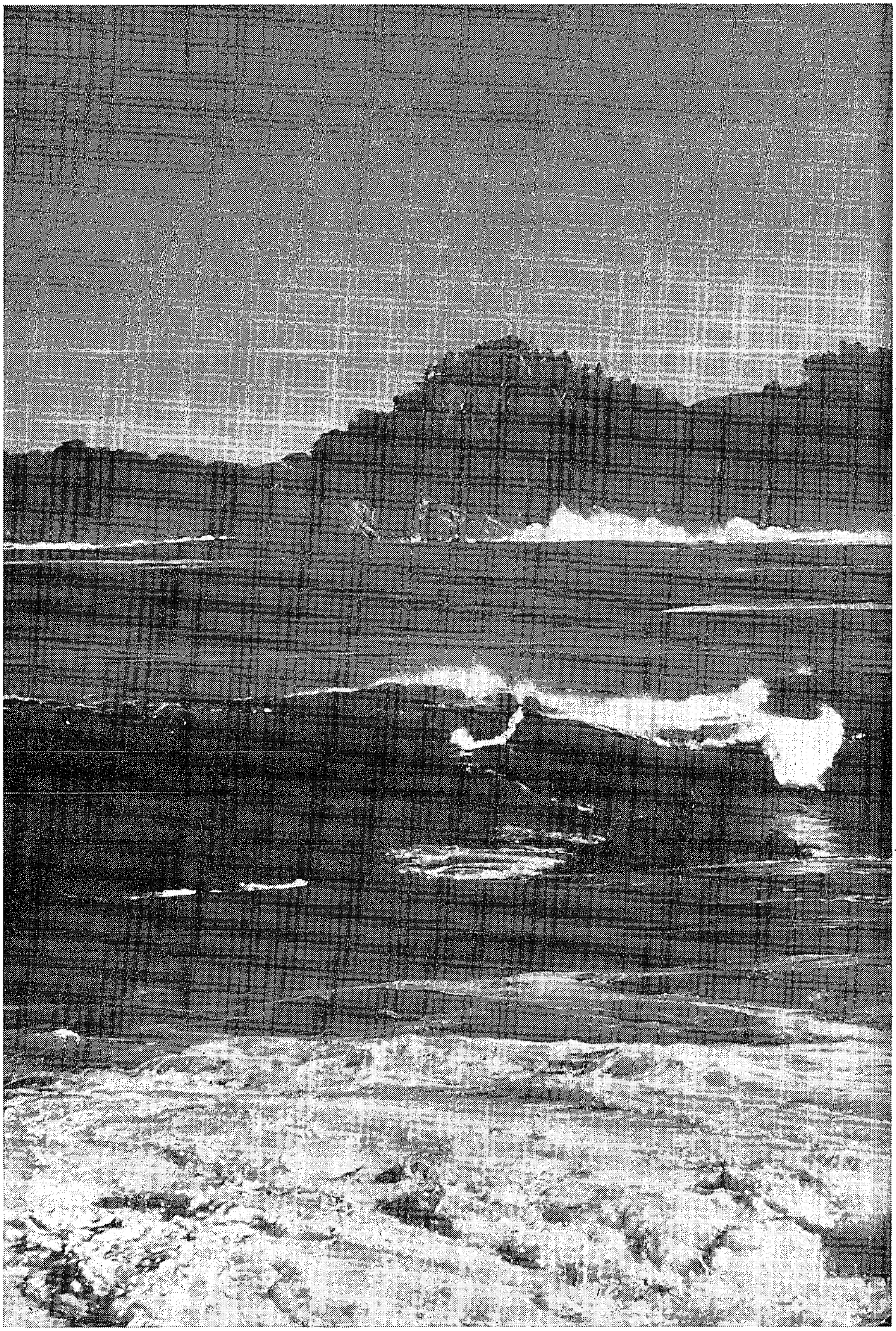


Carmel Bay Area of Special Biological Significance

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

CARMEL BAY
MONTEREY COUNTY

STATE WATER RESOURCES CONTROL BOARD

DIVISION OF PLANNING AND RESEARCH

SURVEILLANCE AND MONITORING SECTION

APRIL 1979
WATER QUALITY MONITORING REPORT 79-10

ACKNOWLEDGMENT

This State Water Resources Control Board Report is based on a reconnaissance survey report submitted by Karen Sjogren, Andrea McDonald, Kathleen Casson and Mark Silberstein. These authors acknowledged the assistance of the following individuals: Bill Wright (boat operator); Gail Shamberg (subtidal illustrations); Sara Tanner and Lynn McMasters (algae identification); Gary McDonald and David Lindberg (invertebrate identification); and Charles Moats (typist).

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

ABSTRACT

The Carmel Bay ASBS is located in Monterey county immediately adjacent to the town of Carmel (population 5,000). The ASBS is south of the Monterey Peninsula, just north of the Santa Lucia mountain range, and west of the Carmel Valley.

The ASBS includes 6.2 miles of coastline, extending from Pescadero Point to Granite Point (just north of Pt. Lobos). Pescadero Point, the northern boundary of the ASBS, is located at co-ordinates 36°34' N. Lat. 121°57' W. Long.; Granite Point, the southern boundary, is located at coordinates 36°31' N. Lat., 121°56' W. Long. The seaward boundary of the ASBS is formed by a straight line drawn between Pescadero and Granite Point; the landward boundary is the mean high tide line. Total surface water of the ASBS is 959 acres.

The coastline of the ASBS is characterized by alternating high rocky cliffs, rocky points, sandstone areas and extensive granitic sand beaches. Pescadero and Arrowhead Points provide major protection for cove and beach areas from the open ocean exposure. Several major watersheds drain into the ASBS via Carmel River and San Jose Creek.

The submarine area is dominated by the Carmel Canyon, which originates about 1/4 mile from shore and drops off steeply to depths of 1,200 feet approximately one mile offshore. The remainder of the floor is sand and mud surrounding the Canyon, conglomerate lining Stillwater Cove, and rocky substrate in many other areas.

Water circulation within the ASBS is poorly understood but is strongly influenced by the California and Davidson currents, the Carmel Canyon and wind patterns. Water quality appears to be good, however, some uncertainty exists regarding the overall impact of an existing wastewater discharge.

As a result of varied intertidal and subtidal habitats and good water quality, the ASBS harbors diverse and abundant biota. In the opinion of the investigators, the richness of Carmel Bay biota justifies the ASBS designation. The relatively accessible and undisturbed nature of the marine environment renders the area ideal for scientific study and observation. Of special interest is the existence of the rare purple hydrocoral, *Allopora californi*a, several deep water marine invertebrates, previously unstudied sponges, and the sea otter.

Water quality in the ASBS appears to be adequately protected; however, as mentioned previously, some uncertainty exists with regard to the Carmel Sanitary District's wastewater discharge. Efforts are continuing to resolve the question of continued discharge to the ASBS.

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

FINDINGS

1. With the exception of Stillwater Cove, the coastline of the Carmel Bay ASBS is exposed to the open ocean. As a result, promontories have a weathered appearance; the beaches are steep, with coarse-grained sand. Several promontories provide limited, localized protection from wave action.

2. The geology of the ASBS is complex and has a profound influence on both the subtidal and intertidal biota. At lease five distinct geological formations occur along the shoreline; the submarine topography is dominated by the Carmel canyon, which begins only 1/4 mile (402 m) offshore and encompasses most of southern Carmel Bay.

3. Current patterns in the ASBS are not well documented. Large-scale, offshore currents are probably a major influence and determine oceanographic seasons in the ASBS. Surface currents are influenced by winds and appear to be predominantly southward in the south bay. The submarine canyon creates tidal oscillations in subsurface waters.

4. The ASBS has a Mediterranean climate. Local meteorology is greatly influenced by adjacent land topography (Carmel Valley), and ocean upwelling activity and marine air.

5. The ASBS is bordered by private land (Del Monte Forest) to the north and primarily public beaches (Carmel City Beach, Carmel River State Beach) to the south. Adjacent land use is for the most part residential, although limited agricultural and grazing activity occur on lands south of the Carmel River. Limited population growth can be expected in the lower Carmel Valley.

6. The shoreline of the ASBS has been developed to accommodate a wide variety of recreational activities, with Carmel City Beach receiving the heaviest use. Skin diving constitutes the greatest recreational use of the ASBS; in 1972 31.6 % of all skin diving activity in northern and central California occurred at Carmel River State Beach.

7. Commercial fishing has not been allowed in the ASBS since its inclusion in Carmel Bay Ecological Reserve in 1977. Kelp is harvested commercially in the ASBS, primarily offshore from Carmel City Beach and usually during the summer. Spearfishing is a major sportfishing activity in the ASBS, with rockfish and lingcod most commonly taken.

8. The rocky intertidal zone biota of the ASBS exhibit a high degree of diversity within a relatively short length of coastline. This feature, combined with the excellent access to most areas, makes the intertidal zone a particularly valuable educational resource.

9. The rocky intertidal zone biota do not appear to be significantly disturbed by human activity, possibly because most recreational use of the shoreline occurs in beach areas.

10. The diversity and richness of Carmel Bay's subtidal biota appears to result from (1) the variety of substrate types, existing in close proximity to each other; (2) the subtidal topography, which includes pinnacles and a submarine canyon, as well as sand areas, boulders, cobbles, and pavement-like rock; and (3) the occurrence of species at the northern or southern extreme of their range. Stillwater Cove, in particular, contains numerous species not usually found so far north. The water clarity is remarkable, particularly in nearshore areas; this feature increases productivity and contributes to the extreme popularity of the ASBS as a diving area.

11. Water quality characteristics in the ASBS are not well documented. Most measurements have been made in shallow portions of the bay; these limited data indicate that average values, ranges, and seasonal variation resemble those of Monterey Bay. However, salinity values appear to be influenced somewhat by the degree of run-off from the Carmel River. Additional monitoring is needed to adequately assess the potential impacts of point and non-point source discharges on the waters of the ASBS.

12. Water quality data are also lacking on the Carmel River, a major drainage system which discharges to the ASBS. Little is known about the

water quality or flows of San Jose Creek or the numerous storm drain discharges into the ASBS. In order to ensure that water quality in the ASBS is being adequately protected, these discharges should be monitored for quality and quantity. Assessment of general water column characteristics, as well as flow data, will allow some determination of the degree to which these discharges are responsible for fluctuations of various parameters within the ASBS.

13. The Carmel Sanitary District sewage treatment plant discharges about 2 MGD of secondary treated effluent to the shallow subtidal zone of the ASBS. The collection system borders the ASBS along Carmel City Beach. The sewage treatment plant has generally provided a high level of treatment during its five years of operation as a secondary treatment plant. Effluent concentrations of conservative elements appear to be relatively low based on the limited data available.

14. The Carmel Sanitary District's discharge occurs in an area of high water movement; however, five years of monitoring during operation of the plant has not produced conclusive information, and five years of monitoring during operation of the plant has not produced conclusive information of any significant impact by the discharge on the ASBS.

INTRODUCTION

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

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 Carmel Bay ASBS, a reconnaissance survey integrating existing information and additional field study was performed by Karen Sjogren, Andrea McDonald, Kathleen Casson and Mark Silberstein. 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.

Carmel Bay was originally sponsored for ASBS status by the California Department of Fish and Game, Department of Parks and Recreation, Hopkins Marine Station and the University of California at Santa Cruz. Carmel Bay was designated an ASBS on July 19, 1975; it was the last of the thirty-four ASBS to be designated.

ORGANIZATION OF SURVEY

The subtidal area of the ASBS was surveyed by means of five short survey dives and two line transects, located to cover areas which are not well described in the literature. The description of the subtidal area in the vicinity of the Carmel sewage outfall is based on receiving water monitoring reports. The species list was compiled from survey and transect dives only.

Six rocky intertidal sites along Carmel Bay ASBS were surveyed during five early morning low tides; the sites were chosen so as to cover the geological types within the intertidal area and the associated diversity in biota. An extensive literature review of intertidal studies in the area was conducted, and these are referenced in the species lists (Appendix 1 and 2) and in the annotated bibliography.

The land and water use description incorporates information from the literature, unpublished data, public agency documents, and personal observations. The description of sources of water pollution is based on examination of treatment plant records, discussions with and tours by plant personnel, engineering feasibility reports prepared for the Carmel Sanitary District, and receiving water monitoring reports.

PHYSICAL AND CHEMICAL DESCRIPTION

Location and Size

The Carmel Bay ASBS is located in Monterey County, immediately adjacent to the town of Carmel (population 5,000). The ASBS is south of the Monterey Peninsula, just north of the Santa Lucia mountain range, and west of the Carmel Valley.

The ASBS includes 6.2 miles (9.98 km) of coastline, extending from Pescadero Point to Granite Point, just north of Pt. Lobos. Pescadero Point, the northern boundary of the ASBS, is located at coordinates 36°34' North latitude, 121°57' West longitude; Granite Point, the southern boundary, is located at coordinates 36°31' North latitude, 121°56' West longitude. The seaward boundary of the ASBS is formed by a straight line drawn between Pescadero and Granite Points; the landward boundary is the mean high tide line. Total surface water of the ASBS is 959 acres (38 ha). See Figure 1.

Carmel Bay is oriented in a north-south direction and has a wide opening to the sea. With the exception of Stillwater Cove, the coastline is exposed to open ocean; this accounts for the coarse sand and the steepness of the beaches. Rocky promontories here receive strong wave action and, therefore, have a weathered appearance.

The ASBS coastline is characterized by alternating rocky points and extensive granitic sand beaches. A high rocky cliff extends northeastward from Pescadero Point, forming partial protection for Stillwater Cove and Pebble Beach. Arrowhead Point, just south of Stillwater Cove, is oriented in a southwesterly direction and partially protects both the cove and Carmel City Beach to the south from wave action. Carmel City Beach extends south to Carmel Point (also known as Mission Point), which marks the midpoint of the Bay's coastline.

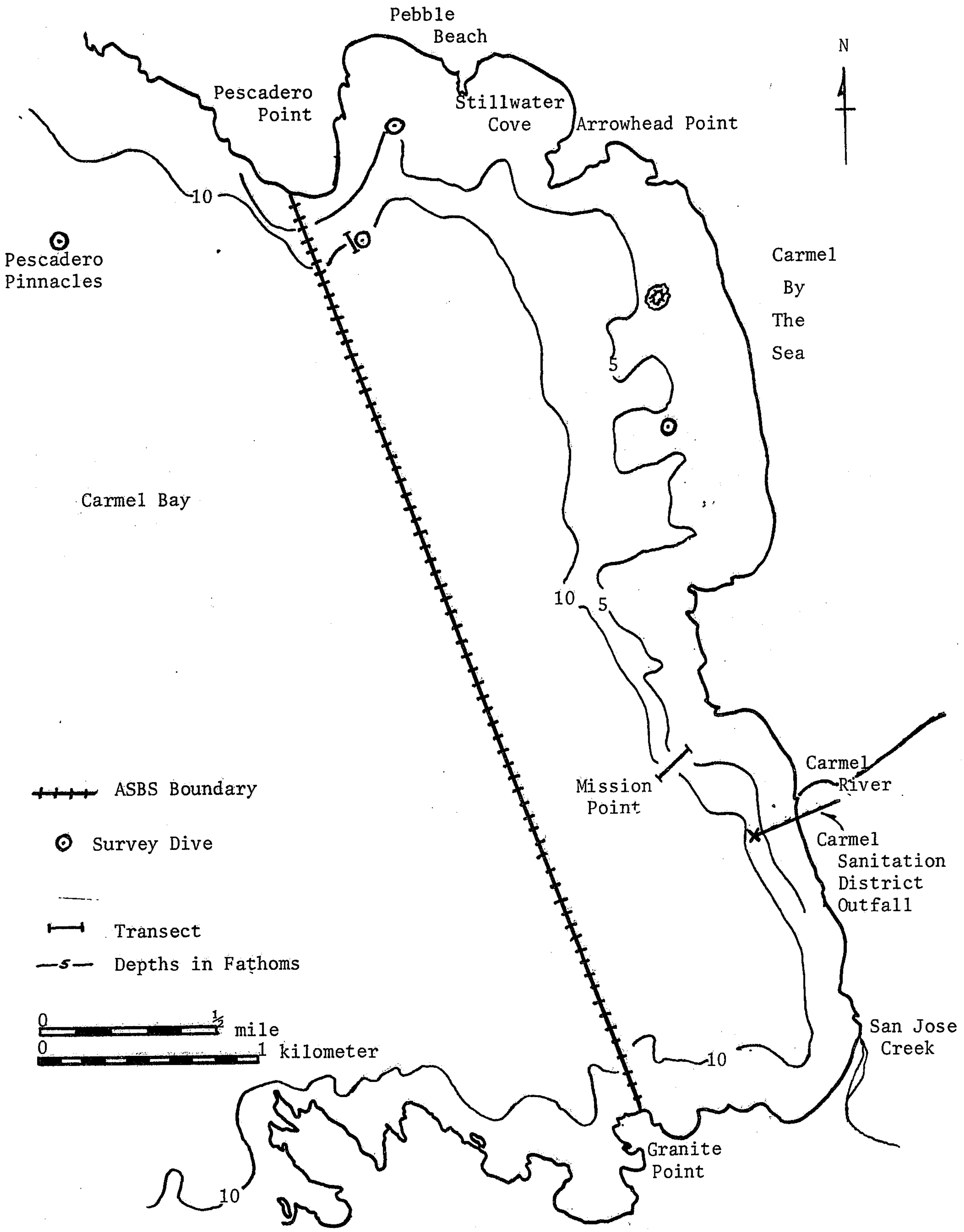


FIGURE 1: Location And Size Of Carmel Bay ASBS. Major Landmarks And Dive Sites.

The Carmel River drains into the ASBS just south of Carmel Point. The coastline just north of the river and a few miles south consists of the steep Carmel River Beach, interspersed with a few granite outcroppings. The Carmel Sanitary District outfall extends offshore, just south of the river mouth, from a rocky intertidal area.

San Jose Creek drains into the south end of Carmel River State Beach, a steep sandy cove which encloses the Carmel submarine canyon. This beach is known as San Jose Beach or Monastery Beach because of the proximity of the Carmelite Monastery to the beach. The rocky, steep cliffs southwest of Monastery Beach extend westward to Granite Point, the southern boundary of the ASBS. A large rocky cove located just northeast of Granite Point is generally referred to as Hudson Cove as it lies adjacent to a portion of the old Hudson Ranch.

Nearshore Waters

Currents: Current patterns in Carmel Bay are influenced primarily by the offshore oceanographic regime, the Monterey and Carmel submarine canyons, and local winds.

The offshore oceanographic regime has a predictable yearly pattern, consisting of three periods: upwelling, oceanic, and Davidson. These distinct periods are correlated with the depth and nearshore proximity of the southward flowing California Current.

The California current is the eastern leg of the North Pacific Gyre, a massive, clockwise-moving current system which encompasses the entire North Pacific ocean. Approximately between February and July, the California current is strong and close to the surface. Northwest winds and other factors cause surface waters to move seaward. Colder, nutrient rich water upwells to the surface. Upwelling is usually very pronounced in the ASBS, partially because the Carmel canyon allows cold, deep oceanic waters access to the bay.

Generally between July and November, the oceanic period, northwest winds subside, and the California Current flows southerly, close to shore. Usually from November to February, the entire North Pacific Gyre and California Current are weakened. The Davidson current, a northward flowing subsurface countercurrent, rises toward the surface along the coast. This current brings warm, southern water to the area.

Local winds modify or counteract large-scale current patterns in surface waters of the ASBS. Blaskovich found that drift cards released between March and August in the bay were blown shoreward by predominant northwest winds. In January, cards released off Pt. Lobos were found at various points along the Monterey Peninsula. The predominant influence at this time could have been the northward flowing Davidson current, and/or southwest winds.

Work by Kinnetics Laboratories (1976, 1977) and others indicates that subsurface currents flow both up and down the Carmel canyon, approximating the period of the diurnal tidal cycle. Net flow appears to be down canyon or offshore. Surface currents in the south bay appear to move southward, toward Pt. Lobos. The predominance of a nearshore, southward moving current has been substantiated by dye release studies by Lee (in Wong, 1970) and observations by SCUBA divers at Monastery Beach and Carmel River State Beach.

Water Column: Carmel Bay is a relatively wide-mouthed bay with little freshwater inflow; water column characteristics would therefore be expected to resemble those of the open ocean. However, very few measurements of the physical and chemical parameters of the bay have been made, and these do not provide a comprehensive description of water quality.

Most water quality measurements have been made in the vicinity of the Carmel Sanitary District outfall, located in the south bay just south of the Carmel River. Odemar (1971) conducted a cursory study of the outfall area and measured temperature and visibility at seven stations. More extensive water quality measurments were made by Hopkins Marine Station and other contracted agencies (Envirotech, Inc., 1974; Oceanographic

Services, Inc., 1975; Kinnetics Laborities, Inc., 1976, 1977) as part of the district's monitoring program. Measurements were made at up to quarterly intervals along ten transects located in the south bay. Location of the transects is shown in Figure 2; monitoring data are summarized in Tables 1 and 2. No water quality data exist for the bay between Pescadero Point and Carmel Point or for other areas greater than 66 feet (20 m) depth.

Water temperature measurements in the bay range between 48° and 63°F (9° and 17°C), and these limited data correspond well with the long-range averages and seasonal variations documented by Skogsberg (1936) for Monterey Bay. Both surface and 66 foot (20 m) temperatures show a decline between February and July, as upwelling causes colder, subsurface water to rise from depths. During late summer and early fall, temperatures throughout the water column increase. None of the monitoring studies detected a distinct thermocline, probably due to the shallow depths of the transects and their proximity to the surf zone. Temperature data from 1976-77 are somewhat higher than that from previous years, possibly because upwelling was less pronounced that year (Kinnetics, 1977). Subsurface temperatures showed a decline between 1973 and 1975.

Data collected between 1973 and 1977 show that salinity in the south bay varied only slightly with depth and transect location at any one time. However, average salinity increased rather dramatically during this period, probably due to the much reduced runoff from the Carmel River and other sources during those drought years. Relatively low salinities were recorded between February and October of 1973, with a definite low in April which coincided with maximum discharge from the Carmel River. Between June 1974 and March 1977, the south bay's average salinity approached that of the North Pacific Ocean (34.1^{o}/oo), as might be expected with almost no freshwater inflow. However, the apparent increase might be due in part to differences in analytical methods and technique. The monitoring studies did not detect a halocline, probably because the transects are located in shallow water close to the surf zone.

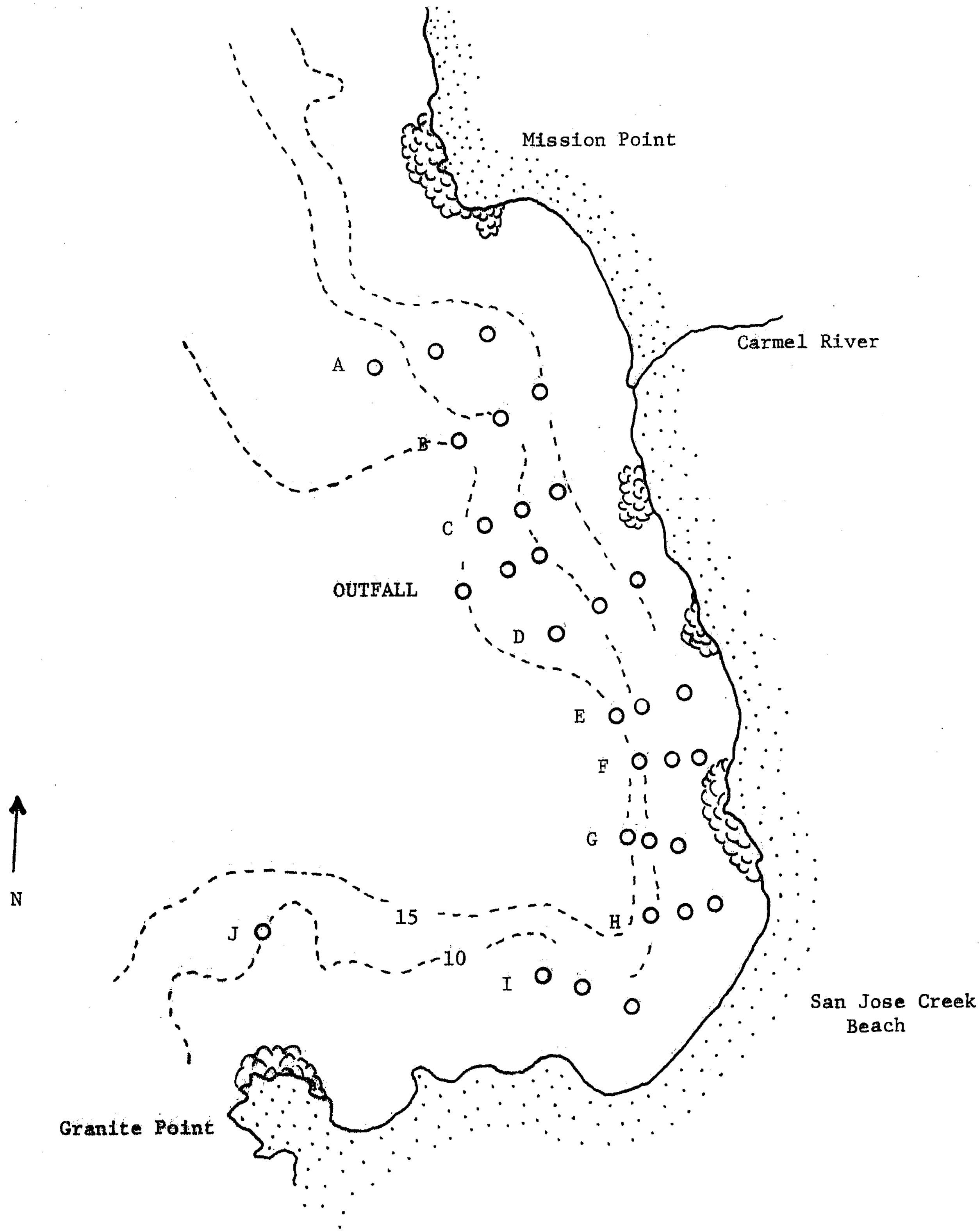


Figure 2. Combined Station Locations for Temperature and Salinity Data in Table 1 and 2.

TABLE 1

Average Temperature Values in ^{o}C at the surface and at 20m depths along ten transect lines in south Carmel Bay 1973 - 1977

		1973				1974		1975				1976				1977	
Transect	71–72	Feb	Apr	Jul	Oct	Jun	Sep	Jan	Jul	Oct	Dec	Jun	Aug	Oct	Dec	Feb	Mar
A		12.7 (12.9)			11.6 (11.0)	11.0 (9.9)	12.3 (10.8)	9.0 (8.5)	13.0 (12.4)	11.1 (10.3)	9.6 (9.6)	11.4	15.9	13.3	14.9	12.5	10.1
B		12.9 (12.9)	11.7 (11.1)	12.6 (11.8)	11.6 (11.0)	11.0 (9.8)	12.1	9.1 (8.5)	13.8 (12.4)	11.0 (10.9)	9.6 (9.6)						
C		13.2 (12.9)	12.2 (11.3)	12.7 (11.9)	11.6 (11.0)	11.0 (9.5)	12.3 (11.6)	9.4 (8.0)	13.9 (12.2)	11.1 (10.6)	9.8 (9.6)	13.2	15.9	13.2	15.0	12.7	10.1
OUTFALL		13.2	12.3 (11.3)	12.8 (11.8)	11.8 (11.0)	10.0	12.0		13.4	11.1	9.8	13.3	16.0	13.3		13.0	10.1
D		13.4 (13.1)	12.3 (11.2)	12.7 (11.7)	11.6 (11.0)	11.0 (10.0)	12.4 (11.4)	9.5 (8.5)	13.6	11.2 (10.6)	10.0 (10.1)	13.3	16.4	13.3	15.2	13.1	10.1
E			12.2 (11.1)	12.6 (11.6)	11.6 (11.0)	10.5	12.6	10.3 (9.0)	13.6 (12.0)	11.4 (10.9)	10.1 (10.0)						
F		14.2	12.2 (11.1)	12.6 (11.5)	11.6 (10.9)	10.5	12.6 (11.6)	10.0 (9.0)	13.4 (12.4)	11.2 (10.9)	10.0 (9.9)						
G						10.6 (9.6)	12.4 (11.2)	10.0 (9.0)	13.1 (12.4)	11.4 (11.1)	10.2 (9.9)						
H					11.6 (10.9)	10.6	12.3 (11.5)	10.3 (9.0)	13.0	11.3	10.4						
I					11.7 (11.0)	11.0	12.3 (11.6)	10.5 (9.0)	13.0			13.8	17.4	13.8	15.4	13.3	10.3
J		12.8 (13.0)															
Range in sea surface temp.		12.7–13.4	11.7–12.3	12.6–12.8	11.6–11.8	10.5–11.0	12.0–12.6	9.0–10.5	13.0–13.9	11.0–11.4	9.6–10.1	11.4–13.8	15.9–17.4	13.2–13.8	14.9–15.4	12.5–13.3	10.1–10.3

TABLE 1 (Cont.)

Average Temperature Values in ^{o}C at the surface and at 20m depths along ten transect lines in south Carmel Bay 1973 - 1977

		1973				1974		1975				1976				1977	
Transect	71-72	Feb	Apr	Jul	Oct	Jun	Sep	Jan	Jul	Oct	Dec	Jun	Aug	Oct	Dec	Feb	Mar
Range in temperature at 20m		12.9-13.1	11.1-11.3	11.5-11.9	10.9-11.0	9.6-10.0	10.8-11.6	8.0-9.0	12.0-12.4	10.3-11.1	9.6-10.1						

* ( ) indicates average value at 20m depth.

TABLE 2

Average Salinities in °/oo at the surface and at 20m depths along ten transect lines in south Carmel Bay * 1973 - 1977

Transect	71–72	1973				1974		1975				1976				1977	
		Feb	Apr	Jul	Oct	Jun	Sep	Jan	Jul	Oct	Dec	Jun	Aug	Oct	Dec	Feb	Mar
A		30.3 (33.2)			30.9 (32.4)	30.5 (30.6)	33.1 (34.1)	34.4 (34.8)	33.8 (33.8)	33.5 (33.5)	34.1 (33.9)	33.9	33.5	33.6	33.6	33.6	33.8
B		30.3 (33.2)	27.7 (32.0)	31.0 (32.1)	30.9 (32.4)	30.7	33.3	34.3 (34.3)	33.6 (33.8)	33.5 (33.6)	34.2 (33.8)						
C		32.3 (33.1)	29.7 (32.0)	30.7 (32.2)	30.9 (32.4)	30.8	33.9 (34.1)	34.2 (34.3)	33.7 (34.0)	33.6 (33.7)	33.7 33.5	33.5	33.4	33.4	33.5	33.4	33.8
OUTFALL		32.6	29.6 (32.1)	30.4 (32.1)	30.4 (32.3)	31.7	32.8		33.3	33.3	33.1	33.6	33.5	33.5	33.5	33.5	33.8
D		32.3 (33.0)	30.2 (32.0)	30.8 (32.1)	30.7 (32.4)	31.3	33.9 (34.1)	34.3 (34.3)	33.7 (34.0)	33.6 (33.8)	33.5 (33.4)	33.5	33.4	33.5	33.4	33.4	33.7
E			30.1 (32.1)	31.0 (32.2)	31.0 (32.4)	30.7 34.0 (34.0)	33.8 (34.0)	34.3 (34.3)	33.8 (33.8)	33.8 (33.6)	34.1 (33.8)						
F		31.7	30.0 (32.0)	31.0 (32.4)	31.0 (32.4)	30.8	34.0 (34.2)	34.3 (34.3)	33.8 (33.8)	33.3 (33.7)	34.2 (33.7)						
G						30.8 (31.0)	33.9 (34.2)	34.3 (34.3)	33.8 (33.8)	33.5 (33.7)	33.9 (33.8)						
H					30.8 (32.4)	30.6	33.9 (33.9)	34.3 (34.3)	33.8 (34.0)	33.4	34.0						
I					30.9 (32.4)	30.6	33.9 (33.9)	34.0 (34.3)	33.9 (33.8)			33.6	33.5	33.6		33.6	33.7
J		32.0 (33.1)															
SS Range in Salinity		30.3– 32.3	27.7– 30.2	30.4– 31.0	30.4– 31.0	30.5– 31.7	32.8– 34.0	34.0– 34.4	33.6– 33.9	33.3– 33.8	33.1– 34.2	33.5– 33.9	33.4– 33.5	33.4– 33.6	33.4– 33.6	33.4– 33.6	33.7– 33.8

TABLE 2 (Cont.)

Average Salinities in $^{o}/oo$ at the surface and at 20m depths along ten transect lines in south Carmel Bay * 1973 - 1977 (Cont.)

		1973				1974		1975				1976				1977	
Transect	71-72	Feb	Apr	Jul	Oct	Jun	Sep	Jan	Jul	Oct	Dec	Jun	Aug	Oct	Dec	Feb	Mar
20m Range in Salinity		33.0-33.2	32.0-32.1	32.1-32.4	32.3-32.4	30.6-34.0	33.9-34.2	34.3-34.8	33.8-34.0	33.5-33.8	33.4-34.0						

* ( ) indicates average values at 20m depth.

Dissolved oxygen measurements ranged between 6 and 10 mg/l with little variation among transect stations. In general, values are consistent at these shallow depths through the year and are similar to average concentrations recorded for Monterey Bay. Data were collected by various surveyors and some variation could be attributed to a difference in analytical techniques.

Information on nutrient levels in the ASBS was not available. Extensive California Cooperative Fisheries Investigations (CALCOFI) work in Monterey Bay indicates that nitrate, nitrite and phosphate levels are elevated in surface waters during periods of upwelling (Engineering-Science, 1977).

Monitoring studies indicate that turbidity in the south bay is highly variable. However, turbidity was measured using a variety of techniques, so direct comparison of data is not possible. Undoubtedly, turbidity increases in sand or mud bottom areas, in areas close to shore, and during periods of wind and/or storm.

Spring upwelling and the resulting plankton bloom decrease visibility drastically. Visability is particulary good at Monastery Beach; hence divers are attracted to the area. High visibility is largely due to the submarine canyon, which consists primarily of resistant granodiorite and contains very little sediment. In addition, the steep drop-off of the canyon close to shore prevents the formation of surf until almost the shoreline; thus preventing bottom sediment from being stirred up.

Topographic and Geomorphic Characteristics

Submarine Topography: The submarine topography of the ASBS is dominated by the Carmel canyon, a major tributary of the Monterey submarine canyon. The Monterey canyon, one of the largest in the world, originates just offshore from Moss Landing, and extends into the center of Monterey Bay. The Carmel canyon originates about 1/4 mile offshore from the mouth of San Jose Creek in the ASBS. It extends offshore in a westerly direction for about 3 miles (6 km), then turns abruptly and continues to the northwest for 12 miles (19 km) before joining the Monterey canyon. The Carmel Canyon drops off steeply, reaching a depth of 1,200 ft. about 1 mile (200 fathoms, 1.6 km) offshore and a depth of 3,000 feet about 6 miles (500 fathoms, 9.7 km) offshore. The 120 foot (20 fathom) contour generally separates the canyon from shallower regions of the bay. In most locations the 120 foot (20 fathom) curve is less than 1/2 mile offshore, meaning that the canyon widens quickly so that it includes most of southern Carmel Bay.

It is thought that fault lines determined the orientation of Carmel canyon (Martin and Emery, 1967). The nearshore 3 mile portion of the canyon is allligned with the westward trending Carmel Valley fault; the offshore 12 mile portion is aligned with the northwesterly feeding Carmel Canyon fault (a seaward extension of the Sur and Palo Colorado faults) (Moritz, 1968).

Geophysical Characteristics: The geology of Carmel Bay has been described by various investigators (Marin and Emery, 1967; Simpson, 1972; Moritz, 1968). Several distinct formations are found at different locations along the shoreline.

The granite outcroppings represent the northwestern-most extension of the Santa Lucia mountain range, for which granodiorite is the basement rock. Granodiorite is an extremely coarse-grained, easily weathered rock containing quartz and large dark crystals of orthoclase feldspar. Subtidally, most of the floor and walls of the Carmel submarine canyon consit of granodiorite, which accounts for the unusually high visibility here. Intertidally, granodiorite occurs as promontories, boulders and cobble at Pescadero Point, Carmel Point, in the vicinity of the buried sewer outfall, and at the north end of Hudson Cove. Inland of the ASBS, granite outcrops occur north of Stillwater Cove, in the Carmel Valley, and along San Jose Creek, extending south to Pt. Lobos. (Simpson, 1972).

The Carmelo series, also common in and adjacent to the ASBS, can consist of four distinct rock types: sandstone, siltstone, conglomerate and shale. The predominate rock type in the ASBS is a conglomerate consisting of igneous pebbles embedded in a coarse-grained, well-cemented matrix. Subtidally, the Carmelo formation consists of all four rock types and underlies Stillwater Cove; from here it continues southward to a point 300 yards (274 m) seaward of Ocean Avenue at the north end of Carmel City Beach. In the intertidal zone, this formation is visible adjacent to Stillwater Cove, in the promontory just north of Monastery Beach, and adjacent to Hudson Cove. Inland, the Carmelo formation occurs north of the Carmel Mission (northeast of the Carmel River mouth).

The Temblor formation, consisting of a white to brownish sandstone intermixed with conglomerate, occurs at several shoreline locations between the volcanics at Arrowhead Point and amongst the Carmelo formation at Pebble Beach and Stillwater Cove. Inland, this formation occurs northeast of the Carmel Mission. Lava outcrops or extrusions from the Miocene era occur both subtidally and intertidally at Arrowhead Point.

Quaternary rocks identified as Aromas Red Sandstone occur in cliffsides and along the beach from Arrowhead Point south to Carmel (Mission) Point. The winter storms of 1977 scoured Carmel City Beach and dramatically revealed the underlying sandstone slabs to an extreme, particularly towards the south end of the beach.

Recent unconsolidated sediments form terraces which underlie the Pebble Beach Golf Course and are visible adjacent to the intertidal area. Submerged terraces of this composition also occur at depths of 210 feet (35 fathoms) throughout Carmel Bay.

Sand beaches occur frequently along the ASBS. Possibly, this sediment results from the weathering of granodiorite rock, located either along the shoreline or in Carmel Valley. Sand transport has not been studied in Carmel Bay, and the origin of sediments there has not been determined.

There are several watersheds adjacent to the ASBS; however, all freshwater discharges are seasonal. Pescadero Canyon drains into the ASBS at the north end of Carmel City Beach and San Jose Creek drains into Monastery Beach. The principle drainage is the Carmel River Basin, which covers a total of about 225 square miles (585 km^2) (Army Corps of Engineers, 1974) in a northwest-southwest direction. Carmel Valley, the lower portion of the watershed, extends eastward about 15 miles (24 km) from the river mouth.

The estimated 50-year mean annual run-off from the Carmel River is 142,300 acre-feet (176 hm^3). Flow is highly variable, both seasonally and from year to year. Between August 1962 and September 1967, mean annual flow was only 63,200 acre feet (78 hm^3) and no measurable flow occurred at the gaging station during the first three-quarters of 1977. (Sedway/ Cooke, 1977). Ninety percent of the river's flow occurs between February and August.

Climate

The climate of the Carmel Bay ASBS is characterized by mild air temperatures and cool ocean breezes. Fog persists (until early afternoon) in late spring and summer. Typically 90% of the rainfall occurs between November and April, and summers are dry.

Table 3 summarizes air temperature and rainfall data from two stations adjacent to the ASBS at the Carmel sewage treatment plant and at Pebble Beach. At the treatment plant, temperatures ranged between 43°F (6°C) and 68°F (20°C) during the past five years; rainfall averaged 19.6 inches/ year (49.8 cm/yr.). Data taken at Pebble Beach over a longer period of time show an average low air temperature of 50°F (10°C) in the winter and an average high air temperature of 58°F (14.4°C) in summer. Yearly rainfall here averaged 17.3 inches (43.9 cm).

Data are not available on wind speed or direction in the ASBS. According to Ranger Culbertson at Pt. Lobos State Reserve, prevailing winds are from the north and northwest, with southerly winds accompanying storms. The proximity of land and water creates a diurnal pattern of onshore-offshore breezes, rarely absent. Winds are generally less than 10-15 miles per hour, (16-24 km/hr.) except during storm conditions.

TABLE 3

Average Monthly Temperatures and Rainfall in the ASBS

	Carmel Sanitary District Temperature *				Pebble Beach Temperature **			
	Average Maximum	Average Minimum	Average	Rainfall	Average Maximum	Average Minimum	Average	Rainfall
Jan	61	43	54	1.75	59	41	50	3.79
Feb	63	51	57	2.49	61	43	52	2.70
Mar	65	56	57	3.89	61	43	52	2.51
Apr	63	51	57	2.06	62	45	54	1.75
May	66	55	60	0.66	63	48	55	0.55
June	67	59	63	0.82	65	50	57	0.17
July	68	61	54	0.09	64	51	58	0.04
Aug	67	60	54	0.40	65	52	58	0.07
Sep	68	60	53	0.28	68	51	60	0.38
Oct	68	57	63	1.46	68	49	58	0.51
Nov	67	53	60	1.87	66	45	56	2.17
Dec	64	49	57	2.83	62	43	52	2.67
				19.60	64	47	55	17.31

* Based on data collected between July 1973 - June 1977.

** Based on 13 years data (temperature) and 16 years data (precipitation)

During the spring, prevailing winds are from the northwest due to the nearshore presence of the Pacific high pressure cell. As inland temperatures increase, the warmer air rises and cooler marine air is pulled inalnd along valley contours. Thus westerly winds are intensified. Fog is caused during the same time period and is generally more intense as upwelling activity increases on into the summer.

In autumn, the Pacific High moves southward, making way for winter storm fronts. After a varying period of calm, clear days, the first winter storms occur, usually in September or October.

BIOLOGICAL DESCRIPTION

Subtidal Biota

Carmel Bay has been the subject of several subtidal studies, particularly the area near the Carmel sewer outfall (offshore of Carmel River Beach) and Monastery Beach. The five survey dives and two line transects were located to cover areas which are not well described in the literature. However, the head of Carmel Canyon was not surveyed. Dive sites and transects are identified in Figure 1.

The following descriptions focus on the major features of the kelp forest: bottom topography and sediment distribution, giant kelp density, and dominant algal, invertebrate and fish species. The survey dives were of brief duration, and the descriptions are only a partial indication of the extremely rich and diverse subtidal biota found in the ASBS.

Pescadero Point Transect: (Figure 3) Pescadero Point is located at the northernmost extreme of the ASBS. The Point is exposed to the open ocean, and during periods of large swell and surge, diving at shallow depths is not feasible.

The boulder field and general rugged relief of the intertidal zone continue subtidally to a depth of about 45 feet (14 m), where an immense pinnacle, occupying 66 feet (20 m) of the transect, rises to within 25 feet (7.6 m) of the surface from a maximum depth of 65-70 feet (19.8-21 m). A tunnel approximately 30 feet high and 30 feet long runs through the rock. Beyond the pinnacle, a very flat, pavement-like area extends to the seaward limit of the transect. Another large pinnacle, rising to within 20 feet (6 m) of the surface, is situated just east of the transect.

A giant kelp, Macrocystis, dominated canopy is located at Pescadero Point, interspersed with bull kelp, Nereocystis leutkeana. There were six adult Macrocystis plants along the transect line, with an average of seven stipes per plant. Undoubtedly, kelp dentisy had been reduced by the severe storm just prior to the survey. Five juvenile kelp plants

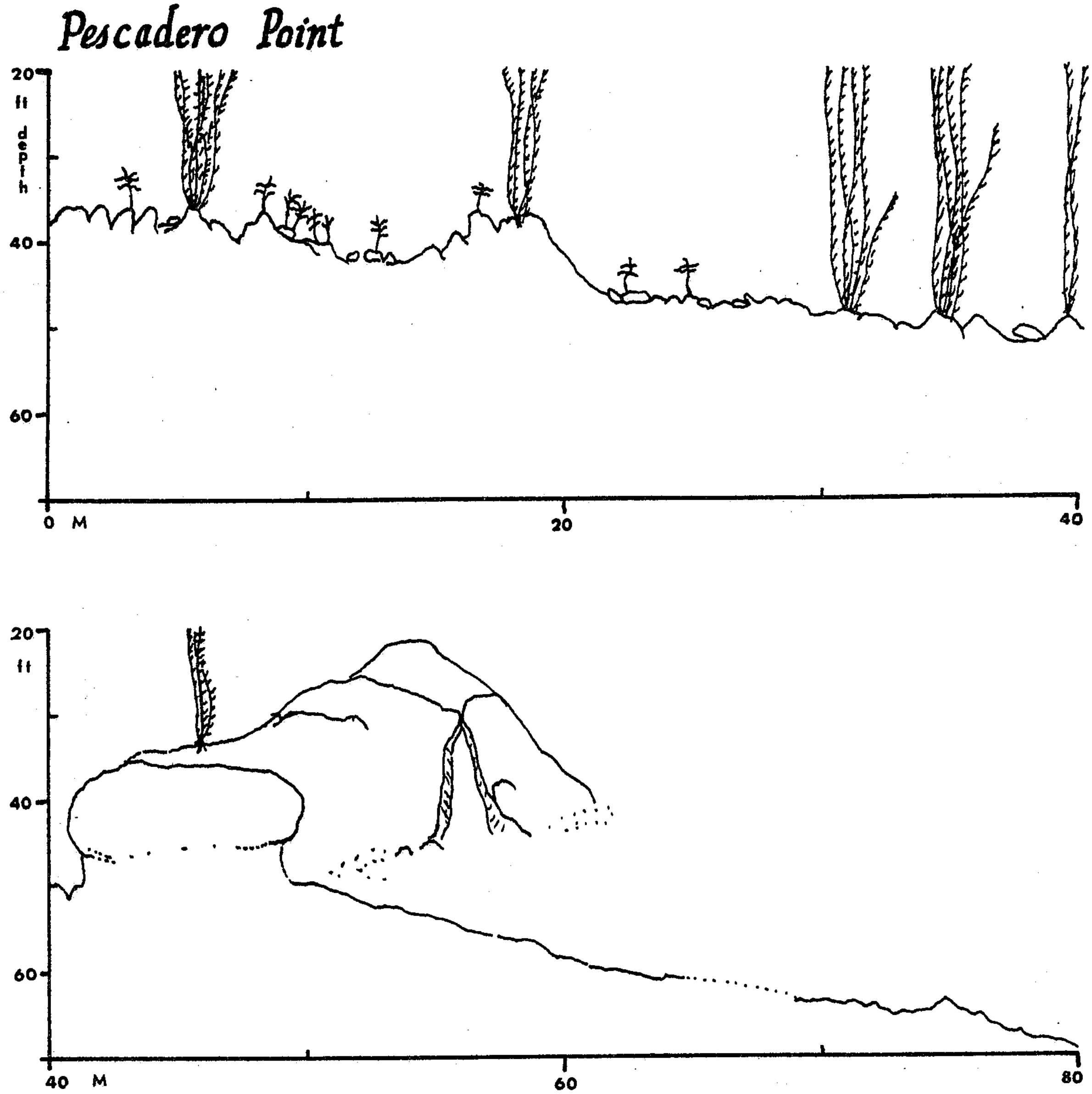


Figure 3: Overview of Pescadero Point transect (to scale).

<u>Pterygophora</u> is shown in the shallow portion of the transect, with <u>Macrocystis</u> dominating in deeper water. The pinnacle and tunnel referred to in the text are shown between the 40 and 60 meter mark.

were also observed. Articulated corallines were overwhelmingly dominant in the boulder field.

An interesting bryozoan, Heteropora sp., was common in the boulder field, where it occurred in small spherical colonies attached to articulated corallines. Didemnum carnulentum and Archidistoma psammion were the two most common tunicate species in this habitat. The lined chiton, Tonicella lineata, was a common molluscan species and occurred throughout on encrusting corallines.

The bat star, Patiria miniata, was present although in relatively low densities. The leather star, Dermasterias imbricata, was one of the more common sea stars. Of unusual interest was the presence of the deep water sea star, Mediaster aequalis, which was abundant along the transect.

The pinnacle within the transect was covered by a bright patchwork of sponges, tunicates, bryozoans and anemones. The entrance to the tunnel was flanked at the top by massive (2 feet in diameter) colonies of the sponge, Stelletta clarella. The purple hydrocoral, Allopora californica, was present in small colonies above the entrance. The rock walls within the tunnel were an intricate mosaic of many species of sponges, tunicates, hyrdroids and some bryozoans. Numerous colonies of the deep water sponge, Toxadocia sp., were conspicuous on the tunnel walls, as was the tunicate, Diplosoma macdonaldi.

On the top and sides of the pinnacle, invetebrates, interspersed with algae, provided an extremely rich and diverse cover. The bryozoans, Heteropora sp. and Phidolopora pacifica, grew in low turfs or thickets. The hydroid species, Abiertinaria spp., and the crust forming bristle worms, Dodecaceria fewkesi, were common on top.

The palm kelp, Pterygophora californica, was also common inshore, and thirteen plants were counted in one 1x10 meter swath. It did not occur, however, beyond 50 foot (15.2 m) depths.

At about 50 foot (15.2 m) depths, articulated coralline algae remained dominant but became interspersed with the algae, Gigartina spp., Prionitis sp., Plocamium cartilagineum, and Weeksia reticulata. The brown algae, Cystoseira osmundacea, occurred throughout the transect but was never dominant.

Although invertebrates were the dominant cover on the pinnacle, encrusting corallines covered large areas; Rhodymenia spp., otherwise absent, was common. The pavement-like area beyond the pinnacle contained a mixture of encrusting coralline and red algae.

Other subtidal areas along the transect provided diverse habitats for a rich invertebrate fauna. Colonial invertebrates dominated the sides and bases of inshore rocks, including the cobalt blue sponge, Hymenamphiastra cyanocrypta, the encrusting bryozoan, Cryptosula pallasiana, and the cup coral, Balanophyllia elegans. Dodecaceria fewkesi, the crust forming bristle worm, was ubiquitous on rock surfaces. The small greenish-black tentacles of this worm could be seen protruding from beneath a characteristic layer of encrusting coralline algae. Other invertebrate species common on the pinnacle are listed in Appendix 3.

Beyond the pinnacle, the deeper, flat portion of the transect was generally barren of invertebrates, except for a small bristle worm, Diopatra, colony found clinging to a sloping rock at about a 65 foot (20 m) depth. The presence of blue sharks was reported in this area by other divers during the survey period, and one was observed during one dive. An influx of open ocean plankton occurred during the survey at Pescadero Point and several species of ctenophores, heteropods and medusae were common in the water column.

Pescadero Point Wash Rock Survey: Pescadero Point wash rock is located at the north, semi-exposed end of the ASBS; waves break over the rock when there is a heavy swell. The southeast (offshore) face has a dramatic relief, with a nearly vertical 20 foot (6 m) wall near the top and steep talus slope below. The sloping bottom is highly irregular, with large boulders and rock masses. The pinnacle and surrounding rock slope were both covered with a dense growth of encrusting animals. To the east of the wash rock is a large sink hole 25 feet (7.6 m) in diameter, with rock walls 15 to 30 feet (4.6 to 9 m) high. Inshore (north) of this is a shelf of softer rock.

Few giant kelp are growing immediately adjacent to the pinnacle. The brown algae, Laminaria dentigera, was more abundant than palm kelp though both were common. Rhodymenia sp. and articulated corallines occurred on vertical faces, though animal cover was dominant over the plants.

The sponges Tethya aurantia, Stelletta clarella, and numerous unidentified species were an important part of the faunal cover. Hydroids were abundant; Abiertinaria spp. and Eudendrium sp. occurred in large colonies, and Plumularia spp., Hydractinia sp., and the alcyonarian, Clavularia sp. were common.

The anemone, Anthopleura xanthogrammica, was found at the base of the wash rock on the east side. The anemone, Tealia lofotensis, was abundant and the strawberry anemone, Corynactis californica, covered many square meters on the vertical walls of the wash rock. Three or four large red abalone, Haliotis rufescens, were in crevices on the eastern side of the wash rock. Very large heads of the bryozoans, Hippothoa hyalina, and Diaperoecia californica, existed on rock surfaces at the base of the wash rock.

A sizeable sea urchin bed, primarily Strongylocentrotus purpuratus but with larger S. franciscanus in crevices, was found on a shelf to the north of the sinkhole formation. The urchins were nestled in individual depressions in the soft rock and occurred in densities up to 40 per square meter.

The shallow water ochre star, Pisaster ochraceus, was found at the base of the wash rock. Sheets of the tunicates Didemnum carnulentum and Diplosoma macdonaldi were present on rock surfaces.

Adult blue rockfish, Sebastes mystinus, were very abundant as were kelp rockfish, S. atrovirens. Kelp greenlings, Hexagrammos decagrammus, and black-and-yellow rockfish, S. crysomelas, were also seen here, and various species of surfperch including Embiotoca lateralis, striped surfperch, and E. jacksoni, black surfperch, were present.

Stillwater Cove Survey: Stillwater Cove is an embayment near the northern end of Carmel Bay, sheltered from northwest swells by Pescadero Point.

The floor of Stillwater Cove is shallow and relatively flat. Soft Carmelo formation rocks lie throughout the cove, although a few larger outcrops exist and flat low rocks interspersed with patches of sand and cobble (2 to 4 inches in diamteter) are present.

The palm kelp was common in Stillwater Cove, particularly at depths of around 30 feet (9 m). The brown algae, Dictyoneurum californicum, was noted on the larger outcrops. Articulated corralines were common throughout and became dominant on the large rock outcrops. The red alga, Nitrophyllum cincinnatum, occurred as an epiphyte on a number of the corallines.

Gigartina spp. commonly grew on the low rocks and boulders. Other common algae were Gelidium sp., Desmarestia ligulata var. ligulata, Prionitis lanceolata, and Botryoglossum farlowianum.

The bat star, Patiria miniata, was common, occurring on rock, sand, other animals and algae. Aplysia californica, the sea hare, was conspicuous feeding on filamentous and fleshy red algae.

The striped surfperch, Embiotoca lateralis, and black surfperch, E. jacksoni, were the fish species most commonly seen.

Carmel Beach Survey: Although the Carmel Beach giant kelp bed is generally one of the most extensive in central California, Macrocystis pyrifera density was low at the time of the survey and the canopy thin and scattered. This bed was probably reduced by the preceding storm as evidenced by uprooted holdfasts and holdfasts with reduced numbers of stipes.

The subtidal substrate typically consists of large sand and gravel areas between low rock outcrops. These outcrops are softer rock, similar in composition to those seen on the shore of nearby Arrowhead Point. One anomalous granite outcrop occurred near the outside edge of the kelp bed, rising within 10 feet (3 m) of the surface.

The biota was fairly diverse, although not extremely dense. A sparse brown algae, Laminaria dentigera, understory occurred inshore and topped the granite outcrop. Articulated and encrusting corallines dominated on this same outcrop.

The spherical sponge, Tetilla arb, was common off Carmel Beach, with tennis ball-sized colonies growing on rocks. The massive greyish-green Spheciospongia grew in colonies on larger rocks.

The anemone Tealia lofotensis was common, and T. coriacea also exists. The bristle worms, Dodecaceria fewkesi, formed extensive crusts on the more gently sloping faces of the granite outcrop. The feather duster worm, Eudistylia polymorpha, was abundant in crevices. Upright thicket-forming bryozoans were absent. The sea stars, Pisaster giganteus and P. ochraceus, were abundant on the granite pinnacle.

This was the only Carmel Bay survey site where the colonial tunicate, Polyclinum planum, commonly occurred. The erect flattened pads formed by this species have earned it the common name of elephant ear tunicate. The colonial tunicates, Archidistoma psammion, Diplosoma macdonaldi and Trididemnum opacum, were widely distributed at this site.

Carmel Beach Wash Rock Survey: This emergent Carmelo Formation rock, with its base at 20-25 foot (6-8 m) depths, had a diverse biotic assemblage including many characteristically shallow water forms.

The offshore edge of the wash rock rises almost directly from a white sand base. Directly inshore and to the south of the rock are outcrops of flat rock which supported small kelp beds. To the south of the wash rock, possibly the result of an eddy formed by the rock, is an area of coarse and shelly sand where considerable debris has collected.

A profusion of plant and animal life covered rocks. Vertical faces were crowded with sessile invertebrates and rock tops supported lush algal growth. The brown algae, Cystoseira osmundacea, was abundant, particularly inshore of the wash rock. Also, the brown algae, Laminaria dentigera, was common in shallow water around and on the wash rock. Palm kelp was common in the more exposed areas including the north and offshore edges of the wash rock, and formed an understory in the kelp bed to the south. The surfgrass, Phyllospadix sp., was present in shallow areas around the eastern perimeter of the outcrop area. Relatively large areas of delicate filamentous red algae were noteworthy. Extensive mats of the yellow finger sponge, Polymastia pachymastia, were also found here.

The anemone, Anthopleura xanthogrammica, generally restricted to the intertidal zone, was common at the base of the wash rock. The anemone, Tealia lofotensis, occurred by the hundreds around the base of the rock. Tealia crassicornis, though less common, was also present as was the brooding anemone, Epiactis prolifera, among the brown alga, Cystoseira osmundacea. In addition to these anemones, dense hydroid growth was observed, including Eudendrium sp., Eucopella sp., Hydractinia sp., and Aglaophenia spp.

Sandy tubes of the polychaete, Phragmatopoma californica, covered some vertical faces of the wash rock. An unidentified species of burrowing clam, probably of the family Pholdidae, occurred inshore where it was able to penetrate the soft rock. The sea hare, Aplysia californica, was commonly found feeding on filamentous red algae.

The ochre star is a typically intertidal sea star which was common at the base of the wash rock. A dense patch of the urchins, Strongylocentrotus franciscanus and S. purpuratus, was seen on a sloping rock shelf to the north of the wash rock. Apparently the urchins are able to burrow into the soft rock sufficiently to avoid predation by sea otters.

There was a remarkable growth of tunicates at this site. Synocium parfustis dominated rock faces on the south side of the wash rock, its globular colonies crowding out other forms. On sand covered rocks and among the roots of the surfgrass the tunicate, Pycnoclavella stanleye, grew in large colonies. Other common tunicates included Ritterella sp. and Polyclinum planum.

Many fish were associated with the wash rock, including species of rockfish, kelp greenlings, and two monkeyfaced eels in a crevice.

Carmel-Mission Point Transect: The transect line extended from the southern side of Mission (Carmel) Point, a rocky peninsula about midway between the north and the south end of the ASBS. The resistant Santa Lucia granodiorite seen onshore extended into the subtidal area where huge granite blocks dominated.

Although several detached giant kelp were observed floating in mid-water, the kelp canopy was dense and noticeably shaded the bottom. The bed was also areally extensive, beginning in shallow water and extending beyond the end of the transect at the 68 foot water depth (Figures 4 and 5).

Algal cover dominated inshore. The brown algae, Laminaria dentigera, was extremely dense (up to 15 plants per square meter) to a depth of about 25 feet (8 m). The red algae, Gigartina corymbifera, formed another equally dense layer beneath the L. dentigera (Figure 6). Brown algae, Dictyoneurum californicum, grew densely on some flat rock tops inshore. Gigartina spp. and articulated corallines were common up to a depth of about 40 feet (12 m). Other species of red and brown algae which occurred regularly at these depths included Botryoglossum farlowianum, Callophyllis spp., Rhodymenia spp. and Cystoseira osmundacea.

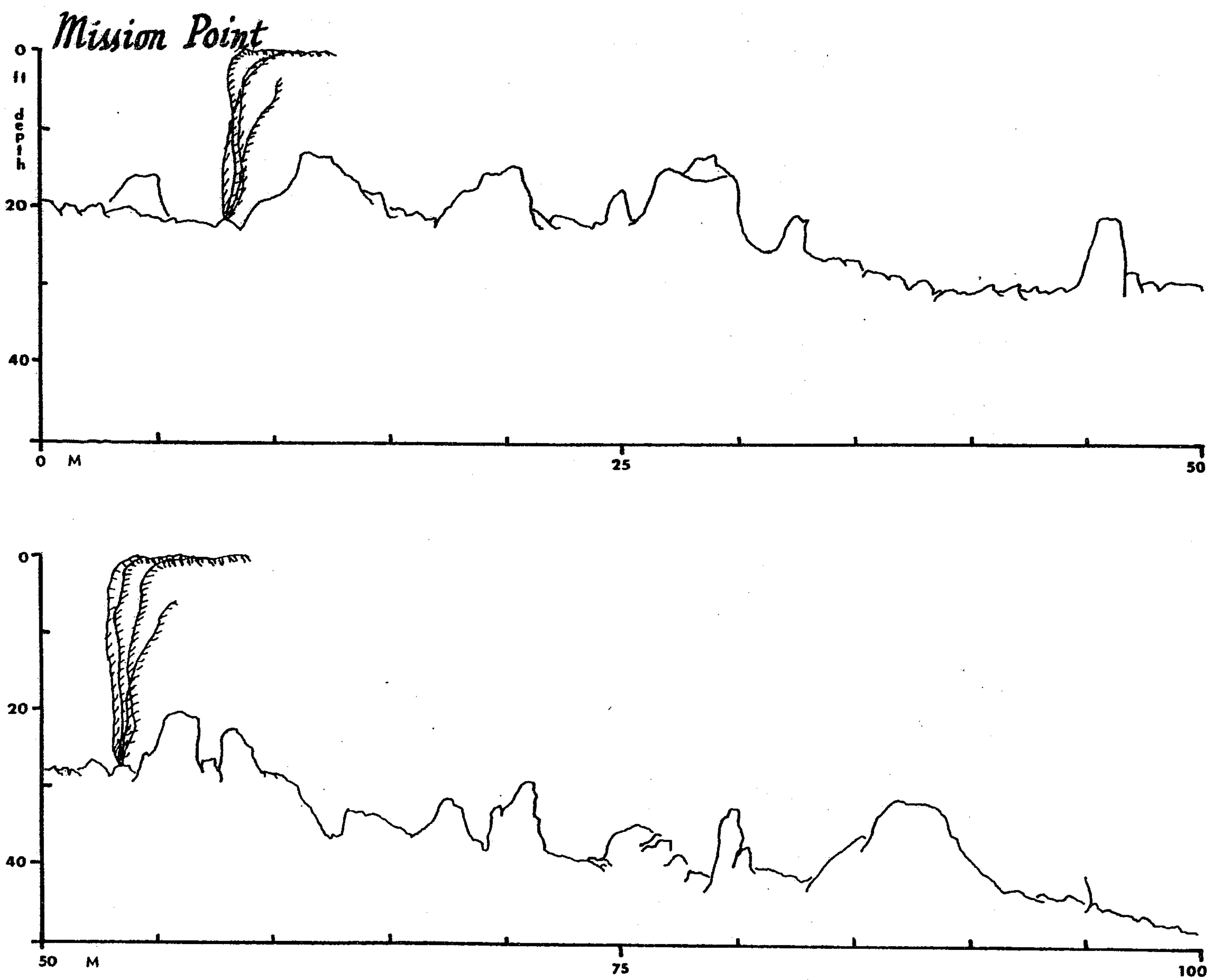


Figure 4: Overview of Mission Point transect, 0-100 meters.

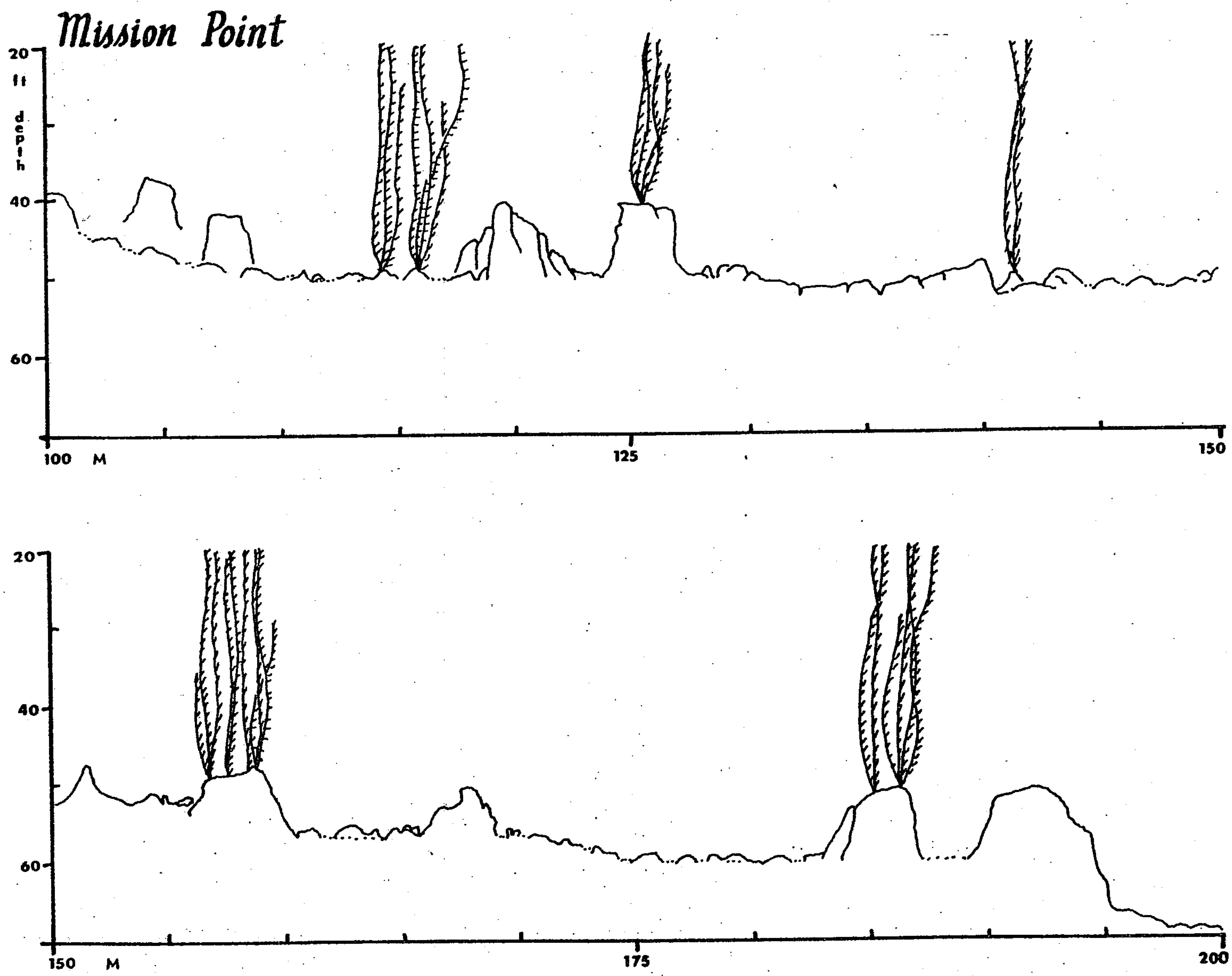


Figure 5: Overview of Mission Point transect, 100–200 meters.

Mission Point 0-10 M.

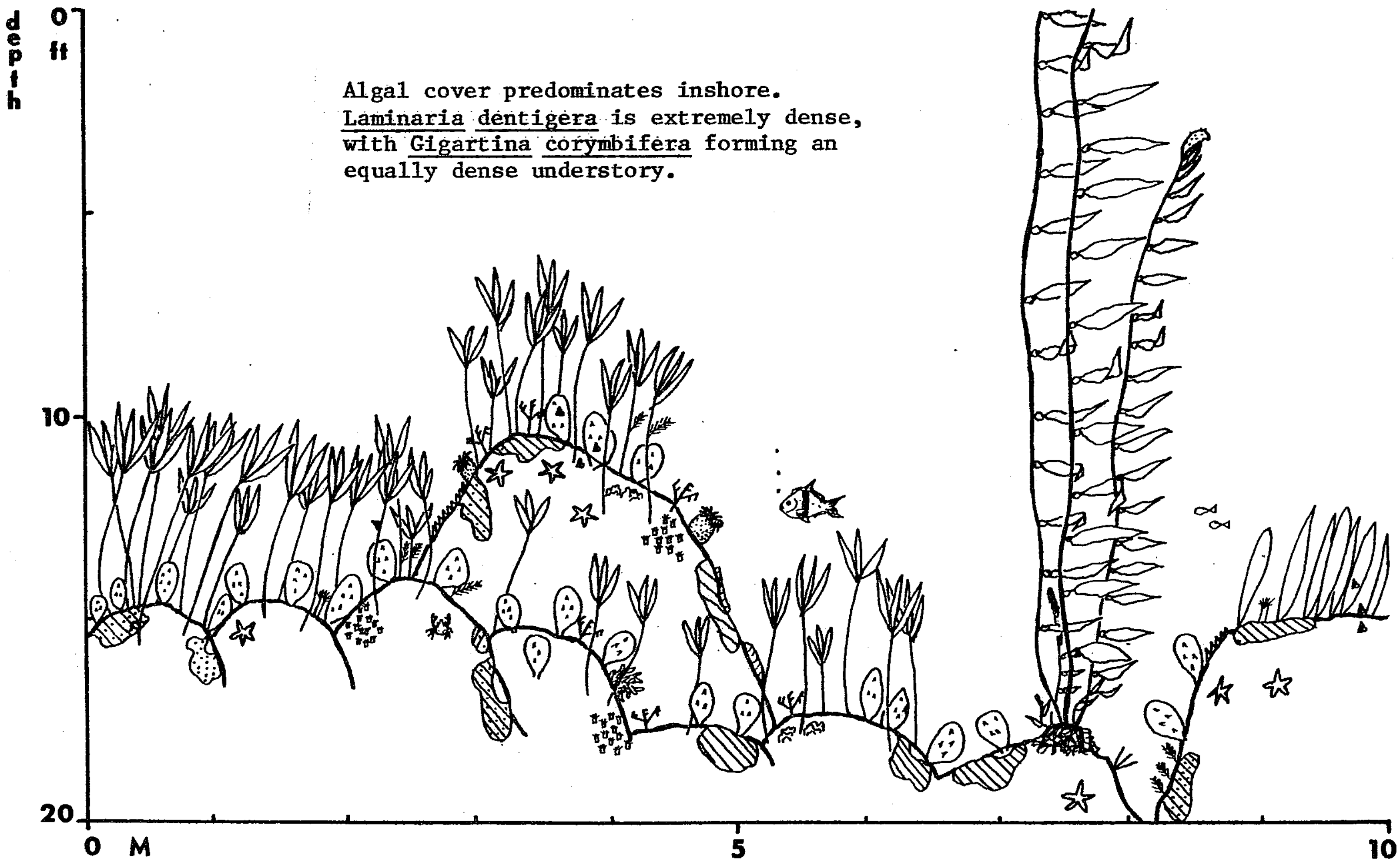


Figure 6: Mission Point transect, 0-10 meters.

Key To Symbols Used In Subtidal Figures

ALGAE

Phaeophyta (Browns)

Cystoseria osmundacea 

Dictyoneuropsis reticulata 

Laminaria dentigera 

Laminaria stipes 

Rhodophyta (Reds)

Botryocladia pseudodictoma 

Botryoglossum farlowianum 

Callophyllis spp. 

Gigartina sp. 

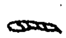
Prionitis sp. 

Plocamium cartilagineum 

Rhodymenia sp. 

Articulated corallines 

Drift 

Encrusting corallines 

Encrusting corallines with Dodecaceria 

Holdfast 

Filamentous reds 

Red crust 

Porifera (Sponges)

Acarnus erithacus

Tethya aurantia

Hymenamphiastra cyanocrypta

Polymastia pachymastia

Unidentified species

Cliona celata

Ectoprocta (Bryozoa)

Hippodiplosia insculpta

Costazia robertsonae

Hippothoa hyalina

Phidilopora pacifica

Lagenipora sp.

Cryptosula pallasiana

Unidentified species

Eurystomela bilabiata

Annelida

Dodecaceria fewkesi

D. fewkesi (large form)

Salmacina tribranchiata

Sabellaria sp.

Diopatra ornata

Eudistylia ornata

Spirorbis sp.

Phragmatopoma californica

Coelenterata

Corals

Astrangia lajollaensis

Balanophyllia elegans

Paracyathus stearnsi

Anemones

Tealia lofotensis

Tealia coriacea

Tealia sp.

Anthopleura elegantissima

Corynactis californica

Pachycerianthus sp.

Hydroids

Abietinaria spp.

Sertularella spp.

Plumularia spp.

Aglaophenia spp.

Fish

Scorpaenidae (Rockfish)

Sebastes mystinus (blue rockfish)

S. mystinus juvenile

S. paucispinus juvenile (bocaccio)

Embiotocidae (Perch)

Rhacochilus vacca (pile surf perch)

Embiotoca lateralis (striped surf perch)

E. jacksoni (black surf perch)

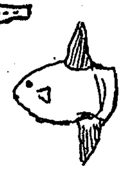
Hypsurus caryi (rainbow surf perch)

Other

Citharichthys stigmaeus (speckled sand dab)

Hexagrammos decagrammus (kelp greenling)

Mola mola (sun fish)



Oxyjulis californica (señorita)

Scorpaenichthys marmoratus (cabezon)

Deeper than 40 feet (12 m), only encrusting algae were common. Crustose corallines were estimated to constitute at least 50 percent of the cover, and crustose red algae were seen on many low rocks. Occasional *Rhodymenia* spp. and *Plocamium cartilagineum* occurred at these depths. Below 60 feet (18 m), near the outside edge of the kelp bed, *Desmarestia ligulata* var. *firma* and a red alga, *Weeksia reticulata*, were abundant (Figure 7).

Invertebrate cover showed a distinct pattern of distribution. In shallow water, animal cover was sparse, with algal cover dominant. Below about 25 feet (7.6 m), algal cover diminished as animal cover increased. However, no concomitant increase in animal cover occurred beyond 40 foot (8 m) depths, giving the deeper portion of the kelp bed a barren appearance.

Among the animals common at Mission Point were numerous species of hydroids growing on both rock and algae. *Aglaophenia* spp. and *Sertularella* spp. were particularly common. The anemones, *Corynactis californica*, *Tealia lofotensis* and *Tealia* sp., were common. The purple hydrocoral, *Allopora californica*, was a conspicuous member of the fauna on deeper rock faces (Figure 8).

The polychaete, *Dodecaceria fewkesi*, was evident, with crusts covered by coralline algae. The feather duster worm, *Eudistylia polymorpha*, was unusually abundant, filling all the available space in many crevices. In some of the deeper areas, mounds of the tube worm, *Diopatra ornata*, filled in the gaps between rounded rocks, giving the bottom a continuous, undulating appearance.

Erect calcareous bryozoans became more abundant as the algal cover diminished with depth. *Hippothoa hyalina* was conspicuous on vertical rock faces shallower than about 40 feet (12 m). On some rocks *H. hyalina* and *Diaporoecia californica* grew in large heads and were the dominant species. Below 40 feet (12 m), the bottom was relatively barren, with small barnacles, *Balanus*, spp. covering large areas.

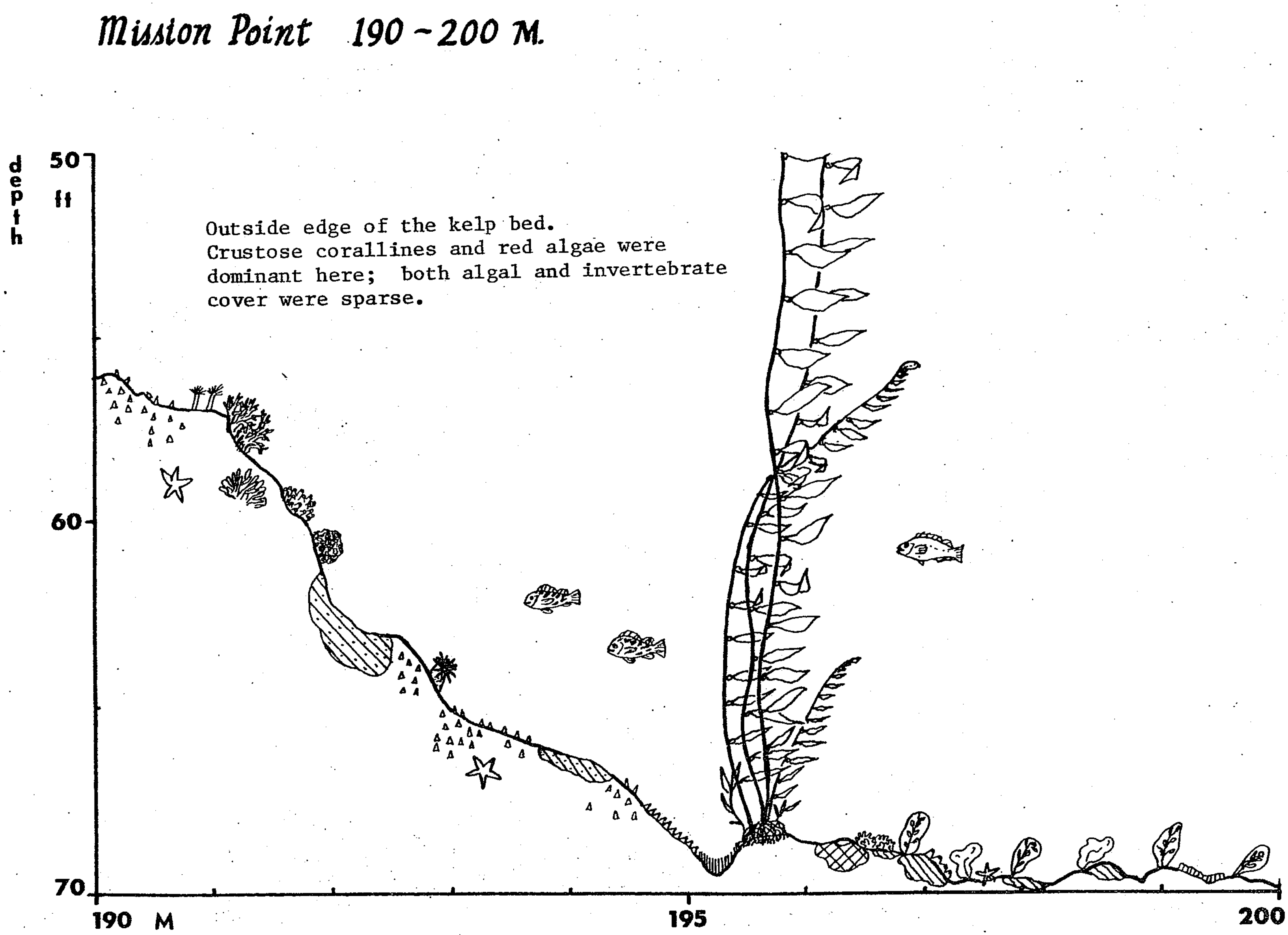


Figure 7: Mission Point transect, 190-200 meters.

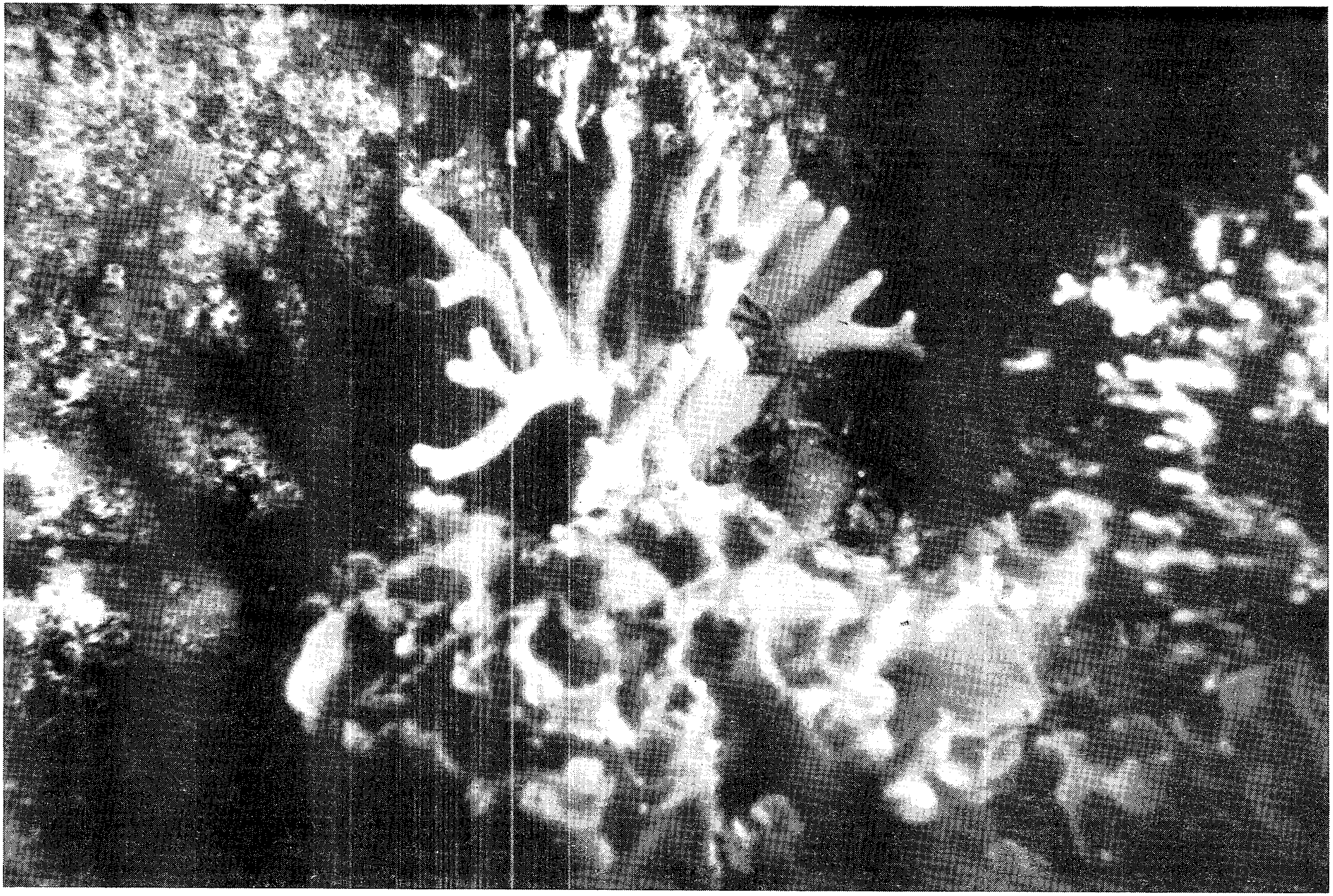


Figure 8: Photograph of the purple hydrocoral, _Allopora californica_, found at Mission Point.

Didemnum carnulentum was the most conspicuous tunicate and grew in sizeable colonies below 40 foot (12 m) depths. Diplosoma macdonaldi was another abundant tunicate, its gelatinous tunic spreading over rock surfaces.

A large school of adult blue rockfish, Sebastes mystinus, was observed at Mission Point along the deeper half of the transect. Other species common during the survey included kelp rockfish, S. atrovirens, and pile surfperch, Damalichthys vacca.

Pescadero Pinnacles Survey: Pescadero Pinnacles are part of an offshore rock outcrop, about an acre in extent, which rises up within 50 or 60 feet (15 or 18 m) of the surface.

The area is characterized by dramatic topography, unusually clear water and massive growths of sessile invertebrates including many rare and deep water forms.

The Pinnacles are about a half mile west of Pescadero Point (seen in Figure 1). Silt free granite slabs up to 30 feet (9 m) high provide enormous vertical faces for attachment of a myriad of sessile forms. One pinnacle has been charted which reaches to within 10 feet (3 m) of the surface. At its outside edge the outcrop drops rapidly to a sand and gravel bottom at 110 to 120 foot (33.5 to 36.6 m) depths.

The Pinnacles can be located by the giant kelp, Macrocystis pyrifera, canopy which occurs there; some kelp plants anchor at depths as great as 90 feet (27 m). Understory algae were not abundant and palm kelp occurred only sparsely. Encrusting corallines were the most abundant plants. Of particular interest was the occurrence of the southern palm kelp, Eisenia arborea. One specimen of the rare deep water red alga, Maripelta rotata, was also collected here.

Tetilla arb, Tetilla sp., Tethya aurantia, Toxadocia sp., and Stelletta clarella were among the sponges observed. Many species were present that could not be identified. The hydroid, Abiertinaria spp., grew in particularly dense thickets on some rock surfaces.

Paracyathus stearnsi was the dominant coral at the depths of the pinnacles, replacing the orange solitary cup-coral, Balanophyllia elegans, which was dominant in shallower water. An unidentified species of colonial madreporarian coral was seen here, consisting of perhaps 6 polyps in a low round mound. Of all the survey sites, Pescadero Pinnalces contained the largest population of the purple hydrocoral, Allopora californica.

The crust forming polychaete, Dodecaceria fewkesi, was ubiquitous on sloping rock faces. Calliostoma annulatum and C. ligatum were among the most common gastropods; the less common species, C. gloriosum, was observed feeding on sponges.

The bryozoans generally grew in large single species heads, unlike other sites where mixed thickets were more common. Phidolopora pacifica, Hippothoa hyalina, and Diaperoecia californica, were common. Very young colonies of Hippothoa hyalina formed an erect branch from an encrusting base on the rock. Colonies of Diaperoecia californica were frequently covered with a membraneous orange sponge. This same association was noted at other sites in Carmel Bay.

Mediaster aequalis, Patiria miniata, Pisaster giganteus, pink to purple Pycnopodia helianthoides and Dermasterias imbricata were the common species of sea stars. The urchin, Strongylocentrotus franciscanus, was seen in crevices.

Of the tunicates, Didemnum carnulentum and Diplosoma macdonaldi were the most common. D. carnulentum dominated on shallower tops of rock masses and on sloping surfaces. These large, 3 feet-diameter, orange colonies could be seen from 40 feet (12 m) above the bottom. D. macdonaldi also occurred in smaller patches in deeper water.

The subtidal flora and fauna in Carmel Bay are perhaps some of the richest in the entire state of California, partially because many northern and southern species have ranges that overlap in the area. This feature, in conjunction with the unique geology and the presence of the Carmel submarine canyon, make Carmel Bay an ideal underwater area for diving and a unique environment for study.

The remarkable biological and geological diversity of the subtidal area warrants an individual discussion of each survey site. The following discussion includes areas covered in the literature but not surveyed for this report.

Pescadero Pinnacles are outside the actual boundaries of the ASBS, a half mile to the east (offshore) of Pescadero Point. The Pinnacles are noteworthy for the relatively profuse growth of the purple coral, Allopora californica, the massive growths of sponges (many species yet undescribed), and the unusual occurrence of several typically southern species. According to the investigators, the very clear water, dramatic topography and diverse biota make Pescadero Pinnacles a beautiful site of truly special biological significance.

Pescadero Point, the northernmost boundary of the ASBS, was described by Andrews (1945) as similar in appearance to exposed Point Pinos in Pacific Grove, in that it has practically a smooth rock bottom and a pure stand of the bull kelp, Nereocystis leutkeana. However, giant kelp, Macrocystis pyrifera, was the dominant canopy with only the occasional Nereocystis present. A decline of bull kelp has been observed by others throughout the central California coast and is frequently attributed to the reappearance of the sea otter. Miller and Giebel (1973) present some evidence that the decline is widespread and has occurred in areas not reoccupied by otters. Though other predation on herbivores may have given an advantage to the perennial Macrocystis over the annual Nereocystis this remains to be demonstrated experimentally.

Stillwater Cove is noted for the unusual algal species which are found in sheltered areas as described by California Department of Fish and Game (in ESI, 1977) and in Smith (1969). Due to warmer water within the cove, several uncommon species occur intertidally, and the shallow subtidal area contains the southern feather boa kelp, Egregia laevigata, and its epiphyte, Halorhipis winstonii.

Water beyond the restricted portions of the cove (outside Pescadero Rocks) does not appear to be similarly warmed; temperatures of 48-52°F

(9-11°C) were observed consistantly here in spring 1976. Algal species composition is therefore different. For instance, the densest population of palm kelp observed during the survey was in this area. A northern zoanthid anemone, Epizoanthus scotinus, formerly noted only as far south as Point Arena, was recorded in Stillwater Cove (California Department of Fish and Game in ESI, 1977).

Carmel Beach and the nearly emergent wash rock demonstrate how substrate type affects certain groups of animals. Beds of urchins and burrowing pholad clams were found only in the softer rock. Hydrocoral, Allopora spp., and many other species which prefer clean vertical rock faces were absent.

The Carmel Mission Point transect consisted entirely of high relief granite and differed from other survey sites in several respects. The deeper portions of the kelp bed contained the largest population of hydrocoral, Allopora californica, observed during the survey at Mission Point. The barrenness of the bottom below 40 feet (12 m) was unusual.

Oceanographic Services, Inc. (1975), observed that rocky outcrops in the vicinity of the outfall support a mixed stand of kelp and other algae. OSI reported the existence of a rather sparse understory, consisting of palm kelp and Laminaria dentigera. Bottom cover consists primarily of crustose and articulated corallines, Bossiella sp., Calliarthron sp., and Lithothamnion, with Rhodymenia pacifica and Plocamium cartilagineum also abundant.

OSI described filter feeders as the dominant marine fauna. Their monitoring work showed that, on a weight basis, bryozoans were the most common invertebrate group at each study site; Hippodiplosia insculpta and Hippothoa hyalina were the most common species found on both rocks and algae. Spheciospongia confoederata and Polymastia pachymastia were the most conspicuous sponges, Synoicum parfustis and Diplosoma macdonaldi the most abundant compound tunicates, and Styela montereyensis and Pyura haustor the most prevelent solitary tunicates.

South of the mouth of Carmel River in the southern portion of the ASBS is Monastery Beach, noteworthy for the submarine canyon which comes within a quarter mile of the intertidal area. At the northern end of Monastery Beach, the lip of the canyon occurs at approximately 60 foot (18 m) depths. While the area was not surveyed for this report, previous investigations found the granite walls of the canyon are inhabited by many unusual forms characteristic of deep water. Peckman and McLean (1961) note the gorgonians Psammogorgia arbuscula, two corals, four starfish and many molluscs including Hemitoma bella, Haliotis kamtschatkana and Acmaea funiculata which usually appear at depths of at least 70 to 100 feet (21 to 30 m). On the vertical walls of the canyon, thick masses of sponges and bryozoans were observed to be prominent, attached to tubes of the polychaete Phyllochaetopterus prolifica.

Numerous other biological surveys have been associated with monitoring activities at the Carmel Sanitary District's wastewater outfall. These efforts are summarized in Appendix 4.

Intertidal Biota

Pescadero Point is a steeply-sloped, highly weathered granite outcrop, containing deep pools and large boulders on its seaward side. The point is almost completely devoid of life down to the intertidal area.

Desiccated algae, Ulva sp., marked the upper extent of the intertidal zone. The high intertidal zone contains several characteristic algal species: Gigartina papillata, Pelvetiopsis limitata, Endocladia muricata, corallines, and occasional patches of Chaetomorpha linum. Periwinkles, Littorina sp., were found in abundance, along with the limpets Notoacmaea scutum and Diodora aspera and occasionally the keyhole limpet, Megathura crenulata. Small barnacles, Balanus sp., existed on the tops and sides of rocks, while numerous rock crabs, Pachygrapsus crassipes, hid in crevices and under rocks.

Animals characteristic of exposed open coast occurred in the high intertidal zone on the north side of the point, principally the sea mussel, Mytilus californianus, and the goose barnacle, Pollicipes polymerus. The third member of this association, the ochre star, Pisaster ochraceus, occured here also but at a lower point in the intertidal zone. Hiding in deep crevices in the cliff were numerous small black abalone, Haliotis cracherodii. Clumps of algae, Codium fragile, were occasionally seen attached to the cliff sides.

The mid-intertidal zone at Pescadero Point was indistinct, and the distribution of low and mid-intertidal flora and fauna overlapped extensively. Algae completely covered the rocks and had to be moved to reveal the animals present. Rock tops were covered with rockweed, Fucus distichus, various species of algae, Ulva, Neoagardhiella baileyi, Prionitis lanceolata, Laurencia spectabilis, Gigartina exasperata, G. harveyana, and other Gigartina spp., Spongomorpha sp. and coralline algae. Egregia menziesii was very common as was Cystoseira osmundacea and Costaria costata. Iridaea flaccida and giant kelp, Macrocystis pyrifera, occurred occasionally.

Bright patches of encrusting sponges and tunicates were occasionally found on sides of rocks and under ledges. The red sponge, Plocamia karykina, and the yellow sponge, Lissodendoryx firma, were most frequently seen. Various species of tunicates, Archidistoma psammion, Aplidium solidum, Archidistoma ritteri and Archidistoma diaphanes occurred in relatively small patches throughout the mid and low intertidal zones. The light bulb tunicate, Clavelina huntsmani, was quite common under rock ledges.

Common anemones present were the aggregating anemone, Anthopleura elegantissima, Corynactis californica and Tealia lofotensis. The solitary stony coral, Balanophyllia elegans, was seen frequently under ledges along with species of the hyrdoid, Tubularia.

Molluscs were not as obvious in the mid and low zones as they were in the high intertidal zone. Tegula brunnea, the brown turban snail, replaced the black turban snail, T. funebralis, and Tegula shells served as homes for Pagurus granosimanus, a hermit crab with claws of granular texture.

The bat star, Patiria miniata, was the most abundant echinoderm, followed by the small sea star, Leptasterias hexactis. The ochre star, Pisaster ochraceus, occurred occasionally along the cliffs and at the base of large rocks. The purple sea urchin, Strongylocentrotus purpuratus, was seen tucked into small cracks in the rock.

The lowest intertidal zone occurred in deep pools and surge channels. ~~Without wet suit or snorkel~~, it was only possible to note some floral changes: the giant kelp became more abundant, and the sea palm, Postelsia palmaeformis, and surfgrass, Phyllospadix sp., were common.

A few additional species of invertebrates were found around the edges of deep tide pools, such as the solitary anemone, Anthopleura xanthogrammica, and the brooding anemone, Epiactis prolifera. Sponges and tunicates already mentioned were abundant, and with Bugula californica and various other encrusting bryozoans covered the undersides of rocks and ledges. The horned slipper shell, Crepidula sp., was observed frequently on the brown turban snail. Three additional species of nudibranchs were noted: Laila cockerelli, Diaulula sandiegensis and Anisodoris montereyensis.

The shoreline continues southeast of Pescadero Point as a steep granite cliff which prohibits passage on foot. Adjoining property, which includes the Pebble Beach golf links, is privately owned, and thus there is no public access to the intertidal area. The intertidal area adjacent to the north end of the golf course appears to consist of rocky ledges; in some areas seawall and rip rap have been used to mitigate erosion. At the south end of Pebble Beach, is a conglomerate rock outcrop which forms a small point. A fine-grained granitic sand beach extends south from here .2 miles (.3 km) to Arrowhead Point, a high cliff consisting of conglomerate with lava intrusions. An area of medium-sized boulders occurs on the north side of Arrowhead Point, in Stillwater Cove.

Two intertidal surveys were conducted in this area, one at the point in front of the Beach and Tennis Club (on a moderate low tide) and one at the base of Arrowhead Point (on a good low tide).

The intertidal habitat on and adjacent to the point in front of the Beach and Tennis Club consists of flat sandstone shelves, with deep eroded pockets. The sandstone shelves are separated by sand channels containing large rocks.

The ledge tops contained typical (Ricketts and Calvin, 1968) flora and fauna. The algae, Ulva sp., Endocladia muricata, and Pelvetia fastigiata, were common, and occasional clumps of Fucus distichus, Gelidium sp. and Scytosiphon sp. were seen here. Corallines occurred in small pools. Limpets were common, with Collisella scabra, and C. digitalis and C. pelta the most frequently seen species. The black turban, Tegula funebralis, Acanthina sp. and Littorina sp. occurred in and around small pools as well as on ledge tops. The most abundant chiton was Nutallina californica, found among groups of small Balanus sp. Large aggregations of the sand tube building worm, Phragmatopoma californica, and anemones were abundant on the upper sides of rocks.

In the upper mid-intertidal zone, more algae, Ulva spp., Neoagardhiella baileyi, Gastroclonium coulteri and Laurencia spectablis, grew on the sides of ledges. Additional species of chitons, Mopalia hindsii and M. muscosa, occurred in grooves in the rocks. Crevices contained crabs, Pachygrapsus crassipes, and purple sea urchin, Strongylocentrotus purpuratus.

In pools at the base of ledges, Neoagardhiella baileyi, Egregia menziesii, Macrocystis pyrifera, Gigartina spp. and corallines were common. Surfgrass with its specific epiphyte Smithora naiadum was abundant. The tube worm, Phragmatopoma californica, and the black turban snail, Tegula funebralis, were very common. The sea hare, Aplysia californica, was found at the base of cliffs.

Mid and low intertidal habitat occurs in channels between ledges and seaward of the point. Algal species included those found at the base of ledges, and in addition Cystoseira osmundacea and Grateloupia californica were common. Prionitis lanceolata, Laminaria farlowii, and Pterygophora sp. were frequently observed.

Molluscs were common in these zones. Chitons included Mopalia lignosa, Cryptochiton stelleri, and Placiphorella velata. Megatebennus bimaculatus and Fissurella volcano were common limpet species. Common nudibranchs were Rostanga pulchra, Hermissenda crassicornis, Phidiana pugnax, Doriopsilla albopunctata, Archidoris montereyensis, Cadlina luteomarginata, C. modesta, C. flavomaculata, Tritonia festiva and Diaulula sandiegensis. The nudibranch, Phidiana pugnax, was unusually abundant; more than twenty individuals were noted during one low tide.

Crabs included Pachygrapsus crassipes, Hapalogaster cavicauda, Pagurus granosimanus, Petrolisthes cinctipes, Pugettia producta, and a species of Lophopanopeus. The colorful shrimp, Spirontocaris prionota, was found under rocks.

Enchinoderms, cnidarians, tunicates and sponges also occurred in the mid and lower intertidal zones. Epiactus prolifera and Tealia lofotensis were the most frequently encountered species of anemone; the stony coral occurred in patches. Sea stars were fairly scarce, with the exception of the young thin star, Henricia leviuscula, the bat star and the ochre star, which were seen occasionally. Encrusting and stalked tunicates were found on rock sides and under ledges; species included Metandrocarpa taylori, Archidistoma diaphanes, A. psammion, A. ritteri, Diplosoma macdonaldi, Euherdmania claviformis, and Clavelina huntsmani. Small patches of the red sponge, Axocielita hartmani, were seen under rock ledges.

At the survey site just north of Arrowhead Point, the intertidal zone consisted of large cobbles covering a finely sorted sand beach.

Flora and fauna were scarce in the high intertidal zone. Algae consisted of Pelvetiopsis limitata, Endocladia muricata and Fucus distichus. The black turban snail was common, as was the aggregating anemone which was found in cracks. Lissothuria nutriens, a small red sea cucumber, was frequently noted.

In the mid-intertidal zone, algae completely covered the boulders, and included Prionitis lanceolata, Cystoseira osmundacea, Egregia menziesii, Neoagardhiella baileyi, Gelidium sp., Cryptopleura lobulifera, Laurencia pacifica, and L. splendens. Microcladia sp. was an epiphyte on P. lanceolata. Several species of Gigartina (canaliculata, papillata, and leptorhynchos), Cladophora sp. and Leathesia difformis were also seen. The ubiquitous corallines were abundant, particularly underneath other algae.

Invertebrates in this area were sparse, and were found primarily under rocks. A distinct hydrogen sulfide odor was present under rocks, possibly resulting from decaying algae. Mollusks included Calliostoma canaliculatum, brown turban snails, and various nudibranchs: Rostanga pulchra, Doriopsilla albopunctata, Cadlina modesta, Triopha maculata, T. carpenteri, Hopkinsia rosacea and Diaulula sandiegensis. Other organisms found under rocks were Clavelina huntsmani, Balanophyllia elegans, Archidistoma psammion, Leptasterias hexactis and bat stars. The paucity of invetebrates in this area is probably due in part to the lack of ledges and overhangs.

On the cliff sides of Arrowhead Point, species composition was somewhat different. The most abundant algae were Iridaea spp., Ulva spp., giant kelp, various species of Gigartina, and Postelsia palmaeformis. The limpet Collisella limatula was abundant in the high intertidal. Crevices in the cliff harbored black abalone and crabs. The lower part of the cliff was covered with the tunicates Archidistoma ritteri, Didemnum carnulentum and Clavelina huntsmani and the red sponge. The sea ochre and giant sea stars were common as well. The crabs Pagurus granosimanus, Pugettia producta and Petrolisthes cinctipes were common in tidepools.

There is no access to the approximately 0.8 miles (1.3 km) of intertidal area from the south side of Arrowhead Point to the City of Carmel Beach. The City of Carmel Beach area is characterized by high dunes and finely sorted sand. No infauna surveys were conducted in that area.

Mission (Carmel) Point intertidal survey site is a large (.8 miles or 1.3 km of shoreline) granite outcrop just south of the beach. The intertidal zone consists of large boulders and rocks covering a basement of granite, with coarse sand and shell fragments between and beneath the rocks. Because intertidal habitat is varied and extensive, the diversity and abundance of organisms is high. The intertidal survey transect line extended from just north of the "Butterfly House" (second home on the point seaward of Scenic Drive, going south) to the water line. Typical splash zone invertebrates occurred on the tops of large boulders: the goose barnacle, the mussel, and barnacles, Balanus spp.

Zone 1 (Ricketts and Calvin, 1968) contained algal species seen at other survey sites in this zone: Pelvetia fastigiata, Fuchus distichus, and Gigartina canaliculata. The sides of rocks contained patches of Ulva spp. and Iridaea spp, along with Gigartina papillata. Limpets were abundant here, including Collisella limatula, C. scabra and C. digitalis. Black turban snails and aggregating anemone also occurred on rock sides, with cracks harboring the rocky shore crab. Large, high intertidal pools contained Prionitis sp., the bat sea star, the pink bubblegum nudibranch, Hopkinsia rosacea, and small rock sculpins.

In Zone 2, additional species became abundant. Algae included Leathesia difformis, Iridaea spp., Cystoseira osmundacea and surfgrass and feather boa kelp. Occasional clumps of Codium fragile were noted. Large encrusting masses of sponges occurred frequently on the sides of rocks and under ledges, and included Antho lithophoenix, Axocielita originalis, Sigmadocia edaphus, Lissodendoryx firma, Leuconia heathi, Craniella sp. and Tetilla sp. Masses of Tethya aurantia were seen occasionally. Undoubtedly, this is only a partial list of sponges present here; species identification of the red sponges in particular would require spicule preparation and could not be done in the field. The strawberry anemone was common, as was the similar-appearing stony coral.

In Zones 3 and 4, rocks and tide pools were completely covered by algae, particularly the long stipes of feather boa kelp. Species already mentioned in Zone 2 were joined by Gastroclonium coulteri, Neoagardhiella baileyi, Prionitis lanceolata, Cryptopleura lobulifera, Laurencia blinksii and Gigartina exasperata, all of which were abundant and grew on other algae as well as rock surfaces. Deeper pools in these zones contained corallines, Costaria costata, Dictyoneurum californicum and occasionally stipes of giant kelp. The sea palm occurred on the seaward edge of the intertidal.

Cniderians were common in the low intertidal zone. Strawberry anemone was abundant, and the large solitary anemone occurred frequently in larger pools. The brooding anemone was seen occasionally. Hydroids, Tubularia sp. and Plumularia spp., were abundant under ledges.

The sea stars Patiria miniata and Leptasterias hexactis were abundant here. The ochre star was found on exposed rock surfaces, whereas the leather star and the sunflower star, Pycnopodia helianthoides, occurred under rocks and algae in small pools. The purple urchin was seen occasionally in crevices.

The kelp crab, Pugettia producta, was common on boa kelp stipes. Small pools harbored Pagurus granosimanus and small Loxorhynchus crispatus, the decorator crab. Crabs common under rocks in pools were juvenile Cancer sp., the furry Hapalogaster cavicauda and the procelain crab, Petrolisthes cinctipes.

Sponges and tunicates were ubiquitous and abundant in the low intertidal zone. The small vase-shaped sponge, Leucilla nuttingi, occurred here, in addition to species previously named. Common tunicates included the light bulb tunicate, Clavelina huntsmani, and encrusting Aplidium solidum, Archidistoma ritteri and A. psammoin. Encrusting bryozoans, Scruocellaria sp., and various tube worms were also common here.

South of Mission Point, Carmel River Beach extends 1.3 miles to a small rocky point which marks the north end of San Jose Creek beach. Generally, the mouth of the Carmel River is located about midway along this stretch of beach; the river discharges seasonally to the bay at this point. However, 1977-78 winter storms caused high flows which cut away at the northern river banks, moving the river mouth to the south end of Carmel Point. Winter storms also caused the coarse-grained beach to be quite steep.

The Carmel Sanitary District outfall line is located south of the river, in a field of large boulders. This intertidal zone was surveyed under the direction of Dr. Isabella Abbott in 1973 (See Appendix 1 and 2).

A survey on a moderately low tide (-0.7 feet) was conducted at the rocky promontory which separates Carmel River Beach from San Jose Creek Beach; Zone 4 could not be surveyed on this occasion. Intertidal habitat consisted of high cliff sides and large boulders with interspersed coarse-grained sand.

The high intertidal zone contained typical biota found at other survey sites. Algal cover on rock tops consisted of Pelvetia fastigiata, Ulva spp. and Endocladia muricata. Limpets occurred occasionally and periwinkles were abundant in the splash zone. High on the cliffs were mussels and goose barnacles.

Sand between rocks was covered with Gracilaria sjoestedtii, an alga common in sandy areas. Several algal species covered the sides of rocks: Chaetomorpha sp., Pelvetiopsis limitata, Fucus distichus, boa kelp, sea lettuce and Gigartina spp. Corallines were common; turban snails were abundant. Both solitary and aggregating anemones were present.

In the mid to low intertidal zone, algal species occurring in abundance were: feather boa kelp, Cystoseira osmundacea, Cryptopleura violacea, Rhodoglossum affine, Grateloupia doryphora, Ulva spp. and corallines. Microcladia californica and M. coulteri occurred as epiphytes on other algae. Gigartina spp., Iridaea spp. and patches of Spongomorpha sp. were present. Surfgrass was common in large sandy areas.

In the boulder field on the south side of the cliff, invertebrates were not particularly abundant. The anemones Anthopleura xanthogrammica and Epiactus prolifera occurred here, as did the hydroid Bugula sp.

The most frequently seen sea stars were the bat star and ochre star. A solitary stalked ascidian was seen occasionally, as was the white and black nudibranch, Diaulula sandiegensis.

Invertebrates were more abundant close to the cliff. The chitons Nuttalina thomasi and Tonicella lineata were common. Additional nudibranch species here were Hermissenda crassicornis, Triopha carpenteri, T. maculata and Cadlina modesta. The strawberry anemone was the most abundant anemone; however, a few Epiactus prolifera and solitary anemone were present. Rocky shore crabs were abundant in rock crevices; Pagurus samuelis in small pools. Common sea stars were the ochre and giant stars and Dermasterias imbricata. The sponges Lissodendoryx topsenti and L. firma were seen frequently. Clavelina huntsmani, Archidistoma ritteri and Aplidium californicum were common tunicates.

The lowest intertidal zone (Zone 4) appeared to contain the same algal species found in Zone 3, as well as Laminaria farlowii, giant kelp and palm kelp.

Granite cliffs form the southern boundary of San Jose Beach. South of the cliffs is a rocky cove which extends to Granite Point, the southern boundary of the ASBS. The cove was the last remaining intertidal site surveyed.

The geology of the cove is completely different from that of the other survey sites. The low cliff face behind the cove is a large outcrop of Carmelo conglomerate. The north end of the cove is a granite outcrop, and the discontinuity between the granite and conglomerate is easily located. The cove itself contains a coarse-grained, steep beach with large cobbles on either side. The intertidal zone begins fairly low, on medium-sized rocks half-buried in sand. Consequently, only splash zone organisms are seen on the cliff faces enclosing the cove.

Splash zone biota was typical and similar to that at other locations. Fucus distichus, Pelvetiopsis limitata and Endocladia muricata were the algal species here. Invertebrates included mussels, goose barnacles and other barnacles. Periwinkles, Littorina sp. and Collisella digitalis were common; rocky shore crab was frequently seen in cracks.

Rocks along the beach and at the edges of the cove were covered with algae. Codium fragile was abundant and more common here than at the other survey sites. Common algal species were feather boa kelp, Gastroclonium coulteri, Ulva spp. and Iridaea spp. In the lower zones, Prionitis lanceolata and corallines were particularly common; Laminaria farlowii, Dictyoneurum californicum, Neoagardhiella baileyi, Cystoseira osmundacea, and various Gigartina and Microcladia species were seen frequently. Botryoglossum farlowianum (or Hymenena sp.) was also seen frequently.

Both brown and black turban snails were common. Other mollusks, Calliostoma costatum, Diodora aspera, and Ocenebra sp., were frequently seen. Several species of nudibranchs were common here: Cadlina luteomarginata, C. modesta, C. flavomaculata, Diaulula sandiegensis, Rostanga pulchra, Hopkinsia rosacea, Tritonia festiva and Triopha maculata.

The same cnidarian species were found as at other survey sites. However, Epiactis prolifera was more abundant here than elsewhere. Solitary and strawberry anemone and Tealia lofotensis were common; the solitary stony coral was found under ledges.

Other invertebrate groups were well represented at this site. The purple urchin, bat starfish and ochre sea star were common in deep pools and on cliff sides. One Pycnopodia helianthoides was noted. The acoel flatworm Polychoerus carmelensis was common as were masses of the colonial tube worm Phyllochaetopterus prolifera. Clumps of the stalked tunicate Ritterella aequalisiphonis were frequently seen, along with the ubiquitous red sponge.

Land Vegetation

Land vegetation adjacent to the ASBS is a mixture of native and introduced species, and reflects both present and past uses of the shoreline.

The Monterey cypress, Cupressus macrocarpa, able to withstand exposed conditions, is conspicuous at Pescadero Point. A stand of mature, open trees lines the private undeveloped property just southeast of the point. The point itself contains a dense, low-laying grove of cypress, and some newly planted trees. The aforementioned private land is covered by a broad expanse of Hottentot fig, Carpobrotus edulis, adjacent to the shoreline, and grasses and sage closer to the road.

The bayfront residential property south of the point appears to be somewhat forested; Monterey pine, Pinus radiata, is prominent from a distance.

Pebble Beach Golf Course contains grasses appropriate for fairways and greens; however, much of the native coastal scrub plant community has been left intact on the cliff faces of Arrowhead Point and south to Carmel City Beach. To a lesser extent, native vegetation (including pines and cypress), has been incorporated into the course's landscaping.

The sand dunes which form the north end of Carmel City Beach contain the most extensive vegetation adjacent to the beach. Native vegetation here includes bush lupine, salt grass, beach sagewart and bracken fern with some introduced small pine and cypress. The bluffs adjacent to the intertidal zone contain numerous dense thickets of acacia and eucalyptus.

The north end of Carmel River State Beach contains a somewhat altered coastal strand plant community, with sand verbena and beach pea covering the low-lying sand dunes. According to Dr. James Barry, State Park Plant Ecologist, "The strand community at Carmel River State Beach is dominated by beach bur, New Zealand spinach, Tetragonia tetragoniodes, yellow sand verbena, Abronia latifolia, bush lupine, beach poppy, Eschscholzia californica var. maritima, seaside salt bush, Atriplex californica, seaside painted cup, Hottentot fig, and sea fig." (Barry, et al. 1977 draft). Hottentot fig replaces native vegetation on the dunes near the parking lot and adjacent to Scenic Road.

Carmel Meadows, the middle portion of the state beach, is bordered by low cliffs or bluffs which contain dense coastal scrub vegetation. The prominent shrubs generally consist of California sagebrush, coyote brush, and bush lupine. California poppy, wild buckwheat, yarrow, and bush monkey flower are present at the fringes of the thicket.

The mouth of San Jose Creek is surrounded by willows. According to Vern Yadon of the Pacific Grove Natural History Museum, the very rare and endangered Hutchinson's delphinium, Delphinium hutchinsonae, occurs along lower San Jose Creek. (in Barry, et al. 1977 draft).

The cliffs south of Monastery Beach contain a variety of ground cover species of a herbaceous type. Succulents are found in crevices on the steepest cliffs. According to Dr. Barry, the very rare and endangered California dichondra, Dichondra donelliana, has been reported from this area.

Unique Components

One reason for the designation of Carmel Bay as an ASBS was the occurrence of the spectacular and rare purple hydrocoral, Allopora californica. The survey noted A. californica as being common at Pescadero Pinnacles, occasional at Mission Point (Figure 8), and rare (one colony) along the Pescadero Point transect. A large sheet of a similar species, the encrusting Allopora porphyra, was observed at Pescadero wash rock.

Many species of invertebrates found in Carmel Bay are scare or not generally encountered by divers in Monterey Bay to the northeast. These include the hydrocorals, Allopora california and A. porphyra, the sea anemone, Tealia crassicornis, the sponge, Toxadocia sp., the tunicate, Polyclinum planum, the sea squirt, Diplosoma macdonaldi, the starfish, Mediaster aequalis, the endoproct, Barentsia sp., the bryozoan, Diaperoecia californica, and Heteropora sp. (observed during the survey), and Poraniosis sp. and Psammogorgia arbuscula (observed by the authors on previous dives in the Carmel submarine canyon). Much of the fauna is poorly known (particularly the sponges, currently under investigation), and further research will undoubtedly reveal the presence of additional species which are rare or unique to the ASBS.

Sea otters are found in high densities in Carmel Bay; the area is primarily utilized by females and pups. Otters have been observed taking shelter in Stillwater Cove during rough weather. These animals have been considered a keystone species (Pearse, 1974), and the influence of the otters on the Carmel Bay subtidal area is evident in the reduced densities of their preferred prey, abalone and sea urchins. Otters were first recorded at Point Lobos in 1954 (Vandevere, 1969) and by 1962 their range had extended north of Carmel Bay to Point Pinos in Pacific Grove. (Farro, 1969).

LAND AND WATER USE DESCRIPTION

Marine Resource Harvesting

Commercial Fishing: The establishment of Carmel Bay Ecological Reserve in August, 1977, effectively eliminated commercial fishing within the ASBS, whose boundaries are the same as those of the Reserve (excluding the Pinnacles).

Prior to designation of the ASBS as a reserve, the bay supported a number of small, primarily winter fisheries, with a total value of about $40,000 per year to the fishermen. Spot prawns were fished in the Carmel canyon, using wicker basket traps set at 40-200 fathom depths. The largest commercial fishery in the bay was for rockfish; these were taken by various methods of longlining, as well as hook-and-line. Sablefish, flatfish, and surfperch were also fished commercially within the ASBS.

Kelp Harvesting: Kelp has been harvested commercially in Carmel Bay since 1967. For the period 1971-76, the harvest varied between 175 and 1,760 wet tons annually with the maximum tonnage harvested in 1976. Small amounts of kelp (less than 1 ton/year) are also removed from Still-water Cove on a regular basis to facilitate boat mooring.

The kelp beds within Carmel Bay are collectively referred to as "Bed 219" in the California Administrative Code and by the industry. Any portion of this "bed" may be harvested with the exception of that portion laying within Point Lobos State Reserve. However, most cutting occurs offshore from Carmel City Beach, between Arrowhead Point and Carmel Point and at minimum depths of 50 ft. (15 m).

The Department of Fish and Game is responsible for regulating use of the resource. Title 14, Section 165 of the Fish and Game Code places restrictions on commercial kelp harvesting as follows:

(1) No kelp shall be harvested at a depth of more than 4 feet (1.2 m) below the surface at time of cutting. (Frequently, kelp is cut at low tide to obtain the greatest quantity of kelp within this 4 ft. distance).

(2) No more than 5 percent of the total quantity harvested shall consist of bull kelp, Nereocystis.

Title 14 does not place additional limitations on the total quantity of the giant kelp, Macrocystis, which may be cut or the frequency of cutting. However, the Carmel Bay bed had never been cut more frequently than four times a year. Cutting is usually done in the summer when growth rate and canopy development of the bed are at a maximum. With the establishment of Carmel Bay Ecological Reserve in 1977, removal of more than 50 percent of Bed 219 in any four month period was prohibited.

Party Boats: Engineering-Science (1977) summarized the partyboat activity in Carmel Bay as follows:

> Of the twelve partyboats operating out of the Monterey port, it is estimated that one or more boats per day pass inside or stay within Carmel Bay to fish ... During the summer, fishing by as many as three to five partyboats is conducted close in to the kelp beds and beach areas whereas winter fishing occurs predominantly toward the middle of the Bay ... The most common fish taken by partyboats within Carmel Bay are rockfish and lingcod.

Skiffs and Shore Fishing: Little, if any, sportfishing occurs within the ASBS, due largely to the lack of skiff access. The closest boat ramp and marina for boat storage are at Monterey, more than 10 miles from the ASBS by boat.

Shore fishing is nearly lacking, as well, within the ASBS. A small amount of shore fishing occurs within Carmel River State Beach. According to a state park ranger, fishermen infrequently use the rocky headlands at the north and south ends of Monastery Beach for shore fishing.

Between 1968-69, the Department of Fish and Game surveyed shore fishermen in Carmel Bay (Miller, unpublished data). Scattered fishermen were encountered from Carmel City Beach south to Pt. Lobos. Perch fishermen were the most successful, with striped and calico surfperch the species most commonly caught. Shore fishermen in rocky areas caught limited numbers of kelp greenling, rock greenling, grass rockfish, black-and-yellow rockfish, and cabezon.

Spearfishing: A major portion of the sport-caught fish in the ASBS are taken by skin divers using spear guns. According to a 1972 Fish and Game survey, divers spent slightly over 4,000 hours spearfishing within the ASBS that year, and their total catch was 1,936 fish. It was estimated that the sportfish take by divers in Carmel Bay ammounted to 88 percent of the total for all of California north of Pt. Arguello.

As indicated in Table 4, rockfish were the major group of fish taken by Carmel Bay divers in 1972; their combined numbers account for 52.3% of the total diver-catch in the ASBS. Rockfish constituted a greater percentage of the catch at Monastery Beach (57%) than at Carmel Beaches (45%). The rockfish species composition at the two areas also differs somewhat. At Carmel Beaches, the catch consists of a mix of shallow water species, with kelp and olive rockfish most commonly caught. At Monastery Beach, kelp and blue rockfish predominate in the catch, which also includes some deeper water species - such as bocaccio - not available at all to divers elsewhere in the ASBS.

Greenlings are the second major fish group taken by divers in Carmel Bay, accounting for 26.1% of the total catch. Comparatively speaking, the bay is a particularly good area for diver take of these species; 22.2% of the total Northern California catch of greenling was from Carmel Bay in the 1972 Fish and Game survey. Lingcod is the most commonly caught species in this group and was the species of fish most frequently taken by divers at Monastery Beach.

Surfperch is the other major group of fish taken by divers in the ASBS (9.9% of total catch); most of these are striped perch. As a group,

TABLE 4

SPECIES COMPOSITION AND NUMBERS OF SPORTFISH TAKEN BY SKIN DIVERS IN ASBS, 1972

Species	Monastery Beach	Carmel Beaches	Total ASBS	% Northern California Total Taken in ASBS
Rockfish (Total)	663	349	1,012	13.5
Black	47	40	87	6.2
Black-and-yellow	57	59	116	28.5
Blue	135	53	188	8.9
Bocaccio	10	0	10	55.6
Brown	11	0	11	13.3
Copper	12	0	12	5.5
Gopher	38	23	61	23.5
Grass	76	14	90	9.3
Kelp	139	74	213	22.6
Olive	58	86	144	27.2
Unidentified	80	0	80	19.6
Greenlings	311	195	506	22.2
Greenling, kelp	33	65	98	29.3
" , painted	99	0	99	100.0
Lingcod	179	130	309	17.1
Surfperch	107	84	191	5.1
Pile	26	0	26	3.3
Striped	81	84	165	10.3
Miscellaneous	85	142	227	6.8
Cabezon	73	142	215	10.0
Clingfish	11	0	11	100.0
Kelp poacher	1	0	1	100.0
Total Fish	1,166	770	1,936	8.8

the take of surfperch is relatively small compared with other areas in Northern California.

Cabezon also ranks prominently among the sportfish commonly taken by divers in the ASBS. The take of cabezon was twice as great at Carmel Beaches as at Monastery Beach, even though the effort expended is considerably less.

Although the total sport take by spear fishermen is considerable in the ASBS, it is not indicative of diver preference or lucrative fishing grounds. The 1972 survey found that only 25% of the divers at Carmel Beaches were engaged in spearfishing, and only 15% at Monastery Beach. The average catch per hour was 0.45 at Monastery Beach and 0.51 at Carmel Beaches, which compares poorly with nearby Pacific Grove (.85 fish/hour) or other Northern California counties (up to 1.9 fish/hour).

The status of the ASBS as an ecological reserve precludes the sport take of invertebrates, such as abalone.

Municipal and Industrial Activities

Del Monte Forest: The northernmost portion of the ASBS is bordered by land owned by Del Monte Properties, Inc. Known as Del Monte Forest, this enormous tract of private land occupies 60 percent of the Monterey Peninsula (about 5,260 acres or 2,125 ha) and has 4 miles (6 km) of ocean frontage. About 3 miles (4.8 km) of coastline adjacent to the ASBS is occupied by Del Monte Forest, from Pescadero Point south to the city of Carmel-by-the-Sea.

Del Monte Forest has a variety of land uses. Thirty percent of the area is occupied by residences. Thirty-nine percent of the forest is undeveloped land. Much of this land is adjacent to Spanish Bay north of the ASBS. Twenty-four percent of the forest is in open space, for the most part in the form of golf courses, although some of it consists of riding trails, a botanical reserve, and scenic easements. Seven percent of the forest consists of private roads, including the Seventeen Mile

Drive which borders the coast from Pescadero Point to the Pebble Beach golf course. Del Monte Forest has a total about about 5,000 residents. The Del Monte Forest lands adjacent to the ASBS are known as Pebble Beach.

Carmel-by-the-Sea: The town of Carmel-by-the-Sea (hereinafter referred to as "Carmel") lies contiguous to the ASBS about midway between its northern and southern boundaries (Figure 9). Carmel is bordered to the north by Pescadero Canyon and to the South by Santa Lucia Street. The town has about 1.1 miles (1.8 km) of coastline. With the exception of some private property, the entire length is occupied by Carmel City Beach.

Carmel occupies 582 acres (233 ha), about one square mile. Its population in 1970 was 4,478.

Monterey County: South of the City of Carmel, land contiguous or adjacent to the ASBS is owned by a number of individuals and agencies. Residential subdivisions are not incorporated, and land use is regulated by the county. Carmel Point is just south of Carmel and north of the Carmel River; the subdivision occupies about 123 acres (49.2 ha) and includes 1.1 miles (1.8 km) of coastline. Mission Fields is a subdivision just east of Carmel Point and north of the Carmel River. Carmel Meadows is a 50-acre (20 ha) subdivision, located at the crest of a hill about 1/4-1/2 mile south of the Carmel River.

Residential development in Carmel Valley extends from Highway 1 east about 15 miles (24 km) along both sides of the Carmel River. The total population of the valley is about 9,000. Land uses here include retirment and resort developments, golf courses, limited truck farming, and commercial establishments. According to a recent study (Sedway/Cooke, 1977), Carmel Valley will experience the greatest population growth of any area in proximity to the Carmel Sanitary District's service area. The county estimates the holding capacity of the valley at 10,663 dwelling units; at the projected 1998 household size of 2.26 persons, the maximum future population in the valley will be about 22,000 persons.

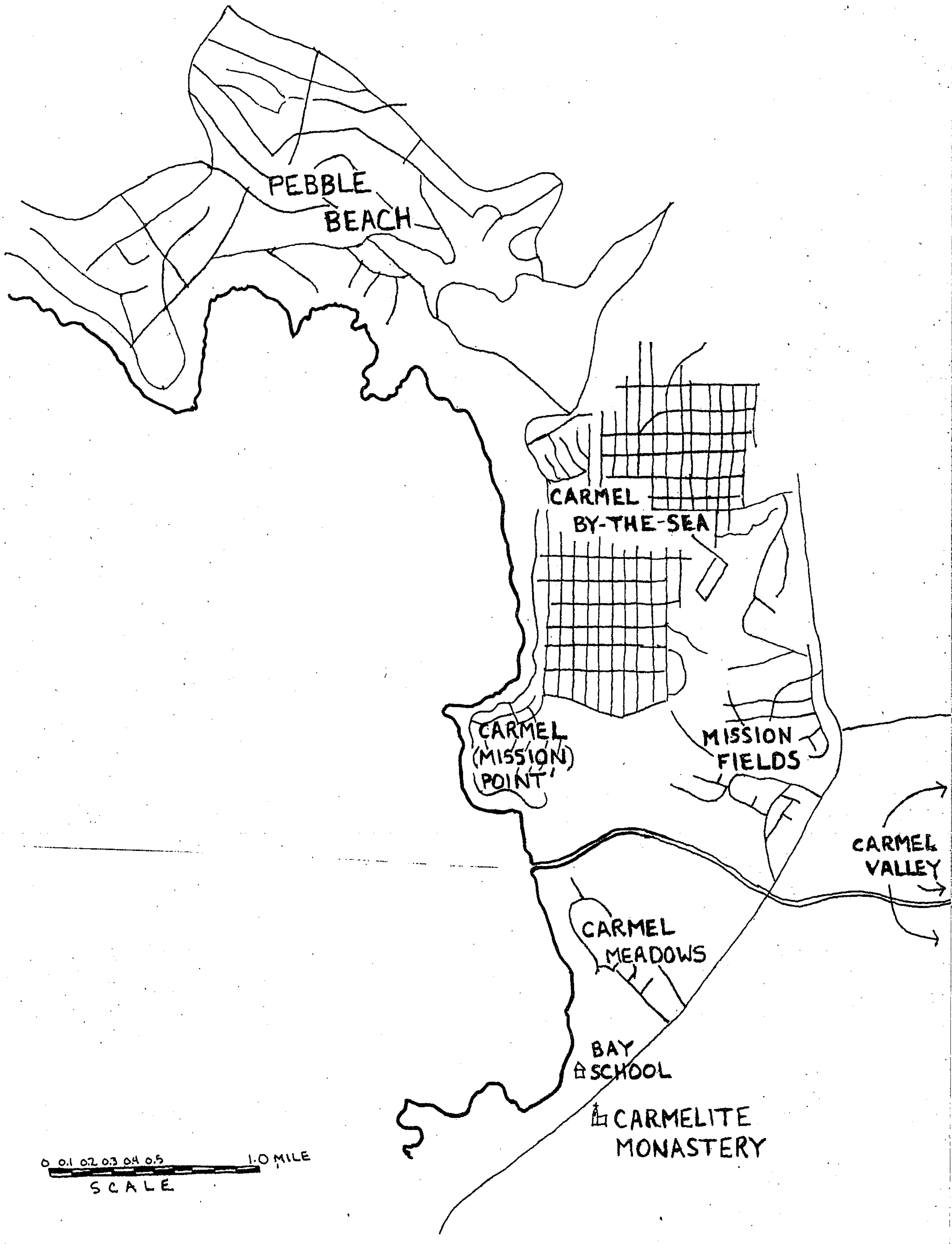


Figure 9: Residential Land Use Adjacent to the ASBS

Industrial Activities: The only industries which exist adjacent to or within one mile of the ASBS are restaurants, hotels/motels and commercial businesses. All wastewater from these industries is discharged to the sanitary sewer and treated at the Carmel plant.

Agribusiness and Silviculture

Lands adjacent to the Carmel River are ideally suited for agricultural production and grazing. However, land values have made such land uses less profitable as compared with residential development. Small acreages of land have retained rural land uses usually only because they are scenic easements, publicly owned, or awaiting approval for development. Several parcels in the vicinity of the ASBS warrant mention:

Odello Ranch West: West of Highway 1, and just south of the Carmel sewage treatment plant, is a 153 acre (62 ha) parcel of land owned by the State of California Department of Parks and Recreation. Prior to public acquisition in 1974, the land was owned and farmed. Presently, the land continues to be cultivated for artichokes. Between 1947-70, this artichoke field and 1/3 of the eastern Odello field were the disposal site for 20-30% of the Carmel plant's primary effluent and all of its sludge. The Department of Parks and Recreation is not adverse to continued sewage effluent dispoal here, if it is compatible with primary use of the land. However, at this time it is not certain that the land will remain in agricultural production.

Odello Ranch East: The 134.2 acre (54 ha) parcel of the Odello Ranch east of Highway 1, and just south of the river, remains in private ownership. Ninety acres (36 ha) of the land is in agricultural production.

Hudson Ranch: The portion of the Hudson Ranch west of Highway 1 has historically been used for grazing cattle. The land continued to be grazed by cattle after it was acquired by the State in 1974.

East of Highway 1, the Hudson Ranch remains in private, multiple ownership and extends several miles inland.

Government Designated Open Space

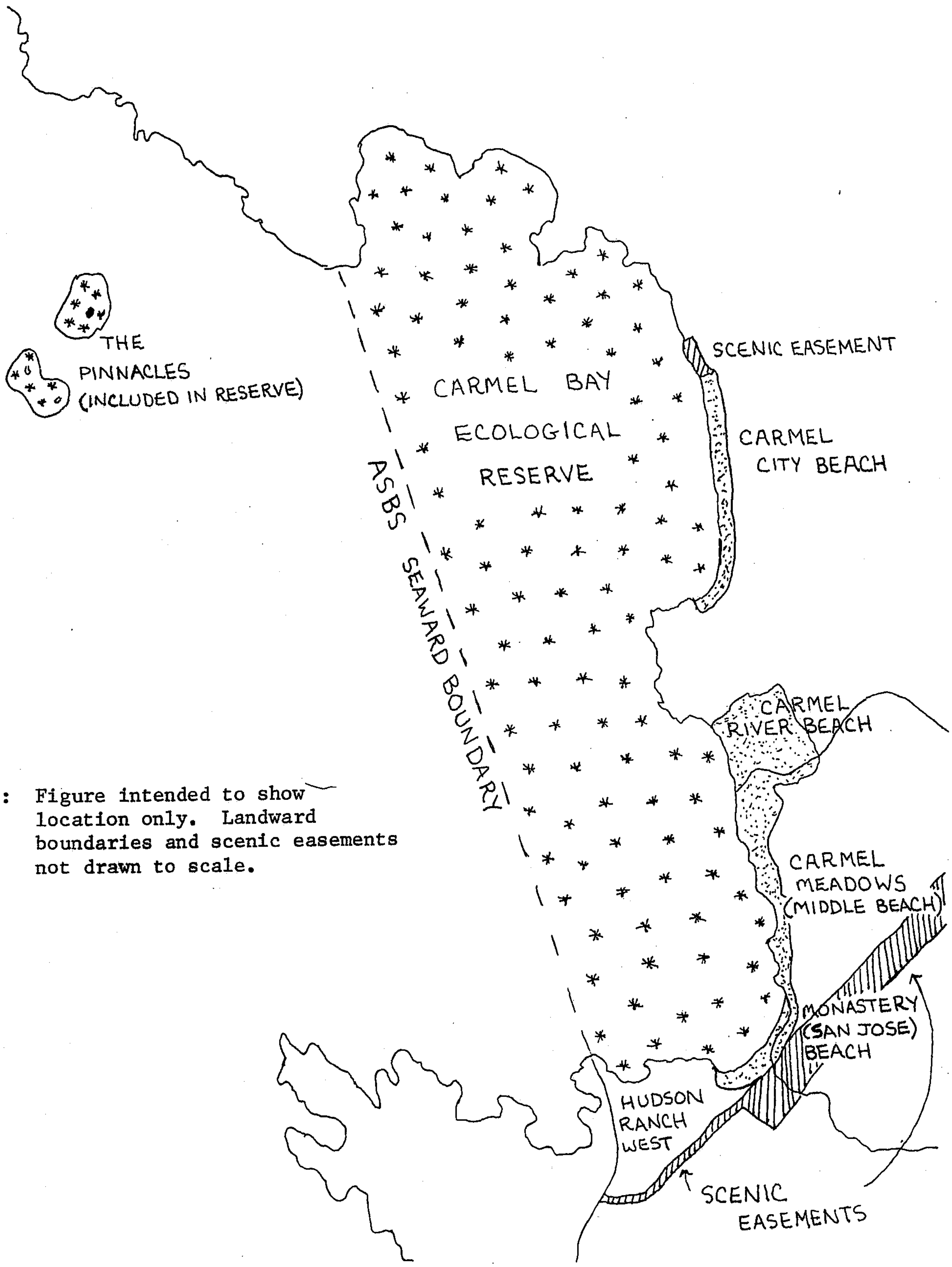
Coastal Zone: The Coastal Zone Commission will largely determine the form and amount of land development adjacent to the ASBS in the near future. As much of the land is presently open space and available for development, this regulatory control is important to the protection of the ASBS. The approximate jurisdictional boundary of the Coastal Commission is shown in Figure 10.

Carmel Bay Ecological Reserve: The ASBS was designated an Ecological Reserve on August 27, 1977 by the California Fish and Game Commission. The Reserve extends from the mean high tide line to offshore boundaries coincidental with those of the ASBS. The Reserve also includes the shallow waters to 90 feet (15 fathoms) depth, surrounding the Pinnacles, which are outside of the ASBS. Total area of the reserve is 1,642 acres (663 ha) (Figure 9).

Within the reserve, commercial fishing and the sport or commercial harvesting of invertebrates is prohibited. Sportfishing by hook-and-line or speargun is permitted. Commercial kelp harvesting is allowed, within regulations established by the Commission (California Administrative Code, Title 14, Section 630(b) (26)), as discussed previously in this report.

Carmel City Beach: Between Pescadero Point and Carmel, coastal lands are privately owned. However, most of the land is open space, as part of the Pebble Beach Golf Course.

Adjacent to the city of Carmel, the bay is bordered by a strip of open space known as Carmel City Beach. The beach occupies about 5,000 feet (1,823 m) of coastline and 21.57 acres (8.7 ha) of land. At the northern boundary (4th Avenue), the beach has its maximum width of about 1,100 feet (400 m) and consists of sand dunes, with native and introduced vegetation. The beach's public facilities, a large parking lot and rest-



Note: Figure intended to show location only. Landward boundaries and scenic easements not drawn to scale.

Figure 10: Government Designated Open Space Adjacent to or in Carmel Bay ASBS

rooms, are located at the foot of Ocean Avenue. The southern end of the beach consists of little more than intertidal sandy beach and cliffs. During heavy storms, most of the sand beach on the south can be washed out, and the cliffs eroded away considerably.

Carmel River State Beach: This State park is a narrow coastal beach with rocky headlands and extends from 1/4 of a mile north (0.4 km) to just south of San Jose Creek. The beach has about 8,100 feet (2.954 km) of shoreline of the Carmel River and an area of about 105 acres (41 ha).

The State park consists of three distinct sections, which vary considerably in topography, access and type of recreational use. The flat sandy beach north of the Carmel River is generally referred to as Carmel River Beach and includes the marshland northeast of the river mouth. The narrow beach and headlands south of the river to Monastery Beach is known as Middle Beach or Carmel Meadows.

South of Carmel Meadows, the State beach forms a semi-protected sandy cove which encloses the head of Carmel submarine canyon and drains San Jose Creek. This section of beach is referred to as San Jose Beach, or Monastery Beach, after the Carmelite Monastery on the opposite side of Highway 1.

Recreational Uses

Carmel Bay and its shoreline are an extremely valuable recreational asset to the Monterey Peninsula. The economy of the Monterey Bay area is, to a large extent, tourist based; and much of the tourist visitation is due to the recreational activities which occur on or adjacent to the bays.

Seventeen Mile Drive (Del Monte Forest): The Seventeen Mile Drive, adjacent to the northern portion of the ASBS, is a major tourist attraction. The Pebble Beach Corporation estimates that its use is around one million visitor days per year. Most visitors enter by private vehicle, although numerous tour buses include the drive in their itinerary. The

Pebble Beach golf links are the main attraction on the drive adjacent to Carmel Bay. The Seventeen Mile Drive is also used for recreational bicycling.

Pebble Beach Golf Links: Pebble Beach Golf Links is an 18-hole private golf course located on 150 acres (60.7 ha) of land adjacent to the northern portion of the ASBS. Much of the course's difficulty, as well as its beauty, stems from its proximity to Carmel Bay. Eight of the fairways are at water's edge with holes seven and eight forming Arrowhead Point. The highly publicized relationship between the fairways and the nearshore waters renders this an important recreational use of the ASBS waters.

Stillwater Cove: The principle recreational use of Stillwater Cove is as a moorage for resident and visiting pleasure craft. During the summer, the cove provides berths for 40 boats, most of them small sailboats.

Carmel City Beach: Carmel City Beach is a clean, white sand beach ideally suited for a variety of recreational uses. These include: strolling, jogging, sunbathing, picnicking, and photography. The water is generally too cold for swimming; the only individuals usually seen in the water are surfers.

Carmel City Beach is of particular importance to local residents, probably because it is within walking distance of residential areas and has good public access.

The city beach receives the heaviest recreational use of any portion of the coastline adjacent to the ASBS. Actual use figures do not exist, but the city estimates average daily use to be 1,000 with maximum crowds of up to about 15,000.

Carmel River State Beach: The State Department of Parks and Recreation estimates an average of 220,000 user-days a year for Carmel River State Beach. Use of the beach is heaviest on weekends and holidays; in

1977, an average of 1,337 people/day used the beach on weekends, and only 260 people/day used the beach during the week.

Recreational use of Carmel River Beach, the northernmost section of the State park, centers around the lagoon which forms just east of the river mouth. This area is frequently used for family outings and picnics. Swimming is done in the lagoon, rather than the bay. North of the lagoon is a large brackish water marsh which has been designated Carmel River State Beach Bird Sanctuary; the marsh attracts bird watchers, photographers and hikers. The Carmel River deposits a considerable amount of driftwood near its mouth, and driftwood collecting is another recreational pursuit.

Monastery Beach, the southernmost section of the park, experiences the heaviest recreational use. On a typical weekend, user density at Monastery is about 2,000/mile/day, and only 450/mile/day for the rest of the beach. On the peak usage day in 1977, there were about 2,750 people at Monastery Beach.

Monastary Beach is used primarily by skin divers. In a 1972 survey, Fish and Game found that skin diving at Carmel River State Beach accounted for about 14,848 diver days or 31.6% of <u>all</u> diving activity in California from Pismo Beach north. Most diving is SCUBA diving started from Monastery Beach.

Scientific Use

Numerous academic and public agencies have utilized Carmel Bay in biological and oceanographic studies. However, the bay has not been studied as extensively as nearby Monterey Bay. Much of the literature relating to this research is listed in the bibliography.

Hopkins Marine Station has, in the past, researched the intertidal aspects of Carmel Bay. Staff or students from Hopkins have studied the distribution, productivity and recruitment of organisms in the vicinity of the previous Carmel outfall. Dr. Isabel Abbott of the Station conducted pre-and post discharge surveys at the old and new discharge locations, and recommended a program for monitoring the biota near the new discharge location. In addition, the species of sea anemones found in Carmel Bay have been surveyed, and Dr. Isabel Abbott has conducted research on Stillwater Cove algae.

Moss Landing Marine Laboratories utilizes Carmel Bay extensively for research and instruction. Recently completed work includes a research on the effects of kelp harvesting on snail populations, (Hunt, 1976) and a study of the bat star, *Patiria miniata* and its commensal polychaete in Stillwater Cove (Farris, 1977). Other work includes a study of the population dynamics of *Pterygophora* sp., a study of the turban snail, *Tegula* sp. distribution, and examination of sea otter-sea urchin interaction (Mike Foster, personal communication). These studies utilize stations off Pescadero Point and in Stillwater Cove.

Moss Landing's Subtidal Ecology class maintains two permanent stations in Stillwater Cove and has recorded the algae and macroinvertebrates present there for the past two years. Individual student projects for the class also utilize these stations. In addition, Moss Landing uses the cove as a dive site for its basic SCUBA class.

Carmel Bay has also provided thesis problems for students at University of California, Santa Cruz and at the United States Naval Postgraduate School.

The California Department of Fish and Game has recently conducted two long-term projects in Carmel Bay. Field work for the Central California Marine Sportfish Survey was completed in 1977, and involved research on the distribution and relative abundance of juvenile sport fish, the effects of kelp canopy removal on juveniles, and life histories of common inshore fishes. The ongoing Sea Otter Study includes aerial surveys of Carmel Bay kelp beds, and documents the distribution, population structure, and life history of sea otters. (Jack Ames, personal communication).

Monitoring studies of the Carmel Sanitary District discharge have generated a great deal of information on the distribution, abundance, and species composition of the subtidal biota in the south bay. The work has been done under contract by various engineering firms (see bibliography). The 1977 biological oceanographic literature review by Kinnetics summarizes studies which have been done in the vicinity of the outfall and elsewhere in Carmel Bay.

The intertidal zone of the bay is particularly valuable for educational purposes, as a variety of relatively unspoiled habitats exist in close proximity to each other and illustrate local geological features. Primary, secondary and college level classes from as far away as Fresno utilize Mission (Carmel) Point during low tides for field trips.

Two major and fairly recent reference works, Marine Algae of California, and Light's Manual to Intertidal Invertebrates of the Central California Coast, draw heavily from specimens collected in Carmel Bay. The bay is the type locality for many species (see Appendix 1) i.e., the original species description was prepared based on a specimen(s) collected from this area. Some species are restricted to the bay (see Appendix 1), and unnamed species are still being found.

The biological diversity and richness of Carmel Bay, together with its proximity to numerous academic institutions, make it an extremely important site for scientific research and education.

Transportation Corridors

Land Transportation Routes: Between Pescadero Point and the city of Carmel, the ASBS is bordered by the privately owned Seventeen Mile Drive (Figure 11).

The drive is used by residents, transients and tourists, with use by the different categories somewhat staggered throughout the day. In 1977, a total of about 3 1/2 million vehicles entered the drive (average = 9,900 vehicles/day). The average for the off season was 8,731 vehicles/day; the average for the summer season was 11,523 vehicles/day, or a 76% increase. Maximum use in 1977 occurred during the PGA golf tournament,

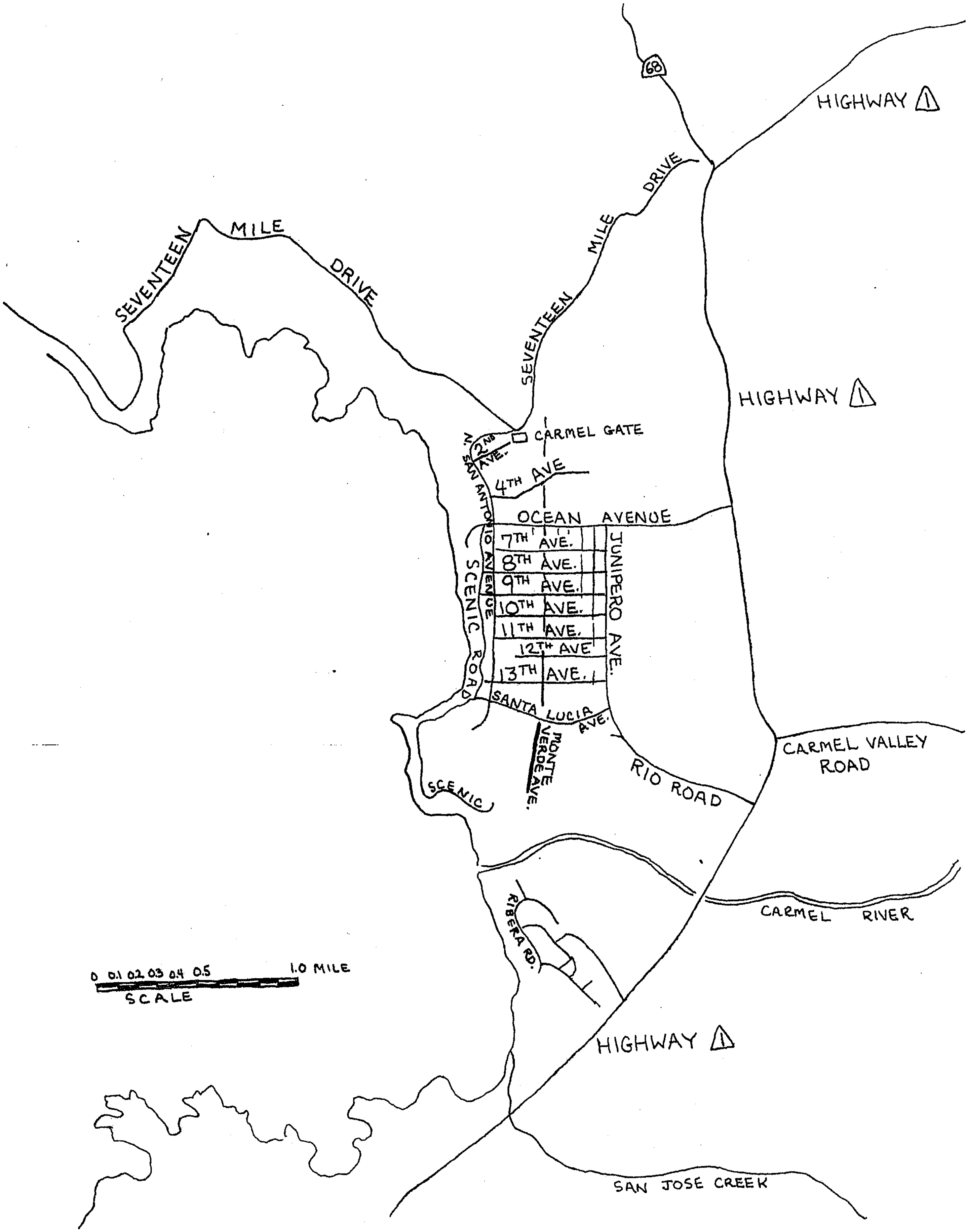


Figure 11: Highways, Scenic Drives and Surface Streets Adjacent to ASBS

when over 17,000 vehicles entered the drive daily (all data, traffic counts by Pebble Beach Corporation).

South of the Seventeen Mile Drive, the ASBS is bordered in Carmel by city streets.

The city estimates that over 12,000 cars enter Carmel daily, with much of this traffic due to the numerous tourist oriented businesses.

South of Carmel, Highway 1 is a fairly straight two-lane road with wide shoulders, gentle gradients, and good visibility. The average annual daily traffic (AADT) in the vicinity of the beach has been estimated at 9,100 (CalTrans, 1975), with peak flows at 1,830 vehicles per hour, close to the highway's capacity at this point.

CalTrans (1975) projected that an average daily traffic flow of about 15,000 cars by the year 1995 on Highway 1 in the vicinity of the ASBS. Although peak traffic loads approach the highway's capacity, public opinion and agency decisions have opposed widening the highway beyond its present two lanes.

ACTUAL OR POTENTIAL POLLUTION THREATS

Point Sources

Carmel Sanitary District Sewage Treatment Plant Discharge: The Carmel Sanitary District (CSD) sewage treatment plant serves a large land area with a relatively small population. The service area extends to the north to include Del Monte Forest (collection system maintained by the Pebble Beach Sanitary District) and to the east to include part of the lower Carmel Valley. Adjacent to the ASBS, the wastewater collection system is a combination of gravity flow and pressure lines. The service area generally does not extend south of the Carmel River, with the exception of Carmel Meadows (1/2 mile south of the treatment plant), and Hacienda Carmel. The total population within the service area is about 17,500.

Potential problems with pump station locations in the flood plain, inadequate peak flow pump capacity, and untreated waste bypasses have been identified and are proposed for correction. With the exception of numerous restaurants and a few photography lab discharges, all wastewater within the system is of domestic origin.

The Carmel treatment plant's current capacity is 2.4 MGD. Within the present service area, this capacity will not be exceeded until about 1994 (Kennedy Engineers, 1978).

However, much of the area adjacent to the present service area is being developed, and the district was asked to consider the impact of an expanded service area on flows into the plant. As a relatively high growth rate is projected for the Carmel Valley in the near future (Sedway/Cooke, 1977), the annexation of these areas would eventually cause a more drastic increase in plant flows. Kennedy Engineers (1978) estimated that flows would reach 4.6 MGD in an expanded service area by 1998, with Carmel Valley and Carmel Highlands contributing 46% of the total flow. The plant's present capacity would be exceeded almost immediately if the service area were expanded to include adjacent lands not presently sewered.

The Carmel sewage treatment plant is located on 15.2 acres of county land just south of the Carmel River and north of the Odello fields. The treatment plant is 3,000 ft. east of Carmel Bay and is fronted by Carmel State Beach and agricultural land. The plant is 15 ft. above sea level, and as stated by the district's information sheet, "all critical treatment units ... are designed to be unaffected by flooding up to the projected 100 year flood level."

The Carmel plant provides secondary treatment (activated sludge process) to about 2 MGD of primarily domestic sewage. The district first committed itself to secondary treatment in 1967; the plant was completed in 1972, and discharge through the extended outfall line commenced in 1973.

The plant, as designed, had a capacity of 3 MGD. Certain elements of the secondary plant are oversized to accommodate future expansion. Both the headworks and effluent pump station have a capacity of 8 MGD, and contain space for additional facilities which would increase their handling capacity to 14 MGD. The treatment plant has sufficient land space to construct additional clarifiers, aerators, and digesters, so that the overall capacity could be increased to 14 MGD if necessary (Kennedy Engineers, 1974).

The secondary plant was designed to produce effluent with a maximum BOD of 20 mg/1 (93% removal), maximum TSS of 20 mg/1 (93% removal) maximum O&GT of 20 mg/1 (67% removal) and is post-chlorinated without dechlorination. During the first four years of the secondary plant's operation, the average percentage removal of TSS was 92% (to 24 mg/1); removal of BOD was 90% (to 25 mg/1); and removal of O&GT was 97% (to 1.6 mg/1) (Appendix 5a). Erratic, high values for TSS and BOD have occurred, primarily during the first two years of the secondary plant's operation, and since then values (measured daily or three times a week) have not deviated far from average values. Average Settleable Solids (SS) during these four years has been .24 mg/1, with the highest monthly average (2.7 mg/1) recorded in August, 1974. These performance data are based on self-monitoring data that are summarized in Appendix 5.

The district also monitors the concentration of total identifiable chlorinated hydrocarbons and polychlorinated biphenyls (PCB) in the effluent once or twice a year. Average values were below detection levels with analytical techniques utilized (Appendix 5b). Monitoring data for bacterial examinations in the effluent are presented in Appendixes 5c and 5d.

The district has measured the acute toxicity of the effluent semi-annually, by performing 96-hour static bioassays using sticklebacks as the test organism. The median tolerance limit varied between 100 and 38% waste by volume, with a gradual increase in toxicity from 1974-1977 (Appendix 5e). The greater toxicity of the effluent could be attributed to higher ammonia, zinc, silver and/or copper values as well as other unidentified constituents, as concentrations of all these parameters increased during these drought years.

The Carmel treatment plant effluent is presently discharged into the ASBS 600 feet (182 m) offshore from the shoreline at a depth of 33-39 feet (9.9-11.7 m). The outfall line begins about 200 feet (61 m) south of the mouth of the Carmel River and extends from there in a west-southwest direction (Figure 1). The 24 inch diameter outfall line lies in a channel between rock formations and is encased and anchored to the rocks with a minimum cover of 1 1/2 feet of concrete. The outfall ends in a 100 foot length diffuser structure, with ten 4 inch diameter ports (five in use) which direct flow at right angles to either side of the diffuser. As the diffuser structure is oriented in a ENE-WSW direction, flow is initially directed in a WNW-ESE direction. The discharge velocity shoreward to the ESE is often amplified by the prevailing NW currents in this area (OSI, 1975).

One of the shoreward diffuser ports impinges directly upon a vertical rock face. In 1975, the company contracted to monitor the discharge area (Kinnetics Laboratories, Inc.) reported that this high impact area "is barren except for a scum-like material" and attributed this to the inability of organisms to recruit here (Kinnetics, 1976). In 1976, Kinnetics estimated that the size of the high impact area was about $20m^2$, with the heaviest impacted area (about $3m^2$) remaining "black". The adjacent area (about $7m^2$) was covered by primarily crustose corallines, and the outer regions (about $10m^2$) contained Balanophyllia elegans, as well (Kinnetics, 1977). In 1977 Kinnetics reported that "The faunal cover of the impact area has increased significantly from 1976 to 1977. This increased cover of animals consists mainly of Balanus and Phragmatopoma." (Kinnetics, 1978). Kinnetics also reported that the black zone had shrunk from 1.5 to 1.2 m in diameter, and "during the fall had essentially disappeared ... (having) a light cover of Prionitis lanceolata and a heavy cover of Balanus sp." (Kinnetics, 1978).

The apparent partial recovery of the high impact area occurred over a period of time when effluent flows were decreasing, and effluent toxicity was variable and probably increasing (as indicated by the bioassays). Thus, it is possible that the adverse effects in the high impact area are due to a significant degree to the high impact of the discharge rather than to any particular characteristic of the effluent itself.

Kinnetics commented that "such local effects" as occur in the high impact area "are expected and cannot be attributed to the general outfall vicinity." (Kinnetics, 1976, 1977).

The discharge occurs in a transition area of granite rock and sand. There is considerable wave action and surge, with the result that the bases of rocks are frequently sand-scoured. Even when the effluent contained an inordinate amount of particulate matter, Kinnetics reported "that no sedimentation was ever noted because of the high water movement associated with the area." (Kinnetics, 1976).

Early (1973-1975) monitoring work included dye studies which attempted to assess the extent of the waste field created by the discharge. The use of dye as an indicator probably shows diminution to occur less rapidly than it actually does, as it does not measure biological decay (OSI, 1975). The maximum extent of the waste field, as indicated by the dye studies, was 800 meters in a north-south direction and 600 meters in an east-west direction. However, the observations were limited to a maximum of seven hours. The maximum field extended northward to the mouth of the Carmel River, and southward to the rocky promontory just north of Monastery Beach. To the west, the field stopped at the 15 fathom curve enclosing the Carmel submarine canyon. The field reached the shoreline east of the outfall in one of the five studies (ESD, 1974; OSI, 1975).

Oceanographic Services, Inc. (1975) postulated that several oceanographic features of the area discouraged further dispersion of the waste field. They hypothesized that upwelling in the Carmel submarine canyon and subsequent vertical currents created a barrier to additional lateral spreading of the field to the south and west. They also noted that "the littoral current driven waves refracted toward the Carmel River Beach acts as a barrier that prevents undiluted effluent from reaching the beach most of the time." (OSI, 1975).

Within the waste field, the dye studies indicated that dispersion occurs more rapidly to the south and west, in part because net transport of water in the south bay is to the south. Dispersion rates and direction did not appear to be affected by the tides (OSI, 1975).

In June, 1976, Kinnetics used ammonia concentrations to measure dilution rates in the receiving waters. During the one-day observation period, ammonia concentrations at various stations indicated that "the effluent flow is shoreward, south, and toward the surface, and also that the high impact area is small." (Kinnetics, 1977). Kinnetics calculated that the initial dilution in the surface boil was 12:1. However, using U.S. EPA's plume model, initial dilution would be 62:1 or greater (personal communication, J. Nighswonger, RWQCB).

The existing outfall line was constructed in 1972, and the sanitary district began discharging secondary treated sewage through it in mid-1973. Since that time, various contracted agencies have attempted to assess and monitor the impact of the discharge on the subtidal environment (Appendix 4).

Between 1973 and 1975, three different contractors measured physical parameters - temperature, salinity, dissolved oxygen, pH, turbidity, and total oil and grease - along an "outfall" transect and 9-10 "control" transects located north and south of the outfall line. However, such an assessment was not possible because: (1) without background information, it was impossible to distinguish between natural fluctuations and those caused by the discharge; (2) insufficient synoptic observations were made on other factors which could have caused fluctuations (such as Carmel River flow), and the separate effects of such factors are not known; (3) no synoptic measurements were made of the effluent at the time receiving water measurements were made, which would have allowed high receiving water values to be correlated with those in the effluent or attributed to an outside cause or poor sampling/analytical techniques; (4) the transects were spread over an area where one would expect a great deal of natural variability in oceanographic features; and (5) the measurements were made far too infrequently.

Occasionally, one or more parameters near the outfall deviated slightly from those found at the "control" stations. However, as often as not these deviations were the opposite of what would be expected in a waste field - temperature was depressed, or salinity values were elevated, indicating that such differences are the result of natural variability. Dissolved oxygen values were infrequently lower at the outfall, but this could be attributed to higher salinites, or differences in thermocline formation as easily as to the influence of the discharge. Oil and grease values were always low (less than 10 mg/l), and earlier high values could be attributed to cruder sampling/analytical techniques as well as to the discharge quality. As oil and grease were not measured in the effluent until late 1975, it is impossible to determine the relationship.

During the sampling period (1973-1975), the effluent may have occasionally reduced light transmittance. Kinnetics noted that visibility was reduced to 2.9-3.5 m in the waste plume and attributed this to the "missing of waters of greatly different salinities. During periods of higher flow ... a suspension of black particulate matter was noted in the effluent along with a noticeable loss in ambient light at the bottom." (Kinnetics, 1976). Kinnetics observed that the greater turbidity did not have any biological effects (Kinnetics, 1977) and did not result in increased sedimentation (Kinnetics, 1976). Their comparison of the sparse data indicated that the Carmel River seasonally caused a greater reduction in light transmittance than the waste discharge and may have been responsible for some of the turbidity measured along the outfall transect (OSI graphs, in OSI, 1975).

Kinnetics concluded that "little or no effect of the wastewater outfall can be detected by monitoring the cardinal parameters of DO, pH, salinity, temperature, etc. The variability in data presented is felt to be attributed to the natural variability found in a well-mixed, high water movement area like southern Carmel Bay." (Kinnetics, 1977).

The Sanitary District has also monitored total coliform in the receiving waters, primarily at three shore stations located just shoreward of the outfall, and 1/4 mile to the north and to the south. Values measured in the receiving waters are almost always low, and do not correlate with effluent values (Appendices 5c and 5d). Receiving water values also appear to be unrelated to the dispersion of the discharge as the more distant shore stations have average values approximating those of the outfall station. The District periodically measures total coliform at the mouth of the Carmel River; the data indicate that the river water consistently has a high coliform content, probably emanating from the lagoon.

During one monitoring period, Kinnetics attempted to determine if the discharge significantly elevated the level of heavy metals in the receiving water. They measured concentrations in both sediments and shellfish in the vicinity of the outfall, and concluded that "The levels of metals found in both shellfish and sediments is one of the order of magnitude for that found in 'normal' sediments and shellfish from this area." (Kinnetics, 1978 - statement from Dr. John Martin, Moss Landing Marine Laboratories).

Various contractors have also attempted to monitor the impact of the discharge on the subtidal biota in the vicinity of the discharge (Appendix 4). The results of several years of biological monitoring are largely inconclusive, for several reasons: (1) A predischarge survey was not conducted. The first biological survey of the discharge area was made after the outfall line had been installed, which caused considerable temporary damage to the biota (Abbott, 1973). Thus, the "normal" species composition, abundances, dominants, and community structure in the outfall area were never ascertained, making it difficult to determine what alterations the discharge caused. (2) Adequate assessment of the natural causes of variability between the biota at the outfall and control stations was not made. Kinnetics noted that "the physical environment around these quadrats was quite different," and "Many of the biotic differences noted in the statistical analyses can be accounted for by the physically dissimilar conditions found at (CSR and CRR) rather than being attributable to an effluent effect." (Kinnetics, 1976). In 1977, Kinnetics analyzed data from two additional stations outside the region of the outfall, in order to better distinguish between natural spatial and effluent-caused variability. Their results indicate that a great deal of natural variability occurs over short distances in the south bay, making the existence of a true "control" station improbable. (3) Previous assessment had not been made of natural seasonal and year-to-year fluctuations in abundances, dominants and community structure, so that a distinction could be made between these fluctuations and those caused by the discharge. One such fluctuation occurred in 1977; "The ascidian cover was largely replaced with *Balanus* sp. and *Phragmatopoma californica*." (Kinnetics, 1978). Kinnetics was unable to correlate the ascidian decline with any long-term trend in effluent quality, and postulated that warmer water temperatures during the fall and winter of 1976-77 were responsible for not only this decline, but for a higher proportion of red algae in the spring of 1977 and less faunal cover.

In addition to the quantitative measurements made at the "control" and outfall stations, the aerial extent of kelp beds and *Diopatra ornata* density were also monitored between 1973-1977. Both species were selected for monitoring because they are common and extremely important components of the subtidal biota in the ASBS. However, both experience a wide range of natural fluctuation in numbers, making it difficult to distinguish effluent-related changes.

Kinnetics summarized the results of three years (1975-1977) of biological monitoring efforts as follows:

> Previous results (1975-1976) did not detect gross biological damage attributed to the wastewater effluent, either by qualitative diver/biologist observations or by quantitative benthic monitoring... (there is) significant spatial and temporal variability in the rocky substrate communities. Except for the high impact station, none of the sampling sites possessed patterns different from the others beyond what can be expected to occur naturally. (Kinnetics, 1978).

Vessel Discharges: There is very little boat traffic or mooring in the ASBS, and consequently vessel discharges are not a significant source of water pollution in the ASBS. The private mooring facilities in Stillwater Cove are used by local residents who would have no reason to stay overnight on their boats. Other temporary moorings are for boats too small to accommodate overnight use. A few transient yachts and large sailboats anchor in the cove primarily during the summer; on major holidays such as the Fourth of July the cove may contain up to forty or so transient boats. It is likely that these larger, more luxurious boats have holding facilities for sanitary waste, although this was not determined for purposes of this report.

Nonpoint Sources

The ASBS drains a large area of undeveloped land; the Carmel River Basin alone is at least 225 square miles in area. San Jose Creek has a large watershed which extends several miles eastward. Pescadero Canyon and other unnamed ravines also contribute a considerable amount of runoff to the ASBS on an intermittent, seasonal basis. Depending on adjacent land uses, non-point source discharges to the ASBS could therefore constitute a considerable water quality threat because of the large land they drain. There is an overall lack of credible information on the potential impact on non-point water quality impacts to the ASBS.

Agricultural and Silviculture Wastes: The use of pesticides and herbicides on Pebble Beach Golf Course, which borders the northern portion of the ASBS, was not investigated, although it is probably minimal. As mentioned previously, the cliff sides immediately adjacent to the ASBS have not been landscaped, so chemicals applied locally would not come in contact with the intertidal zone. Pescadero Canyon and an unnamed ravine within the golf course have also been left in a wild state, so that discharges from them would not be expected to contain pesticide or herbicide residues.

The use of pesticides or herbicides on the Odello artichoke field was not investigated. An unpublished information report on the Three Ranches area by the Monterey County Planning Department (compiled in 1975) states that "Remaining Odello property, east of State Highway One changed from artichoke production to lettuce and other crops as a result of restrictions to pesticide spraying activities."

Historically, both the Hudson and Fish ranches have been used for grazing cattle and, to a lesser extent, horses. Grazing activity is not concentrated in one area and does not appear to adversely affect water quality in San Jose Creek. The creek has been used as a drinking water supply by the property owners for years and was even considered as a potential water supply for the proposed Pt. Lobos Ranch development (Whistler-Patri, 1977).

Oil Spills and Seeps: No known oil spills of any magnitude have occurred in proximity to the ASBS. At the present time oil tankers travel the coast a minimum of five miles offshore. Much of the boat traffic within the ASBS consists of sailboats, kayaks, and other non-powered vessels, further reducing the likelihood of even minor spills or bilge wastes occurring in the ASBS.

Land Development: Non-point source run-off from the City of Carmel (total land area: 580 acres) is discharged to the ASBS via a number of storm drains. The largest storm drain is an open ditch which drains the northern, hilly portion of the City. The collected run-off is discharged to the City beach via a 4-foot diameter concrete culvert, and during dry weather is absorbed by the sand before reaching the bay. Another fairly large drain is located at the foot of Ocean Avenue; the street side of the drain has been modified to prevent sand intrusion. About eight smaller drains discharge to the beach in other areas.

Run-off from the eastern part of the City is directed south and discharged to the Carmel River. ESI (1977) estimated that 60% of the City's run-off is discharged to the beach area, with the remainder going to the Carmel River. The drains are "virtually dry" except during the rainy season (Bill Askew, pers. comm.), which extends from November to April. The only data on storm water quality is from samples taken by the Carmel Sanitary District on April 30, 1976. The samples were taken from two storm drains, at locations close to the discharge point. The average concentrations of trace minerals in the samples were as follows:

Metal	Average Concentration
Copper	0.03 mg/1
Chromium	0.002 mg/1
Iron	0.56 mg/1
Manganese	0.04 mg/1
Nickel	0.01 mg/1
Silver	0.01 mg/1
Cadium	0.002 mg/1
Zinc	0.10 mg/1
Mercury	0.0002 mg/1
Arsenic	0.01 mg/1

The samples were not analyzed for lead, for which elevated levels would be expected in an area with heavy traffic and considerable street parking. The copper and zinc values were higher than anticipated suggesting that storm drain discharges warrant further examination as a possible source of water pollution.

The Monterey County Health Department has a record of 4,000 septic tank permits in Carmel Valley. The Department does not feel that the septic tanks have a direct adverse impact on water quality in Carmel Bay (Wong in ESI, 1977).

Harbor Developments: Stillwater Cove is basically an unimproved anchorage. There are no fuel storage facilities or commercial activities here which would constitute a potential source of water pollution. A small quantity of kelp is cut in the cove each year to facilitate mooring. The effect of moored vessel discharges has not been assessed.

Solid Waste Disposal: Sludge from the Carmel Sanitary District is partially dewatered and temporarily lagooned on site. The lagoons are approximately 3,000 feet east of the ASBS and do not constitute a potential or actual source of water pollution.

SPECIAL WATER QUALITY REQUIREMENTS

The hydrocorals Allopora california and Allopora porphyra are able to grow in the ASBS due to the combination of clear water, high relief rock, and lack of fine sediment. These species would be adversely affected by increased sedimentation, and as they are quite attractive, could also be threatened by diver predation.

Sea otters, found here in large densities, may be particularly vulnerable to oil spills. Otters rest on the surface and would therefore readily pick up surface oil; oil could destroy the integrity of their coats, which is necessary for their survival. In addition, since sea otters are predators of marine organisms, primarily abalone, urchins, and clams, they are susceptible to the adverse effects of accumulated toxicants, such as trace minerals and organics. Source control of these toxicants is essential to minimize build-up in the marine food chain.

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7. Houk, J. 1977. Central California marine sportfish survey: Distribution and relative abundances of juvenile sportfish. Job Performance Report, Project No. D-J F-25-R-10, California Department of Fish and Game, Monterey, California.

Progress report on an ongoing study which utilizes mark and recapture and underwater fish transects to estimate juvenile sport fish distribution and abundance. Kelp was experimentally harvested at study site off Carmel Beach to determine effects on juvenile fish populations.

8. Hunt, D. E. 1977. Population dynamics of Tegula and Calliostoma in harvesting kelp. Unpublished M.A. Thesis. San Francisco State University. 81 pp.

Describes distribution and abundance of these snail species over a 13-month period; T.montereyi, a canopy dweller, suffered a long term reduction from kelp harvesting. Good discussion of the ecology of these ubiquitous kelp bed snails.

9. McLean, James H. 1962. Sublittoral ecology of kelp beds of the open coast areas near Carmel, California. Biol. Bull. 122: 95-114.

Describes subtidal at Granite Canyon, approximately 6 miles south of the ASBS. Nereocystis leutkeana was the dominant canopy species. Zones dominated by Calliarthron cheilosporoides and Pterygophora californica and their associated flora and fauna are described. Species list includes 248 species.

10. Miller, D. J. and J. J. Geibel. 1973. Summary of blue rockfish and life histories; a reef ecology study; and giant kelp, Macrocystis pyrifera, in Monterey Bay, California. California Department of Fish and Game Fish Bulletin 158. 137 pp.

11. Moritz, C. A., Jr. 1968. A descriptive survey of the head of Carmel submarine canyon. M.S. Thesis, United States Naval Postgraduate School, Monterey, California. 81 pp.

Description based on scuba diving observations. Location of granodiorite outcrops, coarse and fine sand areas and an organic sediment mat.

12. Oceanographic Services, Inc. 1975. Carmel Receiving Water Monitoring Program. Final Report. For: Carmel Sanitary District, Carmel, California. (see "Sources of Water Pollution" for annotation).

13. Odemar, M. W. 1972. A survey of the marine environment near the city of Carmel ocean outfall. California Department of Fish and Game. Marine Resources Region. Administrative Report 72-9. 17 pp.

Two day survey included transects along outfall, 500' to the north and south, and at Granite Pt. Includes species list and relative abundances for these areas.

14. Ostarello, Georgiandra Little. 1973. Natural history of the hydrocoral Allopora californica, Verrill (1866). Biol. Bull. 145: 548-564.

Describes habitat and reproductive biology of the purple hydrocoral. Discusses importance of absence of sedimentation to species.

15. Pearse, J. S. (ed.) 1971. Kelp bed as a classroom. Hopkins Marine Station Class Reports 270H. Pacific Grove, California. 139 pp.

One comparison site for the study located near reference rock used in subsequent monitoring of sewage outfall discharge. General description of site and relative abundance data for various groups of organisms.

16. Peckman, V. O. and J. H. McLean. 1961. Biological exploration at the head of the Carmel ubmarine anyon. Abstract. Amer. Malacol. Union Ann. Rep. p. 43.

17. Simpson, J. P. III. 1972. The geology of Carmel Bay, California. M.S. Thesis, United States Naval Postgraduate School, Monterey, California. 74 pp.

Author collected and analyzed rock and sediment samples from the subtidal, as well as intertidal, and combined this data with bathymetric and seismic information to produce the first geologic map of Carmel Bay which includes the subtidal.

18. Smith, G. M. 1969. Marine Algae of the Monterey Peninsula. Second edition incorporating the 1966 supplement by G. J. Hollenberg and I. A. Abbott. Stanford University Press. Stanford, California. 752 pp.

19. Vandevere, J. E. 1969. Feeding behavior of the southern sea otter. Proc. Sixth Ann. Conf. on Biological Sonar and Diving Mammals, Stanford Research Institute, Menlo Park, California. 87-94 pp.

20. Wild, P. W. and J. A. Ames. 1974. A report on the sea otter _Enhydra lutris_ _L._, in California. California Department of Fish and Game. Marine Resources Tech. Rept. 20:1-93.

ANNOTATED BIBLIOGRAPHY

Land/Water Use, Sources of Water Pollution Description

Skindiver Use

1. Miller, Daniel J., et al. 1974. Results of the 1972 skindiving assessment survey, Pismo Beach to Oregon. California Department of Fish and Game Marine Resources Technical Report No. 23 (manuscript). 61 pp.

Central and northern California skindiving effort estimated by county, specific port and spearfishing, etc. Figures compared with those from 1960 survey.

2. Stewart, Katherine. 1976. Diver's preferences and proposals for underwater park management at Carmel Bay, California. M.S. Thesis, California State University, Fresno. 64 pp.

Contains survey information on: (1) diver's knowledge of man induced impacts on Carmel Bay natural resources, and opinions on how such resources should be managed, and (2) number of trips made to Carmel Bay versus distance from home; desired accommodations at the dive sites. Author reviews controversy surrounding designation of the inner bay as an ecological reserve and considers environmental impacts which could lessen Carmel Bay's desirability as an underwater park.

Scientific Use

1. Abbott, Isabella A. and George J. Hollenberg. 1976. Marine Algae of California. Stanford University Press, Stanford, California. 827 pp. (see Intertidal Description for annotation).

2. Environmental Services Division. 1974. Carmel Bay Monitoring Program Final Report, February 1974. 140 pp. (see Receiving Water Monitoring Reports for annotation).

3. Engineering Science, Inc. 1977. Oceanographic Investigations in Carmel Bay Review of Existing Information. 185 pp. (see Receiving Water Monitoring Reports for annotation).

4. Hunt, Douglas E. 1977. Population dynamics of Tegula and Calliostoma in harvesting kelp. June 1977. Unpublished M.S. Thesis. San Francisco State University. 81 pp.

5. Farris, Monica. 1977. The seasonal variation in the occurrence of the commensal polychaete Ophiodromus pugettinsia (Johnson) on the bat star Patiria miniata (Brandt). Aug. 1977. Unpublished M.S. Thesis, San Francisco State University. 55 pp.

6. Oceanographic Services, Inc. 1975. Carmel Receiving Water Monitoring Program, Final Report. OSI #04411, prepared for Carmel Sanitary District (see Receiving Water Monitoring Reports for annotation).

7. Smith, Ralph I. and James T. Carlton, eds. 1975. Lights Manual: intertidal invertebrates of the central California coast. Third edition. U.C. Press; Berkely, California. 716 pp. (see Intertidal Description)

Planning Documents

(a) General Plans

1. City of Carmel-by-the-Sea. 1973. General plan for Carmel-by-the-Sea and environs. Carmel, California. 48 pp.

To be updated in the near future. Describes in concise, general terms land use, circulation patterns, housing, natural resources and open space within the city limits. Within each element, problems identified and recommendations made for their solution. Problems of and impact of "zone of influence" (Del Monte Forest south to Pt. Lobos) on Carmel also considered, particularly annexation and acquisition of open space.

2. Del Monte Properties Company. 1977. Del Monte Forest Plan 1977: A part of the Monterey County General Plan. 51 p.

Outlines allowed land uses and housing density for each of eight subareas in the forest; lists acreage taken up by different land uses within each subarea and for the forest as a whole, with implementation of the plan. Summarizes conclusions and recommendations of contracted studies done on each element (traffic, waste disposal, natural resources, etc.)

3. Monterey County Planning Commission. 1961. Carmel Valley Master Plan. Salinas, California.

Fold-out sheet describes (1) recommended housing density (mapped) (2) present land use (3) present and projected population, and (4) guidelines for further development. Information is extremely outdated; however, this is the planning document in force until the county completes the 1978 Carmel Valley Master Plan.

(b) Zoning Ordinance

1. City of Carmel-by-the-Sea. 1978. Municipal Code (Part X: Planning and zoning code of the City of Carmel-by-the-Sea, Carmel, California. 82. p.

Permitted uses in each zoning district, limitations on building height, lot size, offstreet parking, yards and landscaping. Procedures and requirements for design review, environmental review appeals and variances. Zoning map attached.

(c) Development Plans, Impact Reports

1. Whisler/Patri Associates. 1966. A conservation plan for three ranches, San Francisco, California. Maps, overlays (original at Monterey County Planning Department). 22 pp.

Three ranches are Odello, Fish and Hudson properties. Plan called for residential development primarily on Odello property. Incorporated into the Monterey County General Plan, but never implemented. Contains history of land use and ownership on the three ranches.

2. Whisler-Patri. 1977. A concept plan for Pt. Lobos Ranch, prepared for the Headlands Corporation and the Riley family. San Francisco, California. 27 pp., appendices.

Description of current proposed development of Pt. Lobos Ranch property located east of Highway 1 (residential, tourist-oriented, and commercial recreational). Development features are related to California Coastal Commission Act provisions, and the commission's 1977 Interpretive Guidelines. Appendices discuss (1) the impact of the development on Highway 1 traffic, (2) alternate water supply and sewage disposal systems, and (3) area zoning and regulations. An inventory of plant communities found within Pt. Lobos Ranch is also attached.

3. Bordonaro, Sebastian J. 1978 (Draft). Odello agricultural land preservation system. Carmel, California. 32 pp.

General description of proposed development for Odello Ranch property east of Highway 1. Detailed site plans for each element in the development (condominiums, farmer's market, etc.), including circulation patterns, landscaping, and utilities design.

4. County of Monterey. 1976. Environmental impact report for Del Monte Forest 2030 General Plan. Salinas, California. 77 pp., appendices.

Appendices contain impact reports on the Del Monte Forest Plan 1977 and therefore are the relevant portion of the document. Public response to draft EIR, primarily from Del Monte Forest homeowners, also attached, gives a good indication of why the 2030 plan was not adopted.

(d) Coastal Zone Commission documents

1. Central Coast Regional Coastal Zone Conservation Commission. 1974. Permit boundary revisions. 7 pp. appendix, plates.

Gives revised coastal zone boundaries for Monterey County, based on inland extent of tidal influence. Appendix discusses indicators of brackish waters.

2. Monterey County Planning Department. 1977. Local coastal program: preliminary statement of issues. Salinas, California. 42 pp. appendix.

Description of land use, zoning and potential conflicts between California Coastal Act of 1976 and present/potential land use for (1) unincorporated areas adjacent to Carmel Bay (Pebble Beach, Carmel Meadows) and (2) Carmel River State Beach.

3. City of Carmel-by-the-Sea. 1978. City of Carmel-by-the-Sea local coastal work program (Draft). Carmel, California. 41 pp.

Contains most current description of land use, parks and open space, and public services in the city and the surrounding "sphere of influence." Summary of planning documents and zoning laws in effect or which, if adopted, would alter land use significantly. More detailed description of beach front area. Potential conflicts between actual/potential land use and Coastal Zone Commission policy are identified and work tasks are outlined, with the intent of providing data necessary for reconciling conflicts.

(e) Miscellaneous

1. Sedway/Cooke and J. Richard Recht Associates. 1977. Carmel Sanitary District Areawide Facilities Plan EIS/EIR: population projections. San Francisco, California. 32 pp.

Part of a larger EIS/EIR being prepared on extension of the sanitary district's service area. Projections are made for population growth in the extended service areas as a means of estimating sewage flows if service is provided. Populations considered were permanent, overnight transient, and day visitor. Appendices discuss water supply and transportation corridors as possible constraints on population growth here.

<u>Carmel Sanitary District</u>

(a) Sewage Treatment Plant Design and Operation

1. Kennedy Engineers, Inc. 1969. Carmel Sanitary District Monterey County, California: Adopted waste treatment plant expansion program. San Francisco, California. 6 pp. graphs, maps.

Costs and sources of funding for improvements on primary treatment plant and outfall extension. Projected flow figures and location of secondary treatment facilities graphically presented.

2. Kennedy Engineers, Inc. 1974. Carmel Sanitary District, Carmel: Operation manual for water pollution control plant. San Francisco, California. 155 pp. diagrams, appendices.

Contains generalized description of secondary treatment plant facilities and operation during interim period and when design capacity is reached. Provides a detailed description of each unit process (for plant operators), with anticipated operating parameters, and problems, and recommends inspection, monitoring and maintenance procedures. Support facilities are described and diagrammed in detail, particularly the electrical system with its numerous motor control centers. The alarm system is outlined and procedures listed for possible emergency situations such as power failure, hydraulic overloading, and flooding. Present treatment plant operation is slightly modified from engineers' description presented here.

3. Pacific Environmental Laboratory. November 1974. Final environmental impact report for the proposed extension of sludge drying beds at the Carmel Sanitary District water pollution control plant. San Francisco, California. 33 pp.

Environmental setting (with photographs); project description; consideration of alternative disposal methods and relative adverse impacts of each. Only one of the seven drying beds proposed here is currently in use as such. Appendix contains California State Department of Health regulations concerning wastewater reclamation.

4. Kennedy Engineers, Inc. October 1975. Solids handling facilities and treatment plant modifications, Carmel Sanitary District. San Francisco, California. 160 pp. diagrams, appendices.

Description of present sludge handling facilities; inadequacies and limitations. Six alternatives for improvement described, compared in terms of capital and operating costs. Two favored alternatives further evaluated in terms of flexibility, reliability and public acceptability. Alternative chosen--dissolved air flotation thickner and an additional digester-is currently under construction. Appendices include (1) NPDES permit for Carmel Sanitary District discharge; (2) infiltration analysis for both Carmel and Pebble Beach sanitary districts, including description of collection system, maintenance, and problems; (3) District revenue plan, (4) District ordinances pertaining to discharges into the system, and rates and surcharges, and (5) draft environmental impact report.

(b) Effluent disposal alternatives

1. Kennedy Engineers, Inc. 1970. Odello property report for the Carmel Sanitary District. San Francisco, California. 16 pp. appendix.

Discusses feasibility of increased irrigation of artichokes on Odello property as a means of disposal for the district's secondary treated sewage discharge, in terms of soil characteristics, cost, maximum application possible, and regulations. Map of Odello property; appendix contains state regulations on direct use of reclaimed wastewater.

2. Kennedy Engineers, Inc. 1974. Summary report, Odello property testing program for the Carmel Sanitary District. San Francisco, California. 3 pp. appendices.

Test data to assess the feasibility of applying secondary treated effluent for crop irrigation on Odello land east of Highway 1; groundwater height and composition, land slope and infiltration rates for applied effluent, soil characteristics. Expected quality of subsurface run-off from effluent application correlated with nutrient levels in Carmel Lagoon.

3. Kennedy Engineers, Inc. 1975. Second summary report-wastewater renovation potential, Odello property testing program for the Carmel Sanitary District. San Francisco, California. 46 pp. appendices.

Continued testing at 15 test sites was done to assess the feasibility of the high rate effluent application method for the district's sewage discharge on the Odello property. In particular, groundwater level was observed after effluent application of various durations and volumes; infiltration rate and other relevant soil characteristics are calculated. Report contains preliminary design of land treatment system, including interception wells to collect renovated effluent (nutrient level too high for disposal to Carmel River). Costs estimated, including acquisition of Odello land.

4. Kennedy Engineers, Inc. 1975. Supplement to the second summary report-wastewater renovation potential, Odello property testing program for the Carmel Sanitary District. San Francisco, California. 26 pp. appendices.

Infiltration rate of applied effluent is revised, based on data from three additional periods of loading. Discusses nitrate and phosphate concentrations in renovated wastewater, nutrient removal efficiency of land application, and implications on disposal alternatives for renovated effluent. Summary and copies of letters from public agencies and individuals on alternatives for disposal of the district's sewage effluent.

5. United States Environmental Protection Agency. 1972. Final environmental statement, ocean outfall extension project. Carmel Sanitary District, Carmel, California. 17 pp. appendices.

Description of present outfall, and proposed extension. Adverse impacts considered very generally with little reference to specific situation. Alternatives and cost factors mentioned. Appendices contain lengthy comments by the local scientific community and public agencies, and a copy of the district's receiving water monitoring program.

6. Kennedy Engineers, Inc. 1974. Carmel Sanitary District. Project report on effluent disposal-summary comparison of alternatives. (Chapter VIII) (Draft). San Francisco, California. 30 pp.

Prompted by possible designation of Carmel Bay as an ASBS. Disposal alternatives evaluated in terms of social, economic and ecological costs/benefits. Estimate of cost based on level of treatment required for each alternative, in addition to actual disposal cost. Alternatives considered are similar to those being considered at the present time: extended or new outfall, discharge to Carmel River, and reclamation.

7. Kennedy Engineers, Inc. March 1978. Feasibility report area-wide facilities plan, Carmel Sanitary District. San Francisco, California. 101 pp. appendices.

Report summarizes, then evaluates twenty alternatives for disposal of Carmel Sanitary District's effluent in terms of (1) environmental impact, (2) level of treatment required, and (3) cost (includes (2) and (1)).
Alternatives evaluated for both existing and expanded (Carmel Valley) service area. Appendices contain (1) comments on first draft and alternatives themselves; (2) more detailed cost analyses of alternatives and (3) maps illustrative of alternatives.

<u>Receiving Water Monitoring Reports</u>

1. Abbott, Isabella. 1973. Carmel Bay interim report (biological); being a semi-quantitative effort for evaluating the nearshore biota adjacent to the proposed subtidal sewage discharge line of the Carmel Sanitary District. Carmel, California. 73 pp.

Predischarge study included rocky, sandy and transition subtidal stations near outfall extension, and at "control" station. Attempt to assess impact of outfall construction on kelp beds. Comparison of intertidal biota near existing discharge with (a) control area and (b) discharge area, after cessation of discharge (ranges of algal species). Several recommendations made here adopted in later monitoring programs.

2. Env., Inc. Environmental Services Division. 1974. Carmel Bay monitoring program 1974. Final report for the period April 1973 through October 1973 with references back to September 1972. Long Beach, California. 76 pp. appendices.

Comparison of predischarge and post-discharge data on outfall biota. Data on intertidal biota near old outfall, and "control" stations. Water column data from 10 transects in south Carmel Bay, to 20 meter depths; same transects used in later monitoring. Results of dye studies done to assess location and size of sewage field. Monitoring methods, data analysis, and report presentation were critized by local scientific community.

3. Oceanographic Services, Inc. March 1975. Carmel receiving water monitoring program. Final report. Santa Cruz, California. 125 pp.

Impact of outfall on biota monitored by comparison with "control" station for quantitative assessment of (1) rock scrapings (2) *Macrocystis* (3) *Diopatra* and (4) random and established quadrats. Water column data from same stations occupied in 1973. Discussion of further dye studies done to determine extent of sewage field; influence of nearshore currents.

4. Kinnetic Laboratories, Inc. February 1976. Receiving waters monitoring program, Carmel Bay, California. Final Report-1975, for the period June 1975 through December 1975. Santa Cruz, California. 211 pp.

Statistical analysis of factors causing variability between biota at subtidal outfall and "control" stations, in addition to usual monitoring of these areas. (Done to evaluate location of "control" station). Discussion of biota in "high impact" area, immediately adjacent to one of the diffuser ports. Water column data from same transects used previously, taken in July, October and December.

5. Kinnetic Laboratories, Inc. May 1977. Receiving water monitoring program, Carmel Bay, California. Final Report, 1976, for the period June 1976 through May 1977. Santa Cruz, California. 131 pp., appendices.

In addition to monitoring methods of previous years, impact of discharge on receiving waters was assessed by: (1) measurement of heavy metals and pesticides in biota (rock scallops) and sediments; (2) determining ammonia to be the best indicator of the extent of and dilution factors in sewage field; (3) establishment of a new reference station area for comparison of biota with that near outfall; (4) measuring qualitative and quantitative changes in biota at a high impact area, and (5) use of photoquadrats to assess quantitative differences in biota at outfall and reference stations. Raw data and statistical analyses contained in tables and appendices.

6. Kinnetic Laboratories, Inc. 1978. Biological monitoring program, Carmel Bay, California. Final Report, 1977. Santa Cruz, California. 55 pp. appendix, photographs.

Monitoring consisted of comparison of (1) photoquadrats on rocky substrate adjacent to outfall and in three (two added since 1976) control areas; (2) aerial extent of kelp beds inside and outside sewage field, and (3) biota in high impact area, and outside it. Extent and density of Diopatra ornata beds assessed near discharge point. Other monitoring methods dropped for "lack of definitive results."

Literature Reviews

1. Engineering-Science, Inc. 1977. Oceanographic investigations in Carmel Bay, review of existing information. San Francisco, California. 55 pp. Two appendices.

Report summarizes existing information on point and non-point sources of water pollution, currents, water quality, geology, human uses and marine biology. Study area slightly larger than ASBS. Information on commercial fishing outdated. Recommendations for survey work to establish best location for future submarine outfall. Appendix A is Harding-Lawson geology report; Appendix B is referenced below.

2. Kinnetic Laboratories, Inc. 1977. Carmel wastewater facility planning study: Biological oceanographic literature review. Santa Cruz, California. 185 pp.

Report characterized intertidal, kelp forest, hard and soft bottom subtidal, commercial and sport fisheries, plankton, marine mammals and birds of study area, based on a literature review and data from knowledgeable individuals. Study area and data base are more extensive in size than Carmel Bay ASBS; therefore, it is often impossible to extrapolate information which applies specifically to ASBS. Specific information included for: spearfishing, extent of kelp beds, marine mammals, and fish (in vicinity of old outfall). Receiving water monitoring programs are reviewed. General discussion of toxic constituents of wastewater, average concentrations in Carmel effluent, and probable concentration and impact on receiving waters.

Report contains typographical errors.

3. Kinnetic Laboratories, Inc. 1977. Carmel Bay literature review analysis. Santa Cruz, California. 75 pp.

Summary of existing information (as ascertained in more detailed literature reviews) on oceanographic/water quality features of Carmel Bay. Summary of human uses of bay (much of this data includes areas outside of the bay). Critiques, as well as summaries, of present and previous attempts to monitor the impact of the Carmel sewage discharge. Master species lists for algae rock stations, and animals at sand stations and hard bottom stations. Recommendations for further monitoring work.

Local Sources of Information

Local Sources of Information

Marine Resource Harvesting

1. Jim Hardwick, California Department of Fish and Game, Monterey (commercial fishing).

2. Dan Miller, California Department of Fish and Game, Monterey (skiff effort).

3. Leo Pinkas, California Department of Fish and Game, Long Beach (kelp cutting).

Municipal and Industrial Activities

1. Mr. W. C. McClelland, Pebble Beach Corporation (Del Monte Forest).

2. Mr. Robert Griggs, Planner, City of Carmel-by-the-Sea.

3. Mr. David Young, Planner, Monterey County Planning Department (county zoning, Carmel Valley Master Plan).

Governmental Designated Open Space

1. Chief Ranger Brown, California Department of Parks and Recreation (Carmel River State Beach).

2. Mr. Bill Askew, Department of Public Works, Carmel (Carmel City Beach).

3. Mr. Greg D'Ambrosia, Forester, City of Carmel (Carmel City Beach, seawall).

4. Mr. Don Hood, Department of Parks and Recreation, Sacramento (land acquisition-Hudson, Briggs property).

5. Mr. Emil Smith, Department of Fish and Game, Sacramento (Carmel Bay Ecological Reserve).

Recreational Uses

See C-4, 1. and 2.

Transportation Corridors

See C-2, 1. and 2.

Point Sources of Water Pollution

1. Mr. Max R. Drewien, General Manager, Carmel Sanitary District.

2. Mr. Kevin Walsh, District Engineer, Carmel Sanitary District.

3. Wilce Martin, Assistant Chief Operator, Carmel Sewage Treatment Plant.

Hopkins Marine Station unpublished undergraduate papers, 1970. Note:

Studies were on shallow subtidal outfall discharging primary treated sewage. Outfall has since been moved offshore and sewage receives secondary treatment.

1. Bachelor, Eric Paul. A comparative study of the primary productivity of Prionitis lanceolata Harvey, near and away from the Carmel marine sewage outfall.

Author found samples collected in proximity to the outfall exhibited higher productivity under laboratory conditions than those from control stations. Greater pigment concentration and added nutrients from the discharge are given as possible explanations for higher productivity.

2. Grey, Douglas P. Distribution of marine algae in the vicinity of a sewage outfall at Carmel, California.

Author found definite gradient in abundance of certain species of algae with increasing distance from outfall. Species diversity also increased with greater distance of intertidal area from outfall, except in highest intertidal. Paper also contains results of current studies and water quality sampling.

3. Holstrom, Marshall. Distribution, reproduction, recruitment and pigments of the stalked barnacles Pollicipes polymerus in the vicinity of sewage outfalls at Pacific Grove and Carmel, California.

Author found the gradient in reproduction and recruitment rate was better correlated with distance from the outfall to the south than at Pt. Pinos. The outfall discharge was found to be less harmful to these invertebrates because of the lower chlorine residual.

4. Nakata, Michael M. The distribution and abundance of marine intertidal fauna around a primary sewage effluent in Carmel Bay, California.

Author noted and measured gradient in abundance of certain macroinvertebrates corresponding to increased distance from outfall. Species diversity also measured along transects and in quadrats. Bioassay conducted using limpets as test organisms, with 2-20% concentrations of chlorinated and unchlorinated Carmel sewage effluent. Location of study sites is the same as for Grey's work (referenced above).

5. Schreiber, James R. Effects of residual chlorine in sea water on the photosynthetic activity of three marine algae.

Author found that photosynthetic activity was adversely affected by chlorine residual of 5 ppm. Graph of chlorine residuals vs. distance from Carmel outfall at high and low tides. Carmel Bay current data.

6. Welsh, James. Coliform distribution and coliform uptake by Mytilus californianus in Carmel Bay.

Author correlated abundance of Mytilus with distance from outfall.

Measured total coliform count in surface waters varying distances from outfall; total count too small to correlate with surface currents. Attempt to measure uptake of coliform by transplanted mussels unsuccessful due to contamination of equipment.

APPENDIX 1

Intertidal Flora

Species	Abun	Zone	Substrate		
			Rock	Epiphyte	Other
DIVISION CHLOROPHYTA					
Order Ulotrichales					
Ulothrix flacca	F	2	X	X	Wood
U. pseudoflacca	F	2	X	X	Wood
Pseudulvella applanata*	F	-	-	X	Shells of Littorina
Pseudopringsheimia apiculata	F	-	-	X	-
Endophyton ramosum	F	3-4	-	X	-
Monostroma zostericola	CS	-	-	X	-
Percusaria dawsonii	O-F	3	-	-	Green stratum on limpets & chitons
Blidingia minima var. minima	C	1-3	X	X	Wood
Enteromorpha flexuosa (c,d/1,2)	C	2-4	X	X	-
E. prolifera	C	1-2	X	-	Free floating
Ulva sp. (c,d,e/3)					
U. californica (d,e/1)	C	2-3	-	-	-
U. expansa	-	-	X	X	-
U. lobata	C	3-sub	X	X	-
U. taeniata	C	3-4	X	-	-
Prasiola mericlionalis	F-A	1	X	-	-
?Urospora penicelliformis	A	1	X	-	-
U. wormskioldii	I-A	2-sub	X	X	Pilings
Spongomorpha coalita	SA	4	X	X	-
Chaetomorpha linum	A	1-3	X	-	-
Cladophora columbiana (a/2)	F-A	3-4	X	-	-
C. graminea	F	3-4	X	-	Intermingled with sponges

APPENDIX 1 Continued

Species	Abun	Zone	Substrate Rock	Epiphyte	Other
C. sakaii	SA	4	X	–	–
C. stimpsonii	F	–	X	–	Shells
Bryopsis corticulans	F	3-4	X	–	Exposed to strong surf
B. hypnoides	o-a	3	X	–	–
Derbesia marina	F	4	X	–	Cryptochiton stelleri, corallines
Codium fragile	F-C	–	X	–	–
C. setchellii	F	4	X	–	–
DIVISION PHAEOPHYCEAE					
Order Ectocarpus					
Ectocarpus acutus var acutus	F	4-sub	X	–	–
E. corticulatus	O	–	–	X	–
E. parvus	C	–	–	X	–
Feldmannia chitonicola	C	3	–	–	Chiton or limpet shells
F. cylindrica	F	3-4	–	X	Limpets
Giffordia mitchelliae	C	4	X	X	–
G. saundersii	–	3	–	–	–
Spongonema tomentosum	I-F	–	–	X	–
Streblonema myrionematoides	C	3-4	–	X	–
Order Chordariales					
Myrionema balticum	F	4	–	X	–
M. corunnae	O-A	4	–	X	–
Compsonema intricatum*	–	3	–	X	–
Hecatonema primarium	C	4	–	X	–
Ralfsia hesperia*	I-R	1-2	–	X	–
R. pacifica	C	2-3	X	–	–
Hapalospongidion gelatinosum	C	1	X	–	–

Species	Abun	Zone	Substrate Rock	Substrate Epiphyte	Substrate Other
Leathesia difformis	C	2-3	X	X	-
L. nana (b/4)	O	2-3	-	X	-
Cylindrocarpus rugosus (b/4)	C	2	-	X	-
Analipus japonicus (a/2)	F-C	2	X	-	Exposed to heavy surf
Haplogloia andersonii	-	3-4	X	-	-
Order Dictyosiponales					
Coilodesme californica	C	4	-	X	-
C. plana	C-O	4	-	X	-
Punctaria hesperia	O	4	-	X	-
Halorhipis winstonii* (b/4)	a	4	X	X	-
Soranthera ulvoidea	C	3	-	X	-
Order Scytosiphonales					
Scytosiphon dotyi	O-F	2	X	-	Winter annual
S. lomentaria (a,b/2,4)	A	3-4	X	-	-
Petalonia fascia (b/4)	F	2-3	X	XX	-
Colpomenia bullosa	O	3	X	-	-
C. peregrina	C	4	X	X	-
Order Sphacelariales					
Sphacelaria didichotoma*	R	4-sub	-	X	-
Order Desmarestiales					
Desmarestia latifrons	F	4-sub	X	-	-
D. ligulata var ligulata	A	4-sub	X	-	Wood
Order Laminariales					
Laminaria dentigera (e/3)	C	4-sub	X	-	-
L. ephemera	I	4	X'	-	-
Costaria costata (c/3)	C	4-sub	X	-	-

APPENDIX 1 Continued

Species	Abun	Zone	Substrate Rock	Epiphyte	Other
Alaria marginata (5)	A	-	X	-	-
Eisenia arborea	-	4-sub	X	-	-
Egregia menziesii (b,c,d,e,/1,3,4)	C	3-sub	X	-	-
Lessoniopsis littoralis (5)	C	4	X	-	Exposed to full surf
Dictyoneurum californicum	F	4-sub	X	-	-
Postelsia palmaeformis	a	3-4	X	-	Exposed to surf
Nereocystis luetkeana	F	-	-	-	-
Macrocystis pyrifera	F	-	X	-	-
Order Fucales					
Fucus distichus	A	2-3	X	-	-
Pelvetia fastigiata	A	2-3	X	-	-
P. fastigiata f. gracilis*	A	-	X	-	-
Pelvetiopsis limitata	I	1-2	X	-	-
Hesperophycus harveyanus	A	2	X	-	-
Cystoseira osmundacea	O	4	X	-	-
Sargassum muticum	A	4-sub	X	-	Quiet water
DIVISION RHODOPHYTA					
Order Goniotrichales					
Goniotrichum alsidii	C	4-sub	-	X	-
Order Bangiales					
Erythrocladia irregularis	F	4-sub	-	X	-
E. subintegra	C	4-sub	-	X	-
Erythrotrichia carnea	C	2-sub	-	X	-
E. pulvinata*	O	4	-	X	-
Smithora naiadum	A	4	-	X	-
Bangia fuscopurpurea	F	2	X	-	-

Species	Abun	Zone	Substrate Rock	Substrate Epiphyte	Substrate Other
Peyssonellia hairii	-	4	X	-	-
P. meridionalis (d/1)	C	-	X	-	Shells
Rhododiscus carmelita*	-	2	-	-	Only from intertidal near Carmel River
Hildenbrandia dawsonii	F	2-3	X	-	-
H. occidentalis	C	2	X	-	-
H. prototypus	C	4-sub	X	-	-
Lithothammium aculciferum	O	IT-sub	X	-	-
L. californicum	C	IT-sub	X'	-	-
L. crassiusculum	O	IT-sub	X	-	-
L. pacificum* (c/3)	C	-	X	-	Shells
L. phymatodeum	F	4-sub	X	X	Shells
Melobesia marginata	C	-	-	X	-
M. mediocris	C	-	-	X	-
Mesophyllum conchatum	C	-	-	X	On corallines
M. lamellatum	C	IT-sub	X	X	On corallines
Clathromorphum parcum	C	-	-	X	On corallines
Neopolyporolithon reclinatum	C	IT-sub	-	X	On corallines
Lithophyllum imitans	C	4-sub	X	-	-
L. lichenare	A	-	X	-	Surf
Tenarea ascripticia	C	4-sub	-	X	-
T. dispar	C	4	-	X	-
Pseudolithophyllum neofarlowii	C	-	X	-	-
Hydrolithon decipiens	C-F	-	X	-	Shells
Lithothrix aspergillum (c,e,/3)	A	4	X	-	Sandy areas, on animals
Corallina officinalis var chilensis (c,d,e,/1,3)	C	4-sub	X	-	-

Species	Abun	Zone	Substrate: Rock	Substrate: Epiphyte	Substrate: Other
Porphyra sp. (c,d,e,/3)					
*P. lanceolata**	C	2	X	-	-
P. nereocystis	F-A	-	-	X	-
P. perforata	C-a	2	X	-	-
*P. schizophylla** (a)	F	2	-	-	-
*P. smithii** (c)	O-F	-	-	X	-
P. thuretii	I-R	-	X	X	-
Porphyrella gardneri	C	-	-	X	-
Class Florideophyceae					
Order Nemaliales					
*Rhodochorton concrescens**	I	4-sub	-	-	Epizoic on inverts
Nemalion helminthoides (b/5)	SA	-	-	-	-
Cumagloia andersonii (4)	A	2	X	-	-
*Gelidium aborescens**	C	4-sub	X	-	-
G. coulteri	A	-	X	-	Dense mats
G. purpurascens	C	3-sub	-	-	-
G. pusillum	A	2-sub	-	-	-
G. robustum	C	4-sub	X	-	-
Pterocladia media	O	-	X	-	-
Order Cryptonemiales					
Farlowia conferta	C	4	X	-	Sandy areas
F. mollis	F	3-sub	X	-	Sandy areas
Pikea californica	F	4-sub	X	-	-
Cryoptsiphonia woodii	-	4	X	-	-
Dilsea californica	F	4-sub	X	-	-
Constantinea simplex	A	4-sub	X	-	-

Species	Abun	Zone	Substrate Rock	Substrate Epiphyte	Substrate Other
C. vancouveriensis (c,d,e,/1,3)	C	-	X	-	-
Arthrocardia silvae	A	-	X	-	-
Serraticardia macmillanii	A	-	X	-	Heavy surf
Bossiella sp. (c,e,/1,3)					
B. californica ssp californica (e/3)	C	-	-	-	-
B. orbigniana ssp dichotoma	F	4	X	-	-
B. plumosa	C	4	X	-	-
Calliarthron cheilosporioides (e/3)	F	4-sub	X	-	-
C. tuberculosum	C	4-sub	-	-	-
Gloiosiphonia capillaris	C	4	X	-	-
G. verticillaris	C	4	X	-	Sand scoured
Endocladia muricata (a,c,e/2,3)	A	1-3	X	-	-
Halymenia schizymenioides*	F	4-sub	X	-	-
Grateloupia doryphora	A	4	X	-	Sheltered areas
G. setchellii (d/3)	R	4	X	-	-
Cryptonemia ovalifolia	A	-	X	-	-
Prionitis australis	O-F	4-sub	X	-	-
P. lanceolata (c,d/3)	A	2-sub	X	-	-
P. linearis (e/3)	A	4	X	-	Course sand
P. lyallii (d/3)	C	4-sub	X	-	-
Erythrophyllum delesserioides (c/3)	A	4	X	-	Heavy surf
Callophyllis crenulata	A	4-sub	X	-	-
Callophyllis firma	F	4-sub	X	-	-
C. linearis	A	4-sub	X	-	-

Species	Abun	Zone	Substrate: Rock	Substrate: Epiphyte	Substrate: Other
C. pinnata	A	4-sub	X	X	Epizoic
C. violacea	A	4-sub	X	-	-
Order Gigartinales					
Petrocelis franciscana (a,c,d,e/1,2,3)	C	2-3	X	-	-
Schizymenia pacifica	C	4-sub	X	X	-
Neoagardhiella baileyi	C	4-sub	X	-	Mostly near sand
Plocamium cartilagineum	C	IT-sub	X	-	In sand
P. violaceum	C	3	X	-	Heavy surf
Gracilaria robusta	F	4-sub	-	-	-
G. sjoestedtii	C	3-sub	X	-	Buried in sand
Ahnfeltia plicata (d,e/3)	C	3-4	-	-	Buried in sand
Gymnogongrus linearis	C-A	3-4	X	-	Sand swept
Ozophora latifolia	I	4-sub	X	-	-
Gigartina sp.	-	-	X	-	Partially protected areas
G. agardhii (c,e/3)	F-C	2-3	X	-	-
G. canaliculata (e/3)	A	3-4	X	-	-
G. corymbifera	C	4-sub	X	-	Surf areas
G. harveyana	A	4	X	-	In fine sand
G. leptorhynchos	C	4	X	-	-
G. papillata (c,d,e/3)	C	2-3	X	-	-
G. spinosa (c/3)	F	4	X	-	Exposed to surf
G. volans	A	4-sub	-	-	Sand scoured areas
Iridaea cordata	C-A	4-sub	-	-	-
I. cordata var *splendens** (c,e/3)	A	-	X	-	Exposed coast

Species	Abun	Zone	Substrate Rock	Substrate Epiphyte	Substrate Other
I. flaccida* (c,e/3)	A	3-4	X	-	-
I. heterocarpa	C	3	X	-	-
I. lineare*	A	4	X	-	Exposed coast
Rhodoglossum affine (c/3)	A	3	X	-	-
R. californicum	C	4-sub	X	-	In sandy areas
R. roseum	F	4-sub	X	-	Exposed coasts
Order Rhodymeniales					
Halosaccion glandiforme	A	2-3	-	-	-
Botryocladia pseudodichotoma	F-A	4-sub	X	-	-
Rhodymenia californica var californica	F-C	4-sub	X	-	-
R. pacifica (e/3)	F-C	4-sub	X	-	-
Coeloseira compressa	F	3-sub	X	X	-
Gastroclonium coulteri	C	IT-sub	X	-	-
Order Ceramiales					
Antithamnion defectum	C	IT-sub	-	X	-
A. kylinii	C	IT-sub	-	X	-
Antithamnionella glandulifera	C	4	-	X	-
A. pacifica var uncinata	C	-	-	X	-
Scagelia occidentale	C	4-sub	X	X	-
Platythamnion pectinatum	C	4-sub	X	-	-
P. recurvatum	O	4	X	-	-
P. villosum	C	4-sub	X	-	Pilings
Ceramium gardneri* (a)	O	4	X	-	Exposed coast
Ceramium pacificum (e/3)	A	3-sub	X	X	-
Centroceras clavulatum	A	3-4	X	-	Sand swept
Microcladia borealis (a/2)	C	2	X	-	Exposed to surf

APPENDIX 1 Continued

Species	Abun	Zone	Substrate Rock	Substrate Epiphyte	Substrate Other
M. coulteri (e/3)	A	3-sub	-	X	-
M. californica	C	4	-	X	-
M. sp.					
Callithamnion sp.					
C. pikeanum	C	-	X	-	-
C. rupicolum	I-C	3-4	X	X	-
Pleonosporium squarrosum	A	4-sub	-	X	-
P. vancouverianum	A	4-sub	-	X	-
Tiffaniella snyderiae	A	4-sub	X	-	-
Ptilothamnionopsis lejolisea	C	4-sub	-	X	On coralline
Ptilota filicina	A	4	X	-	-
Neoptilota densa	A	4-sub	-	X	On coralline
N. hypnoides	O	4-sub	X	X	On corallines
Membranoptera weeksiae	CS	4-sub	X	X	-
Delesseria decipiens	CS	4-sub	X	-	-
Phycodrys profunda	F	4-sub	X	-	-
Anisocladella pacifica	A	4	-	-	Sandy areas
Nienburgia andersoniana	F	4-sub	X	-	-
Nitophyllum hollenbergii	O	4-sub	X	-	-
Hymenena flabelligera	F	4-sub	X	-	-
H. multiloba	A	4-sub	X	-	-
Cryptopleura corallinara	C	4	-	X	On coralline
C. lobulifera (e/3)	F	4	X	X	-
C. violacea	F-A	4-sub	X	X	-
Botryoglossum farlowianum	C	4-sub	X	-	-
Herposiphonia plumula	F	3-sub	X	X	-

APPENDIX 1 Continued

Species	Abun	Zone	Substrate Rock	Epiphyte	Other
H. verticillata	C	4	-	X	-
Pogonophorella californica	F	3-sub	X'	-	-
Polysiphonia hendryi var gardneri	C	2	X	-	-
P. hendryi var hendryi	F	4	-	X	-
P. pacifica var pacifica	F	4-sub	X	-	Pilings
P. pacifica var determinata*(b)	C	4	X	-	-
P. pacifica var distans*	O	-	X	-	-
P. paniculata	-	4	X	-	Sand swept
P. scopulorum var villum	F	-	X	X	-
Pterosiphonia baileyi	F	IT-sub	X	-	-
P. bipinnata	F	3-sub	X	-	Esposed coast
P. dendroidea	C	3-sub	X	-	-
Amplisiphonia pacifica	F	3-sub	X	X	-
Chondria decipiens	F	2-4	X	-	Pilings
Laurencia blinksii	F	4	X	-	-
L. pacifica	C-A	4	-	-	-
L. spectabilis var spectabilis	F-C	3-4	-	-	-
Erythrocystis saccata	C	4	-	X	-
Janczewskia gardneri	O-F	4-sub	-	-	Parasite

VASCULAR PLANT

Phyllospadix scouleri (c,d/3)

Ref. for algae list

1. Abbott, 1972

2. Brumbaugh, 1964

3. Environmental Services Division, 1974

4. Oceanographic Investigations in Carmel Bay, Review of Existing Information, 1977.

5. Smith, 1944.

APPENDIX 2

Intertidal Fauna

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
Phylum Porifera									
Class: Demospongiae									
Aplysilla glacialis	C	3-4	-	7,23	X			X	
Spongia idia	R	4	-	5			X		
Haliclona ecbasis	P	-	-	10		X			
Reniera sp. B	R	4	-	5		X			
Xestospongia vanilla	A	4	-	5		X			
Adocia gellindra	P	-	-	23			X		
Sigmadocia edaphus	P	-	-	5				X	
Mycale macginitiei	P	3-4	-	5		X			
Antho lithophoenix	P	3-4	-	5		X			
Axocielita originalis	C	4	-	5		X			
Clathria sp.	O	-	-	5		X			
Microciona parthena	R	4	-	5		X			
Microciona microjoanna	O	4	-	5,9		X*			
Acarnus erithacus	O	3-4	-	5,9		X	X		

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
<u>Anaata spongigartina</u>	O	3-4	-	5		X*			
<u>Lissodendoryx firma</u>	C	3-4	Under rock	5,23	X	X			
<u>Lissodendoryx topsenti</u>	C	3-4	-	9		X*			
<u>Plocamia karykina</u>	C	3-4	-	5		X			
<u>Polymastia pachymastia</u>	R	4-sub	-	23			X		
<u>Tethya aurantia</u>	P	3-4	Under rock	24	X				
<u>Tetilla arb</u>	U	4	-	9		X*	X		
<u>Tetilla</u> sp. <u>B</u>	U	4	-	-		X			
<u>Penares cortius</u>	R	-	-	9		X*			
<u>Stelletta clarella</u>	C	4	Under ledges	9,24		X*			
Class: Calcarea									
<u>Leucosolenia eleanor</u>	C	4	Under rocks	5,23,24			X		Still-water
<u>Leucandra heathi</u>	C	4	Under rocks	5,23	X		X		
Phylum Cnidaria									
Class: Hydrozoa									
<u>Campanularia</u> spp.	P	4	-	3,24		X			

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
Calycella syringa	P	-	On algae	3		X			
Aglaophenia spp.	P	4	Rocks/Eelgrass	5,24		X			
Plumularia spp.	P	4	-	3,24		X			
Abietinaria spp.	P	3	Rocks	24		X			
Sertularia spp.	P	-	-	3		X			
Hydractinia ssp.	P	3-4	-	3,5,23	X		X		
Class: Anthozoa									
Anthopleura spp.	P	-	-	6					Outfall
Anthopleura elegantissima	A	2-3	Rocks	7,13,4		X	X	X	Outfall
Anthopleura xanthogrammica	P	3	Solitary.	4,24		X			
Tealia crassicornis	P	4	Outer coast	16,24	X				
Tealia lofotensis	P	3-4	Outer coast	16		X			
Cactosoma arenaria	P	-	Open coast	15					Pebble Beach
Halcampa decemtentaculata	P	4	Hold fasts/ Eelgrass	15	X				
Corynactis californica	C	3-4	Protected	5,15,24		X	X		
Clavularia sp.	P	4	Under rocks	23			X		

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
Phylum Platyhelminthes									
Order: Acoela									
Polychoerus carmelensis	P	3-4	Under rocks	3,24			X*		
Order: Polycladida									
Pseudostylochus burchami	P	-	-	23			X		
Phylum Nemertea									
Baseodiscus punnetti	P	3-4	Red algae	23			X		
Amphiporus bimaculatus	P	3-4	Rock crevices	23			X		
Emplectonema sp.	P	1	Hold fasts	7				X	
Phylum Annelida									
Class: Polychaeta									
Family: Polynoidae									
Harmothoe imbricata	C	-	Free living	23			X		
Family: Hesionidae									
Ophiodromus pugettensis	C	-	Oral grooves asteroids	7			X	X	
Family: Syllidae									
Autolytus sp.	P	-	-	7			X	X	

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
Haplosyllis sp.	P	–	Rocky	7			X	X	Outfall
Syllis sp.	P	–	Holdfasts	7				X	Outfall
Family: Nereidae									
Eunereis sp.	P	–	Rocky	7				X	
Neanthes sp.	P	–	Rocky	7				X	
Nereis sp.	P	–	–	–			X	X	Outfall
N. eakini	P	–	Rocky	7			X	X	Outfall
N. grubei	P	–	Algae on rocks	–			X		
N. latescens	C	–	Algae holdfasts	–			X		
Platynereis sp.	–	4	Rocks	7			X	X	
Family: Eunicidae									
Marphysa stylobranchiata	P	IT	Rocky	23			X		
Family: Arabellidae									
Arabella iricolor	C	–	Rocky	23			X		
Family: Orbiniidae									
Naineris dendritica	C	–	Holdfasts, rocks	23			X		
Family: Terebellidae									
Eupolymnia crescentis	–	–	–	23			X		

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
Family: Sabellidae									
<u>Sabella</u> <u>crassicornis</u>	P	–	–	23			X		
Family: Terebellidae									
<u>Thelepus</u> <u>crispus</u>	P	–	Tubes under rock	23			X		
Family: Serpulidae									
<u>Spirorbis</u> sp.	C	–	Rocks	4		X			
Phylum Arthropoda									
Class: Cirripedia									
<u>Balanus</u> sp.	P	–	–	7			X	X	
<u>Balanus</u> <u>glandula</u>	C	1	Rocks	6,4		X			Outfall
<u>Chthamalus</u> <u>fissus</u>	C	1	Rocks	6		X	X	X	Outfall
<u>Tetraclita</u> sp.	C	1	Rocks	6,13,4		X	X	X	Outfall
Order: Mysidacea									
<u>Acanthomysis</u> <u>sculpta</u>	C	–	Surf zone	–					Outfall
Order: Isopoda									
<u>Idotea</u> sp.	C	–	–	–			X	X	Outfall
<u>I</u>. <u>stenops</u>	P	–	–	–			X	X	Outfall
<u>Cirolana</u> <u>harfordi</u>	C	1	Mussel beds	–			X	X	Outfall

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
<u>Dynamenella</u> sp.	P	–	–	7		X			
<u>Dynamenella</u> <u>dilatata</u>	P	–	–	8		X			
Order: Amphipoda									
S.O.: Gammaridae									
<u>Elasmopus</u> sp.	P	–	–	23			X		
<u>Parallorchestes</u> <u>ochotensis</u>	P	–	–	23			X		
<u>Pleustes</u> <u>panopla</u>	P	–	–	23			X		
S.O.: Caprellidea									
<u>Caprella</u> <u>californica</u>	P	Low	–	7				X	
Order: Eucarida									
<u>Heptacarpus</u> <u>pictus</u>	–	3-4	Under rocks	23,24			X		
<u>Spirontocaris</u> <u>prionota</u>	P	4	Rocks	23			X		
<u>Betaeus</u> <u>harfordi</u>	P	–	–	23			X		
<u>Mimulus</u> <u>foliatus</u>	P	4	Under rock	23			X		
<u>Pugettia</u> sp.	P	4	–	7			X	X	
<u>P</u>. <u>producta</u>	P	4	–	23,24			X		
<u>Cancer</u> <u>antennarius</u>	P	4	–	23,24			X	X	
<u>C</u>. <u>productus</u>	P	4	–	23,24			X		

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
Lophopanopeus bellus	P	-	-	23			X		
Pachygrapsus crassipes	P	2-3	On rocks	6,7,23,24			X	X	Outfall
Pagurus hirsutiusculus	P	-	-	7			X	X	
P. samuelis	A	2	-	-				X	Outfall
Cyyptolithodes sitchensis	P	4	Under rock	23,24			X		
Hapalogaster cavicauda	C	4	Under rock	24			X		
Petrolisthes cinctipes	C	2-3	Under rock	23,24			X		
P. eriomerus	P	3	Under rock eelgrass	23			X		
Phylum Mollusca									
Class: Polyplacophora									
Callistrochiton crassicostatus	P	1-4	Under rock	23,24,14				X	
Nuttallina californica	C	3	-	4,5,24	X				Outfall
Basiliochiton heathi	Sc.	-	-	5,25	X				
Cyanoplax dentiens	C	2-3	On abalone	7,25			X		
Ischnochiton radians	C	4-sub	-	5				X	
Lepidozona mertiensii	P	4	Under rocks	5,24,					Carmel Beach
Stenoplax heathiana	C	4	Under rocks	24,25	X				
Tonicella lineata	-	-	-	4,7		X		X	

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
<u>Dendrochiton</u> <u>thamnoporus</u>	S	4-sub	Under rocks	24	X				
<u>Katharina</u> <u>tunicata</u>	C	4	On rocks	4,24,6, 23,7	X	X	X	X	Outfall
<u>Mopalia</u> sp.	P	-	-	5				X	
<u>M</u>. <u>ciliata</u>	P	3-4	-	23				X	
<u>M</u>. <u>lowei</u>	P	-	-	5			X		
<u>M</u>. <u>muscosa</u>	C	4	Under rocks	6,24			X	X	Outfall
Class: Gastropoda									
Sub Class: Prosobranchia									
<u>Diodora</u> <u>arnoldi</u>	-	-	-	22	X*				
<u>D</u>. <u>aspera</u>	C	-	-	5			X		
<u>Fissurella</u> <u>volcano</u>	P	2	On rocks	4,5,24		X	X		
<u>Collisella</u> <u>digitalis</u>	C	1	Sides rock	4,5,24		X	X	X	Outfall
<u>C</u>. <u>limatula</u>	P	3	-	5,24			X		
<u>C</u>. <u>ochracea</u>	S	4	On rocks	5,25			X	X	
<u>C</u>. <u>pelta</u>	P	2	-	7,24			X		
<u>C</u>. <u>scabra</u>	P	2	Tops rocks	4,5,7,12		X	X	X	Outfall
<u>Lottia</u> <u>gigantea</u>	P	1	-	4,7,24		X	X		
<u>Notoacmea</u> <u>insessa</u>	P	4	With Egregia	6,24			X	X	Outfall

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
N. persona	P	1-2	-	7,24				X	
N. scutum	C	3	Rocky	5,24			X		
Tegula brunnea	C	3-4	-	7,24				X	
T. funebralis	A	2	On tocks	7,24			X	X	Outfall
Astraea gibberosa	P	4	-	23,24			X		
Lacuna sp.	P	-	-	6				X	
L. marmorata	P	-	-	7			X	X	
Lacuna porrecta	P	-	-	7			X		
Littorina planaxis	A	1	-	7			X		
L. scutulata	A	2	-	2,24				X	
Bittium eschrichtii	P	2	Course sand	7				X	
B. interfossa	P	-	Under algae	7			X		
Epitonium sp.	P	-	-	7				X	
Lamellaria sp.	S	-	-	23			X		
Velutina c.f.V. velutina	P	4	With ascid	7				X	
Thais sp.	C	4	-	6					Sewer
Nucella canaliculata	C	4	-	5,6,23,24		X	X	X	Sewer
N. emarginata	C	2	-	4,5,6,7		X	X	X	Sewer

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
Sub Class: Opisthobranchia									
Berthella californica	P	–	–	20,23			X		
Aegires albopunctatus	P	–	–	23,25	X		X		
Aldisa sanguinea	P	–	–	20,23			X		
Ancula pacifica	P	–	–	20			X		
Anisodoris nobilis	P	–	–	20		X	X		
Archidoris montereyensis	P	–	–	20,23			X		
Archidoris odhneri	P	–	–	20			X		
Cadlina flavomaculata	S	–	–	20,25		X	X		
C. luteomarginata	S	–	–	20,23,25			X		
C. modesta	P	–	–	20,23			X		
Catriona alpha	P	–	–	20			X		
Conualevia alba	P	–	–	23			X		
Coryphella trilineata	P	–	–	21,23			X		
Dendronotus subramosus	P	–	–	20			X		
Diaulula sandiegensis	C	–	–	20,25		X	X		Del Monte Beach
Dirona picta	C	–	–	20,25	X		X		
Discodoris heathi	S	–	–	20,25		X	X		

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
Doriopsilla albopunctata	C	–	–	20,21,23		X	X		
Flabellinopsis iodinea	S	–	–	21,23,25			X		
Hermissenda crassicornis	C	–	–	20,25			X		
Hopkinsia rosacea	C	–	–	20,21		X	X		
Laila cockerelli	S	–	–	21,23			X		
Rostanga pulchra	A	–	–	21,25		X	X		
Trinchesia abronia	P	–	–	20		X			
Triopha carpenteri	C	–	–	21,25		X	X		
T. maculata	C	–	–	23,25			X		
Tritonia festiva	P	–	–	20,23,25	X	X	X		
Phidiana hiltoni	P	–	–	21,23			X		
Sub Class: Pulmonata									
Onchidella sp.	P	–	–	6				X	Outfall
Class: Bivalvia									
Mytilus californianus	C	1	–	4,5,7		X		X	
Phylum Ectoprocta									
Alcynidium spinifera	P	–	–	5			X		
Crisia cornuta	P	–	–	–		X			

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
Caulibugula ciliata	P	–	–	23		X			
Hincksina velata	P	–	–	21			X		
Phylum Entoprocta									
Barentsia sp.	P	4	–	23			X		
B. gracilis	P	–	–	5		X			
B. ramosa	P	–	–	23			X		
Phylum Sipuncula									
Golfingia margaritacea californiensis	–	4	–	11	X				
Themiste pyroides	P	–	–	23			X		
Phascolosoma agassizii	P	–	–	7,11	X			X	Sewer
Phylum Echinodermata									
Class: Echinoidea									
Strongylocentrotus purpuratus	P	3-4	Violent surf	4,23,24		X	X		
Class: Asteroidea									
Dermasterias imbricata	O	4	–	23,24			X		
Henricia leviuscula	P	4	–	23,24		X	X		
Leptasterias hexactis	P	–	–	7,23			X		

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
Pisaster brevispinus	P	–	–	23	X				
P. giganteus	P	4	Under rock	23,24	X				
P. ochraceus	P	–	–	6,7,23			X	X	Sewer
Class: Ophiuroidea									
Amphipholis pugetana	P	–	–	23			X		
Ophioplocus esmarki	P	3	Under rock	19,23,24	X		X		
Ophiothrix spiculata	P	4	–	19,24				X	
Class: Holothuroidea									
Leptosynapta sp.	P	–	–	23			X		
Cucumaria curata	P	–	–	4,23		X			
C. piperata	P	–	–	23			X		
Eupentacta quinquesemita	P	–	–	23			X		
Lissothuria nutriens	O	4	Under rock	23,24		X	X		
Phylum Chordata									
Subphylum Urochordata									
Didemnum carnulentum	C	–	–	1		X			
Styela montereyensis	P	–	–	23			X		
Intertidal Fishes									
Micrometrus aurora	P	–	–	23			X		
Hexagrammos superciliosus	P	–	–	23			X		

APPENDIX 2 Continued

Species	Abun	Zone	Substrate	Source	Carmel Bay	Pescadero Point	Carmel Point	San Jose Creek	Other
Artedius lateralis	P	-	-	23			X		
Clinocottus analis	P	-	-	18,23		X	X		
Clinocottus recalvus	C	4	-	18,23			X		
Oligocottus snyderi	P	-	-	18,23		X	X		
O. rimensis	P	-	-	23			X		
O. rubellio	U	-	-	23		X			
Liparis florae	P	-	-	23		X			
Gobiesox maendricus	P	3	Under rock	23,24			X		
Rimicola muscarum	P	-	-	23			X		
Gibbonsia metzi	C	-	-	18		X			
G. montereyensis	P	-	-	23			X		
Anoplarachus purpurescens	P	-	-	23			X		
Xererpes fucorum	P	-	-	23			X		
Xiphister atropurpureus	P	-	-	18,23		X	X		
X. muscosus	P	3	-	18,23,24		X	X		
Orthonopias triacis	P	-	-	2	X				

* indicates type from this locality

References for Appendix 2

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2 Bolin 1934
3 Bowman 1947
4 Brumbough 1964
5 California Acadamy of Sciences, Dept. Invert. Zool.
6 Abbott, 1972
7 Environmental Services Division 1974
8 Davis 1947
9 deLaubenfels 1932
10 Fell 1967
11 Fisher 1952
12 Frazier 1947
13 Goff 1947
14 Gordon 1947
15 Hand 1954
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19 May 1924
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24 Ricketts and Calvin 1968
25 Smith and Gordon 1948

APPENDIX 3

Species List from Subtidal Survey of ASBS Conducted 11/20/77-12/11/77

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
Length of transect (meters)		85	100	100	
Exposure		EX	EX	EX	
Percentage Sand		4%	5%	5%	
Transect Depth		32-66'	18-47'	47-68'	
MARINE FLORA					
Division Phaeophyta					
Macrocystis _pyrifera_ adult	Rock	6	5	-	
Average # of stipes		7	5	-	
Juveniles		5	3		
Cystoseira _osmundacea_	Rock tops	P	P		
Desmarestia _ligulata_ var. _firma_	Rock tops			C	
_D._ _ligulata_ var. _ligulata_	Rock tops				X
Dictyoneurum _californicum_	Rock tops		C		
Eisenia _arborea_	Rock tops				X
Laminaria _dentigera_	Rock tops		C		
Pterygophora _californica_	Rock tops	P			
Division Rhodophyta					
Botryocladia _pseudodichotoma_	Low rocks				X

APPENDIX 3 Continued

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
Botryoglossum farlowianum	Rock tops		P		
Calliarthron cheilosporioides	Rock tops				X
Callophyllis sp.	Rock tops		P		
Gelidium spp. (G. arborescens, G. pupurascens, G. robustum)	Rock tops				X
Gigartina spp. (G. corymbifera, G. exasperata)	Rock tops		A		
Maripelta rotata	Deep				X
?Nitophyllum cincinnatum	Epiphyte				
Plocamium cartilagineum	Rock tops	P	P		
Prionitis lanceolata	Rock tops	P	P	P	
Rhodymenia sp. (R. pacifica)	Rock tops	P	C	P	
Weeksia reticulata	Rock tops	P			
Articulated corallines	Rock tops	A	P		
Encrusting corallines	Rock tops	A	A	A	
Filamentous red algae	Rock tops		P		
Red crust	Rock tops		P	P	
Flowering plants					
Phyllospadix scouleri	Rock tops				X

APPENDIX 3 Continued

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
Phylum Porifera					
Acarnus erithacus	Rock	P	P	P	
?Axocielito originalis					X
Cliona celata	Boring in $CaCO_3$				X
Hymenamphiastra cyanocrypta	Rock/crevices	P	P	P	
Leucandra heathi					X
Leucilla nuttingi			P		
Leucosolenia eleanor					X
Ophlitaspongia sp.			P		
Polymastia pachymastia	Sand covered rock				X
Spheciospongia confoederata	Tall rocks				X
Stelletta clarella	Tall rocks		P		
Tethya aurantia	Rock tops		P		
Tetilla arb	Rock				X
Toxadocia sp.	Pinnacle		P		
Xestospongia vanilla					X
Unidentified species	Various		P	P	
Phylum Cnidaria					
Abietinaria spp.	Rock	P	P		

APPENDIX 3 Continued

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
Aglaophenia spp.	Rock/algae				X
Allopora californica	Rock faces	P		P	
A. porphyra					X
Anthopleura artemisia					X
A. elegantissima	Sand/gravel				X
A. xanthogrammica	Base of rocks				X
Astrangia lajollaensis	Rock faces				X
Balanophyllia elegans	Rock	C	P	C	
Campanularia sp.					X
Clavularia sp.					X
Corynactis californica	Rock faces	P	C	P	
Epiactis prolifera	Cystoseira				X
Eucopella sp.	Rocks/algae				X
Eudendrium sp.	Algae				X
Hydractinia sp.					X
Metridium senile	Rock				X
Pachycerianthus sp.	Sand			P	
Paracyathus stearnsi	Rock	P			
Plumularia spp.	Algae				X

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
Sertularella sp.	Rock/algae	P	P		
Sertularia sp.					X
Tealia coriacea					X
T. crassicornis					X
T. lofotensis	Bases of rocks	P	P	P	
T. sp.			P	C	
Tubularia sp.					X
Phylum Nemeratea					
Tubulanus polymorphus					X
T. sexlineatus					X
Phylum Annelida					
Class Polychaeta					
Cirratulidae					X
Diopatra ornata	Sand			C	
Dodecaceria fewkesi	Rock	A	P	C	
D. fewkesi (Large form)	Rock				X
Eudistylia polymorpha	Crevice	P	A	P	
Myxicola infundibulum					X

APPENDIX 3 Continued

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
Phragmatopoma californica			P		
Sabellaria sp.	Rock				X
Salmacina tribranchiata	Rock		P		
Serpula sp.	Rock				X
Spirorbis spp.	Algae				X
Thelepus crispus	Sand				X
Phylum Mollusca					
Class Polyplacophora					
Cryptochiton stelleri	Rock		P		
Tonicella lineata	Coralline crusts	C	P		
Class Gastropoda : Prosobranchia					
Astraea gibberosa	Rock				X
Calliostoma annulatum	Algae				X
C. canaliculatum	Sponges				X
C. gloriosum	Algae				X
C. ligatum	Rock/tunicates		P		
C. supragranosum	Rock				X
Ceratostoma foliatum	Barnacle covered rock				X

APPENDIX 3 Continued

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
Diodora aspera					X
Erato sp.					X
Haliotis rufescens	Crevice				X
H. walallensis	Crevice				X
Hipponix sp.	Rock/shell				X
Lamellaria sp.	Colonial tunicate				X
Megatebennus bimaculatus	Colonial tunicate				X
Megathura crenulata	Rock/tunicate	P			
Mitra idae	Rock				X
Ocenebra sp.	Rock				X
Petaloconchus montereyensis	Rock	P		P	
Pseudomelatoma sp.	Rock				X
Serpulorbis squamigerus	Rock/shell				X
Tegula brunnea	Macrocystis/algae				X
T. montereyi	Macrocystis/algae				X
T. pulligo	Macrocystis/algae				X
Class Gastropoda : Ophistobranchia					
Anisodoris nobilis					X

APPENDIX 3 Continued

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
Aplysia californica	Sand/rock/algae				X
Archidoris montereyensis	Rock				X
A. odhneri	Rock				X
Cadlina luteomarginata	Rock				X
Coryphella trilineata	Rock				X
Diaulula sandiegensis	Rock				X
Doriopsilla albopunctata	Rock				X
Flabellinopsis iodinea	Rock				X
Hermissenda crassicornis	Rock				X
Hopkinsea rosacea	Rock				X
Laila cockerelli	Rock				X
Phidiana pugnax	Rock				X
Trinchesia lagunae	Rock				X
Triopha carpenteri	Rock				X
T. grandis	Rock				X
Class Gastropoda : Biualvia					
Hinnites giganteus	Rock	D			

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
Phylum Arthropoda					
Class Crustacea					
Alpheus sp.	Rock		P		
Balanus nubilus	Rock		P		
Balanus sp.	Rock			C	
Cryptolithodes sitchensis	Sand/rock				X
Loxorhynchus spp. (*L. crispatus*, *L. grandis*)	Rock	P	P	P	X
Mimulus foliatus	Rock/*Diopatra*		P		
Pachycheles sp.	Holdfasts				X
Pandalus gurneyi					X
Pagurus spp.					X
Phyllolithodes papillosus	Under rocks/kelp				X
Pugettia producta					X
P. richii					X
Scyra acutifrons					X
Phylum Sipunculida					
Themiste dyscritum					X

APPENDIX 3 Continued

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
Phylum Bryozoa					
Bugula spp.	Rock				X
Celleporaria brunnea	Rock				X
Costazia robertsonae	Rock/algae		P		
Crisia spp.					X
Cryptosula pallasiana		C			
Diaperoecia californica			P	P	
Eurystomella bilabiata					X
Flustrellidra corniculata					X
Heteropora sp.		C	P	P	
Hippodiplosia insculpta	Rock/algae	P	P		
Hippothoa hyalina	Rock/shell/algae	P	P		
Lagenipora sp.					X
Lichenoporididae (Lichenopora or Disporella)					X X
Membranipora spp.	Macrocystis				X
Phidolopora pacifica	Rock/algae	P	P		
Scrupocellaria sp.		P			
Thalmoporella sp.					X

APPENDIX 3 Continued

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
Tubulipora spp.					X
Unidentified species			P	P	
Phylum Entoprocta					
Barentsia sp.		P			
Phylum Echinodermata					
Class Asteroidea					
Astropecten verrilli	Sand				X
Dermasterias imbricata	Rock	C	P	P	
Henricia leviuscula	Rock	P			
Leptasterias spp.			P		
Mediaster aequalis	Deep rock	P		P	
Orthasterias koehleri	Rock	P	P	P	
Patiria miniata	All	P			
Pisaster brevispinus	Sand/rock		C	C	
P. giganteus	Rock	P			
P. ochraceus	Rock		P	P	
Pycnopodia helianthoides	All		P		
Class Echnoidea					
Strongylocentrotus franciscanus	Crevices, depressions	P	P		

APPENDIX 3 Continued

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
S. purpuratus	Crevices, depressions				X
Class Holothuroidea					
Cucumaria miniata	Crevices				X
?C. piperata	Crevice				
Eupentacta quinquesemita	Crevice				
Stichopus californicus	Rocks				
Class Ophuroidea					
Ophioplocus esmarki	Crevices/under rock				
Ophiopteris papillosa	Crevices/under rock				
Ophiothrix spiculata	Holdfasts/under rock				
Phylum Chordata					
Subphylum Urochordata (Tunicata)	Rock				
Aplidium spp.	Rock			P	
Archidistoma molle	Rock	P			
A. psammion	Rock	C			
Ascidia ceratodes	Rock				
Boltenia villosa	Rock				
Cnemidocarpa finmarkiensis	Rock				

APPENDIX 3 Continued

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
Cystodytes lobatus	Rock, *Macrocystis*				
Didemnum carnulentum	Rocks/algae	C	A	P	
Diplosoma macdonaldi		P		P	
Metandrocarpa taylori					
Perophora annectens	Various	P			
Polyclinum planum					
Pycnoclavella stanleyi	Sand covered rock				
Pyura haustor					
Ritterella rubra					
Styela montereyensis	Rock		P	P	
S. truncata					
Synoicum parfustus	Rock faces			P	
Tridideminum opacum		P			
Unidentified species			P		
Class Pices					
Scorpaenidae					
Sebastes atrovirens				P	
S. carnatus					X

APPENDIX 3 Continued

Species	Substrate	Pescadero Point	Inside Mission Point	Outside Mission Point	Present in ASBS
S. crysomelas					X
S. mystinus adult		1	A		
S. mystinus juvenile		47	C		
S. spp. juvenile					X
Embiotocidae					
Damalichthys vacca		1	C		
Embiotoca jacksoni		2			
E. lateralis					X
Hypsurus caryi		1			
Miscellaneous					
Anarichthys ocellatus					X
Cebidichthys violaceous					X
Hexagrammos decagrammus		2			
Prionace glauca		P			
Scorpaenichthys marmoratus		1			

APPENDIX 4. A SUMMARY OF THE BIOLOGICAL MONITORING PROGRAMS OF THE CARMEL SANITARY DISTRICT'S SUBTIDAL OUTFALL 1972 TO 1978.

Author and Dates Sampled	Sampling Stations	Depth (meters)	Type of Monitoring at Each Station
I. A. Abbott (1973) Sept. 20, 25, 26, 27, and Oct. 25, 1972.	<u>Rock</u>:		
	Onshore Sewer	-*	$\frac{1}{4}m^2$ diver-counted quadrats (7-11)**
	Offshore Sewer	-	$1/32m^2$ rock scrapes (3)
	Sister (Reference)	~10m	*Macrocystis* sp. stipe counts (20)
	<u>Sand</u>:		
	N. Sewer	-	Cove samples (0-3)
	S. Sewer	11m	Sediment samples (3)
	N. Sister	11m	$1m^2$ diver-counted quadrats (6-9)
	S. Sister	10m	Ripple marks measured
	<u>Transitional</u> (*Diopatra ornata* bed):		
	Offshore Sewer	-	Core samples (0-2)
	Onshore Sewer	11m	*Diopatra* tubes collected (4)
	N. Sister	14m	
Environmental Services Division (1974) April and October, 1973	<u>Rock</u>:		
	Sewer Rock (CSR)	10.6m	$\frac{1}{4}m^2$ diver-counted quadrats (3-5)
	Reference Rock (CRR)	10.3m	$1/50m^2$ rock scrapes (3-5)
			Macrocystis stipe counts, April
			Macrocystis plant counts, October
	<u>Sand</u>:		
	Sewer	12m	½ liter infaunal samples, 05(?)mm mesh (-)
	N. Sewer	12m	Sediment cores (6, April)
	Reference	11.5m	$1m^2$ quadrats (-)

* Dash (-) indicates information not given in report.
** Parentheses around a number indicate the number of replicate samples.

APPENDIX 4 . (Cont.)

Author and Dates Sampled	Sampling Stations	Depth (meters)	Type of Monitoring at Each Station
	Transitional *Diopatra* bed:		
	Sewer	11.5m	Coffee can cores, .5mm mesh (-)
	Reference	13.5m	Sediment cores (2-3)
			Diopatra tubes collected (3)
Oceanographic Services, Inc. (1975) June 19-21, 1974 Sept. 24-25, 1974 (New Stations)	Rock:		
	Sewer (CSR)	10.6 to 11.5m	Fixed $\frac{1}{4}m^2$ quadrats (5)
	Reference (CRR)	8.5 to 10.9m	Blind-cast $\frac{1}{4}m^2$ quadrats (3-5)
			$1/50m^2$ rock scrapes (5)
			Macrocystis stipe counts
			Macrocystis plant counts
	Sand:		
	Sewer	11.5m	One gallon scoops; .75mm mesh (3)
	Reference	10.6m	
	Transitional *Diopatra* beds:		
	Sewer	11.5m	Blind-cast $\frac{1}{4}m^2$ quadrats (9)
	Reference	10.6m	
Kinnetic Laboratories Inc. (1976) June/July 1975 Sept./Oct. 1975 (New Stations)	Rock:		
	Sewer	-	Fixed $\frac{1}{4}m^2$ quadrats (5)
	Reference	-	Random $\frac{1}{4}m^2$ quadrats (5, June)
			Line intercept *Macrocystis* count
	Transitional *Diopatra* bed:		
	Sewer	-	Coffee can cores; .5mm mesh (3)
	Reference	-	Sediment cores (3)

APPENDIX 4 . (Cont.)

Author and Dates Sampled	Sampling Stations	Depth (meters)	Type of Monitoring at Each Station
Kinnetics Laboratories Inc. (1977) June 24, 25, 26, 1976 Sept. 25, 27, 28, 1976	Rock:		
	Sewer	10.0 to 12.2m	Fixed $\frac{1}{4}m^2$ quadrats (5)
	Reference (new)	10.6 to 11.5m	Random $\frac{1}{4}m^2$ quadrats (5, June)
			Fixed $\frac{1}{4}m^2$ photoquadrats (5)
			$1/50m^2$ rock scrapes (5)
	High Impact (HI)	-	Fixed $\frac{1}{4}m^2$ photoquadrats (3)
	High Impact Control (HIC)	-	Random $1/8m^2$ photoquadrats (-)
			$1/50m^2$ rock scrapes (5, fall)
	Transition Diopatra beds:		
	Sewer	-	Coffee can cores (3)
	Reference	-	Sediment samples (3)
Kinnetics Laboratories Inc. (1978) June 7, 13 Nov. 11 Dec. 1	Rock:		
	Sewer	-	Random $1/8m^2$ photoquadrats (45 or more)
	Reference	-	Aerial kelp cover
	High Impact (HI)	-	Random $1/8m^2$ photoquadrats (45 or more)
	High Impact Control (HIC)	-	Map of high impact area
	Alternative I	-	Random $1/8m^2$ photoquadrats (45 or more)
	Alternative II	-	Grain size analysis
			Clod card analysis
	Alternatives III-VII	-	Grain size analysis
			Clod card analysis
	Transitional Diopatra beds:		
	Sewer	-	Random $\frac{1}{4}m^2$ quadrats (9-19)

APPENDIX 5a

Effluent Monitoring Data For Carmel Sanitation District
1973-77 EFFLUENT VALUES FOR STANDARD
WASTEWATER PARAMETERS, CARMEL SEWAGE
TREATMENT PLANT

Wastewater Parameter	Monthly Mean, Fiscal Year 1973-74	Monthly Mean, Fiscal Year 1974-75	Monthly Mean, Fiscal Year 1975-76	Monthly Mean, Fiscal Year 1976-77	Annual Mean, 1973-1977	Range in Monthly Means, 1973-77 or total data available; Year & Month of Maximum Value
Flow (MGD)	1.8	2.1	2.1	1.5	1.9	.9-3.7*(1/75)
SS (mg/1)	.23	0.5	.15	.08	tr .24	trace 2.7*(8/74)
Chlorine residual (mg/1)	-	1.32	.94	1.20	1.15	5-5.0*(9/74; 8/77)
TSS (mg/1)	24	34	22	15	24	5-71*(8/74)
BOD (mg/1)	25	25	22	28	25	3-56*(7/74)
pH	7.2	7.1	7.3	7.3	7.2	6.6-7.4*(7/74)
O&GT (mg/1)	-	-	2.3	.9	1.6	<0.1-9.8*(7/75)
NH_3-N (mg/1)			16.38	22.02	19.2	<.05-41.77 (4/77)
TKN (mg/1)		(Feb-May 1975) 9.3			9.3	2.8-27.2
Nitrate Nitrogen (mg/1)		(Feb-May 1975) 14.8			14.8	.45-22
Phosphate (mg/1)		(Feb-May 1975) 7.8			7.8	6.4-9.6
Phenols (mg/1)	-	-	-	-	.006	-

APPENDIX 5b

Effluent Monitoring Data For Carmel Sanitation District

CARMEL EFFLUENT AVERAGE AND MAXIMUM VALUES FOR CONSERVATIVE ELEMENTS[1]

Constituent	Average Concentrations, 1975-1977[8]	Maximum Value, 1975-1977; Month and Year Sampled
Arsenic[2]	<.01 mg/1[9]	.03 mg/1 (5/76)
Cadmium[3]	<.002 mg/1[9]	.006 mg/1 (5/76)
Chromium[2]	.003 mg/1	.009 mg/1 (5/76)
Copper[4]	.04 mg/1	.13 mg/1 (11/77)
Lead[3]	.022 mg/1	.08 mg/1 (11/75)
Mercury[5]	<.0002 mg/1[9]	.0017 mg/1 (5/75)
Nickel[2]	<.01 mg/1[9]	.01 mg/1 (5/75, 5/76)
Silver[6]	.021 mg/1	.07 mg/1 (5/77)
Zinc[7]	.089 mg/1	.22 mg/1 (11/77)
Cyanide	<.05 mg/1[9]	.05 mg/1 (5/76)
PCB	<.00010 mg/1[9]	.0002 mg/1 (5/76)
Chlorinated Pesticides	<.0010 mg/1[9]	NONE
TICH	<.0010 mg/1[9]	NONE
Gross ALPHA*	<2 pCi/L+6[9]	NONE
Gross BETA*	20± 1 pCi/L+6	26±1 pCi/L+6 (6/75)

1 Data from Carmel Sanitary District. Measurements made semi-annually. Analyses currently performed by Pacific Environmental Laboratory (Sue Roberts, chemist) on a Perkin-Elmer 460 model atomic absorption spectrophotometer.

2 Flameless technique.

3 MIBK APDC extraction; flame technique.

4 Flame; MIBK APDC extraction and flame for concentrations <.1 mg/1.

5 Cold vapor technique.

6 Flame.

7 Flame; MIBK APDC extraction for concentrations < .2 mg/1.

8 "Less than" values are averaged as half of the given value.

9 Below level of detection (using technique footnoted for metals).

APPENDIX 5c

Effluent Monitoring Data For Carmel Sanitation District

1975-78 TOTAL AND FECAL COLIFORM VALUES: EFFLUENT, CARMEL SEWAGE TREATMENT PLANT

Month	1975[1]	1976[1]	1977[2]	1978[2]
January	18	2	542	372
February	3	2	416	186
March	27	2	713	150
April	417	1	251	77
May	9	6	34	72
June	4	25	180	120
July	138	3	46	
August	4	1	23	
September	36	4	53	
October	105	7	79	
November	4	6	447	
December	6	5	63	
Annual Mean	64	5	237	163

[1]Fecal Coliform

[2]Total coliform. Values would be expected to be higher as test is for a broader class of bacteria.

APPENDIX 5d
Effluent Monitoring Data For Carmel Sanitation District

1973-78 TOTAL COLIFORM VALUES
CARMEL SANITARY DISTRICT SHORE STATIONS
AND MOUTH OF CARMEL RIVER[1]

Sampling Location	Monthly Mean, Fiscal Year 1973-74	Monthly Mean, Fiscal Year 1974-75	Monthly Mean, Fiscal Year 1975-76	Monthly Mean, Fiscal Year 1976-77	Monthly Mean, Fiscal Year 1977-78	Annual Mean, 1973 - 78
Beach surf 1/4 mile NW of outfall	114	81	36	35	101	73
Beach surf 1/4 mile south of outfall	62	38	38	71	108	63
Beach surf at outfall	59	77	34	94	61	65
Mouth of Carmel River	Data Base Too Small	Data Base Too Small	492	878	2873	1414 (1975-78)

[1]All values are MPN/100 ml.

[2]When river not flowing, taken just inside sand bar

APPENDIX 5e

Effluent Monitoring Data For Carmel Sanitation District

TOXICITY OF CARMEL TREATMENT PLANT EFFLUENT, AS MEASURED BY 96-HOUR STATIC BIOASSAY ON STICKLEBACKS (*Gasterosteus aculeatus*)

Year	TL_{50}*	pH**	Dissolved Oxygen	Residual Chloride
1974	100+	8.0	7.2	<0.1
1975	85	7.8	8.2	<0.1
1976	62	7.45	7.2	.4
1977	38	7.45	8.2	Not Determined

* Percent concentration at which 50% of test organisms survive after 96 hours.

** In undiluted effluent, at start of test.

Source: Carmel Sanitary District, unpublished data.

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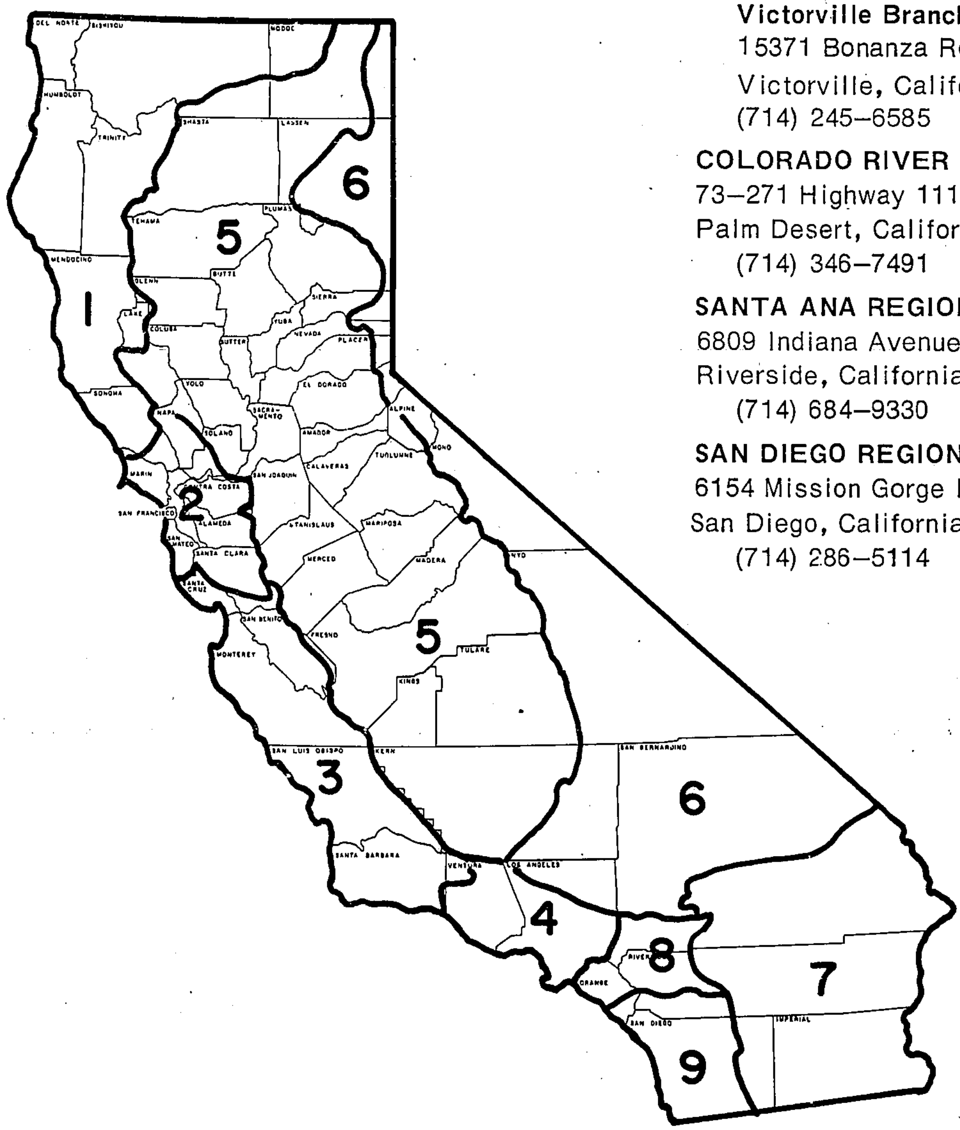

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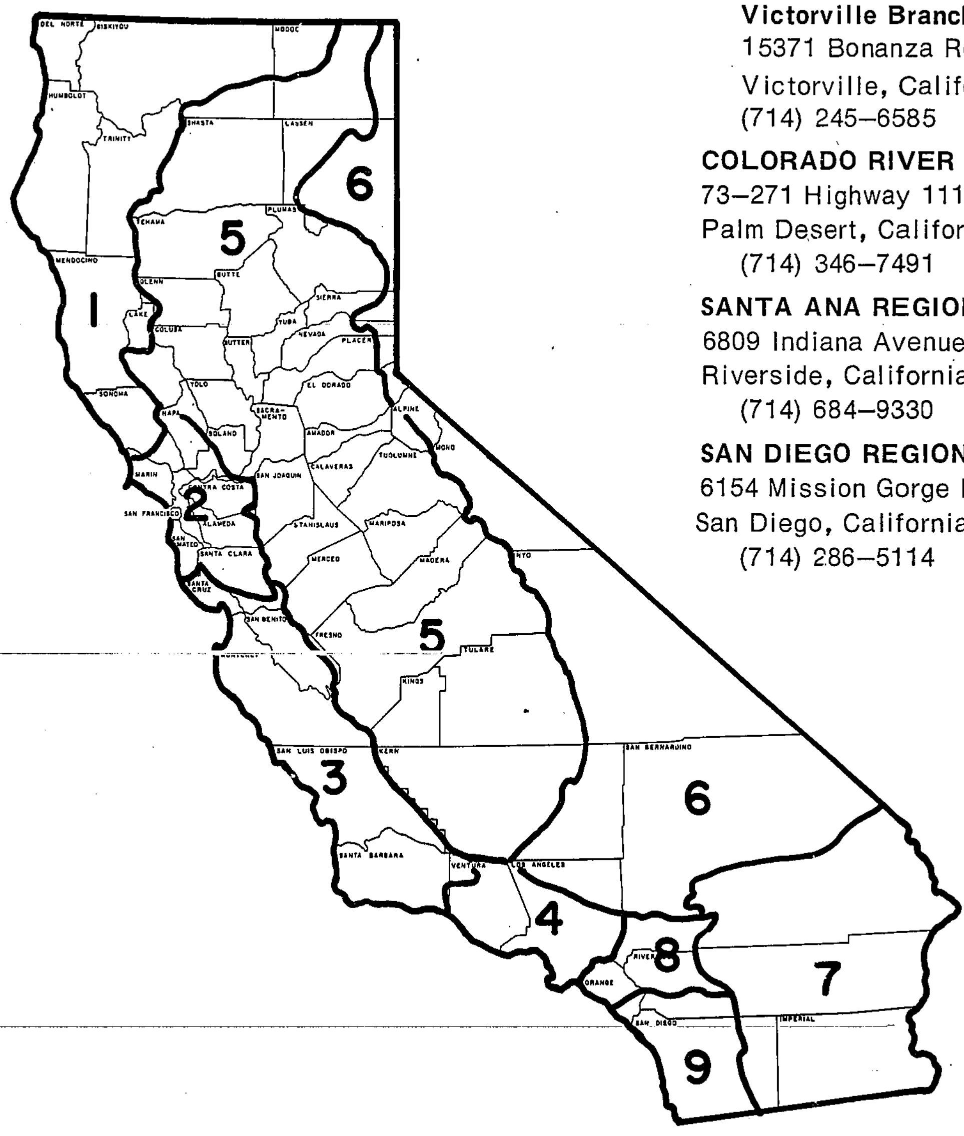

California Marine Waters
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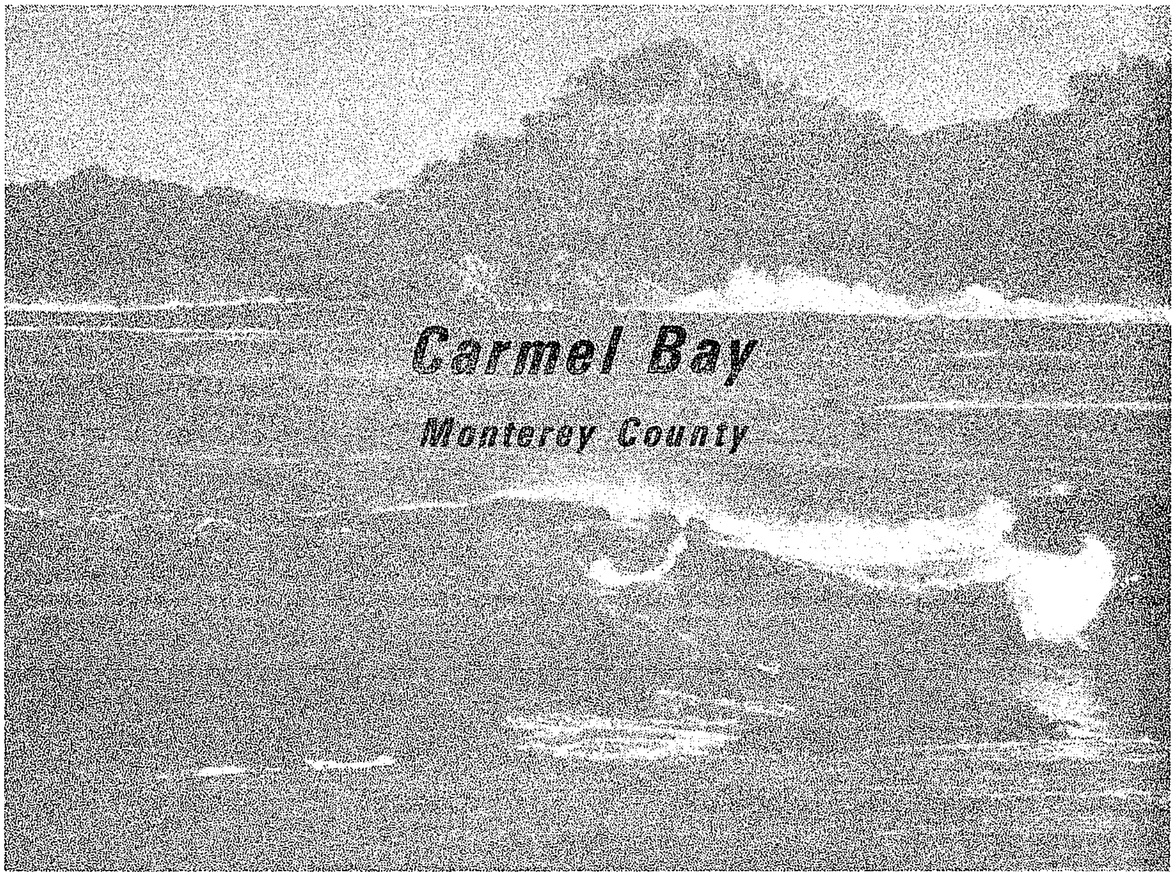

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DIVISION OF PLANNING AND RESEARCH

SURVEILLANCE AND MONITORING SECTION

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