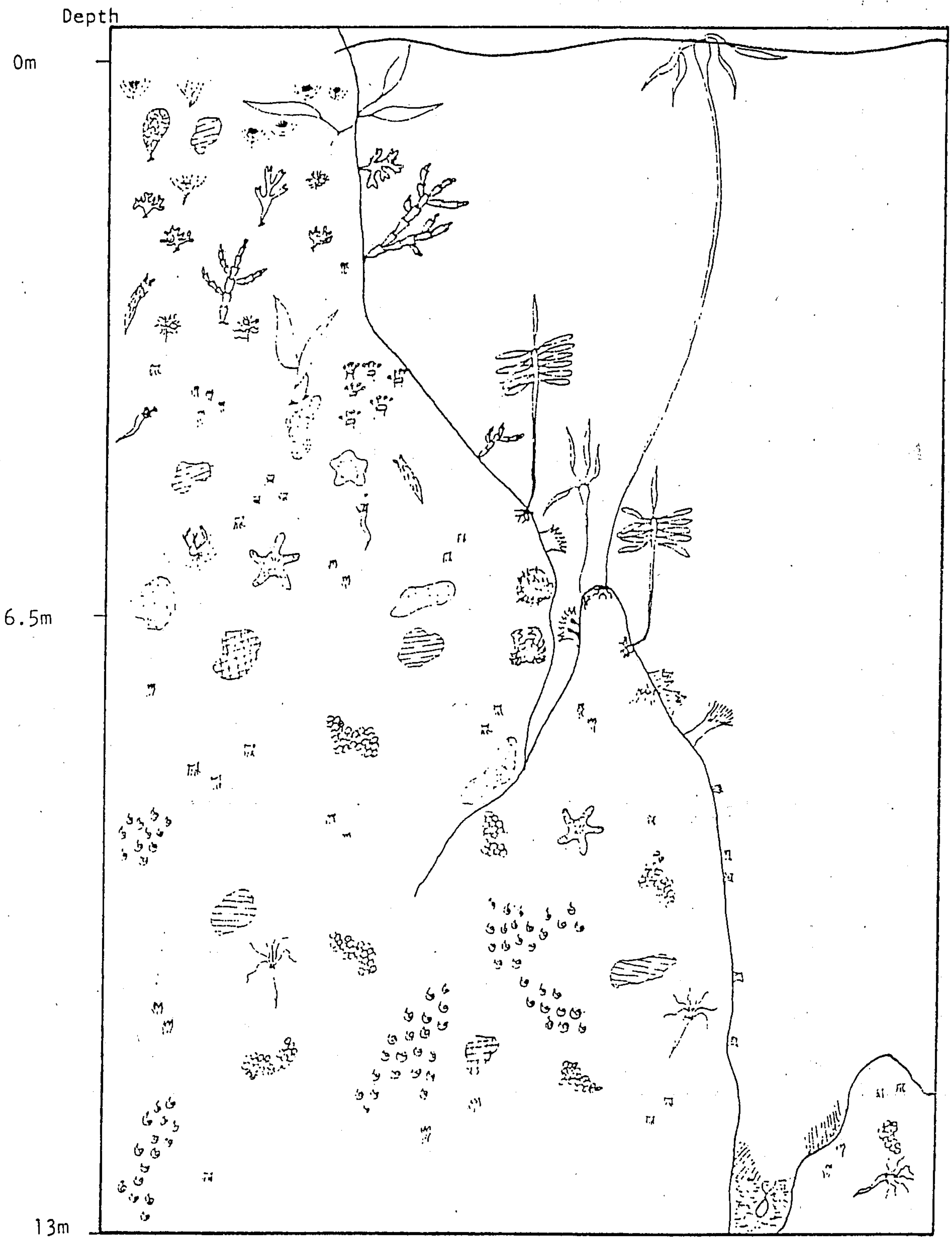

Figure 7. The macrobiota observed on and adjacent to the north side of Prisoner Rock.

The invertebrates observed in the algal zone were the following: the sea anemones A. xanthogrammica and T. crassicornis; the corallimorph anemone C. californica; the cup coral B. elegans; the polychaete S. vermicularis; the rock scallop Hinnites giganteus; the nudibranch H. crassicornis; the acorn barnacle B. crenatus; the crabs O. gracilis and Phyllolithodes papillosus; the bryozoans E. bilabiata, P. collifera and T. ternata; and the sea stars D. imbricata, Pisaster giganteus (1 specimen) and P. brevispinus.

Below the algal zone, the following invertebrates were common: the white sea anemone M. senile (closely associated with the giant barnacle B. nubilis); the polychaetes Phyllochaetopterus prolifica, Spirorbis sp. and T. crispus; the tunicate C. productum (abundant near the bottom); and the clam M. inquinata (in adjacent sediments).

Flat Rock: This rock lies east and inshore of Prisoner's Rock and experiences a stronger northwesterly swell than the latter rocks. The entire rock was surveyed, and the south and north faces were diagrammed.

South Side of Flat Rock (Figure 8)

1. Physical Features: This side had an extensive ledge about 9 to 12 ft. (3 to 4 m) deep. Above and below the ledge, the face was about vertical to the bottom at about 27 to 30 ft. (8 to 9 m) deep. The adjacent bottom bore boulders or bedrock surrounded by silty sand.

2. Biological Features: An algal zone extended to about 18 to 22 ft. (5 to 7 m) deep. The algae included: A. marginata, Bossiella sp., Calliarthron tuberculosum, Cystoseira osmundacea, D. ligulata var. ligulata, I. splendens, Laminaria dentigera, Lessoniopsis littoralis (near datum), Polyneura latissima and Pterygophora californica. Most algae were in the upper 9 to 12 ft. (3 to 4 m) with P. californica extending to about 18 to 22 ft. (5 to 7 m). Lithophyllum sp. and P. hairii extended to near the bottom.

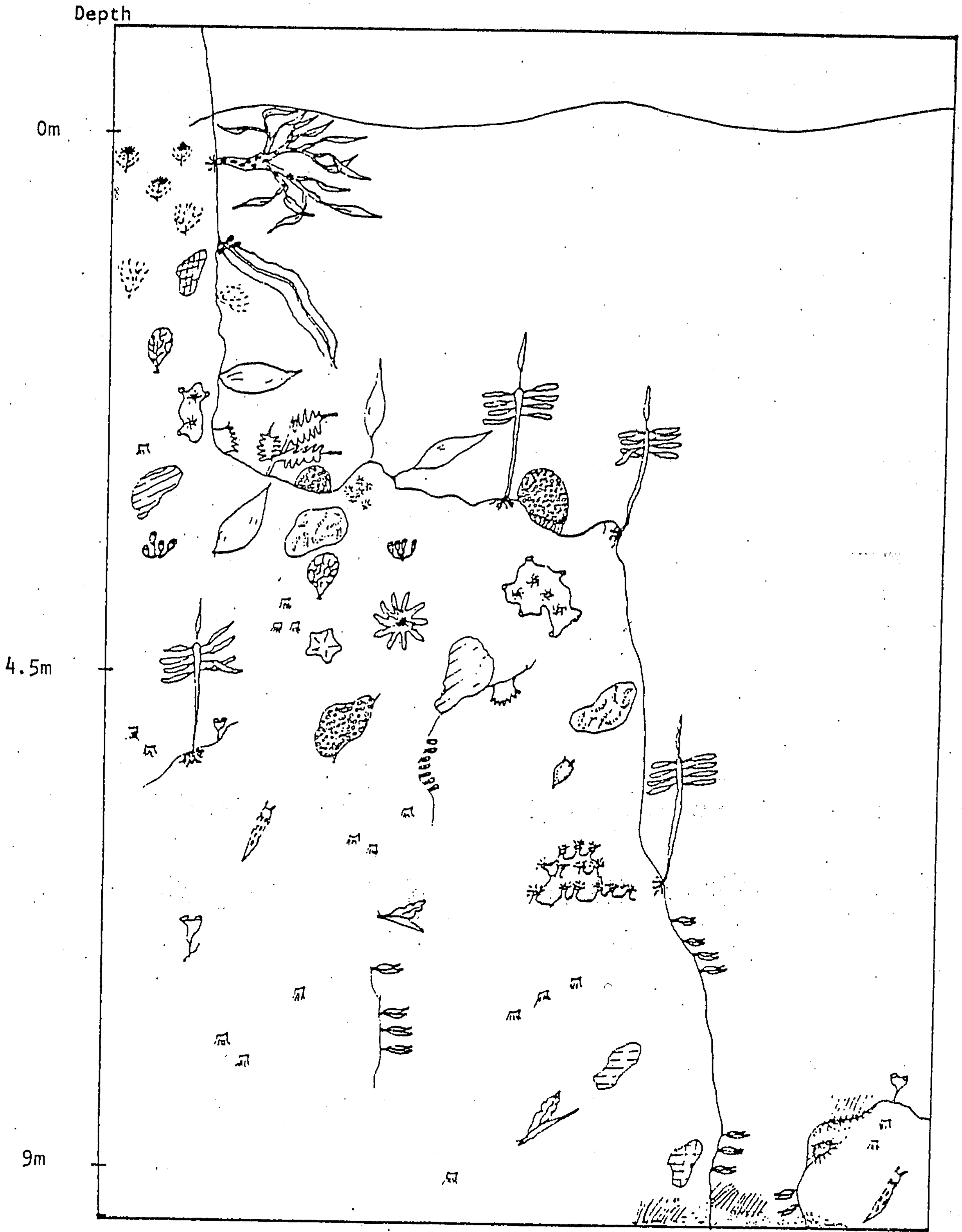

Figure 8. The macrobiota observed on and adjacent to the south side of Flat Rock.

The invertebrates common in the algal zone were the sponges Leucosolenia eleanor and an unidentified crustose purple species; the hydroid Garviea sp. and unidentified hydroids; the zoanthid anemone E. scotinus; the sea anemone A. xanthogrammica; a few specimens of the sea urchin Strongylocentrotus franciscanus; the sea stars D. imbricata and S. stimpsoni; and the tunicates Aplidium sp. and C. huntsmani.

Below the algal zone the following invertebrates were seen: the cup corals B. elegans and P. stearnsi; the sea anemone A. xanthogrammica (in depressions); the zoanthid anemone E. scotinus; the polychaetes D. concharum and P. prolifica (where veneers of fine sediment coated rock); the predatory snail C. foliatum; the nudibranchs C. luteomarginata and H. crassicornis; the crab S. acutifrons; the bryozoan H. pacifica; the brachiopod T. transversa, common below 20 ft. (6 m) deep; the sea stars E. troschelii and H. leviuscula; and the tunicates C. finmarkiensis, H. hilgendorfi (in crevices) and S. montereyensis.

North Side of Flat Rock (Figure 9)

1. Physical Features: As on the south side, a ledge jutted out at about 9 to 12 ft. (3 to 4 m) deep; the remaining surface was steep, highly irregular and pitted. The bottom was about 30 ft. (9 m) deep. the perimeter had rocks ranging from fist-size to about 3 ft. (1 m) in diameter that were surrounded by silt. Under conditions of northwesterly swell, the water movement was equivalent to that experienced by the south side.

2. Biological Features: The algal zone resembled that of the south side; additionally, the brown alga N. luetkeana occurred. The invertebrates of the algal zone included the following: the hydroids Garviea sp. and Sertularella sp. (in dense patches); the sea anemone T. lofotensis; the polychaetes S. vermicularis and T. crispus; the bryozoans E. bilabiata and T. ternata; the sea stars D. imbricata, E. troschelii, Solaster stimsoni and its predator S. dawsoni; and the tunicates Aplidium sp., C. productum and P. annectens.

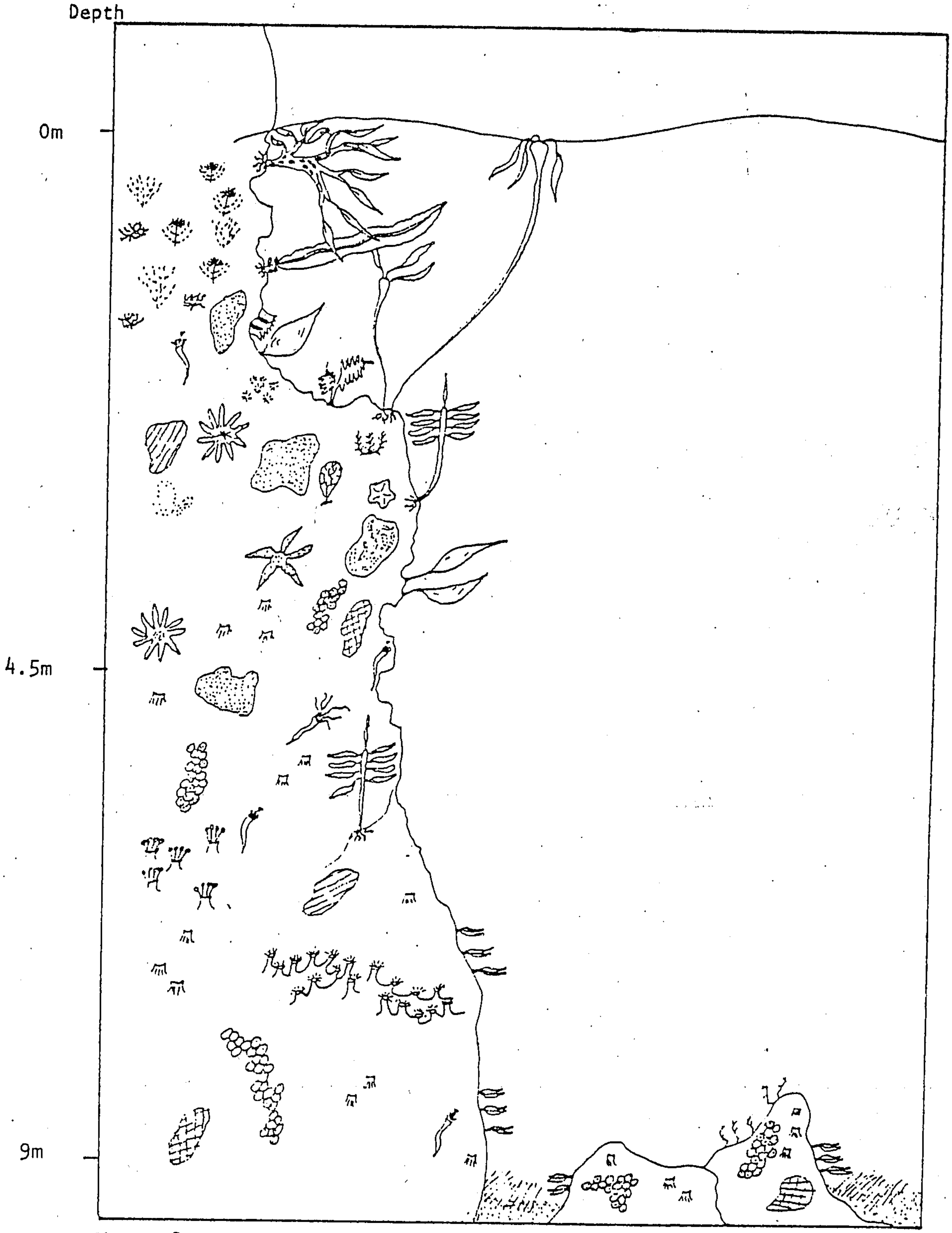

Figure 9. The macrobiota observed on and adjacent to the north side of Flat Rock.

Only the algae Lithophyllum sp. and P. hairii were observed below the algal zone. Below the algal zone the following invertebrates were seen: the cup corals B. elegans and P. stearnsi; the corallimorph anemone C. californica; a dense patch of zoanthid anemone E. scotinus; the polychaete P. prolifica; and the brachiopod T. transversa.

Boulders along the perimeter bore heavy growths of B. elegans, C. productum, T. transversa and an unidentified caprellid amphipod. The surrounding sediment contained the clam M. inquinata.

Barnacle Rock (Figure 10)

This rock is the most easterly of the southern offshore rocks of the study area and was exposed to a stronger swell on all sides than either of the aforementioned rocks.

1. Physical Features: The sides are relatively steep and highly pitted. The bottom is at about 30 ft. (9 m) deep on the north side and about 34 to 36 ft. (10 to 11 m) deep on the south side. The perimeter is bordered by coarse sand, except on the east side and in places elsewhere; a scour lined extends up to about 3 ft. (1 m) or so above the bottom. The presence of stronger swell here than farther west is indicated by scouring and by the sandy bottom surrounding most of the rock.

2. Biological Features: An algal zone extended to about 19 to 22 ft. (6 to 7 m) deep. The dominant algae were C. flabellulata, D. ligulata var. ligulata, E. delesserioides, H. flabelligera, I. splendens, Laminaria dentigera, L. sinclairii, Lessoniopsis littoralis, Polyneura latissima, Pterygophora californica and Ptilota densa. Lithophyllum sp. and P. hairii were at all depths.

The invertebrates of the algal zone included: several unidentified sponges; the hydroids Garviea sp., Hydractinia sp. and other unidentified species; the cup coral B. elegans; the sea anemone A. xanthogrammica (in broad crevices); the sea strawberry G. rubiformis; the stoloniferan coral Clavularia sp.; zoanthid E. scotinus (largest aggregation seen during study); the chiton T. lineata (on crustose coralline algae); the nudi-

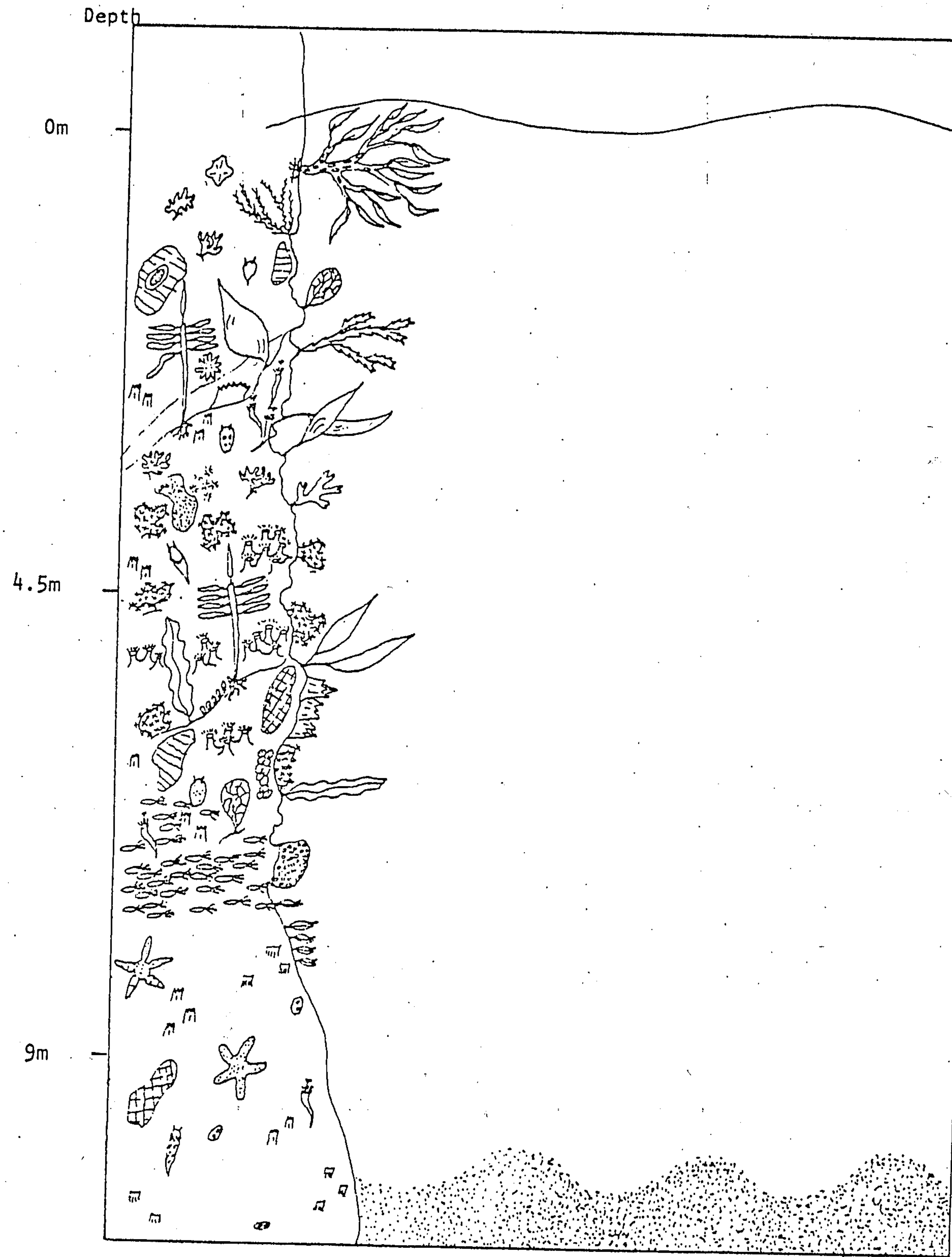

Figure 10. The macrobiota observed on and adjacent to Barnacle Rock.

branchs Acanthodoris nanaimoensis, Archidoris montereyensis, A. odhneri, D. sandiegensis and T. tetraquetra; the barnacles B. crenatus and B. nubilis; the bryozoans F. corniculata (on the alga P. californica); the sea stars D. imbricata and S. stimpsoni; the sea cucumber E. quinquisemita (the largest aggregation of adults seen in the bay and, just immediately subtidally, thousands of juveniles covering the entire sides; and the tunicates Aplidium sp., Clavelina hunstmani, Chelyosoma productum and Distaplia occidentalis.

Below the algal zone occurred the stony coral B. elegans (common); the polychaetes D. concharum, S. vermicularis and Spirorbis sp. (all three were dominant and the highly pitted surface apparently favored S. vermicularis); the barnacle B. crenatus (abundant and being eaten by the sea stars E. troschelii, P. brevispinus and P. ochraceus); the tunicates Chelyosoma productum and Cnemidocarpa finmarkiensis (both common); the nudibranch H. crassicornis (common); and the brachiopod T. transversa (common). Scoured areas near the bottom were depauperate. The east side was silty near the bottom and dominated by P. prolifica.

Except for the eastern portion, the surrounding bottom was of coarse sand containing much broken shell and was biologically depauperate. The bottom on the eastern flank had finer sediment, apparently due to the rock forming a lee.

Spruce Rock and Vicinity (Figure 11)

1. Physical Features: The sides of Spruce Rock consist of bedrock and giant boulders extending about 25 ft. (8 m) deep. The adjacent area consists of clean, coarse sand and clean gravels with boulders and/or bedrock protruding.

2. Biological Features: An algal zone was about 20 ft. (7 m) deep. P. californica occurred throughout the algal zone. The upper 10 ft. (3 m) also had B. farlowianum, Calliarthron tuberculosum, Callophyllis flabellulata, D. ligulata var. ligulata, L. sinclairii, Plocamium coccineum, Polyneura latissima, Prionitis linearis, Pterygophora californica and

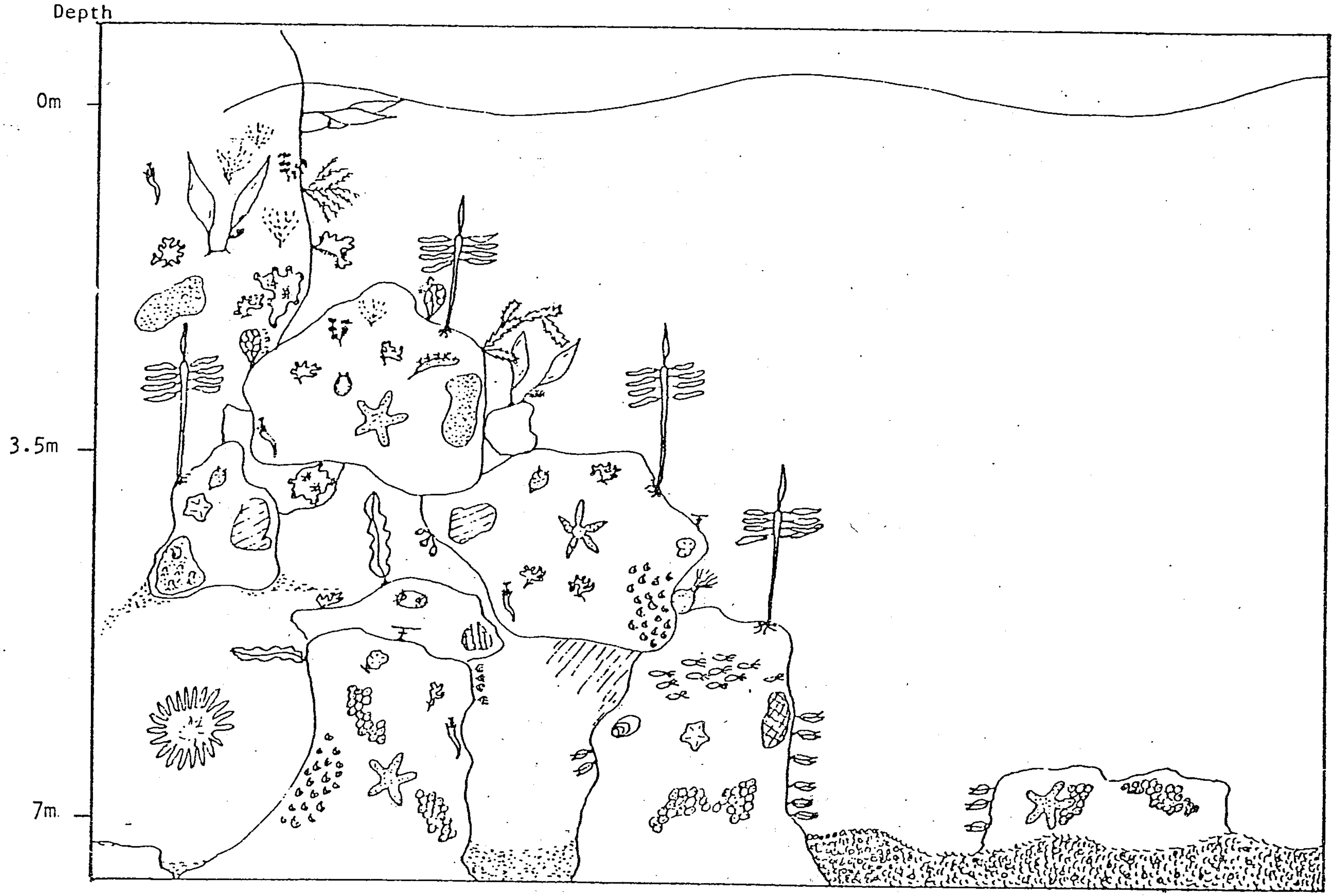

Figure 11. The macrobiota observed on and adjacent to Spruce Rock.

Ptilota filicina. Greater than 10 ft. (3 m) deep C. flabellulata, E. delesserioides, Lithophyllum sp., Peyssonellia hairii and Pugetia firma occurred.

The invertebrate fauna closely resembled that found along the open coast just north of Trinidad Head, correlating with strong water movement. The invertebrates observed were: several unidentified sponges plus Leucilla nuttingi, Leucosolenia eleanor and Polymastia pachymastia (where sand shallowly covered rock); the hydroids Abietinaria sp. and Phialidium sp. (on red algae); the cup coral B. elegans; the zoanthid E. scotinus; the nemerteans Tubulanus polymorphys and T. sexlineatus; the snails Calliostoma ligatum and Ceratostoma foliatum; the nudibranchs Acanthodoris nanaimoensis, Archidoris montereyensis, C. luteomarginata, Dialula sandiegensis, Dirona albolineata, Rostanga pulchra and T. carpenteri; the abalone jingle P. cepio; the chiton C. stelleri (common); the polychaetes P. elongata, S. vermicularis and Spirorbis sp.; the crab Hapalogaster cavicauda (in pits); the bryozoans B. californica, Dendrobeania lichenoides and P. collifera; the entoproct Barentsia ramosa; the brachiopod T. transversa (dominating many vertical surfaces); the sea stars D. imbricata, E. troschelii, Pisaster brevispinus, P. ochraceus and Pycnopodia helianthoides; and the sea cucumbers C. miniata, E. quinquesemita and Lissothuria nutriens (only specimen observed during this study); the tunicates Chelyosoma productum, Clavelina huntsmani, Cnemidocarpa finmarkiensis, H. hilgendorfi (in cracks), M. taylori, Perophora annectens, Pyura haustor and S. montereyensis. Below about 18 ft. (5 m), the tunicate C. productum was dominant and being eaten by the sea stars E. troschelii and P. brevispinus.

The surrounding bottoms of fine gravel had no evident macrofauna; however, coarse and fine sand bottoms contained the innkeeper worm U. caupo. Low relief rock protruding through sediments was dominated by the tunicate C. productum and its predators, the sea stars E. troschelii and P. brevispinus.

Moor Rock (Figure 12)

1. Physical Features: Moor Rock receives some protection from northwesterly swells. The sides are about vertical with some large, shal-

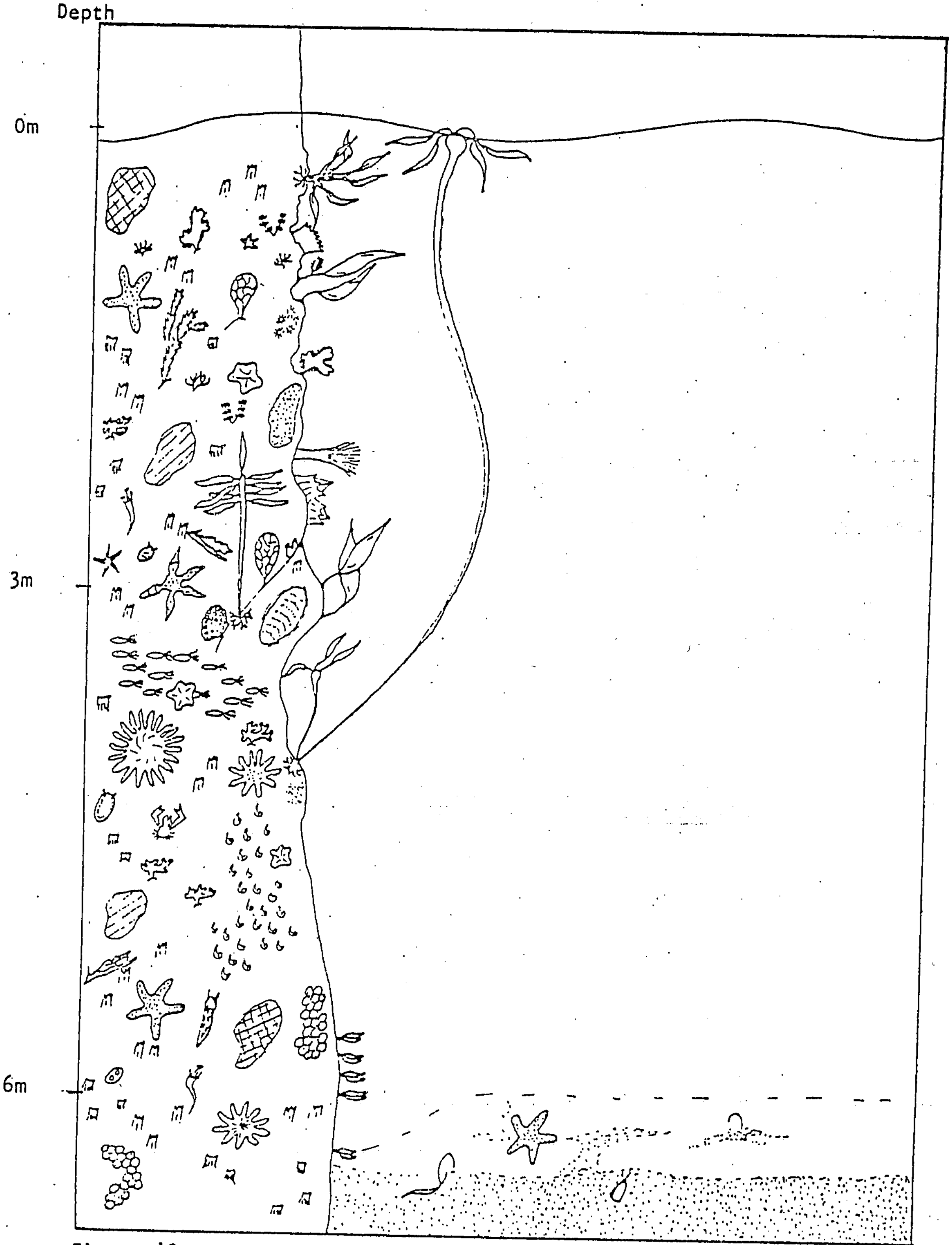

Figure 12. The macrobiota observed on and adjacent to Moor Rock.

low depressions. Much pitting is present on the east side. The bottom is about 20 ft. (6 m) deep, and surrounded by dirty coarse sand, shell and gravel. Boulders protruded and were especially numerous on the north side.

2. Biological Features: The algal zone was about 15 ft. (5 m) deep, with its more inshore location. The upper 15 ft. (5 m) bore the algae B. farlowianum, Calliarthron tuberculosum, Callophyllis flabellulata, D. ligulata var. ligulata, Laminaria dentigera, Lessoniopsis littoralis (some on the south side where swell was strongest), Lithophyllum sp., N. luetkeana, Peyssonellia hairii, Polyneura latissima and Pterygophora californica. Lithophyllum sp. and P. hairii extended to the bottom.

The invertebrates observed were: the sponges Leucilla nuttingi and Leucosolenia eleanor; the hydroids Abietinaria sp., Hydractinia sp., Phialidium sp. and T. marina; the corallimorph C. californica; the cup corals B. elegans and P. stearnsi; the sea anemones A. xanthogrammica, M. senile and Tealia coriacea (one seen in October, 1978); the polychaetes D. concharum (rare), S. vermicularis and Spirorbis sp.; the chiton C. stelleri; the snails C. foliatum and Ocenebra sp.; the nudibranchs A. nanaimoensis, C. luteomarginata and H. crassicornis; the abalone jingle P. cepio; the barnacles B. crenatus and B. nubilis; the crab S. acutifrons; the bryozoans B. californica, E. bilabiata, P. collifera and T. ternata; the brachiopod T. transversa, below 16 ft. (5 m); the sea stars D. imbricata, E. troschelli, H. leviuscula, L. hexactis, Pisaster brevispinus, Pycnopodia helianthoides, S. dawsoni and S. stimpsoni; the sea cucumber E. quinquesemita (large aggregations of small juveniles being eaten by D. imbricata and S. stimpsoni during 1976, but lacking completely in October, 1978); and the tunicates Chelyosoma productum, Clavelina huntsmani, Cnemidocarpa finmarkiensis, Perophora annectens and Pyura haustor.

The clams Macoma spp. were common in the sediment around the rock and were being consumed by the sea star P. brevispinus.

Offshore Kelp Beds (Figure 13)

1. Physical Features: Two such kelp beds occurred, one about 150 ft. (50 m) south of Barnacle Rock and another about 100 ft. (30 m) south of Flat Rock (Figure 1 and 2). Both were on outcroppings rising from about 35 ft. (11 m) deep to within about 15 ft. (4 m) of the surface. The top of each rock was flattened and its walls were vertical. The rock surfaces were either smooth or convoluted and crevices were numerous.

2. Biological Features: An algal zone was restricted to the upper 22 ft. (6 to 7 m), resulting in most algae occurring on the uppermost surface and a few species were on the sides. Both rocks were dominated by thick growths of N. luetkeana with an understory of Bossiella sp., D. ligulata var. ligulata, I. splendens, Laminaria dentigera, L. sinclairii (kelp bed south of Barnacle Rock), Lithophyllum sp., Peyssonellia hairii, Polyneura latissima and Pterygophora californica. The submerged rock off Flat Rock also had C. flabellulata. Both rocks had Lithophyllum sp. and P. hairii extending to the bottom.

The invertebrates observed were the following: the hydroid Abietinaria sp. (on top of rock off Flat Rock); the sea strawberry G. rubiformis; the cup corals B. elegans and P. stearnsi; the sea anemones M. senile and T. lofotensis, the polychaetes D. concharum, Spirorbis sp. and P. prolifica (near the bottom); the chiton T. lineata; the snails C. foliatum and Ocenebra sp.; the nudibranch A. nanaimoensis; the clam P. cepio; the tubicolous amphipod Erichthonius brasiliensis; the crabs O. gracilis and S. acutifrons; the barnacles B. crenatus and B. nubilis (largest aggregations seen in kelp bed off Barnacle Rock); the bryozoans Alcyonidium polyoum (on L. sinclairii) and P. collifera, the brachiopod T. transversa, the sea stars D. imbricata, Pisaster brevispinus, P. ochraceus and Pycnopodia helianthoides; the tunicates C. finmarkiensis (very common) and C. productum (a dominant).

Around the kelp bed off Flat Rock, the sediments contained the clam Tresus pajaroana and the burrowing sea cucumber Caudina chilensis.

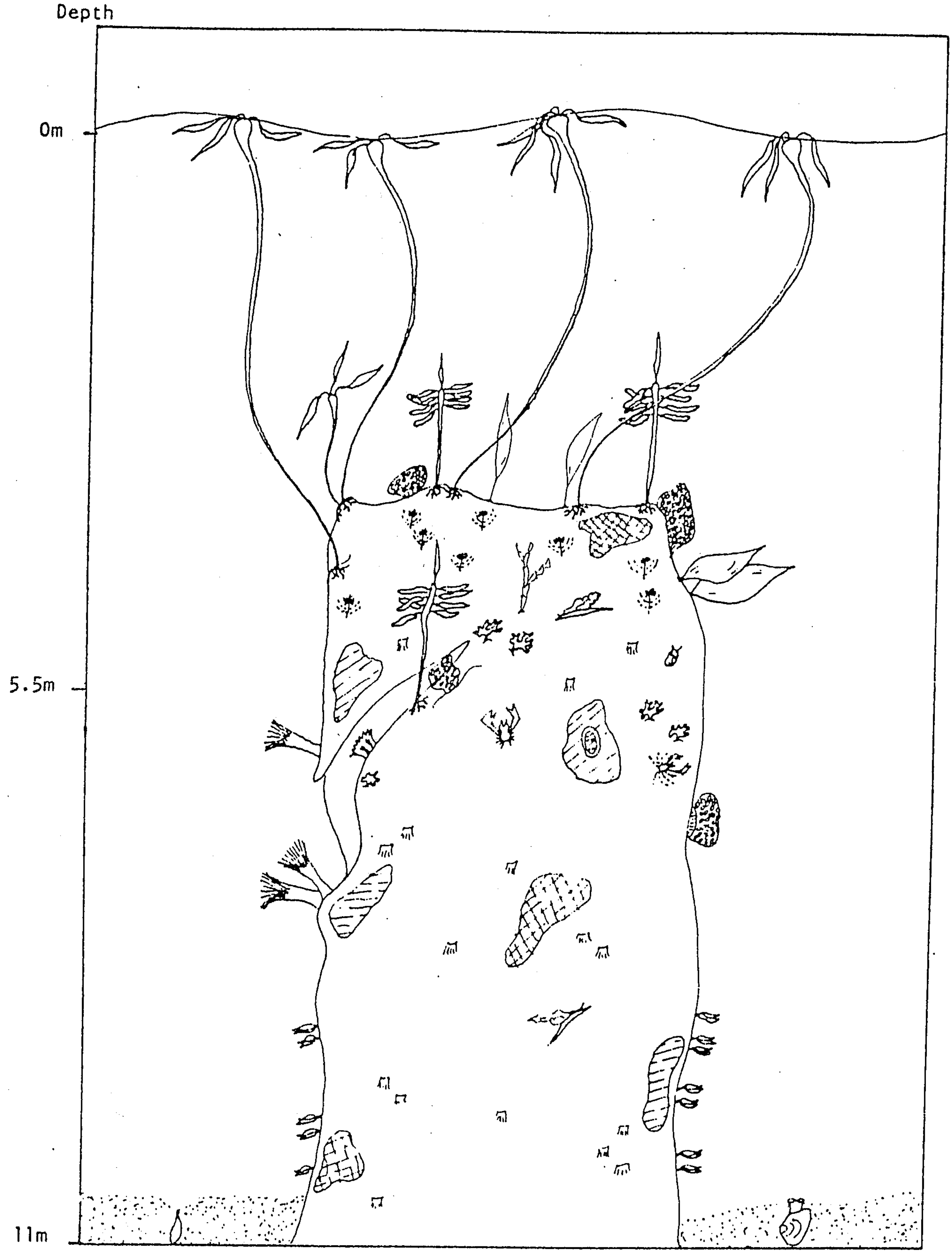

Figure 13. The macrobiota observed on and adjacent to offshore kelp beds within Trinidad Bay.

Inshore Kelp Beds (Figure 14)

1. Physical Features: These kelp beds were much more extensive than the offshore kelp beds and occurred in the area of rock bottom habitat mostly east of the Mooring Area (Figure 1 and 2). Most of these beds occurred on outcroppings, some of which rise to within less than 5 ft. (1 m) of the surface. Upper surfaces vary from flat to rounded. The sides are generally sheer, vertical, and descend to the bottom at about 25 ft. (8 m) deep. With swell less than 3 ft. (1 m), they experience little surge.

2. Biological Features: An algal zone extended about 18 ft. (5 m) deep. Algae were sparse on the vertical faces correlating with generally higher turbidity experienced here than farther off shore. The upper surface of the rocks were dominated by an overstory of N. luetkeana extending to the surface, and an understory of L. dentigera, L. sinclairii and P. californica. Abundant among these algae and extending about 3 to 6 ft. (1 to 2 m) down vertical surfaces were C. flabellulata, D. ligulata var. ligulata, Lithophyllum sp., Peyssonellia hairii and Pugetia firma. As on offshore rocks, Lithophyllum sp. and P. hairii extended to the bottom.

The invertebrates observed were the following: the hydroids Abietinaria sp. and E. californicum (both on the tops); the soft coral Clavularia sp.; the cup corals B. elegans and P. stearnsi; the sea anemones A. xanthogrammica and M. senile; the corallimorph C. californica (rare); the polychaetes S. vermicularis, Spirorbis sp. and T. crispus; the chiton T. lineata; the snails Acmaea mitra and Ocenebra sp.; the rock scallop H. giganteus; the nudibranchs C. luteomarginata, D. albolineata, H. crassicornis and T. carpenteri; the crabs O. gracilis and P. papillosus; the barnacles B. crenatus (dominant) and B. nubilis (common); the bryozoan P. collifera; the brachiopod T. transversa; the sea stars D. imbricata, E. troschelii, H. leviuscula, Pisaster brevispinus, Pycnopodia helianthoides and S. stimpsoni; and the tunicate C. productum. The bases of some of these rocks were scoured and were depauperate biologically.

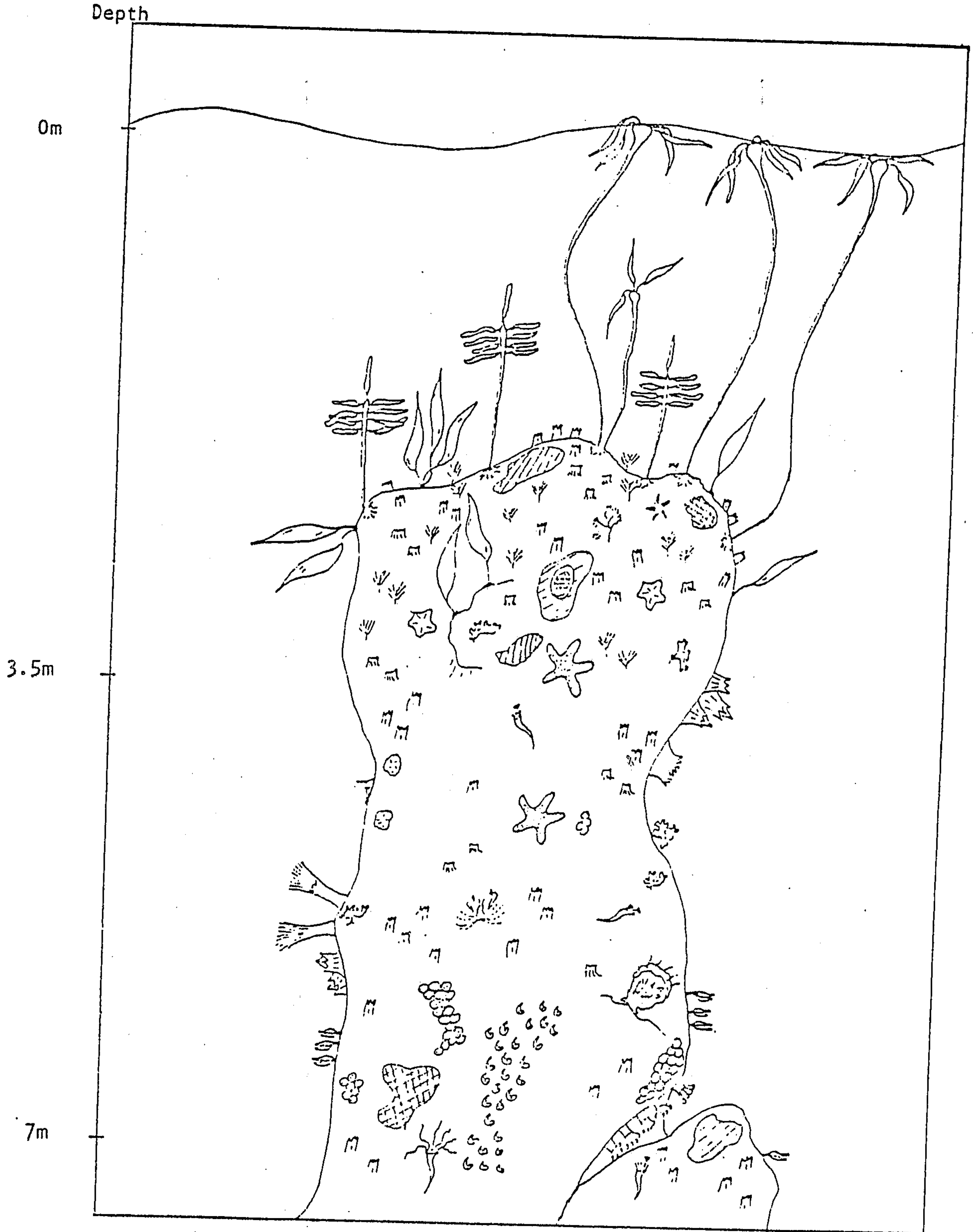

Figure 14. The macrobiota observed on and adjacent to inshore kelp beds within Trinidad Bay.

Rocky Bottom Habitat (Figure 15)

1. Physical Features: This bottom type is common in and extends eastward from the Mooring Area (Figure 1 and 2). Rocks vary in size from pebbles through bedrock stacks, often not high enough to reach the algal zone. When rocks do come within about 20 ft. (6 m), they generally bear kelp. Silty gravel and silty, shelly sands occurred, especially in the western sector, but not in the region east of Jones Rock where clean coarse sands and gravels were common.

Rocky surfaces and their attendant biota were often covered with a veneer of fine sediment, especially in the Mooring Area, but not east of Jones Rock.

2. Biological Features: If shallower than about 20 ft. (6 m), the algae Callophyllis sp., L. dentigera, Pterygophora californica and sometimes Pugetia firma generally were present. As observed elsewhere, Lithophyllum sp. and P. hairii extended to the bottom.

The dominant invertebrates on rock were the cup corals B. elegans and P. stearnsi; the polychaetes P. prolifica and Spirorbis sp.; the chiton Mopalia sp.; the nudibranch H. crassicornis; the barnacle B. crenatus; the dungeness crab C. magister; the brachiopod T. transversa; the sea star P. brevispinus; the sea cucumber E. quinquesemita (juveniles only); and the tunicate C. productum. Also observed were the sponge L. nuttingi, the hydroids Abietinaria sp., E. californicum and Tubularia sp. (not a dominant, but characteristic of this habitat); an unidentified stauromedusan; the corallimorph C. californica (rare); the zoanthid anemone E. scotinus (rare); the sea anemone M. senile; the nemertean T. polymorphus; the polychaetes S. vermicularis and T. crispus; the snails C. foliatum and Ocenebra sp.; the nudibranchs A. nanaimoensis and D. albolineata; the crabs Cancer productus, O. gracilis and S. acutifrons; the shrimp Pandalus danae (rarely seen); the bryozoans C. maxima, H. pacifica and P. collifera; the sea stars D. imbricata, E. troschelii, P. helianthoides and S. stimpsoni; the sea cucumbers E. quinquesemita (juveniles in extensive aggregations) and S. californicus; and the tunicates Clavelina hunts-

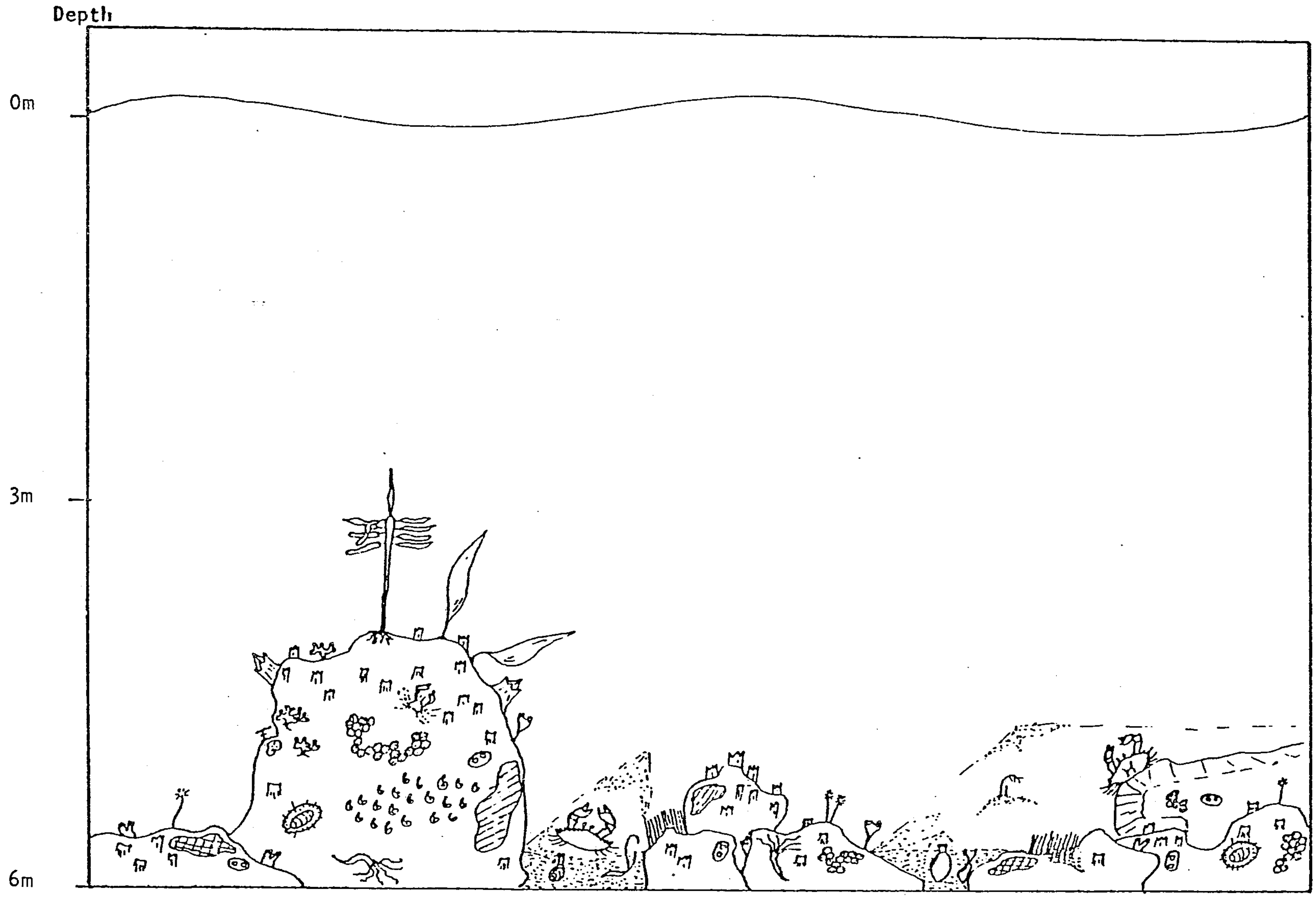

Figure 15. The macrobiota observed on and adjacent to the rocky bottom habitat within Trinidad Bay.

mani, Cnemidocarpa finmarkiensis, H. hilgendorfi (in cracks), P. haustor, and S. montereyensis.

The soft substrates contained the clams Macoma inquinata, M. nasuta, Protothaca staminea and Saxidomus giganteus; the polychaete Pista pacifica (scattered); and the sea star P. brevispinus which was often seen digging clams.

Nearshore Sands and Mixed Rock and Sand Habitats within Trinidad Bay (Figure 16)

1. Physical Features: These habitats were primarily sand and were generally less than 15 ft. (5 m) deep. However, between rocks, finer sediments containing sulfur bacteria often occurred, associated with reduced, localized water movements favoring deposition; thus, a result was a mosaic of substrates often within a few meters of each other.

2. Biological Features: On rock, an algal zone generally extended about 15 ft. (5 m) deep, correlating with the generally greater turbidity of the overlying water. The dominant algae were L. sinclairii and P. californica. Where sand was not cast over rock, some rocks bore B. farlowianium, Callophyllis sp., Cryptopleura violacea, Iridaea sp., Lithophyllum sp., Peyssonellia hairii and Plocamium coccineum var. parcificum. Where sand was applied shallowly to rock, the algae Ahnfeltia plicata, Gymnogongrus leptophyllus and G. linearis occurred. P. californica also occurred, and prevailed, where rock was covered by several inches of sand, indicating that it must recruit during periods of sand removal from rock. L. dentigera and L. sinclairii were rarely seen.

The invertebrates observed were: the sponge L. nuttingi; the hydroid Tubularia sp.; the stauromedusan Haliclystus auricula (common on algae); the polychaetes Chone minuta (almost completely dominated some of the rocks in the boat launching area during summer 1976, but lacking by late summer 1976), D. concharum (few small colonies), Schizobranchia insignis, Serpula vermicularis and Spirorbis sp.; the nudibranchs A. nanaimoensis, C. luteomarginata, H. crassicornis and T. carpenteri; the barnacle B.

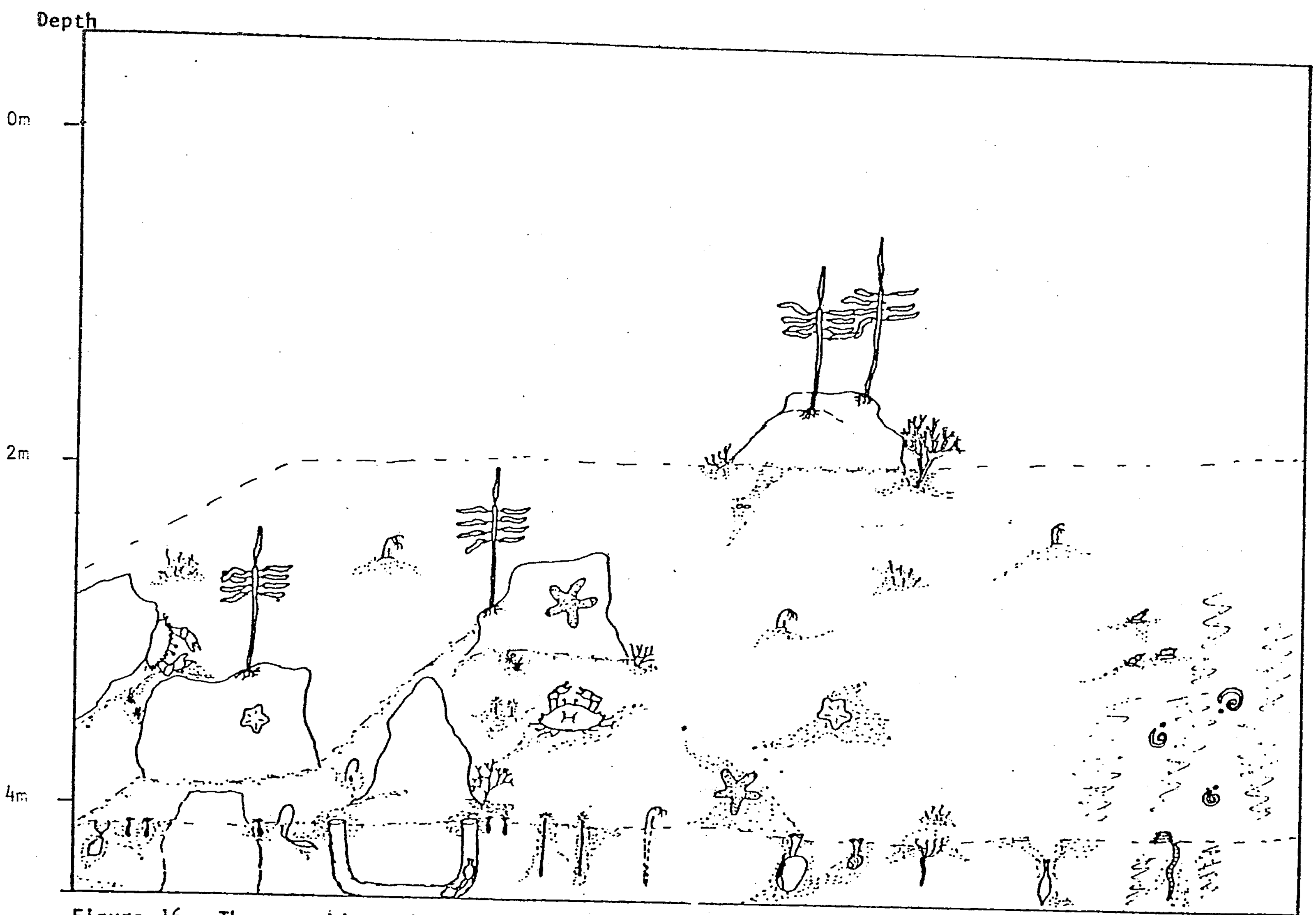

Figure 16. The macrobiota observed on and adjacent to the nearshore sands and mixed rock and sand habitats within Trinidad Bay.

crenatus; the bryozoans F. corniculata (often attached to L. sinclairii) and P. collifera; the sea stars E. troschelii, H. leviuscula, P. brevispinus and P. ochraceus; the tunicates Clavelina huntsmani, Cnemidocarpa finmarkiensis, M. taylori (not common), P. haustor and S. montereyensis.

Extensive sandy areas occurred both east and west of Little Head. Where sand was undisturbed, diatom slicks often developed. The following burrowing and tube-dwelling invertebrates were seen: the polychaetes Abarenicola sp., Cirriformia luxuriosa, Mesochaetopterus taylori, Nephtys sp., P. pacifica and Tharyx sp.; the innkeeper worm U. caupo (along the east side of Trinidad Head); the snail Olivella biplicata; the clams M. inquinata, M. nasuta, P. staminea, S. giganteus and Tellina bodegensis; the crabs C. antennarius and C. magister; the sea star P. brevispinus; the brittle star Amphipholis pugetana (in aggregations); the burrowing sea cucumber C. chilensis and the phoronid worm Phoronopsis viridis (in patches of sand amongst rocks). Where rock was overlain by several centimeters of sand, extensive aggregations of the peanut worm, Themiste dyscritum, occurred as the dominant species.

Offshore Coarse Sand Habitat within Trinidad Bay (Figure 2)

The habitat was devoid of a well developed macrofauna. Only a few specimens of the snail Olivella biplicata were seen.

Mixed Sand Habitat within Trinidad Bay (Figure 2)

This habitat was difficult to assess because finer sediments were readily suspended while working here and, coupled with light loss with depth, yielded visibilities approaching zero. At times one could not read compasses and depth gauges. The polychaete P. pacifica, the shrimp Crangon sp., the crab C. magister, apparent burrows of the innkeeper worm U. caupo, the snail O. biplicata and the clams M. inquinata and Tresus pajaroana were observed.

Clayey-Silt Habitat within Trinidad Bay (Figure 2)

This unit was also difficult to assess because of poor visibility. The polychaete P. pacifica, the crab C. magister and the clams M. inquinata, M. nasuta, P. staminea and S. giganteus were observed.

Western Sector of Kelp Beds at Trinidad Head ASBS

West Side of Trinidad Head (Figure 17)

1. Physical Features: This side consists of vertical bedrock extending to about 40 ft. (12 m) deep. For at least 15 to 20 ft. (4.5 to 6 m) seaward, the adjacent bottom has boulders ranging from 2 to 10 ft. (0.5 to 3 m) in diameter, surrounded by sand.

2. Biological Features: Observations were made on October 16 and 23, 1978. An algal zone extended to about 10 ft. (3 m) deep. The algae included Bossiella sp., Calliarthron cheilosporioides (characteristic of very surgy areas), C. tuberculosum (immediately subtidal), Callophyllis flabellulata, Constantinia simplex (in large aggregations), E. delesserioides (starting to degenerate), L. sinclairii and Prionitis lanceolata. Invertebrates were scarce and only the sea anemone A. xanthogrammica was seen.

Below the algal zone, the algae Lithophyllum sp. and P. hairii were common. The following invertebrates were seen: the low, encrusting sponge Plocamia karykina; the hydroids Abietinaria sp., Aglaophenia sp. and E. californicum (all three were common on tops of boulders); the hydrocoral S. porphyra; the sea anemones A. xanthogrammica (several small aggregations on exposed surfaces, but mainly in wide crevices), M. senile (few patches), Metridium sp. and T. crassicornis; the corallimorph anemone C. californicus (small patch); the cup corals B. elegans and P. stearnsi (both mainly near the bottom); the polychaetes D. concharum (large colonies common), E. polymorpha and S. vermicularis; the chitons Ischnochiton radians, Mopalia lignosa and T. lineata; the snails C. foliatum and Nucella canaliculata (both eating the barnacle B. crenatus) and Ocenebra sp.; the nudibranchs

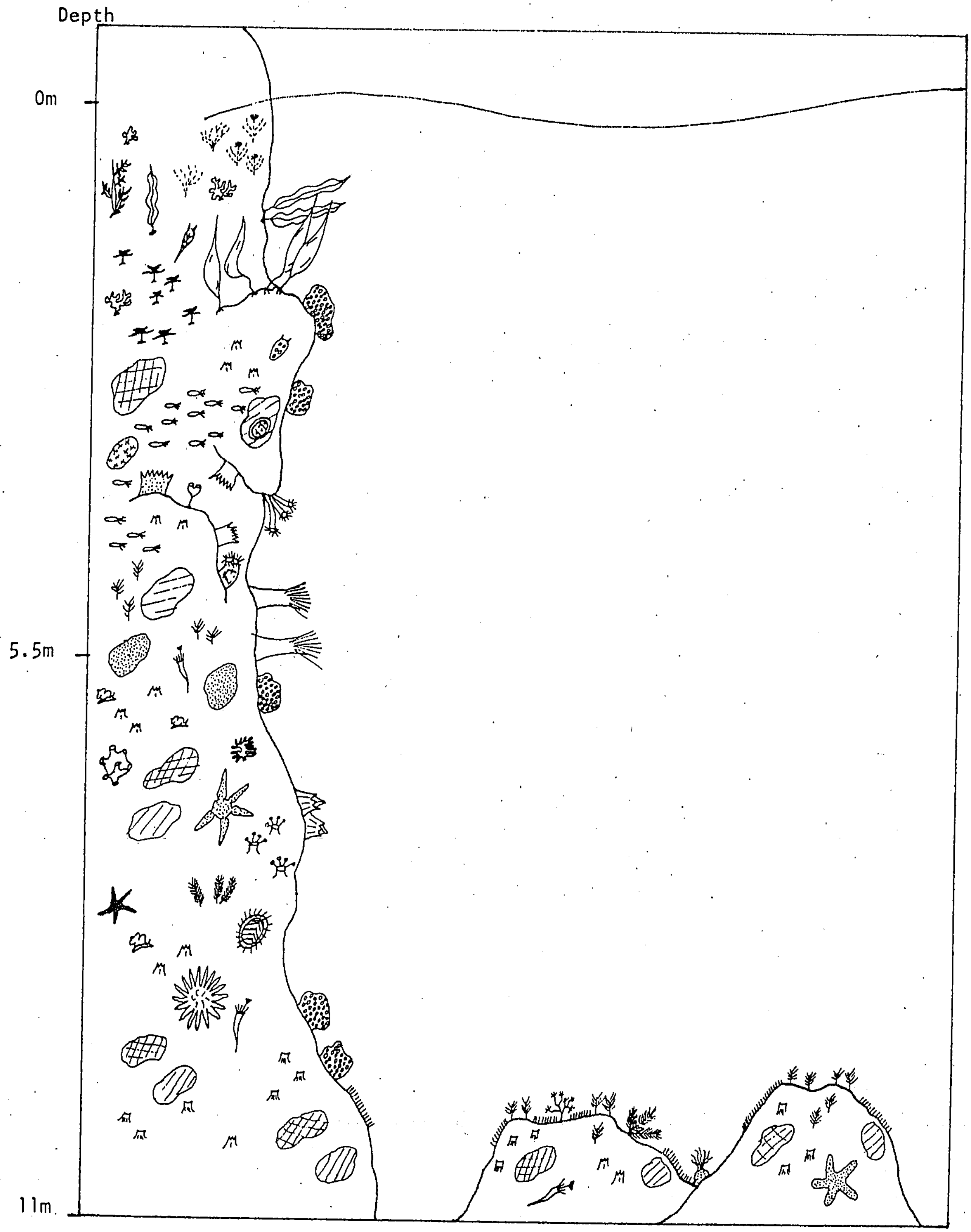

Figure 17. The macrobiota observed on the west side of Trinidad Head.

A. nanaimoensis, Dendronotus frondosus, Dialula sandiegensis and H. crassicornis; the nestling clam E. saxicola; the barnacles B. crenatus (abundant throughout) and B. nubilis; the amphipods Photis californica (locally dominant, especially on tops of boulders along the bottom), an unidentified gammarid amphipod and an unidentified caprellid amphipod; the bryozoans P. collifera and H. pacifica; the sea stars D. imbricata (one eating Dodecaceria concharum), E. troschelii, H. leviuscula, L. hexactis (abundant and of various size classes), Pisaster brevispinus (on bottom), P. ochraceus and Pycnopodia helianthoides (one juvenile); the sea cucumbers C. miniata (in crevices) and E. quinquesemita (large patches of juveniles were locally abundant); and the tunicates M. taylori (few patches near the bottom between side and boulders), P. haustor (in small crevices), S. montereyensis and an unidentified compound species.

The northwest side of Trinidad Head receives much sand-scouring, resulting in a depauperate biota near its base. Rocks protruding through the adjacent sand bottom were covered by the algae Ahnfeltia gigartinoides, A. plicata, Corallina frondescens, G. linearis, Odonthalia washingtoniensis and Prionitis filiformis. The only evident but dominant invertebrate was the barnacle, B. crenatus.

East Side of Off Trinidad Rock (Figure 18)

1. Physical Features: This side is about vertical and extends about 30 ft (9 m) deep. The immediately adjacent bottom consists of well-worn boulders of low relief, and about 3 ft. (1 m) or more in diameter.

2. Biological Features: An algal zone extended about 10 ft. (3 m) deep. The evident algae included Bossiella plumosa, Calliarthron tuberculosum, Callophyllis violacea, Delesseria decipiens, Desmarestia ligulata var. ligulata, H. flabelligera, L. littoralis (formed a dense band about datum), Neoptilota hypnoides, P. latissima, Serraticardia macmillanii and Schizymenia pacifica. The invertebrates observed were the sponge L. nuttingi; the sea strawberry G. rubiformis; the polychaete Dodecaceria fewkesi; the sea cucumber Eupentacta quinquesemita in aggregations of large specimens interrupting the algal zone, and the tunicate P. annectens.

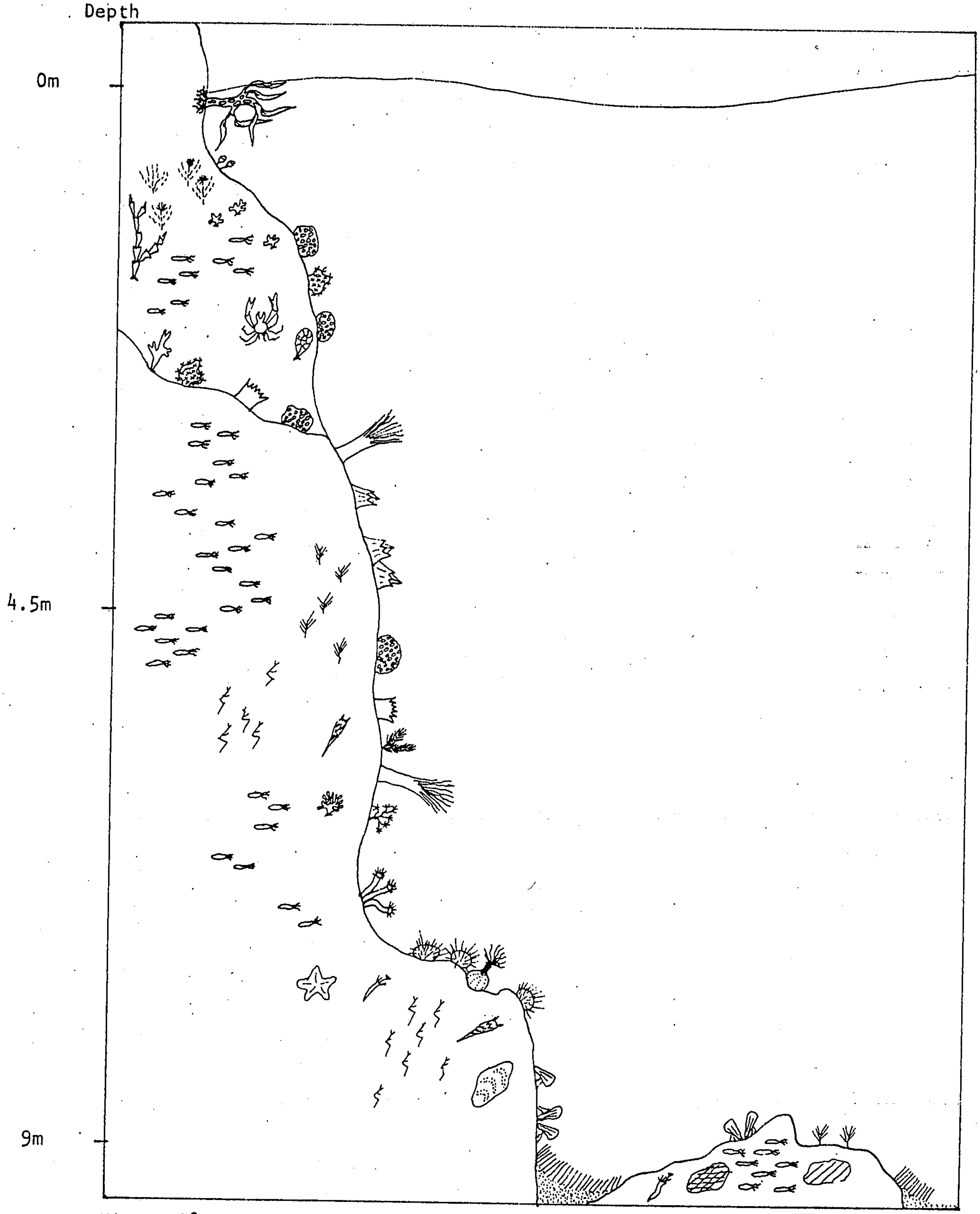

Figure 18. The macrobiota observed on the east side of Off Trinidad Rock.

Below the algal zone, the following invertebrates were observed: the hydroids Abietinaria sp., Aglaophenia sp., E. californicum, Hydractinia sp., Plumularia sp. and Sertularella sp.; the hydrocoral S. porphyra; the sea anemones A. xanthogrammica and M. senile; the polychaetes D. concharum, D. fewkesi, E. polymorpha, Pseudopomatilla sp., S. vermicularis and P. prolifica, abundant to about 7 ft. (2 m) above the bottom where surface was very silty; the nudibranch H. crassicornis; the barnacle B. nubilis; the amphipod M. kennerlyi; the bryozoan H. pacifica; the sea star D. imbricata; the sea cucumbers C. miniata and E. quinquesemita completely dominating much of the surface to 20 ft. (6 m) deep and in some places to 30 ft. (9 m) deep; the sea urchin Strongylocentrotus purpuratus about 25 ft (7.5 m) deep; and the tunicate Aplidium sp.

Rocky Area Immediately East of Off Trinidad Rock (Figure 19)

1. Physical Features: This area consists of irregular bedrock and boulders to a depth of about 25 ft. (6 m). Obtrusive bedrock extends upward and often above datum. Patches of gravel occur. The area experiences much turbulence.

2. Biological Features: This area was examined on September 1, 1978. An algal zone extended to about 20 ft. (6 m) deep. Bull kelp N. leutkeana formed a patchy overstory; otherwise, surfaces often bore Lessoniopsis littoralis (near datum), immediately followed by Laminaria dentigera. Laminaria sinclairii and Pterygophora californica grew on horizontal surfaces. C. tuberculosum formed a patchy turf to about 10 ft. (3 m) deep. Other algae included Lithophyllum sp. and P. hairii.

The algal zone contained many invertebrates, often extending to the bottom. We observed the sponges Axocieleta originalis (greatest number seen here), Leucilla nuttingi, Leucosolenia eleanor, Cliona celata, Haliclona sp. and unidentified forms; the hydroids Abietinaria sp., Aglaophenia sp., E. californicum, Hydractinia sp., Plumularia sp. and Sertularella sp.; the sea strawberry G. rubiformis; the corallimorph anemone C. californica, the sea anemones Tealia coriacia (where gravel was present), T. crassicornis; T. lofotensis and an

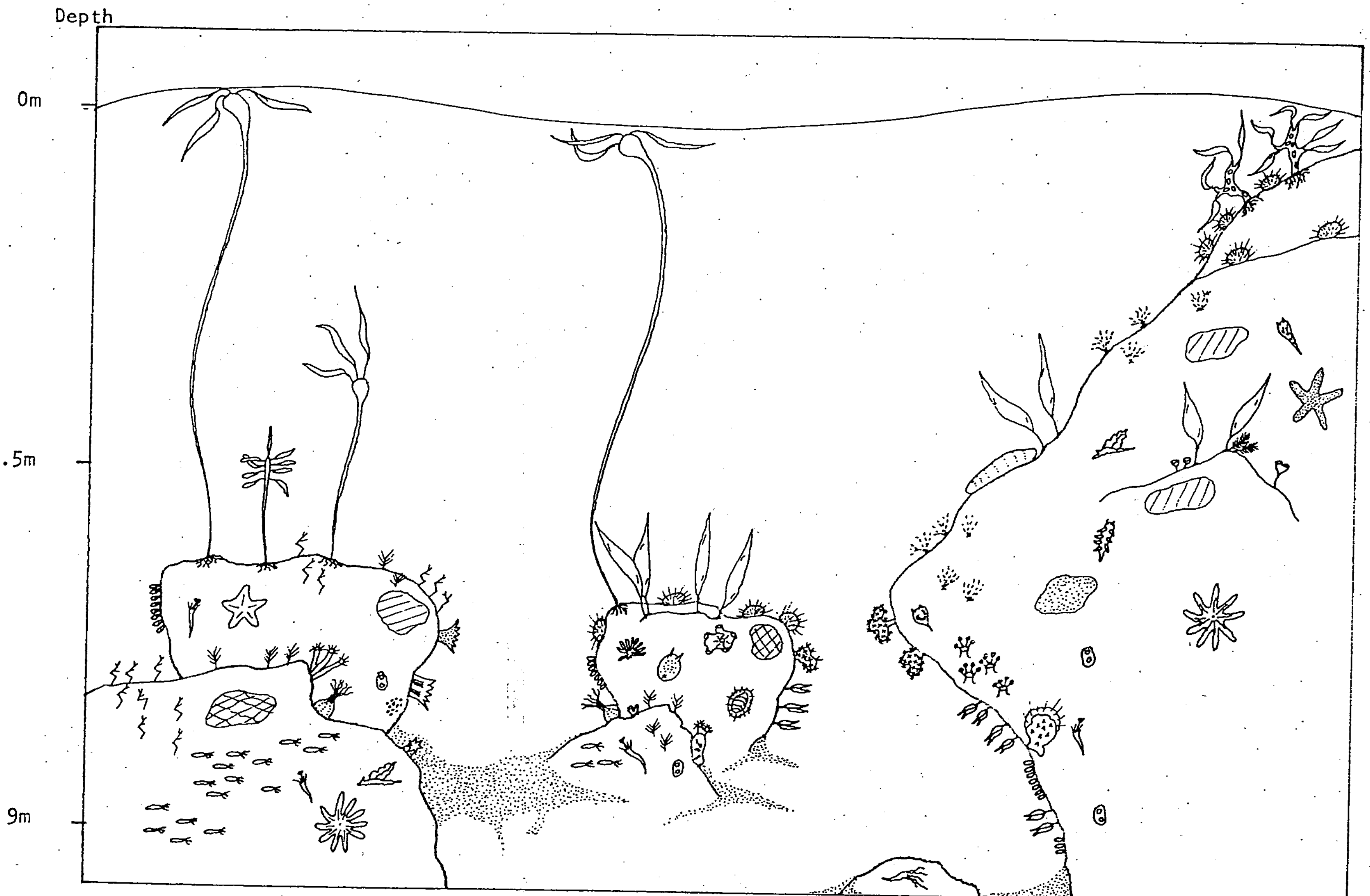

Figure 19. The macrobiota observed in the rocky area immediately east of Off Trinidad Rock.

unidentified species; the polychaetes E. polymorpha, S. vermicularis, unidentified terebellid and an unidentified tube-dweller; the chitons C. stelleri, Ischnochiton sp. and M. lignosa; the snails Calliostoma ligatum, Ceratostoma foliatum, Mitrella carinata (abundant under boulders) and Nucella lamellosa; the nudibranchs Anisidoris nobilis, Archidoris montereyensis, C. luteomarginata, D. alboliniata, H. crassicornis, R. pulchra, T. tetraquetra (associated with prey G. rubiformis) and Tritonia festiva; the bivalves E. saxicola and H. giganteus; the amphipod M. kennerlyi (in large turf-forming aggregations on tops of some rocky protrusions); the bryozoans E. corniculata, E. bilabiata, H. pacifica and several unidentified species; the brachiopod T. transversa; the sea urchins Strongylocentrotus franciscanus and S. purpuratus (the densest aggregations observed in the ASBS); the sea stars D. imbricata (very common and eating E. quinquesemita); Pisaster ochraceus, Pycnopodia helianthoides and S. stimpsoni; the sea cucumbers C. miniata and E. quinquesemita (large aggregations on bottoms near shoreward side of Off Trinidad Rock and elsewhere); the tunicates Clavelina huntsmani (many large aggregations on sides of rocks), Cnemidocarpa finmarkiensis, Perophora annectens, Pyura haustor (in crevices) and S. montereyensis.

Sandy Habitat North of Trinidad Head (Figure 20)

1. Physical Features: This area consists of relatively clean sand from 0 to 25 ft. (0 to 7.5 m) deep. Well-developed ripple marks occur sporadically. Overlying water movement is fairly strong.

2. Biological Features: Since rock was lacking, benthic algae was not present. The fauna included the tubicolous polychaetes P. pacifica and Owenia collaris (both uncommon); the burrowing snail Olivella pycna; the market crab C. magister; and the sand dollar Dendraster excentricus (in large aggregations as shallow as 26 ft. (6 m). Less than 15 ft. (4.5 m) deep, macrofauna was not evident.

Figure 20. The macrobiota observed in the sandy area north of Trinidad Head.

Fishes

Few species of fish were observed in Trinidad Bay. This was partly due to poor visibility and partly to the intensity of observation devoted to the attached biota. There was much apparent fish habitat in deep crevices and amongst large boulders which were not accessible. Based on fish poisonings with rotenone that the senior author was involved in with the California Department of Fish and Game near Crescent City, cryptic fishes were undoubtedly overlooked and probably play an important predatory role in the ecology of the bay.

The following fishes were seen:

1. Family Anarrhichadidae

    Wolf-eel Anarrhychthys ocellatus: One specimen was observed and collected off the south face of Trinidad Head. Its stomach contained a chiton Mopalia sp., a specimen each of the crabs Phyllolithodes papillosus and Scyra acutifrons, and the barnacle Balanus crenatus.

2. Family Cottidae

    Cabezon Scorpaenichthys marmoratus: Only one specimen was seen in rocky habitat.

3. Family Embioticidae

    Stripe perch Embiotoca lateralis: This species was commonly seen in beds of the kelp Pterygophora californica.

4. Family Hexagrammidae

    Kelp greenling Hexagrammos decagrammus: This species was not uncommon where rock was present.

    Lingcod Ophiodon elongatus: Several specimens were observed in rocky habitat.

5. Family Pleuronectidae

    Sanddab Citharichthys sp.: Specimens were seen in the nearshore sandy habitat.

6. Family Rajidae

    Longnosed skate Raja rhina: Two specimens were seen, one in nearshore sand and one in the Mooring Area. This ray may be an important predator of clams.

7. Family Scorpaenidae

Black rockfish Sebastes melanops: This species was most common along the south side of Trinidad Head, around Prisoner's Rock and in the Pterygophora californica beds of the nearshore sand and rock habitat.

8. Family Stichaeidae

Decorated warbonnet Chirolophus decoratus: The identification of this species was verified by Robert A. Behrstock (Humboldt State University), who recently recorded the species for the mouth of Humboldt Bay. This species' apparent rareness is undoubtedly due to its small size and cryptic habitat preference.

Marine Birds

Blank Rock and Off Trinidad Rock serve as nesting areas for the following birds: Fork-tailed petrel Oceanodroma furcata, Leach's petrel O. leucorhoa, Brandt's cormorant Phalacrocorax penicillatus, Pelagic cormorant P. pelagicus, Western gull Larus occidentalis, Common murre Uria aalge, pigeon guillemot Cephus columba and Cassin's auklet Ptychorhamphus aleutica (Warren J. Houck, Humboldt State University, personal communication).

Marine Mammals

The California sea lion Zalophus californianus and the Steller sea lion Eumatopius jubata use Blank Rock and Off Trinidad Rock as hauling areas. Most sea lion activity was observed in the western sector of the ASBS. The harbor seal Phoca vitulina utilized low-relief, exposed rock for hauling in both Trinidad Bay and in the western sector of the ASBS. During the summer of 1976, a family of river otters Lutra canadensis was observed along the east side of Trinidad Head. The family stayed for several days.

DISCUSSION

General Ecology: The western sector of the ASBS is exposed to swell coming from the northwest, west and south. The eastern sector of the ASBS and Trinidad Bay are protected from the brunt of northwesterly swell by Trinidad Head. Northwesterly swell prevails for much of the year and it is refracted by the head, resulting in a gradient of wave intensity increasing eastwardly within the bay. With waves breaking increasingly deeper eastwardly from the head, concomitantly, sediments become coarser and rocky surfaces become cleaner, associated with scouring and low sedimentation on the bottom. These physical factors influence the structure of biotic assemblages.

Seasonal variation in subtidal biotic assemblages was not assessed because this study was restricted to the months of June through October. However, cursory observations made around Trinidad Bay and numerous observations made on the Mendocino County coast indicate that seasonal variation is typical for the northern California coast.

Distribution of algae: Primary production, the production of plant materials, is performed by phytoplankton in the water column and, on the bottom, primarily by multicellular rock-dwelling algae. The crustose red algae *Lithophyllum* sp. and *Peyssonellia hairii* occurred on rock at all depths; however, their contribution to primary production is apparently slight. Most primary production was limited to 20 ft. (6 m) or less, correlating with high turbidity and attendant rapid light extinction. The algal zone is defined as the lower limit of evident algal growth during the summer, excepting *Lithophyllum* sp. and *P. Hairii*. The presence of beds of bull kelp *Nereocystis luetkeana* indicates accompanying rocky bottom 20 ft. (6 m) deep or less. The major rocks, both in the bay (i.e. Prisoner's Rock, Figure 7) and in the western sector of the ASBS (i.e. Off Trinidad Rock, Figure 18), had the highest subtidal algal diversity and standing crops occurring to about 10 ft. (3 m) below datum. In this band were turf-formers like *Calliarthron tuberculosum* and *Callophyllis flabellulata*, and low canopy forms like *Desmarestia ligulata* var. *ligulata* (an annual) and *Laminaria dentigera* (a perennial). Especially on horizontal rocky surfaces, and increased depth to the lower limit of the algal zone, the low canopy form Pterygophora californica usually occurred.

Moving inshore, turbidity generally increased, depth decreased, and the algal zone shallowed. High turbidity alone was responsible apparently for the shallow algal zone on the western side of Trinidad Head (Figure 17). In nearshore mixed rock-sand habitat, high turbidity plus sand abrasion correlated with a distinct algal assemblage consistency of forms like Ahnfeltia plicata, Gymnogongrus leptophyllus, G. linearis and P. californica. The widely distributed latter species often had its stipes partly covered by sand, indicating that recruiting occurs here when sand is removed. Nearshore sands, less than 16 ft. (5 m) deep around the dock, often bore diatom slicks indicating periods of little disturbance.

Benthic algae may be eaten directly, but algal grazers were not abundant. Much local benthic algae probably detach and are either cast ashore, or settle in deeper, quieter waters to become detritus and be utilized by deposit-feeders.

The shallow benthic algal zone of Trinidad Bay is characteristic of the coastline of Humboldt and Del Norte counties. The senior author has observed shallow algal distribution off Egg Point and Patricks Point, Humboldt County, and off Enderts Beach and Point Saint George, Del Norte County. On the other hand, the Mendocino County coast to the south has an algal zone down to 40 or 50 ft. (12 or 16 m) or more, correlating with water of lower turbidity.

Distribution of Macrofauna: The macrofauna is subdivided into an infauna living within soft substrates and into an epifauna living on substrates.

In the nearshore sand habitat located on both sides of Little Head, the stability of the bottom was enough for establishment of an infauna (Figure 16). Faunal components were burrowing deposit-feeders like the polychaetes Abarenicola sp. and the sea cucumber Caudina chilensis, and the tube-dwelling polychaetes Mesochaetopterus taylori, a suspension-feeder, and Pista pacifica, a surface deposit-feeder. The innkeeper worm, Urechis caupo, a suspension-feeder, occurred along the east side of Trinidad Head. A short distance to the east of Little Head, the bottom became mixed rock and sand habitat (Figure 16). Concomitantly, water movement was more intense, the sand was coarser and the infauna became generally depauperate. However, where sand surrounded small, low boulders, large aggregations of the peanut worms Themiste dyscritum occurred. They were apparently suspension-feeding. Varying rocky topography cause water movements to fluctuate over short distances. A result was pockets of fine sand and silts surrounded by large boulders and containing either the polychaete Abarenicola sp., or the phoronid Phoronopsis viridis, a suspension-feeder, or the brittle star Amphipholis pugetana, a suspension-feeder.

In the western sector of the ASBS, the sandy habitat north of Trinidad Head (Figure 20) exhibited tube-dwellers like Owenia collaris and P. pacifica, the snail Olivella pycna and the market crab Cancer magister. However, none of these were abundant, probably because of the relative harshness of the area. The suspension-feeding sand dollar, Dendraster excentricus, in contrast, was very abundant. Large sand dollar aggregations have been observed along the Samoa peninsula to the south. The smaller infauna here appears similar to its counterpart for the sands off the Samoa peninsula.

The soft bottom habitats of the southern portion of the bay (Figure 2) lacked a diverse macrobiota. Both clayey-silt and mixed sand habitats contained the clams Macoma inquinata, M. nasuta and Tresus pajaroana and numerous dungeness crab, Cancer magister. T. pajaroana until recently was only known as a fossil. Offshore coarse sands in the bay were biologically depauperate. High substrate instability precludes abundant presence of most tube-dwelling and burrowing species. The strong water movements occurring here do not favor the existence of an epifauna.

Rocky bottom habitat with interspersed sediment dominated much of the bay and of the ASBS, including the Mooring Area (Figure 2). With increasing depth the sediments generally became finer in the western portion of Trinidad Bay. The infauna lacked most of the large worms observed in sand. The deposit-feeding clams Macoma inquinata and M. nasuta were common, and the suspension-feeding clams Protothaca staminea and Saxidomus giganteus were observed. A thin veneer of fine sediment commonly coated both rocks and attendant epifauna. The rocky surfaces lacked a highly diverse macrobiota. However, large standing crops of the following suspension-feeders occurred: the polychaetes P. prolifica and Spirorbis sp.; the barnacle Balanus crenatus, the brachiopod Terebratalia transversa and the tunicate Chelyosoma productum. The presence of silt can deter some invertebrates by clogging their respiratory or feeding mechanisms, or both. Such stresses naturally favor species that can tolerate these conditions, and often result in low species diversity and high dominance of a few species. In 1976, juveniles of the suspension-feeding sea cucumber Eupentacta quinquesemita formed large aggregations here and elsewhere within the bay. However, they were lacking in 1978 where they were abundant in 1976. These recruits were probably unsuccessful due to sea star predation. The dominant motile epifauna consisted of the dungeness crab Cancer magister, often in abundance, the ubiquitous nudibranch Hermissenda crassicornis, and the sea star Pisaster brevispinus often seen excavating and eating clams and eating C. productum. The deposit-feeding sea cucumber Parastichopus californicus was also observed. The eastern-most region of rocky bottom habitat had a less diverse fauna than similar habitat in the Mooring Area.

On rocky bottom habitat were noted two size classes of the tunicate C. productum, apparently representing two age classes. A given aggregation was of one size class. Predation by the sea star Evasterias troschelii (noted only in the eastern sector of rocky bottom habitat) and P. brevispinus was observed occurring on aggregations of the large size class. Numerous sea stars were often observed cleaning one rock of the tunicate, while an aggregation on an adjacent rock was not being attacked. Predation by E. troschelii and P. brevispinus may be keeping C. productum from dominating more of the rocky bottom habitat.

The most diverse epifauna was associated with the major rocks having approximately vertical sides, such as those on the south side of Trinidad Head (Figure 4), Prisoner's Rock (Figures 6 and 7) and the Off Trinidad

Rock area (Figures 18 and 19). Suspension-feeders dominated. Various sponges were common. In the Off Trinidad Rock area, sponge growths resembled those that were observed in Mendocino County, including numerous specimens of Axocielita originalis. Hydroids, including Abietinaria sp., Aglaophenia sp. and Plumularia sp. were abundant. The sea strawberry, Gersemia rubiformis, was common. This species is a northern form; south of the ASBS it was only seen in abundance at Arena Rock, near Point Arena, Mendocino County. The sea anemone Anthopleura xanthogrammica was commonly aggregated in broad crevices and the sea anemone Metridium senile was common on rocky protuberances. The polychaetes Dodecaceria concharum and Serpula vermicularis were common. The nudibranch Toquina tetraquetra, a northern form, was associated with G. rubiformis, its prey. The barnacle Balanus crenatus was ubiquitous both on rock and on stipes of P. californica. Large subtidal aggregations of these barnacles have been observed from Fort Ross, Sonoma County, to Crescent City, Del Norte County. B. nubilis formed aggregations and commonly occurred with M. senile. The caprellid amphipod Metacaprella kennerlyi formed huge aggregations consisting of many thousands of individuals on some giant boulders along the south side of Trinidad Head. The aborescent bryozoan Tricellaria ternata was abundant in the subtidal areas immediately around Prisoner's Rock and Moor Rock. The crustose bryozoan Parasmittina collifera was abundant on rocky surfaces that experience much surge. The sea cucumber, Eupentacta quinquesemita, was represented by large aggregations of adults and juveniles just below the tide line on Barnacle Rock and from just below the tide line to the bottom on the east side of Off Trinidad Rock. The presence of E. quinquesemita, especially of adults, correlates with the lack of its predator, the sea star Solaster stimpsoni. Only at Enderts Beach, Redwood National Park, Del Norte County, were other large aggregations of the sea cucumber observed. Sea stars increased both in numbers of species and individuals at about 10 ft. (3 m) below datum. Sea urchins were uncommon in the bay and in the ASBS. The largest numbers occurred in the area east of Off Trinidad Rock.

Near the bottom of near vertical rocky surfaces along the south side of Trinidad Head and within Trinidad Bay, the surfaces often bear a thin veneer of sediment. The fauna here was the same as that of rocky bottom habitat. Additionally, the cup corals Balanophyllia elegans and Paracyathus stearnsi occurred commonly, and aggregations of the abalone jingle Pododesmus cepio occurred on the south side of Trinidad Head and especially on the south side of Prisoner's Rock. The senior author has seen similar aggregations in the Morrow Bay channel, San Luis Obispo County.

The kelp beds themselves, consisting of bull kelp Nereocystis luetkeana, do not represent a distinct habitat. The beds indicate the presence of stable rocky bottom no deeper than about 20 ft. (6 m).

The western sector of the ASBS contains nesting habitat for marine birds and hauling areas for pinnipeds (seals and sea lions). Trinidad Bay provides hauling areas for harbor seals. The Trinidad Head area also supplies marine birds and marine mammals with food. Thus, a disturbance within the local food chains could influence these top carnivores.

Invertebrates of Either Sport or Commercial Importance: The most important invertebrate is the market or dungeness crab Cancer magister. During 1976, members of the 1975 class occurred by the thousands around and on the south side of Trinidad Head and in the Mooring Area. Also during the summer of 1974, the senior author noted numberous young C. magister in Trinidad Bay. The bay serves well as juvenile market crab habitat.

After the flood of December 1964, virtually all large rock scallops Hinnites giganteus observed in Trinidad Bay were dead. The heavy run-off may have caused smothering and possibly osmotic stress due to dilution of sea water. No evidence of strong scallop recruitment was observed during this study.

According to a local brochure, red abalone Haliotis rufescens may be collected around Trinidad Bay. In recent years only two abalone have been observed by the authors in the area immediately east of Off Trinidad Rock. Based on the senior author's studies on red abalone along the coast from Sonoma through Del Norte counties, the Trinidad Bay area offers poor red abalone habitat. Very young red abalone are associated with boulders having clean undersides covered with crustose coralline algae, a habitat not noted during this study. Adults require kelps for food and usually collect drifting pieces. Kelp is located in very shallow areas of the bay and in the ASBS, and is not as abundant here as in the major abalone areas to the south. In the Trinidad area, few red abalone could be expected in the relatively shallow waters where attached or drifting pieces of kelp are available.

Environmental Impacts

The Dumping of Large Numbers of Fileted Fish Beneath the Dock: Large mounds of moldering fileted fish (rock fish and lingcod) were under the dock during 1976. Scavengers (fishes, crabs and sea stars) could not clean the carcasses before decomposition had set in. While diving over the carcasses, a foul smell was apparent. Low water visibility prevented visitors on the dock from observing the carcasses. However, if visibility were to reach 26 ft. (8 m) or more, the dumping practice would detract from the aesthetics of the dock. Also, such practice does reduce water quality near the offal.

The Presence of Metallic Refuse Under the Dock: Apparently the southern half of the dock has been used as a dump for unwanted equipment. Another mode of disposal should be considered.

Removal of Moorings from the Bay: According to Mr. Robert Hallmark, operator of mooring facilities, he is required to remove moorings after the fishing season. These impermanent moorings consist of old engine blocks, train wheels, etc. At least through 1976, his removal operations involved attaching a line to a mooring and dragging it across the bottom to the end of the dock, where the mooring is hoisted onto the dock. During their removal, the moorings hit rocky outcroppings; both these outcroppings and their attached biota can thereby be damaged. Placement and removal of moorings should be done so that the bottom topography is minimally disturbed. Placement of permanent moorings should also be considered. Permanent moorings could actually enhance the ecology of the bay.

Placement of Boating Lanes: Concern has been expressed as to whether boat traffic may have a negative impact on the bull kelp, Nereocystis luetkeana, beds of the bay. However, observations made by the authors during 1976-78 indicate that boating is not detreimental. During 1976, most of the sites of bull kelp production had kelp either at or near the surface early in the fishing season; through the summer the beds became denser, but boat traffic lessened as the 1976 fishing season continued. Boats generally were not seen traveling through the kelp beds. The present traffic is therefore apparently not impacting bull kelp and boat lane changes may be unnecessary.

Capacity for Boats: Much of the Mooring Area and regions immediately to the east are over rocky bottom habitat. Additional area to the east of the Mooring Area appears to have potential for additional moorings, without degeneration of the environment.

Effects Caused by Construction of a Breakwater or Short Groin in Trinidad Bay: Based on the assessment of Thompson (1977), the placement of a breakwater extending eastward from Trinidad Head to the vicinity of Prisoner or Moor Rocks, and perhaps a short groin from the shoreline to Dome Rock, would apparently result in minimal problems of sediment accumulation. If this were to be the case, then infauanl deposit-feeders such as Macoma spp. and epifaunal rock-dwellers such as Chelyosoma productum, Phyllochaetopterus prolifica and Terebratalia transversa may all be favored. Further resolution on this matter requires more accurate prediction of bottom changes and further knowledge of the ecology of dominant species.

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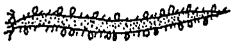
APPENDIX - Figure 1
A diagramatic code for use with Figures 4 through 20

Division Phaeophyta

 *Alaria marginata*

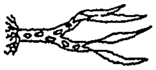
 *Cystoseira osmundacea*

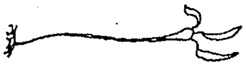
 *Desmarestia ligulata*

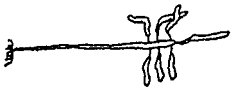
 *Egregia menziesii*

 *Laminaria dentigera*

 *Laminaria sinclairii*

 *Lessoniopsis littoralis*

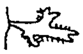
 *Nereocystis luetkeana*

 *Ptergophora californica*

Division Rhodophyta

 *Ahnfeltia plicata*

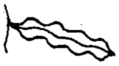
 *Bossiella spp*

 *Botryoglossum farlowianum*

 *Calliarthron spp*

 *Callophyllis flabellulata*

 *Constantinea simplex*

 *Erythrophyllum delesserioides*

 *Gymnogongrus linearis*

 *Ahnfeltia plicata*

 *Hymenena flabelligera*

 *Iridaea splendens*

 *Lithophyllum sp*

 *Peyssonellia hairii*

 *Plocamium spp* or *Ptilota filicina*

 *Polyneura latissima*

 *Prionitis linearis*

 *Pugetia firma*

Phylum Porifera

 *Leucilla nuttingi*

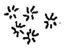
 *generalized encrusting sponge*

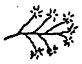
Phylum Cnidaria
Class Hydrozoa

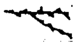
 *Abietinaria sp*

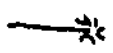
 *Aglaeophenia spp*

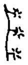
 *Eudendrium californicum*

 *Garveia sp or Hydractinia sp*

 *Obelia spp*

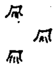
 *Sertularella sp*

 *Tubularia sp*

 *Phialidium sp*

Class Anthozoa

 *Anthopleura xanthogrammica*

 *Balanophyllia elegans or Paracyathus stearnsi*

 *Corynactis californica*

 *Epiactis prolifera*

 *Epizoanthus scotinus*

 *Gersemia rubiformis*

 *Metridium senile*

 *Tealia crassicornis*

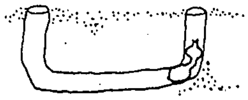
 *Tealia coriacea*

 *Tealia lofotensis*

Phylum Sipuncula

 *Themiste dyscritum*

Phylum Echiura

 *Urechis caupo*

Phylum Annelida

Abarenicola sp

Cirriformia luxuriosa

Dodecaceria concharum

Eudistylia polymorpha

Phyllochaetopterus prolifica

Pista pacifica

Serpula vermicularis

Spirorbis spp

Thelepus crispus

Phylum Mollusca
Class Polyplacophora

Cryptochiton stelleri

Lepidozona cooperi

Mopalia sp

Placiphorella velata

Tonicella lineata

Class Gastropoda
Subclass Prosobranchia

Ceratostoma foliatum

Nucella canaliculata

Ocenebra sp

Olivella biplicata

Subclass Opisthobranchia

Acanthodoris nanaimoensis

Anisodoris nobilis or
Archidoris montereyensis

Dialula sandiegensis

Dirona albeolineata

Hermissenda crassicornis

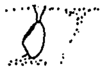
Tochuina tetraquetra

Triopha carpenteri

Class Bivalvia

 *Entodesma saxicola*

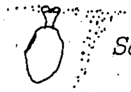
 *Hinnites giganteus*

 *Macoma inquinata*

 *Macoma nasuta*

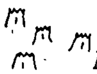
 *Mytilus californianus*

 *Protothaca staminea*

 *Saxidomus giganteus*

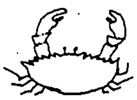
 *Tresus spp*

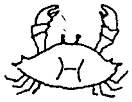
Phylum Arthropoda
Class Crustacea
Sub Class Cirripedia

 *Balanus crenatus*

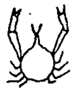
 *Balanus nubilis*

Sub Class Malacostraca
Order Decapoda

 *Cancer antennarius*

 *Cancer magister*

 *Cryptolithodes sitchensis*

 *Loxorhynchus crispatus*

 *Oregonia gracilis*

 *Phyllolithodes papillosus*

 *Scyra acutifrons*

Order Amphipoda

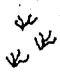
 *Metacaprella kennerlyi*

 *Photis californica*

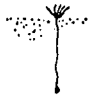
Phylum Bryozoa

 *Bugula californica*

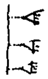
 *Eurystomella bilabiata or*
Parasmittina collifera

 *Tricellaria ternata*

Phylum Phoronida

 *Phoronopsis viridis*

Phyum Entoprocta

 *Barentsia ramosa*

Phylum Brachiopoda

 *Terebratalia transversa*

Phylum Echinodermata
Class Asteroidea

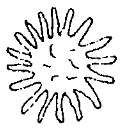
 *Dermasterias imbricata*

 *Evasterias troschelii*

 *Leptasterias hexactis*

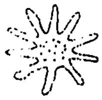
 *Orthasterias koehleri*

 *Pisaster brevispinus or*
Pisaster ochraceus or
Pisaster giganteus

 *Pycnopodia helianthoides*

 *Henricia leviuscula*

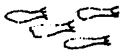
 *Solaster stimpsoni*

 *Solaster dawsoni*

Class Holothuroidea

 *Caudina chilensis*

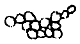
 *Cucumaria miniata*

 *Eupentacta quinquesemita*

 *Lissothuria nutriens*

Phylum Cordata
Subphylum Urochordata

 *generalized compound tunicates*

 *Chelyosoma productum*

 *Clavelina huntsmani*

 *Cnemidocarpa finmarkiensis*

 *Metandrocarpa taylori or*
Perophora annectens

 *Pyura haustor*

 *Styela montereyensis*

APPENDIX - Table I

The flora observed subtidally in Trinidad Bay and in Kelp Beds at Trinidad Head ASBS.

Division Phaeophyta - brown algae

Alaria marginata
Alaria nana
Cystoseira osmundacea
Desmarestia ligulata var. *ligulata*
Egregia menziesii
Laminaria dentigera
Laminaria sinclairii
Lessoniopsis littoralis
Nereocystis luetkeana
Pterygophora californica

Division Rhodophyta - red algae

Ahnfeltia gigartinoides
Ahnfeltia plicata
Botryoglossum farlowianum
Bossiella sp
Calliarthron cheilosporoides
Calliarthron tuberculosum
Callophyllis flabellulata
Callophyllis violacea
Constantinea simplex
Corallina frondescens
Corallina sp
Cryptopleura violacea
Delesseria decipiens
Erythrophyllum delesserioides
Gigartina sp
Gracilaria sjoestedtii
Gymnogongrus leptophyllus
Gymnogongrus linearis
Halymenia californica
Hymenena flabelligera
Iridaea splendens
Lithophyllum sp
Odonthalia washingtoniensis
Neoptilota hypnoides
Peyssonellia hairii
Plocamium coccineum var. *pacificum*
Plocamium violaceum
Polyneura latissima
Porphyra sp
Prionitis andersonii
Prionitis filiformis
Prionitis linearis
Ptilota filicina
Pugetia firma
Schizymenia pacifica
Serraticardia macmillanii

Division Spermatophyta - seed plants

Phyllospadix scouleri
Phyllospadix torreyi

APPENDIX - Table II

The invertebrate fauna observed subtidally in Trinidad Bay and in Kelp Beds at Trinidad Head ASBS.

Phylum Porifera - sponges

Class Calcarea

Leucilla nuttingi
Leucosolenia eleanor

Class Demospongiae

Antho lithophoenix
Axocielita originalis
Haliclona sp
Neosperiopsis sp
Pachychalina lunisimilis
Polymastia pachymastia
Reniera sp
Scypha sp
Suberites sp
Toxadocia sp

Phylum Cnidaria

Class Hydrozoa - hydroids and hydrocorals

Abietinaria amphora
Abietinaria costata
Aglaophenia diegensis
Aglaophenia inconspicua
Aglaophenia lophocarpa
Campanularia urceolata
Eudendrium californicum
Eudendrium insigne
Garveia sp
Hydractinia sp
Hydrallmania distans
Obelia geniculata
Obelia griffini
Obelia surcularis
Phialidium sp
Plumularia alicia
Plumularia goodei
Plumularia lagenifera
Plumularia setacea
Sertularella turgida
Sertularia furcata
Sertularia pumila
Stylantheca porphyra
Thuiaria tenera
Tubularia aurea?
Tubularia marina

Class Anthozoa - sea anemones, stony corals and allies

Anthopleura elegantissima
Anthopleura xanthogrammica
Clavularia sp
Corynactis californica
Balanophyllia elegans
Edwardsia sp
Epiactis prolifera
Epizoanthus scotinus
Gersemia rubiformis
Metridium exilis
Metridium senile
Paracyathus stearnsi
Tealia coriacea
Tealia crassicornis
Tealia lofotensis

Class Scyphozoa - jellyfish

Haliclystus auricula?
unidentified stauromedusan #1
unidentified stauromedusan #2

Phylum Nemertea - ribbon worms

Tubulanus polymorphus
Tubulanus sexlineatus

Phylum Sipuncula - peanut worms

Phascolosoma agassizi
Themiste dyscritum

Phylum Echiura - echuirid

Urechis caupo

Phylum Annelida - segmented worms

Class Polychaeta

Abarenicola sp
Arctonoe fragilis
Arctonoe vittata
Chone minuta
Cirriformia luxuriosa

†*Dodecaceria concharum*
†*Dodecaceria fewkesi*
†*Eudistylia polymorpha*
†*Glycinde armigera*
†*Mesochaetopterus taylori*
†*Nephtys* sp
†*Owenia collaris*
†*Phyllochaetopterus prolifica*
†*Pista elongata*
†*Pista pacifica*
†*Pscudopomatilla* sp
†*Schizobranchia insignis*
†*Serpula vermicularis*
†*Spirorbis* sp #1
†*Spirorbis* sp #2
†*Tharyx* sp
†*Thelepus crispus*

Phylum Mollusca

Class Polyplacophora - chitons

†*Cryptochiton stelleri*
†*Ischnochiton radians*
†*Ischnochiton* sp
†*Lepidozona cooperi*
†*Lepidozona mertensii*
†*Mopalia ciliata*
†*Mopalia hindsii*
†*Mopalia lignosa*
†*Mopalia* sp #1
†*Mopalia* sp #2
†*Placiphorella velata*
†*Tonicella lineata*

Class Cephalopoda

†*Octopus dofleini*
†*Octopus rubescens*

Class Gastropoda

Sub Class Prosobranchia - shelled snails

†*Acmaea mitra*
†*Calliostoma canaliculatum*
†*Calliostoma ligatum*
†*Ceratostoma foliatum*
†*Collisella instabilis*
†*Crepipatella ligulata*
†*Cymakra gracilior*

Diaphana californica
Diodora aspera
Hipponix cranoides
Lamellaria sp
Megatebennus gracillima
Mitrella carinata
Ocenebra atropurpurea
Olivella biplicata
Olivella pycna
Puncturella multistriata
Urosalpinx cinerea
unidentified neograstropod

Sub Class Opisthorbranchia - sea slugs

Acanthodoris nanaimoensis
Aegires albopunctata
Aldisa sp
Anisocoris nobilus
Archidoris montereyensis
Archidoris odhneri
Cadlina luteomarginata
Dendronotus frondosus
Dialula sandiegensis
Dirona albolineata
Hermissenda crassicornis
Rostanga pulchra
Tochuina tetraquetra
Triopha carpenteri

Class Bivalvia - clams

Clinocardium nuttallii
Entodesma saxicola
Hinnites giganteus
Macoma inquinata
Macoma nasuta
Mytilus californianus
Pododesmus cepio
Protothaca staminea
Saxidomus giganteus
Tellina bodegensis
Tresus pajaroana
Tresus sp.

Phylum Arthropoda

Class Crustacea

Sub Class - Cirripedia - barnacles

Balanus crenatus
Balanus glandula
Balanus nubilus

APPENDIX - Table II (Cont.)

Sub Class - Malacostaca - crabs, shrimps and allies

Order Decapoda - crabs and shrimps

Cancer antennarius
Cancer magister
Cancer productus
Crangon sp
Cryptholithodes sitchensis
Hapalogaster cavicauda
Loxorhynchus crispatus
Mimulus foliatus
Oregonia gracilis
Pagurus sp
Pandalus danae
Phyllolithodes papillosus
Pugettia gracilis
Pugettia producta
Scyra acutifrons

Order Amphipoda

Erichthonius brasiliensis
Metacaprella kennerlyi
Photis californica
unidentified caprellid amphipod
unidentified pleustid amphipod

Phylum Bryozoa - moss animals

Alcyonidium polyoum
Bowerbankia gracilis
Bugula californica
Crisia maxima
Dendrobeania lichenoides
Eurystomella bilabiata
Flustrellidra corniculata
Heteropora pacifica
Parasmittina collifera
Tricellaria ternata
unidentified ctenostome bryozoan #1
unidentified ctenostome bryozoan #2

Phylum Phoronida - phoronid worms

Phoronopsis viridis

Phylum Entoprocta

Barentsia ramosa

Phylum Brachiopoda

Terebratalia transversa

Phylum Echinodermata

Class Asteroidea

Dermasterias imbricata
Evasterias troschelii
Henricia leviuscula
Leptasterias hexactis
Orthasterias koehleri
Patiria miniata
Pisaster brevispinus
Pisaster ochraceus
Pycnopodia helianthoides
Solaster dawsoni
Solaster stimpsoni

Class Ophiuroidea - brittle stars

Amphipholis pugetana
Ophiopholis sp

Class Echinoidea

Dendraster excentricus
Strongylocentrotus franciscanus
Strongylocentrotus purpuratus

Class Holothuroidea - sea cucumbers

Caudina chilensis
Cucumaria miniata
Cucumaria piperata
Eupentacta quinquesemita
Lissothuria nutriens
Stichopus californicus

Phylum Chordata

Sub Phylum Urochordata - tunicates or sea squirts

Aplidium californicum
Aplidium sp
Archidistoma psammion
Chelyosoma productum
Clavelina huntsmani
Cnemidocarpa finmarkiensis
Cystodytes lobatum
Didemnum carnulentum
Distaplia occidentalis
Halocynthia hilgendorfi igaboja
Metandrocarpa dura
Metandrocarpa taylori
Perophora annectens
Pyura haustor
Ritterella pulchra
Styela montereyensis

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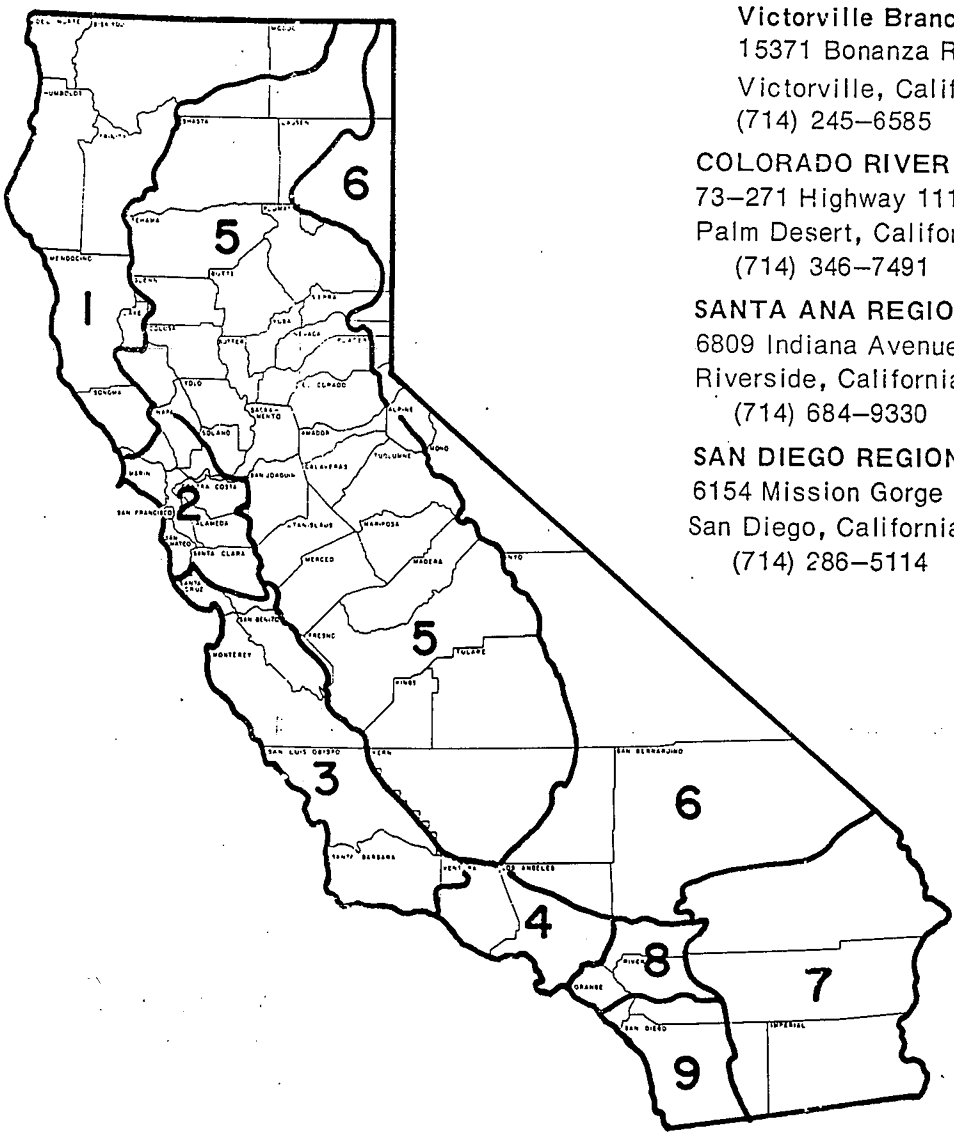

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