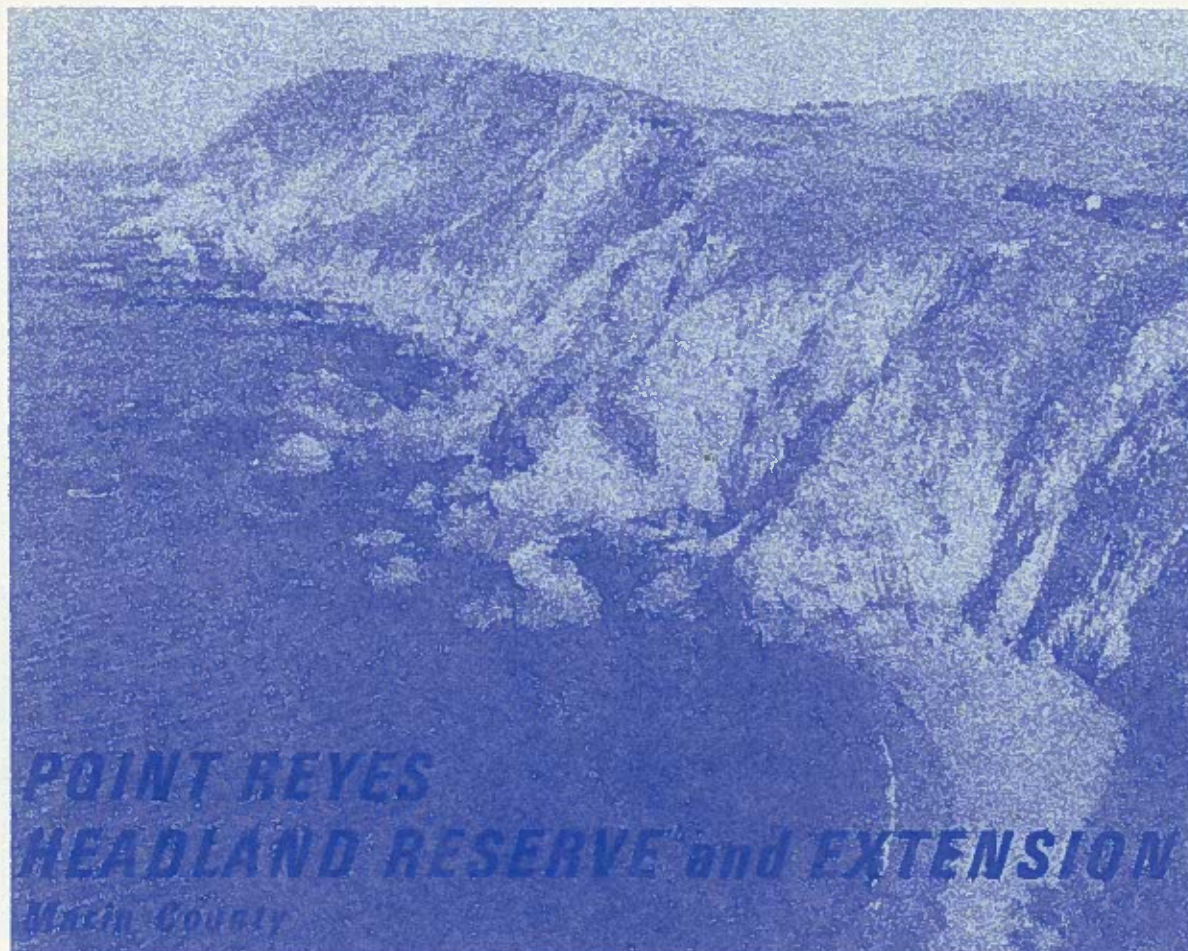


***California Marine Waters
Areas of Special Biological Significance
Reconnaissance Survey Report***



***CALIFORNIA STATE WATER RESOURCES CONTROL BOARD
DIVISION OF PLANNING AND RESEARCH
SURVEILLANCE AND MONITORING SECTION
April 1980***



STATE OF CALIFORNIA

Edmund G. Brown Jr., Governor

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**Point Reyes Headland Reserve and Extension
Area of Special Biological Significance**

Printed July 1980

CALIFORNIA MARINE WATERS
AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE
RECONNAISSANCE SURVEY REPORT

POINT REYES HEADLAND RESERVE AND EXTENSION
MARIN COUNTY

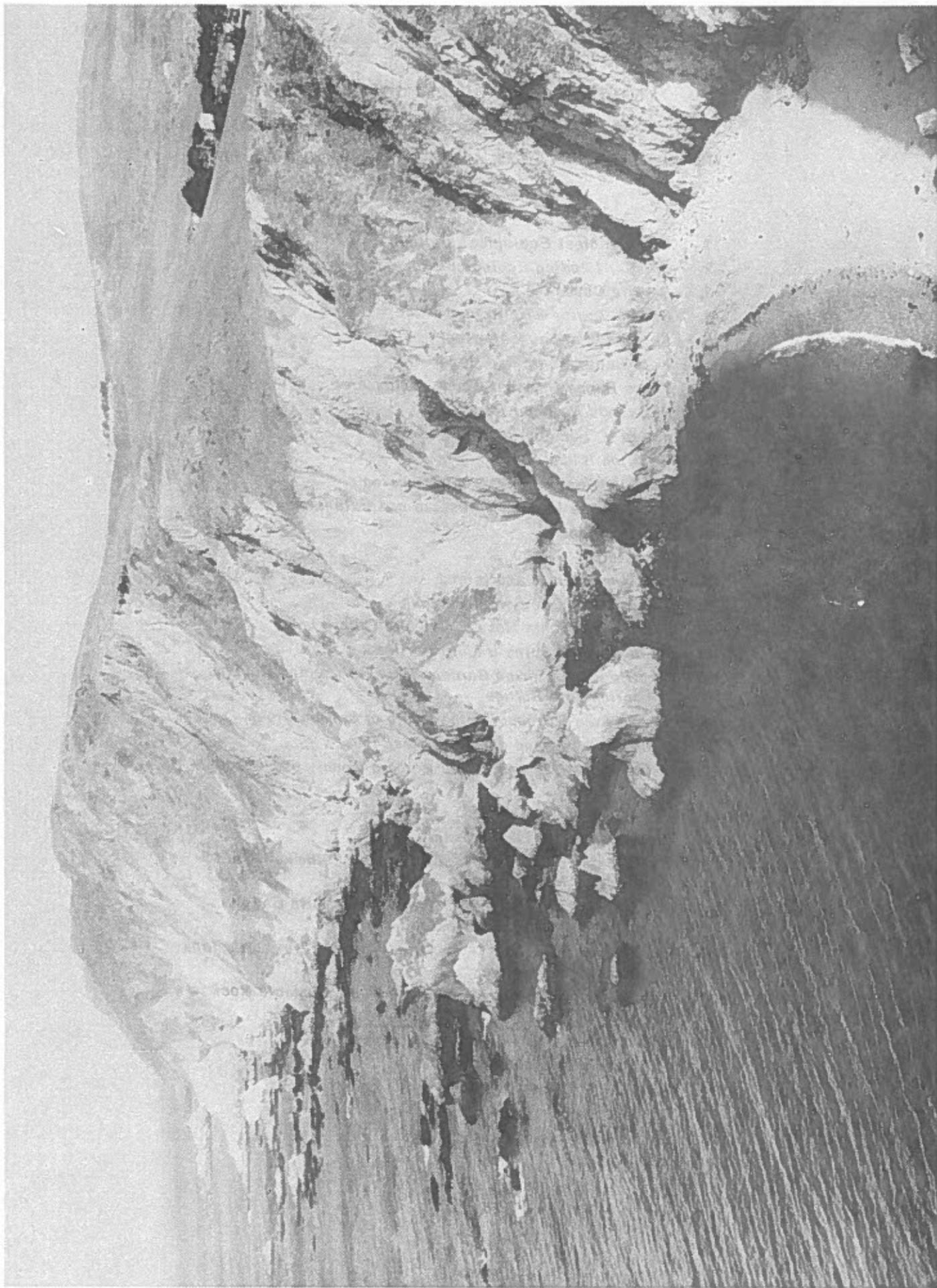
STATE WATER RESOURCES CONTROL BOARD
LEGAL AND TECHNICAL SERVICES DIVISION
SURVEILLANCE AND MONITORING SECTION

MAY, 1980
WATER QUALITY MONITORING REPORT NO. 80-1

**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**



Point Reyes Headland Reserve and Extension Area of Special Biological Significance

ACKNOWLEDGEMENT

This State Water Resources Control Board Report is based on a reconnaissance survey report submitted by Dr. Gordon L. Chan of College of Marin. 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 Point Reyes Headland ASBS is within the boundary of the Point Reyes National Seashore Park, located in Marin County, California. The total area of the ASBS is 1,359 acres (5.5 km²). Not only is the ASBS within a National Park, it also has been designated a Marine Life Reserve by the California Department of Fish and Game. This gives all marine life protection from collecting and fishing activities.

The major oceanic current that influences the Headland is the southerly flowing California Current. Waves generated from this current strike the Headland and refract around the Point and travel towards the inner beaches of Drakes Bay.

The basic geomorphology of the Point Reyes National Seashore Park is based on the San Andreas Fault which makes up the eastern boundary. The Point Reyes Peninsula is comprised of granitic-based rock, while the mainland east of the Peninsula is Franciscan rock. One of the more unique sites within the ASBS is "The Wall", a large submarine cliff near the Lighthouse. This wall is a result of ancient faulting.

With the granitic rocks affording a solid substrate for the attachment of marine organisms, the subtidal community at the ASBS is one of the most diverse in the San Francisco Bay region.

Some of the more common invertebrates found within the subtidal zone are the red abalone, giant green anemone, rose anemone and the red urchin. Due to the sea stacks in this locality, a protected habitat is created allowing for greater species diversity.

The intertidal zone also has great species diversity including California mussel, gooseneck barnacles, acorn barnacles and red abalone.

The combination of the red abalone and the breeding population of sea lions and sea birds enables the Point Reyes Headland to have as many assets for a marine environment as any habitat on the California coast.

The water quality of the ASBS is deemed very good in comparison to the marine waters closer to urban areas. The inclusion of the Headland ASBS within the protective boundary of the Point Reyes National Seashore Park reduces the likelihood of pollutants injuring the marine habitat.

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FINDINGS AND CONCLUSIONS

Findings

1. The Point Reyes Headland ASBS is located in Marin County, California, entirely within the western portion of the Point Reyes National Seashore Park. Besides the protection afforded by the Point Reyes National Seashore Park, the Headland is a Fish and Game Marine Life Reserve.

2. Because of the remoteness of the Point Reyes Headland and the protection provided to this ASBS site by the park and reserve status, the waters of this promontory area are relatively free from the pollutants of man. The water quality of this ASBS is deemed quite good in comparison to the marine waters closer to the urban center of San Francisco.

3. The major recognizable pollution threats to the marine life of the Point Reyes Headland ASBS seem to be the potential oil spills from tanker traffic moving up and down the Northern California waters. Other threats could come from chronic oil spills if offshore continental shelf oil and gas development commences. If offshore mining for gold is activated, increased sedimentation could harm marine filter feeding organisms. Finally, plutonium at the depth of 6,562 ft. (2,000 m) south of the Farallon Islands could pose a hazard to the ASBS food chain if northward-moving, upwelling currents carry these radionuclides to these waters.

4. The paramount marine organisms at the Headland ASBS are the large, year-round populations of California and Steller sea lions which inhabit and breed on the offshore rocks at Sea Lion Cove. At Lighthouse Point on the western promontory of the Headland are rocks where thousands of Common Murre and other birds reside. The numbers of birds which breed here make up the largest breeding site in Marin County. The marine invertebrates of the Headland ASBS are highly diverse, with the largest population of red abalones in Marin County at Split Rock Cove. These mollusks are large in size because of the protection they receive by the marine reserve status of the area.

Conclusions

1. The current guideline of "no trespassing" down the Headland cliffs by man should be emphasized and maintained. The sea lions and birds of the area are very sensitive to human encroachment and the Federal Marine Mammal Protection Act prohibits harrassment to these marine mammals.

2. Aircraft should be restricted by law from flying below an altitude of at least 3,000 ft. (921 m) in this area to prevent noise harrassment of the sea lions and birds.

3. Boats on fishing or sightseeing missions should be prohibited from coming within 1,640 ft. (500 m) of Sea Lion Cove and Murre Rock. Such action would prevent harrassment to the marine mammals and sea birds. Scientific studies requiring the use of boats should have permits from the National Park Service and the Department of Fish and Game.

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. To date, thirty-four coastal and offshore island sites have been designated ASBS. The ASBS are intended to afford special protection to marine life through prohibition of waste discharges within these areas. The concept of "special biological significance" recognizes that certain biological communities, because of their value or fragility, deserve very special protection that consists of preservation and maintenance of natural water quality conditions to practicable extents (from State Water Resources Control Board's and California Regional Water Quality Control Boards' Administrative Procedures, September 24, 1970, Section XI. Miscellaneous--Revision 7, September 1, 1972).

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

1. Discharge of elevated temperature wastes in a manner that would alter natural water quality conditions is prohibited.
2. Discharge of discrete point source sewage or industrial process wastes in a manner that would alter natural water quality conditions is prohibited.
3. Discharge of wastes from nonpoint sources, including but not limited to storm water runoff, silt and urban runoff, will be controlled to the extent practicable. In control programs for wastes from nonpoint sources, Regional Boards will give high priority to areas tributary to ASBS.
4. The Ocean Plan, and hence the designation of Areas of Special Biological Significance, is not applicable to vessel wastes, the control of dredging, or the disposal of dredging spoil.

In order for the State Water Resources Control Board to evaluate the status of protection of the Point Reyes Headland ASBS, a reconnaissance survey integrating existing information and additional field study was performed by Dr. Gordon L. Chan of College of Marin. 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.

The California Regional Water Quality Control Board of the San Francisco Bay Region recommended the Point Reyes Headland Area for ASBS designation, based on this rationale:

"The area is principally a hauling-out grounds for the California and Steller sea lions, especially in the area designated Sea Lion Cove. Although there are six species of seabirds that have colonies within the designated area, only one species, the black oystercatcher, gains its sustenance from the immediate vicinity. Three breeding pairs of the black oystercatcher were reported by the staff of the Point Reyes Bird Observatory during July, 1972. The area is designated an ASBS for the protection of the above listed marine mammals and seabird as well as for the unique scientific value of the reserve."

ORGANIZATION OF SURVEY

The subtidal description at Point Reyes Headland ASBS was based on observations made by the principal consultant and his students over a period of 15 years, 1963 to 1978, in a total of 20 dives. After each dive, a descriptive log of the physical and biological data was completed; these logs are stored at the College of Marin. The appendices list a compilation of organisms observed. The dives involved two basic aspects of observations:

1. Underwater transect surveys. Eight transect sites were established by affixing subtidal markers with a yellow vinyl line attached to each block. These blocks were wedged between large boulders and divers used compass bearings to determine placement of transect lines at these sites.

2. General reconnaissance underwater surveys. These were taken by divers swimming along transects, parallel to the shore.

Data from both observational techniques was recorded on underwater slates. The information gathered was later transferred to data sheets.

Intertidal baselines were plotted along the high tide, Zone 1 area of the reefs at Point Reyes Headland -- at Chimney Rock and at Split Rock. Large rocks were used as permanent landmarks for baseline divisions. The baseline was divided into five equal segments, then ten-meter perpendicular transect lines were employed from the baseline. Square meter quadrats were utilized to determine densities of marine organisms along the transect line. Information was logged on data sheets for each quadrat, beginning at the low intertidal Zone 4 to the high intertidal Zone 1 area. Some organisms were collected for later identification. Notes were also taken on the visual inspection of the marine life in other intertidal areas adjacent to the transect line. Such observations confirmed the variety of species found in the transect for that area.

Walks along the upper shoreline and bluffs were conducted to observe and record the geology and the botanical makeup of the Point Reyes Headland ASBS. Maps were utilized to determine the distances of roads and locations of towns and other important landmarks.

Other sources of information include literature obtained from the Point Reyes National Seashore Park Library, the Point Reyes Bird Observatory, and other academic, government, and municipal agencies within the San Francisco Bay Area.

PHYSICAL AND CHEMICAL DESCRIPTION

Location and Size

The Point Reyes Headland ASBS is located in Marin County, California. The area is situated entirely within the boundary of the Point Reyes National Seashore Park (Figure 1). The official description as found in Areas of Special Biological Significance (SWRCB, 1976) is as follows:

"The area of ocean waters extending offshore 2,000 feet from the high tide line and bounded on the west by a line extending due west (true) from Point Reyes Lighthouse and on the east by a line extending due east (true) from Chimney Rock constitutes the Area of Special Biological Significance." See Figure 2.

The total area of the Point Reyes Headland ASBS encompasses about 1,359 acres, or 5.5 square kilometers. The Headland site is 11 miles (17.6 km) from the nearest town which is Inverness (Figure 1).

In 1972, the California Department of Fish and Game declared the Point Reyes Headlands as a Marine Life Reserve. Therefore, Article 1.57 of Title 14 states:

"Point Reyes Headlands Reserve (Marin County). No form of marine life may be taken from the ocean area within 1000 feet of the high tide mark in the Point Reyes Headlands bounded on the west by a line extending due west (true) from Point Reyes Lighthouse and on the east by a line extending due east (true) from Chimney Rock, without a written permit from the department. (Register 72, No. 1--1-1-72)."

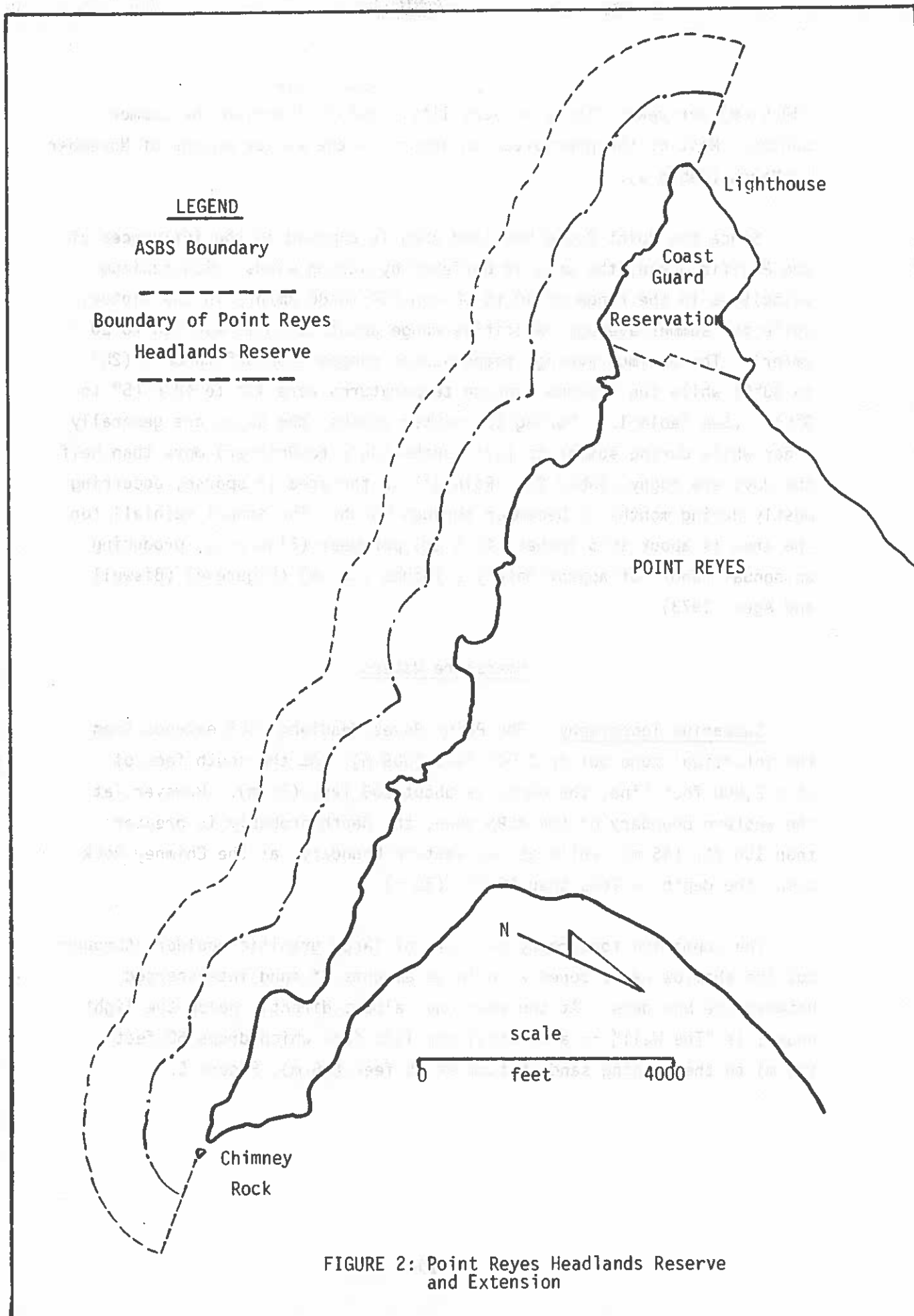
Since 1972, the Point Reyes Headlands has had the reserve status protection and all marine life has been protected from human collecting and fishing activities.

Climate

The general climate of the Point Reyes National Seashore Park is known as Mediterranean. Characteristics of this climate are moderate summers and cool, wet winters. The annual rainfall is about 19.5 inches

(after Morris, 1971)





(49.5 cm) per year. There is very little rainfall during the summer months. Most of the precipitation occurs in the winter months of November to March (Table 1).

Since the Point Reyes Headland ASBS is exposed to the influences of the Pacific Ocean, the area is buffeted by strong winds, with maximum velocities in the range of 40 to 50 mph (64 to 80 km/hr) in the winter, while the summer average velocities range about 10 to 13 mph (16 to 20 km/hr). The maximum average temperatures ranged from 68° to 86°F (20° to 30°C) while the minimum average temperatures were 41° to 48°F (5° to 9°C). (See Table 1.) During the winter months, the skies are generally clear while during summer to fall months (July to October) more than half the days are foggy (Table 2). Rainfall in the area is sparse, occurring mostly during months of December through March. The annual rainfall for the area is about 19.5 inches (49.5 cm) per year (Figure 3), producing an annual runoff of approximately 6 inches (15 cm) (Figure 4) (Biswell and Agee, 1973).

Nearshore Waters

Submarine Topography: The Point Reyes Headland ASBS extends from the intertidal zone out to 2,000 feet (609 m). At the south face of this 2,000 foot line, the depth is about 100 feet (30 m). However, at the western boundary of the ASBS zone, the depth probably is greater than 150 ft. (45 m), while at the eastern boundary, at the Chimney Rock area, the depth is less than 60 ft. (18 m).

The submarine topography consists of large granitic boulders throughout the shallow water zones with large amounts of sand interspersed between the boulders. At the west end, almost directly below the light-house, is "The Wall" -- a vertical granitic face which drops 60 feet (18 m) to the sloping sandy bottom at 85 feet (26 m), Figure 5.

TABLE 1						
WEATHER DATA FOR POINT REYES (No Date, After Felton: 1965)						
TEMPERATURE SUMMARY (in °F)					PRECIPITATION SUMMARY (in inches)	
	HIGHEST	AVERAGE MAXIMUM	AVERAGE MINIMUM	RECORD MEAN	LOWEST	RECORD MEAN
MARCH	88	55.3	46.1	50.8	30	2.68
APRIL	83	55.6	46.6	51.1	36	1.50
MAY	85	56.0	47.3	51.7	38	0.84
JUNE	87	57.4	48.4	53.0	40	0.26
JULY	91	58.2	49.3	53.8	42	0.06
AUGUST	90	58.5	50.3	54.5	41	0.04
SEPTEMBER	98	61.3	51.7	56.5	45	0.47
OCTOBER	91	61.0	50.8	55.8	41	1.23
NOVEMBER	83	59.3	49.3	54.4	34	2.26
DECEMBER	73	55.8	46.6	51.1	27	3.31
JANUARY	78	54.3	45.3	49.7	29	3.86
FEBRUARY	78	54.8	46.2	50.4	31	3.04
ANNUAL	98	57.3	48.2	52.7	27	19.55

Average number of days with 0.01 inches or more precipitation: 73

Average growing season: 361 days.

TABLE 2								
U. S. WEATHER BUREAU DATA FOR POINT REYES LIGHTHOUSE STATION								
Summary of Averages for the Period 1949-53								
	WIND VELOCITY		TEMPERATURE		WEATHER (days)			
	MAX	AV	MAX	MIN	BRIGHT	CLOUDY	FOGGY	RAINY
MARCH	47	14 Mph	71°	41°	18	7	1	5
APRIL	43	14	68	45	13	10	6	1
MAY	45	13	76	43	15	7	8	1
JUNE	45	13	80	46	15	8	6	1
JULY	34	11	77	48	9	5	17	0
AUGUST	37	10	77	49	7	7	16	1
SEPTEMBER	36	9	86	49	9	9	12	0
OCTOBER	42	10	81	47	13	4	12	2
NOVEMBER	51	11	74	46	13	6	8	3
DECEMBER	51	10	67	43	15	7	3	6
JANUARY	44	11	64	39	15	9	3	4
FEBRUARY	43	11	65	40	14	5	6	3

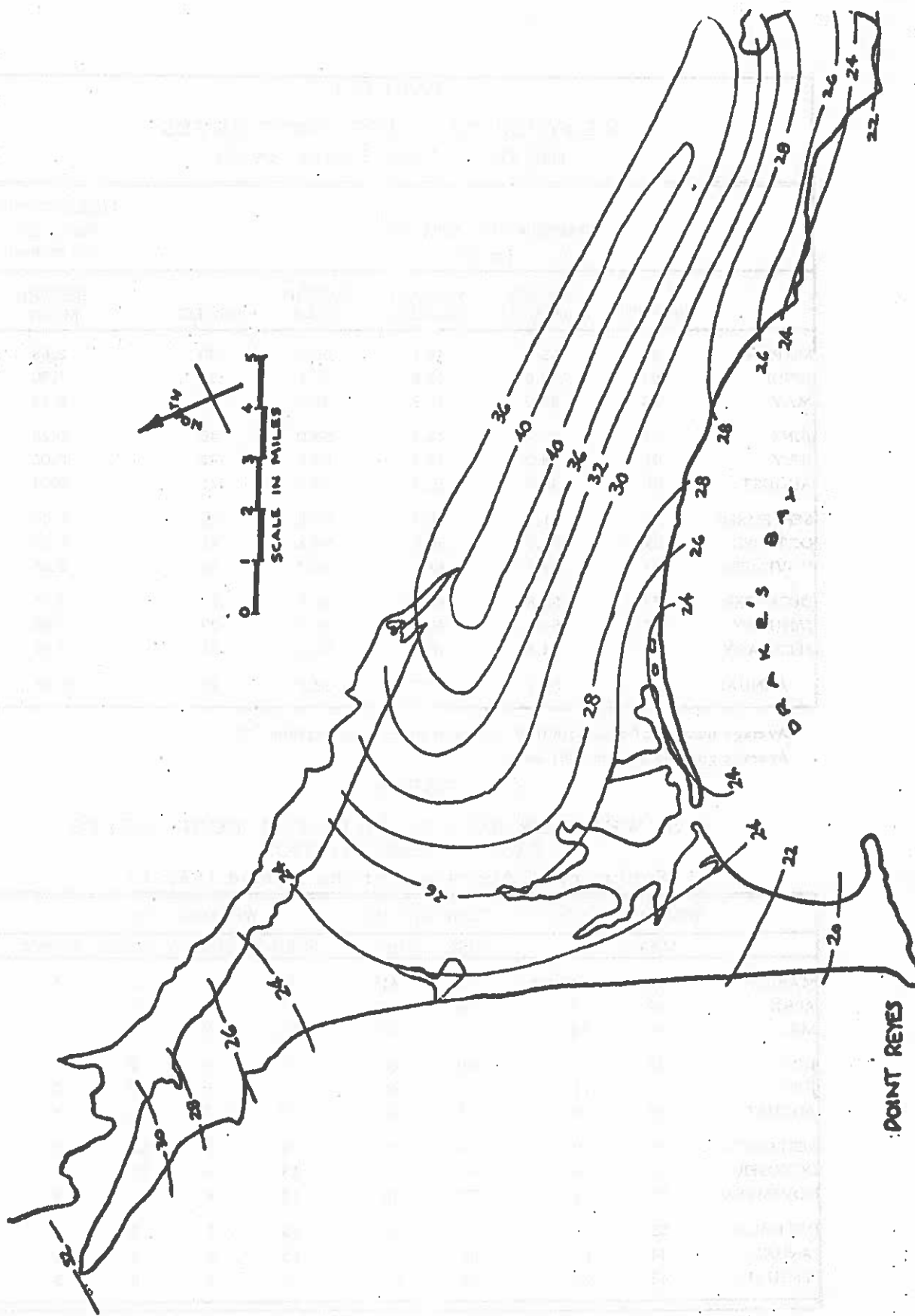


Figure 3. ANNUAL RAINFALL (inches). POINT REYES (Biswell and Agee, 1973)

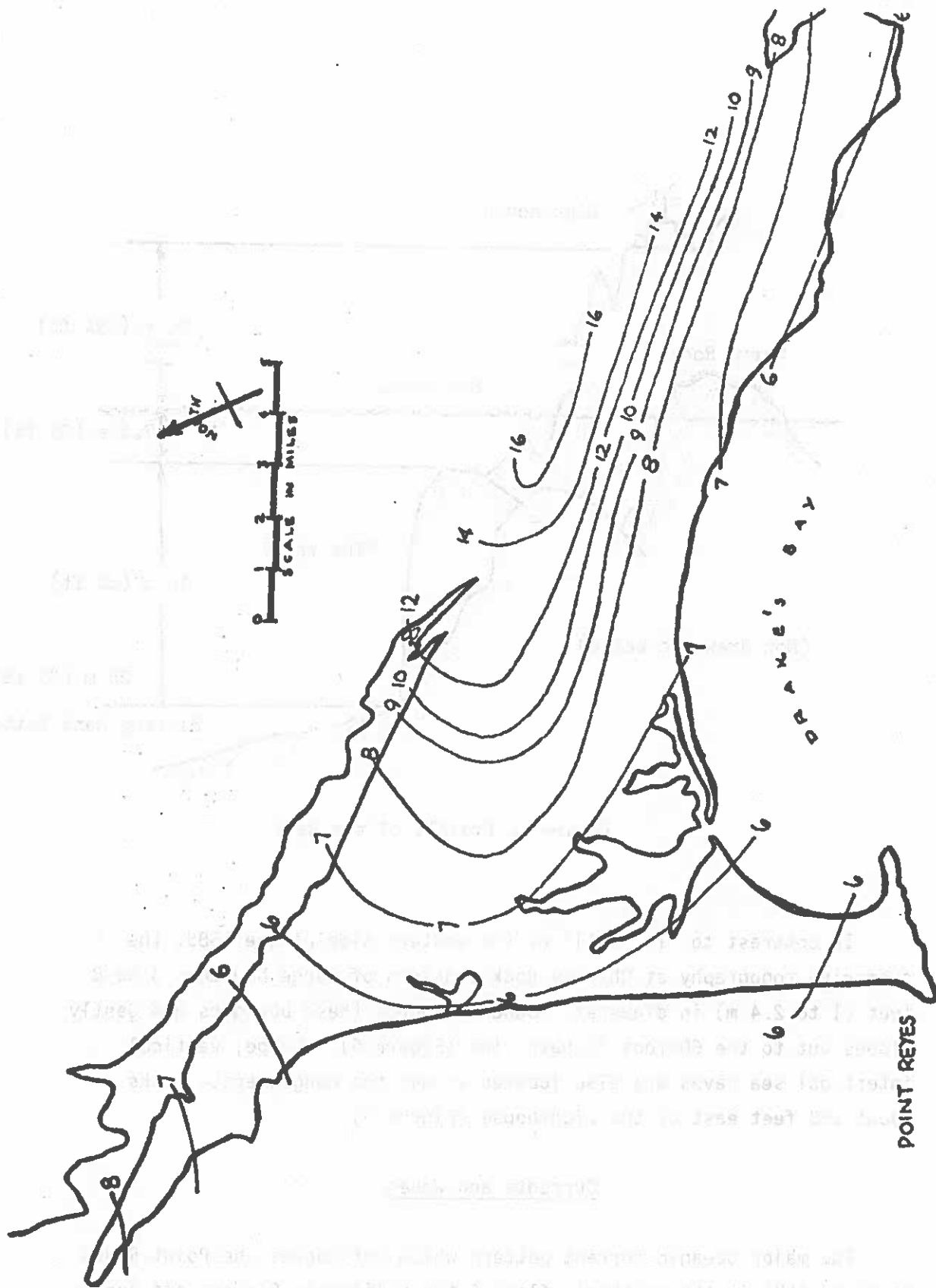


Figure 4. ANNUAL RUNOFF (inches). POINT REYES (Biswell and Agee, 1973)

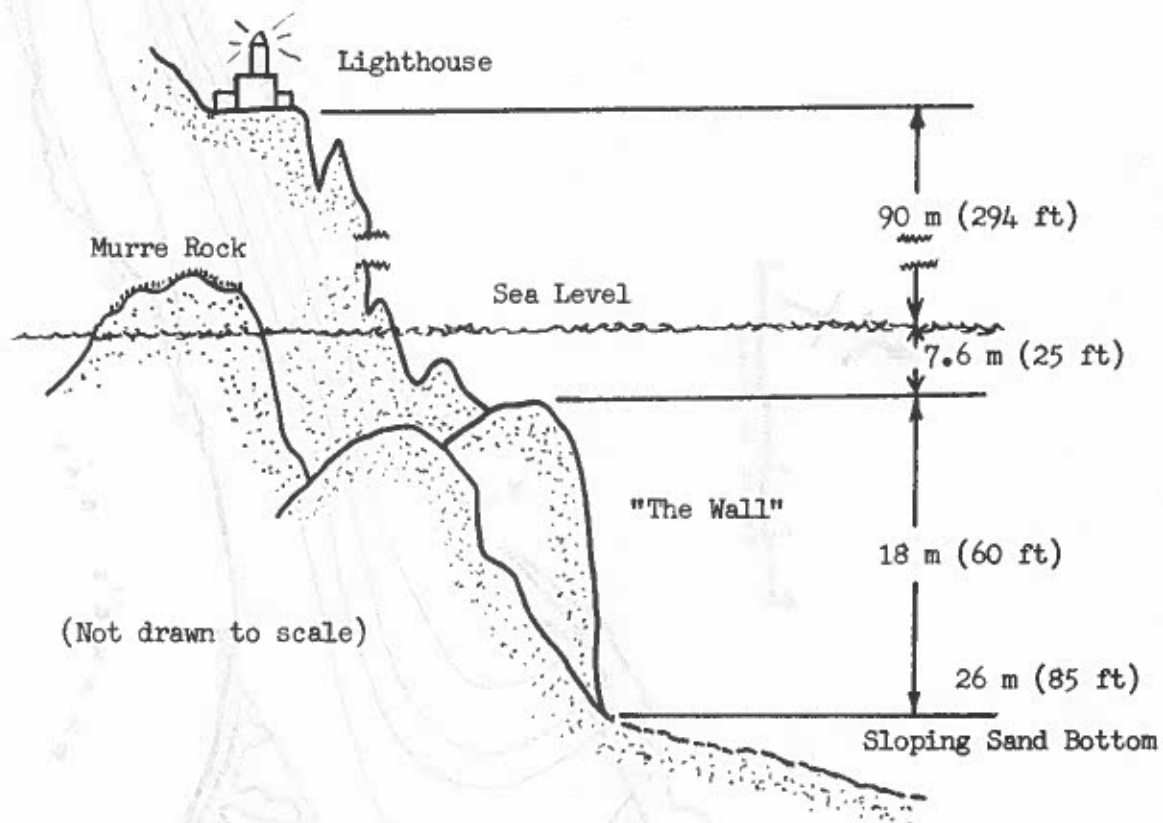
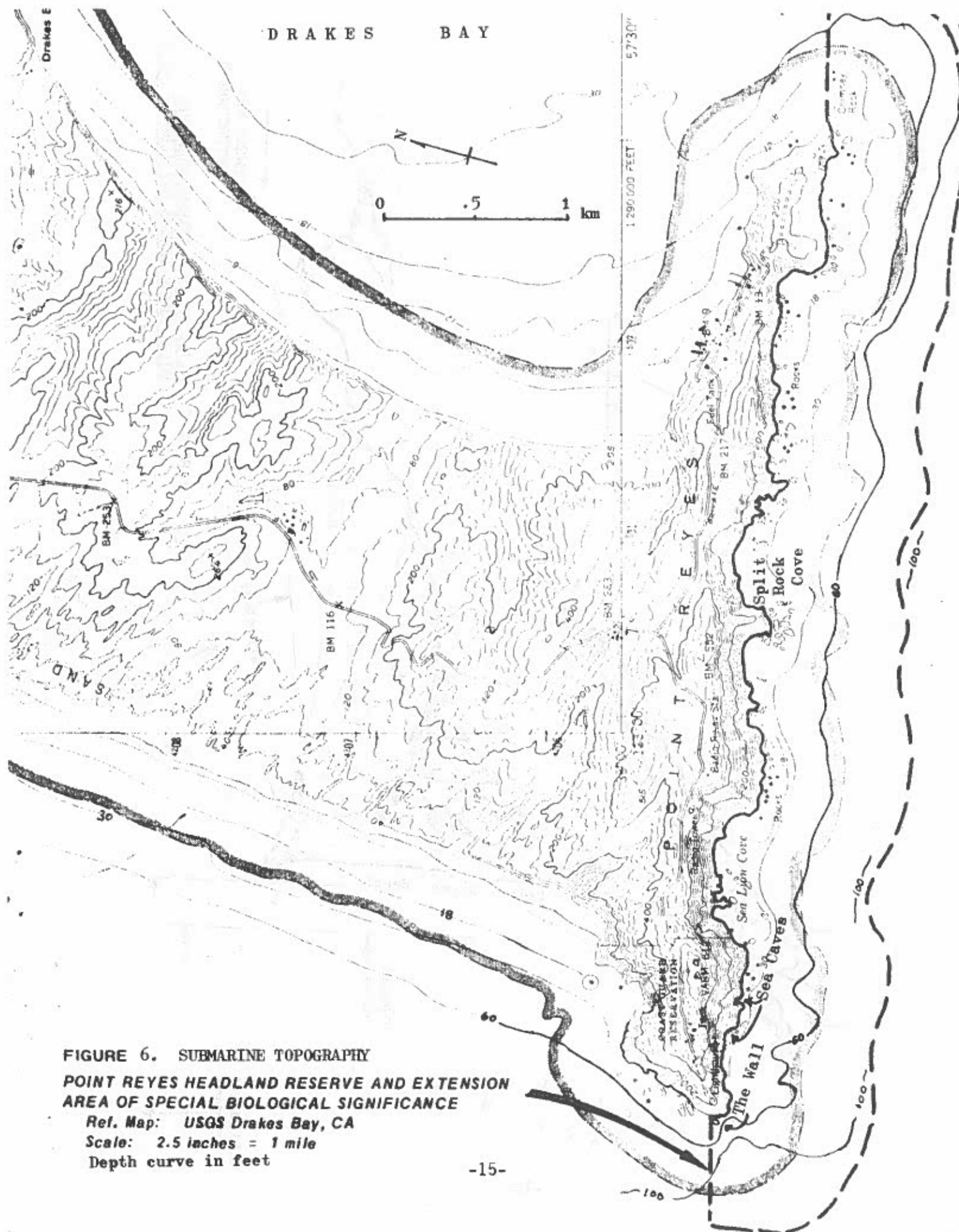


Figure 5. Profile of "the Wall"

In contrast to "The Wall" of the western side of the ASBS, the submarine topography at Chimney Rock consists of large boulders 3 to 8 feet (1 to 2.4 m) in diameter. Sand surrounds these boulders and gently slopes out to the 60-foot isobath line (Figure 6). Large, vertical intertidal sea caves are also located amidst the conglomerate rocks about 150 feet east of the Lighthouse (Figure 6).

Currents and Waves

The major oceanic current pattern which influences the Point Reyes Headland ASBS is the southerly flow of the California Current off northern and central California. Waves which are generated by northwest winds strike the Point Reyes Headland (Figure 7) and refract around the Point



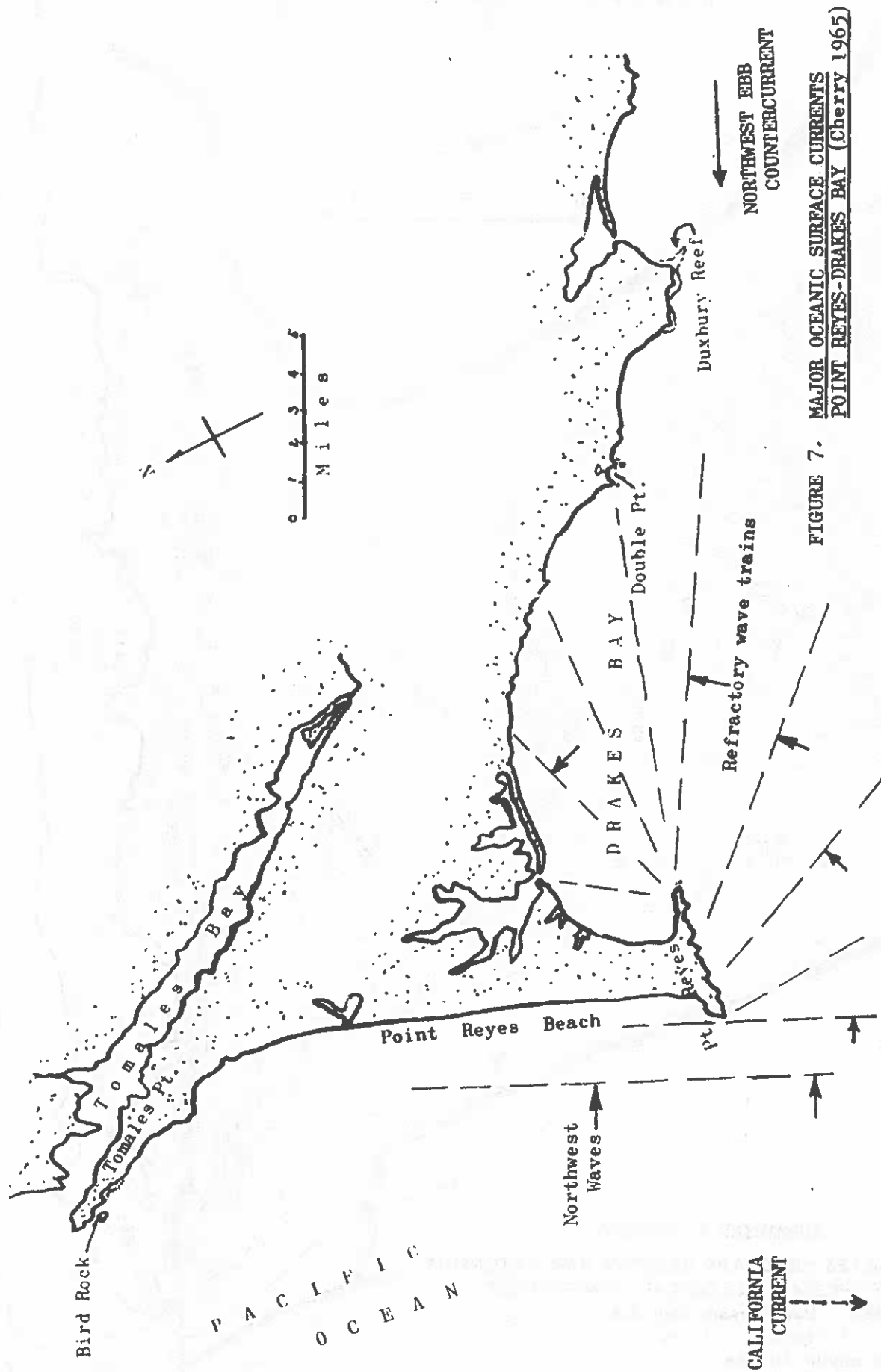


FIGURE 7. MAJOR OCEANIC SURFACE CURRENTS
POINT REYES-DRAKES BAY (Cherry 1965)

towards the inner beaches of Drakes Bay (Cherry, 1965). There is constant erosion of the Point Reyes Headland from the action of these waves which carry much sediment from the Headlands to Drakes Bay where the sediments are sorted along the beach front.

The waves which affect the littoral zone vary according to the patterns and influences of winds and other weather conditions which occur in this locality. In some areas of the ASBS, the waves strike the intertidal zone with variable intensity. At Sea Lion Cove, the offshore sea stacks break up the velocity of the waves; therefore, the beaches in the cove are made up of well-mixed, medium particle size sands. The sea lions find this area suitable habitat for hauling out. In contrast to Sea Lion Cove, the beach at Split Rock Cove (Figure 6) consists of 4 to 16 inch (10 to 40 cm) cobbles. This beach does not have any sea stacks to break up the waves; therefore, the velocity of waves striking the beach is intense. The term "boulder beach" aptly describes the characteristics of this cove.

No thermoclines were experienced during the survey dives. The water was consistently cold, averaging 50.9°F (10.5°C) (Table 3). The influence of upwelling at the Point Reyes Headland ASBS is unknown. If upwelling does occur, it probably exists in the deep water area just under the Lighthouse area. Dyer, in his 1975 study of radioactive waste dumped southwest of the Farallon Islands, reported an upwelling current which seemed to head towards the Bolinas and Point Reyes Headlands. Whether this current reaches the ASBS is not known at this time.

Water Column

The water clarity at the ASBS ranges from 3 feet in the nearshore area to about 15 feet at the 30 foot (9 m) contour line. Water clarity and visibilities are fairly good for Marin County waters, averaging about 7.4 feet (2.3 m) during the underwater dives (Table 3). Due to the intense wave action of the area, there are many sediments which become suspended in the water column close to shore and during summer months the plankton blooms are the highest, thus contributing to the

TABLE 3. SUMMARY OF ABIOTIC WATER PARAMETERS
POINT REYES HEADLAND, 1957-1979, G. CHAN

DATE	ACTIVITY		SURFACE WATER TEMPERATURES		SURFACE SALINITY	WATER VISIBILITY		DISSOLVED OXYGEN	NITRATES PHOSPHATES
	Inter-tidal	Div-ing	°C	(°F)	o/oo	meters (feet)		mg/l	ppm
June 21, 1955	X		-	-	-	-	-	-	-
Dec. 7, 1958	X		-	-	-	-	-	-	-
Feb. 10, 1962	X		-	-	-	-	-	-	-
Feb. 17, 1962	X		8.8	(48)	-	-	-	-	-
July 16, 1963	X	X	10.5	(51)	-	1.5	(5.0)	-	-
July 3, 1964	X		-	-	-	-	-	-	-
June 23, 1965	X	X	10.0	(50)	-	2.4	(8.0)	-	-
July 14, 1965	X		-	-	-	-	-	-	-
July 9, 1966	X		10.0	(50)	-	-	-	-	-
Dec. 12, 1967	X	X	10.5	(51)	-	1.5	(5.0)	-	-
June 20, 1968	X	X	10.0	(50)	-	2.4	(8.0)	-	-
Nov. 3, 1969	X	X	11.0	(52)	-	1.5	(5.0)	-	-
Apr. 28, 1970	X		-	-	-	-	-	-	-
June 25, 1970	X	X	10.5	(51)	32.7	1.5	(5.0)	8.8	< 0.01
July 1, 1970	X	X	11.6	(53)	33.0	2.0	(6.5)	8.8	< 0.05
July 6, 1970		X	10.0	(50)	-	2.4	(8.0)	-	-
July 7, 1970		X	10.0	(50)	32.3	2.7	(9.0)	9.0	< 0.01
Aug. 5, 1971		X	10.5	(51)	32.0	3.0	(10.0)	-	-
Oct. 17, 1971		X	10.5	(51)	-	2.0	(6.5)	-	-
Nov. 2, 1971		X	10.0	(50)	32.8	1.5	(5.0)	-	-
Nov. 7, 1971		X	10.0	(50)	-	0.9	(3.0)	-	-
June 1, 1972	X	X	10.5	(51)	31.5	2.7	(9.0)	-	-
July 7, 1973	X	X	10.0	(50)	31.6	3.0	(10.0)	-	-
Aug. 20, 1974	X	X	11.6	(53)	-	3.0	(10.0)	8.9	< 0.01
May 28, 1975	X		11.0	(52)	-	-	-	-	-
Sept 25, 1975		X	11.0	(52)	-	3.0	(10.0)	-	-
July 13, 1976	X	X	11.0	(52)	32.0	-	-	9.2	< 0.01
July 22, 1976	X		11.0	(52)	32.1	2.7	(9.0)	-	-
Dec. 1, 1977	X	X	10.0	(50)	32.0	3.0	(10.0)	9.0	< 0.01
June 3, 1978	X	X	10.5	(51)	32.0	2.4	(8.0)	-	-
Oct. 13, 1978	X		11.0	(52)	31.5	1.5	(5.0)	-	-
May 16, 1979	X	X	10.5	(51)	32.0	2.5	(7.4)	-	-
Totals	25	21							
	Averages		10.5	(50.9)	32.1	2.3	(7.4)	8.9	< 0.01

poor visibilities of the water column. During winter when plankton blooms are lowest, the visibility in the near shore waters reaches a maximum of about 10 feet (3.0 m).

Surface salinities (total dissolved solids) averaged 32.1 parts per thousand (Table 3). This figure is slightly higher than the average salinities in the coastal waters near the Golden Gate Bridge. The Brown and Caldwell report of 1971 showed 31.5 parts per thousand for the same location.

Water temperatures averaged about 50.9°F (10.5°C) over a period of 24 years of observations at Point Reyes Headland (Table 3).

Dissolved oxygen levels averaged about 8.9 mg/l. Nitrates and phosphates were at levels less than 0.01 ppm (Table 3).

Topography and Geomorphology

The basic geomorphology of the Point Reyes National Seashore Park revolves around the famous San Andreas Fault on its eastern boundary and the Pacific Ocean on the western boundary. Galloway (1977) refers to the Point Reyes Peninsula as a "little geological island" of granitic-based rock, while the mainland section east of the Peninsula consists of "Franciscan" rock. The discontinuity of these two large rock masses has led Galloway to postulate that in the past 25 million years the land west of the San Andreas fault, the Point Reyes Peninsula, has been moving northward at an average rate of 1/2 inch (1.3 cm) per year, and has traversed northward hundreds of miles (Galloway, 1977).

Land Geomorphology: The Point Reyes Headland ASBS is a rugged rock promontory composed basically of granitic rocks, referred to as "Point Reyes granodiorite". The age of the granitic rock is estimated as early Upper Cretaceous, or 84 million years old. Core samples have revealed that the granitic rocks extend 1,370 feet (417 m) below sea level. These rocks range in composition from quartz diorite to adamellite, containing more quartz and potash feldspar. Although most of the granitic

rocks of the Point Reyes Peninsula are deeply weathered, geologists have examined these rocks and found similarity to the granitic rocks of Bodega Head, Farallon Islands, Montara Mountains of San Mateo County, and even those of the Santa Lucia Range in Monterey and San Luis Obispo Counties.

Overlying parts of the granite on the Point Reyes Headland are large patches of conglomerate, a hard sedimentary rock composed of large and small-size pebbles and cobbles, all cemented together. From the Lighthouse area of the Headland to the intertidal zone, there are large blocks of conglomerate. Giant sea caves have been etched into the conglomerates at the surf zone. These conglomerates are younger in age than the granitic rocks, and are not found anywhere else on the Point Reyes Peninsula. The conglomerates, interspersed with layers of fine-grain sands, were probably deposited underwater and are similar to the Paleocene conglomerates at Point Lobos in Monterey County. Galloway reports that similar rocks were dredged up at the Cordell Banks, some 20 miles (37 km) west of the Headland. Finally, the conglomerates are overlayed in an unconformed manner by basal glauconitic sand of the Drakes Bay Formation. (All of the preceding geology information was taken from Galloway, 1977).

The Point Reyes Headland is virtually in an east-west alignment with the massive cliff facing south. The highest point of the Headland is at the western end, rising up to 612 feet (186 m), while at the Chimney Rock area of the east side, the cliff is approximately 173 feet (52 m). Galloway (1977) suggests that this massive cliff is an eroded fault-line scarp, down thrust to the south. The submarine drop-off, known as "The Wall", probably resulted from this downward fault-line scarp movement.

To the north of the Point Reyes granitic promontory are alignments of ridges and valleys which run approximately east-west. The ridges are harder layers of the Drakes Bay Formation and are folded into an anticline-syncline pattern. The valleys are remains of tributaries which drain into the drowned-valleys of Drakes Estero and Estero de Limantour (Figure 8) (Galloway, 1977).

Intertidal and Subtidal Geomorphology: The granitic and conglomerate rocks make up the formation of the intertidal and offshore rocks at the Point Reyes Headland ASBS. The ages of these rocks range from upper Cretaceous to Paleocene.

Chimney Rock: (Figure 9) At the east end of the ASBS is a large granitic sea stack with a single 50 foot (15 m) pinnacle that resembles an isolated chimney. This stack was a part of the main cliff during the past; erosion divided the section from the eastern promontory. Surrounding Chimney Rock are large boulders which make up the intertidal and subtidal configuration. Sand surrounds these granitic rocks, and continues in a gentle slope out beyond the 60 foot (18 m) isobath. Since the refractory waves sweep around the Chimney Rock area, there is movement of sand throughout the year.

Pelican Arch: (Figure 9) This unique granitic rock is 30 feet (9 m) in height and is a sea arch that is a frequent habitat of the Brown Pelican, Pelecanus occidentalis. The birds often perch on the arch while resting from their feeding activities within the area.

Saddle Cove: (Figure 9) The cliffs between Chimney Rock and Saddle Cove are nearly vertical, rising from sea level to about 190 feet (58 m). A small beach at the base of a sloping grade illustrates much erosion.

Split Rock: (Figure 9) Massive granitic rocks which have split off from the south cliffs provide the name of this area as Split Rock Cove (Figure 10). The waters of this cove are much deeper than that of the major coves within these southern-facing cliffs. The 30 foot (9 m) isobath bends deeply into Split Rock Cove. The deep water enables large waves to come very close to the area which gives Boulder Beach a steep profile with rounded cobbles and boulders.

Sea Lion Cove: (Figure 9) Granitic rocks, large and small, are scattered through the area west of Split Rock Cove. The smooth surfaces of these rocks enable many sea lions to haul out in this area. The habitats are labeled "Sea Lions" (1), (2), and (3) in Figure 9. Coarse

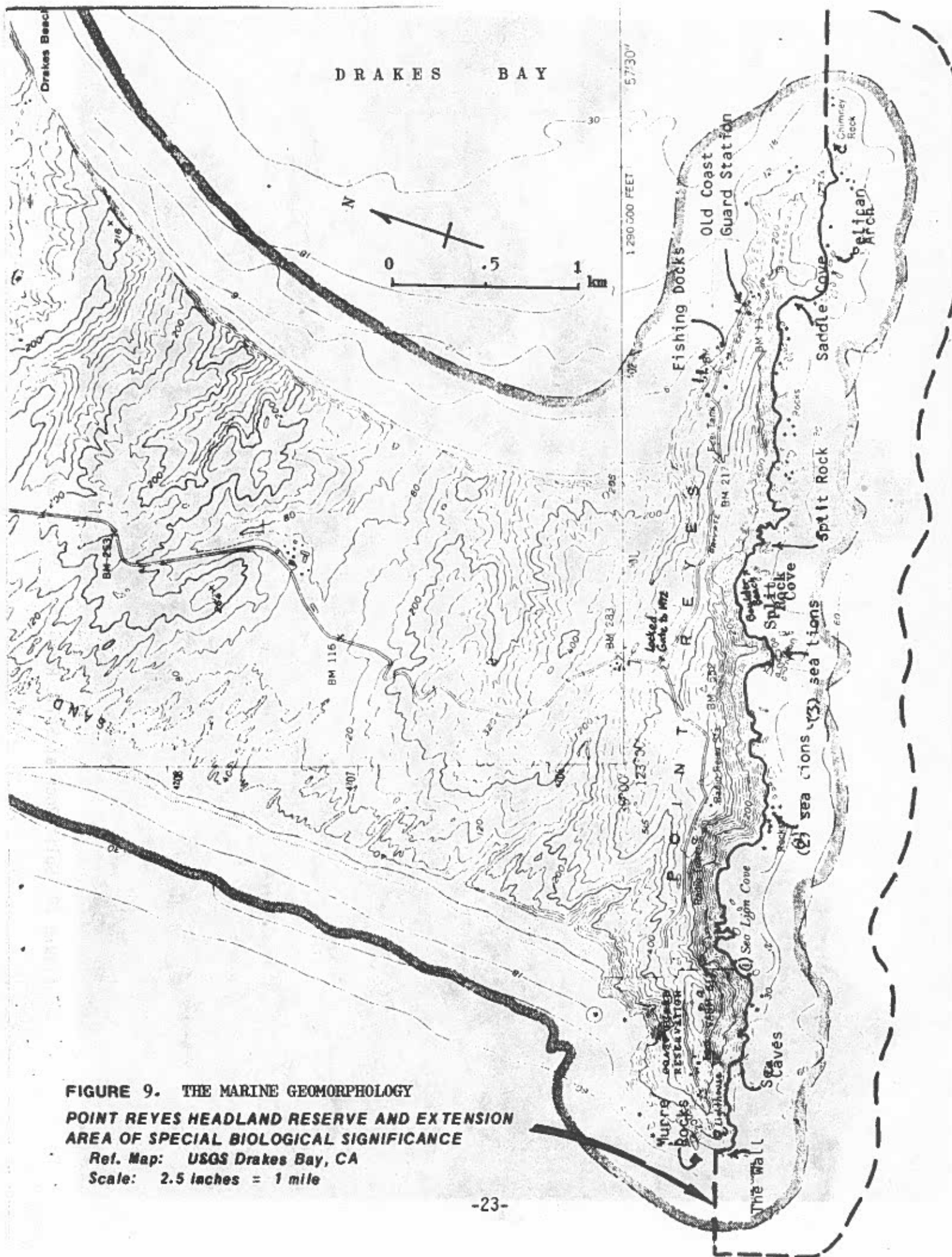


**FIGURE 9. THE MARINE GEOMORPHOLOGY
POINT REYES HEADLAND RESERVE AND EXTENSION
AREA OF SPECIAL BIOLOGICAL SIGNIFICANCE**
Ref. Map: USGS Drakes Bay, CA
Scale: 2.5 inches = 1 mile



Figure 10. Split Rock at Split Rock Cove, Point Reyes Headland.

sand surrounds these granitic stacks. Sea Lion Cove (1) is the major area for the California Sea Lions. Two sandy beaches in Sea Lion Cove enable hundreds of these mammals to haul out.

Sea Caves: (Figure 9) The conglomerates of the Point Reyes Headland ASBS extend from the highest point of the cliff at 612 feet (186 m) to the surf zone where the depth is 30 feet (9 m). The waves erode these conglomerates, etching out giant sea caves. Large conglomerate boulders and coarse sand make up the benthic substrate at the base of these cliffs, which are a favorite niche for the Common Murre, Uria aalge.

"The Wall": (Figures 6 and 9) "The Wall" is a 60 foot submarine cliff just below the Lighthouse at the western edge of the ASBS. The base of "The Wall" is 85 feet (26 m) below sea level with sand and rocks sloping out beyond 100 feet (30 m). This unique vertical wall is probably a result of faulting action of the Headland.

Ideal diving conditions are almost impossible to realize as giant waves smash across this western promontory the year-round. The underwater surge from the refractory wave trains are severe, preventing divers from maintaining a fixed position on the wall. Moreover, the water visibility is extremely poor, at best about 30 inches (76 cm), both from the sediments stirred up by the wave-surge and by the darkness of these depths.

Murre Rock: (Figure 9) Just west of the Lighthouse, outside of the ASBS boundary, are two large granitic sea-stacks which are the main nesting sites for thousands of Common Murre, Uria aalge. These birds reside at the rock year-round.

BIOLOGICAL DESCRIPTION

Plankton Samples

The plankton community represents the base of the food pyramid with the diatoms forming the role of primary producers in the water column. The zooplankton are the first order consumers.

For the Point Reyes Headland ASBS, two plankton samples were taken, which produced the following data:

TABLE 4. PLANKTON SAMPLE, POINT REYES HEADLAND ASBS

	<u>July 6, 1970</u>		<u>July 22, 1976</u>	
	<u># in 1.6</u> <u>cm³ grid</u>	<u>No. of</u> <u>organisms</u>	<u># in 1.6</u> <u>cm³ grid</u>	<u>No. of</u> <u>organisms</u>
<u>Major Animals</u>				
Nauplii (barnacle larvae)	3	5.3×10^4	4	5.4×10^4
<u>Calanus</u> sp. (copepod)	6	5.6×10^4	5	6.0×10^4
<u>Carcinus</u> sp. (brachyuran larvae)	3	1.0×10^4	1	0.3×10^4
<u>Sagitta</u> sp. (chaetognath worm)	1	0.7×10^4	2	1.0×10^4
Euphasiacea (pelagic shrimp)	3	1.6×10^4	5	2.1×10^4
<u>Major Plants</u>				
<u>Coscinodiscus</u> sp. (diatom)	10	6.0×10^4	4	2.5×10^4
<u>Chaetoceros</u> sp. (diatom)	12	5.0×10^5	10	4.0×10^5
<u>Ceratium</u> spp. (dinoflagellate)	9	5.5×10^4	6	5.0×10^4

The plankton sample at the Point Reyes Headland ASBS appeared to contain more ocean species than in-shore littoral species. The calanoid copepods, the euphasiid shrimps, brachyuran crab larvae, and the chaetognath worm all indicated oceanic species. The density of nauplii-barnacle larvae is representative of in-shore littoral zone plankton. In 1970, the California Department of Fish and Game biologists collected oceanic plankton 6 miles (9.6 km) from the Point Reyes Headland ASBS and the density and species list of organisms were very similar to those found in Table 4.

December, 1977, a mother and calf gray whale, Eschrichtius gibbosus, were seen feeding on a dense mass of Euphasiacea shrimps. This event illustrated that the deeper oceanic waters and their plankton forms are found within the ASBS boundary, thus accelerating the high diversities and rich abundance of the trophic organisms in the marine food pyramid of this special marine habitat.

Benthic Shelf Communities

Although dives were made between 60 to 100 feet (18 to 30 m) at the Point Reyes Headland ASBS, no organisms were observed because of sand movement by the strong wave surge off Chimney Rock and Split Rock.

Brown and Caldwell, 1971, established six benthic shelf stations ranging from about 5 to 7 miles (8 to 11 km) south of Point Reyes Headland ASBS. The major organisms recovered from these six sites by the use of the Petersen grabs and benthic nets were:

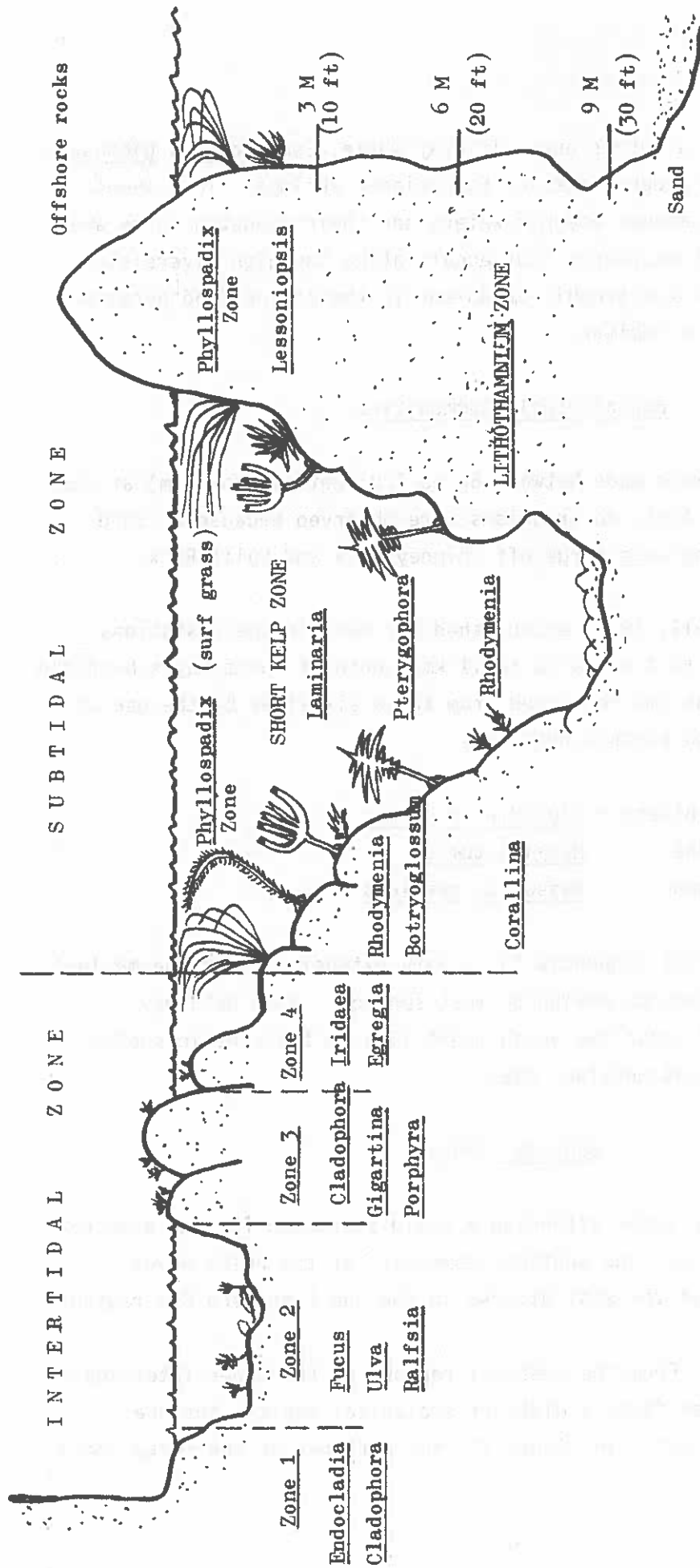
Foraminifera	- <u>Elphidiella hannai</u>
Bivalves	- <u>Mysella tumida</u>
Gastropod	- <u>Nassarius mendicus</u>

The benthic species list (Appendix 1) is very extensive, with the molluscan bivalves and gastropods making up most species. Such data may indicate the types of organisms which might live in the benthic shelf-zone off the Point Reyes Headland ASBS.

Subtidal Biota

With the granitic rocks affording a solid substrate for the attachment of marine organisms, the subtidal community at the Point Reyes Headland ASBS is one of the most diverse in the San Francisco Bay region.

Subtidal Plants: From the subtidal regions to the upper intertidal rocks, the marine algae forms a distinct ecological habitat for the invertebrates of the reef. In Figure 11, the outlines of the rocky reefs



(not drawn to scale)

FIGURE 11. GENERAL DEPTH DISTRIBUTION OF INDEX PLANTS, POINT REYES HEADLAND

are delineated and, within this region of algal growth, the plants form distinct habitat zones.

Pequegnat (1964) divided the offshore reefs of California into distinct zones: reef tops, reef sides, reef bases, and sand and gravel substrates. These descriptions have been adopted with some modifications to aid in the following discussions. These plants have a specific selection zone depending on depth, wave action, amount of life, and exposure during ebb tides.

The major plants in both subtidal and intertidal areas at Point Reyes Headland are listed in Appendix 2. The key plants which are most abundant and which dominate the specific zones are called "index plants"; these are itemized in Table 5.

Starting from the greatest depth, Table 5 describes the ecology of the general distribution of plants (Figure 11) in the area.

The marine plants of Point Reyes Headland ASBS conforms to the general distribution of Table 5 with the following exceptions:

(1) In the subtidal zone surrounding Chimney Rock, the short kelp are sparse due to the fluctuations of the coarse sand which is transported to and from this area from tidal currents and wave actions. However, the surf grass, Phyllospadix torreyi, is extremely dense and long, over 10 feet (3 m) in length, growing on the sides and tops of the rocks in the area.

Since the Chimney Rock sea stack protects a rather large Zone 2 (Figure 12) there are more Zone 2 plants, Fucus distichus, Ulva spp., etc. (Appendix 2) than in other areas of the Headland reefs.

(2) The wave action all along the south facing reefs of the Headlands is quite severe, and the amount of algae varies according to the amount of protection afforded by the offshore rocks.

TABLE 5. DESCRIPTION OF THE MAJOR PLANTS, POINT REYES ASBS

<u>Avg. Depth</u>	<u>No. of Major Plants</u>	<u>Index Plant Zone</u>	<u>Ecology</u>
7 meters (25 feet)	11	<u>Lithothamnium</u> sp. and other encrusting red algae	This encrusting red algae zone covers large portions of the wash rocks and sea stacks from the surface down to the sand level at 12 meters (40 feet).
4.5 meters (15 feet)	35	<u>Rhodomenia callophyllidoides</u> <u>Pterygophora californica</u> <u>Laminaria dentigera</u> <u>Lessoniopsis littoralis</u>	Red algae, about 10 cm. tall, covering the granitic boulders, very abundant on tops and sides of rocks. This area is known as the short kelp zone. These heavy stiped kelps form a dense cover of the large boulders. <u>P. californica</u> is zoned lower than <u>L. dentigera</u> which is near the intertidal surface, just below the surf grass.
1.5 meters (5 feet)	27	<u>Phyllospadix torreyi</u> <u>Botryoglossum farlowianum</u> <u>Iridaea cordata</u> <u>Egregia menziesii</u>	At the interface of subtidal waters to Zone 4 or low intertidal is this surf grass which grows to a length of over 3 meters (10 feet) especially in the Chimney Rock area. The red algae, <u>Botryoglossum</u> , is quite dense below the surf grass zone.
+1.5 MLLW Hedgpeth (1968)	10	<u>Intertidal Zone</u> <u>Gigartina papillata</u>	Zone 3 is also known as the mussel zone. Dense patches of <u>G. papillata</u> cover the rocks and mussels within this zone.
+3.5 MHLW	13	<u>Ralfsia pacifica</u> <u>Fucus distichus</u> <u>Ulva</u> spp. <u>Caldophora columbiana</u>	The Zone 2 area is very narrow among the Headland reefs. These plants are protected by the off-shore boulders and sea stacks.
+5.6 MHW	3	<u>Endocladia muricata</u> <u>Gigartina canaliculata</u>	Zone 1 is exposed for many hours; these small plants can withstand much drying.

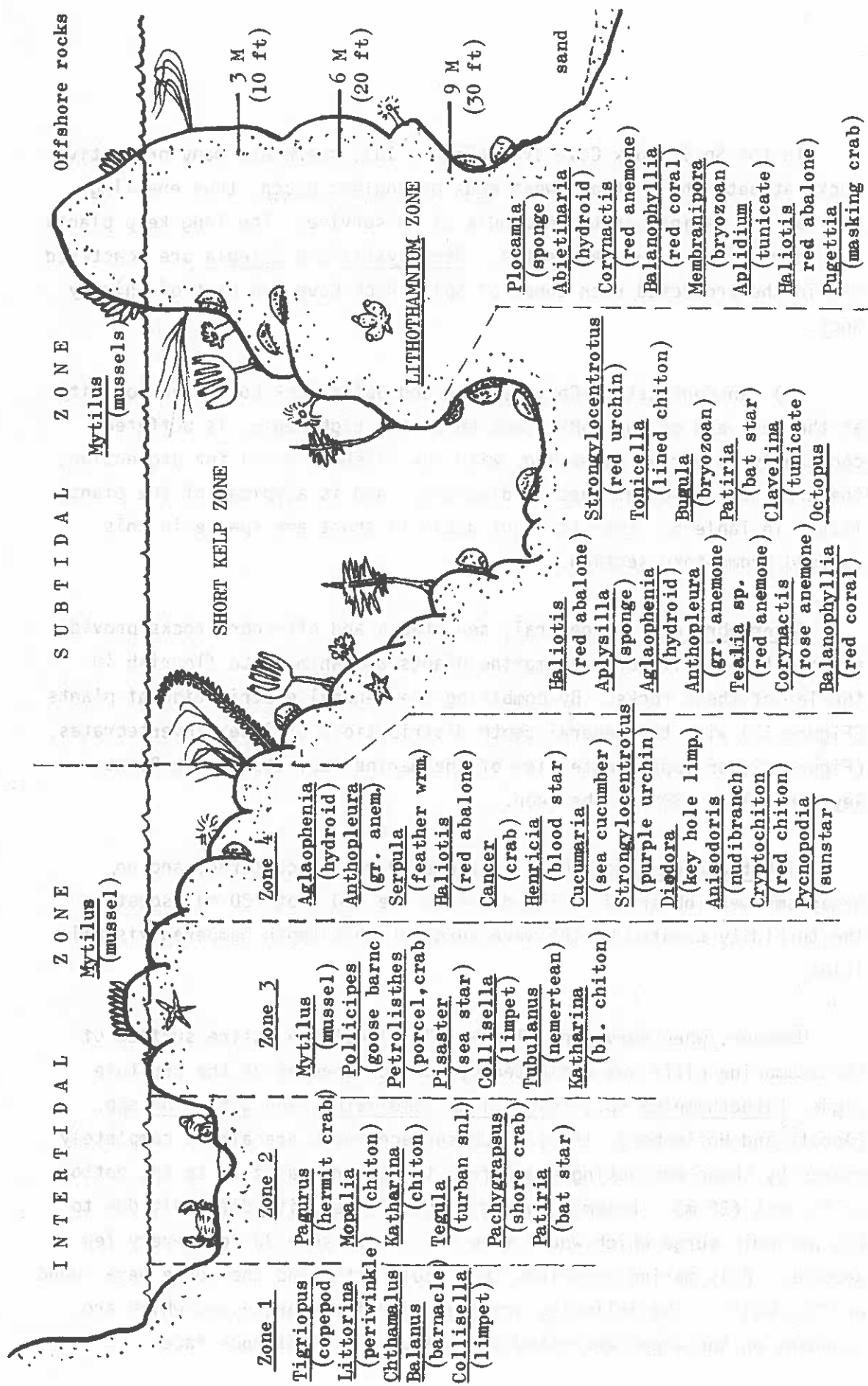


Figure 12. GENERAL DEPTH DISTRIBUTION OF INDEX INVERTEBRATES, POINT REYES HEADLAND

(not drawn to scale)

In the Split Rock Cove area (Figure 13), there are many protective rocks at both the east and west ends of Boulder Beach, thus enabling many of the marine plants (Appendix 2) to survive. The long kelp plants are sparse in the Headland sites. Nereocystis and Egregia are scattered within the protected rock zones of Split Rock Cove and east of Chimney Rock.

(3) In contrast to Chimney Rock and Split Rock Cove, the locality at the west end of the ASBS, just below the Lighthouse, is buffeted constantly by strong waves and, with few offshore rocks for protection, the area has low plant species diversity, and is atypical of the plants listed in Table 5. Even the surf grass is short and sparse in this exposed promontory section.

Invertebrates: In general, sea stacks and off-shore rocks provide a protective shelf for many marine plants and animals to flourish in the lee of these rocks. By combining the general distribution of plants (Figure 11) with the general depth distributions of index invertebrates, (Figure 12) an approximate view of the marine habitats of the Point Reyes Headland ASBS can be seen.

Lithothamnium Zone: Only coarse sand was encountered, and no organisms were observed during dives to the 100 foot (30 m) isobath. The turbidity created by the wave surge at this depth hampered visibilities.

However, when surveying "The Wall", almost the entire surface of the submarine cliff was dominated by various species of the crustose algae, Lithothamnium sp., Mesophyllum lamellatum, and Corallina spp. (Abbott and Hollenberg, 1976). Sub-surface rocks are almost completely coated by these encrusting algae from the intertidal zone to the bottom at 85 feet (26 m). Swimming along this wall is quite difficult due to the periodic surge which would move the divers some 30 feet every few seconds. Only marine organisms that could withstand the surge were found on "The Wall". The following are the major index organisms which are abundant on the algal encrusted surface of the giant rock face:

0 100 200
Meters



Subtidal transects = (A) (B) (C)

Intertidal transects = 1 2 3 4

Seals and Sea Lion Rocks

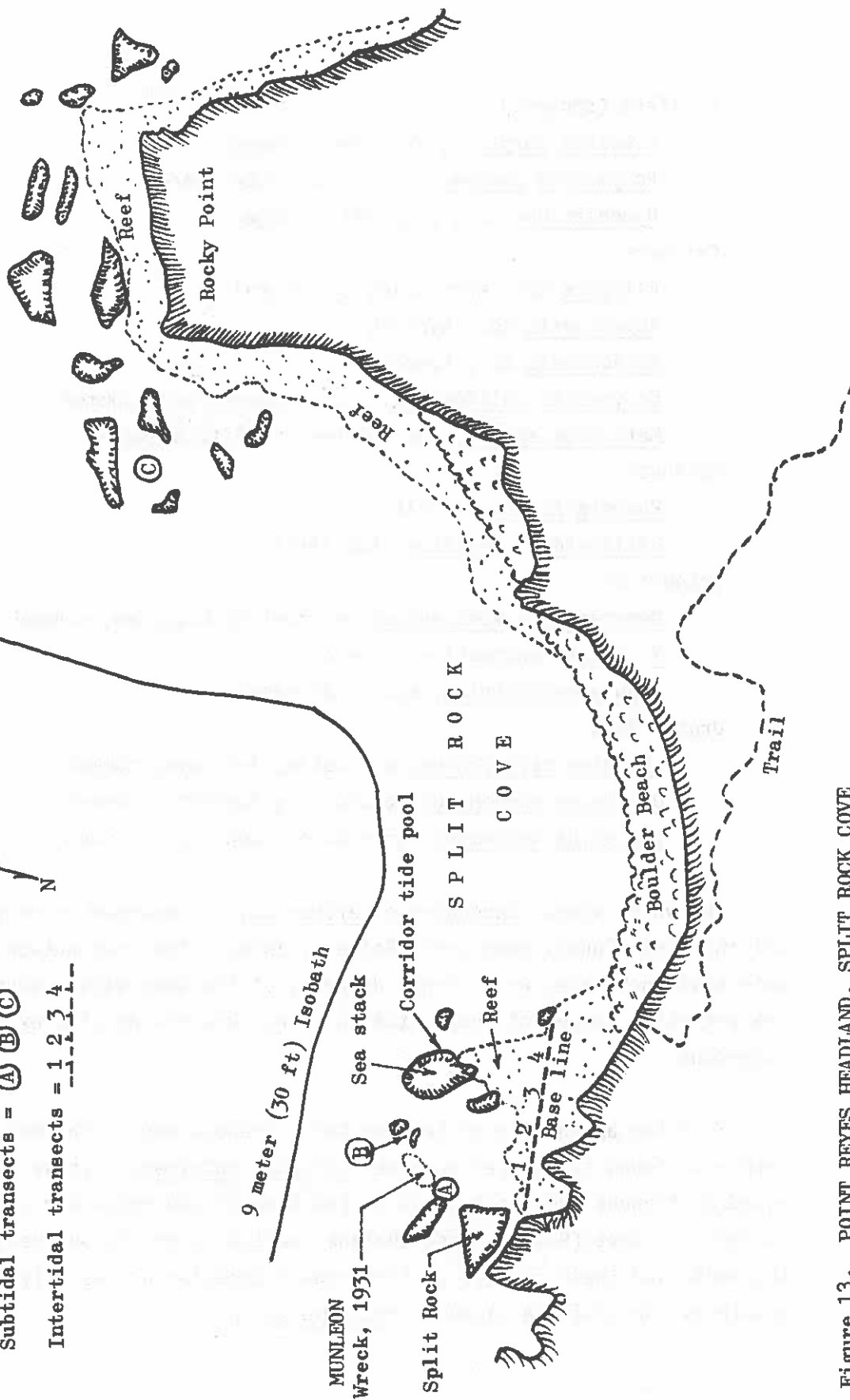


Figure 13. POINT REYES HEADLAND, SPLIT ROCK COVE

Porifera (sponges)

Plocamia karykina, red sheet sponge

Polymastia pachymastia, yellow tube sponge

Hymeniacidon sp., grey-ball sponge

Cnidaria

Allopora sp., encrusting hydrocoral

Abietinaria sp., hydroid

Aglaophenia sp., hydroid

Corynactis californica, rose anemone, very common

Metridium exilis, the cotton-top white anemone

Mollusca

Purpora foliata, whelk

Calliostoma annulatum, top shell

Ectoprocta

Membranipora membranacea, encrusting bryozoan, common

M. fusca, encrusting bryozoan

Bugula californica, spiral bryozoan

Urochordata

Aplidium californium, encrusting tunicate, common

Diplosoma macdonaldi, encrusting tunicate, common

Clavelina huntsmani, transparent tunicate, common

The white shark, Carcharodon carcharias, is reported in deep waters off the Marin County headlands (Follett, 1974). The combination of no safe boat anchorage, wave surge, darkness of the deep water, along with the potential danger of shark attacks makes this diving site extremely hazardous.

With the appearance of kelp on the off-shore rocks, the major herbivore found is the red abalone, Haliotis rufescens. These large-sized gastropods are often found at the base of the rocks and sea stacks at about 30 feet (9 m). These abalones nestle under the overhangs of the rocks and their crowded shell-to-shell behavior allows only a sparse growth of the crustose algae, Lithothamnium sp.

Short-Kelp Canopy Zone: The water depths of the short-kelp canopy zone range from 25 to 10 feet (7.6 to 3 m) and the kelp forms a dense canopy, particularly on the lee side of the offshore rocks and sea stacks, as illustrated by Figure 12. The primary kelps are (from top to bottom):

Lessoniopsis littoralis, shredded kelp

Costaria costata, leaf kelp

Egregia menziesii, feather boa kelp

Laminaria dentigera (L. andersonii), palm or finger kelp, or split whip

Pterygophora californica, tree kelp

The deepest of the kelp, P. californica, is particularly dense in this area with its thick stipe averaging about 4 feet (1.2 m). The major algae which cover these boulders are the coralline algae, Corallina officinalis var. chilensis, and the red algae, Rhodymenia pacifica and Botryoglossum farlowianum (Figure 11). With the abundance of coralline algae, the red abalone has a flourishing population.

Prior to 1972, the Headland was open to the public for abalone fishing. Since 1972, the area between Chimney Rock and the Lighthouse has been set aside by the California Department of Fish and Game as the Point Reyes Headland Reserve, and no form of marine life may be taken from this ocean site, within 1,000 feet (305 m) of the high tide mark, without a written permit from the Department of Fish and Game (Smith and Johnson, 1972).

Populations of red abalone within the protected Headland Reserve have increased in numbers and size, as the primary consultant's latest census revealed in 1976 and 1979 (Table 6). In 1970, the population of abalones at Split Rock Cove (Figure 13) for transects A and B was an average 0.3 and 4.4 organisms per square meter (Table 6). The average size for abalones at site B was 8.0 inches (20.0 cm). In 1979, the populations in both A and B transects increased to 1 and 5 abalones per square meter respectively, and the average size for these mollusks at

site B increased to 8.5 in. (21.6 cm). These large-sized abalones are a direct result of the protective reserve system.

TABLE 6. ABALONE POPULATIONS, POINT REYES HEADLAND, 1970-1979

Subtidal Site	Transect	1970-1972 Avg. No./m. ²	95% confidence limits	1979 Avg. No. per square meter
Split Rock Cove	A	0.3	± 0.26	1.0
	B	4.4	± 2.65	5.0
	C	0.5	± 0.2	
		20.0 cm. (8.0 in.) Avg. size for Site B	Avg. number of growth layers was 16	21.6 cm. (8.5 in.) Avg. size for Site B.
	Transect	June 25, 1970 Avg. No./m. ²	95% confidence Limits	July 13, 1976 Avg. No./m. ²
Chimney Rock	A	1.9	± 0.65	0.3
	B	1.5	± 0.55	0.0
	C	1.3	± 0.7	2.0
		14.9 cm. (5-7.8 in.)	Avg. number of growth layers = 10	

In contrast to Split Rock Cove, the abalones at two of the Chimney Rock transects (Figure 14) have decreased. At sites A and B which are outside the protection of the Reserve, divers still fish for the mollusks in this area; thus, the populations have been reduced from 1.9 and 1.5 per square meter in 1970 to 0.3 and zero, respectively, in 1976. At site C, within the Reserve, the abalones have increased from 1.3 in 1970 to 2.0 in 1976 (Table 6).

The abalones in the Chimney Rock area are small and young in comparison to the specimens at Split Rock Cove. The reason for this is that

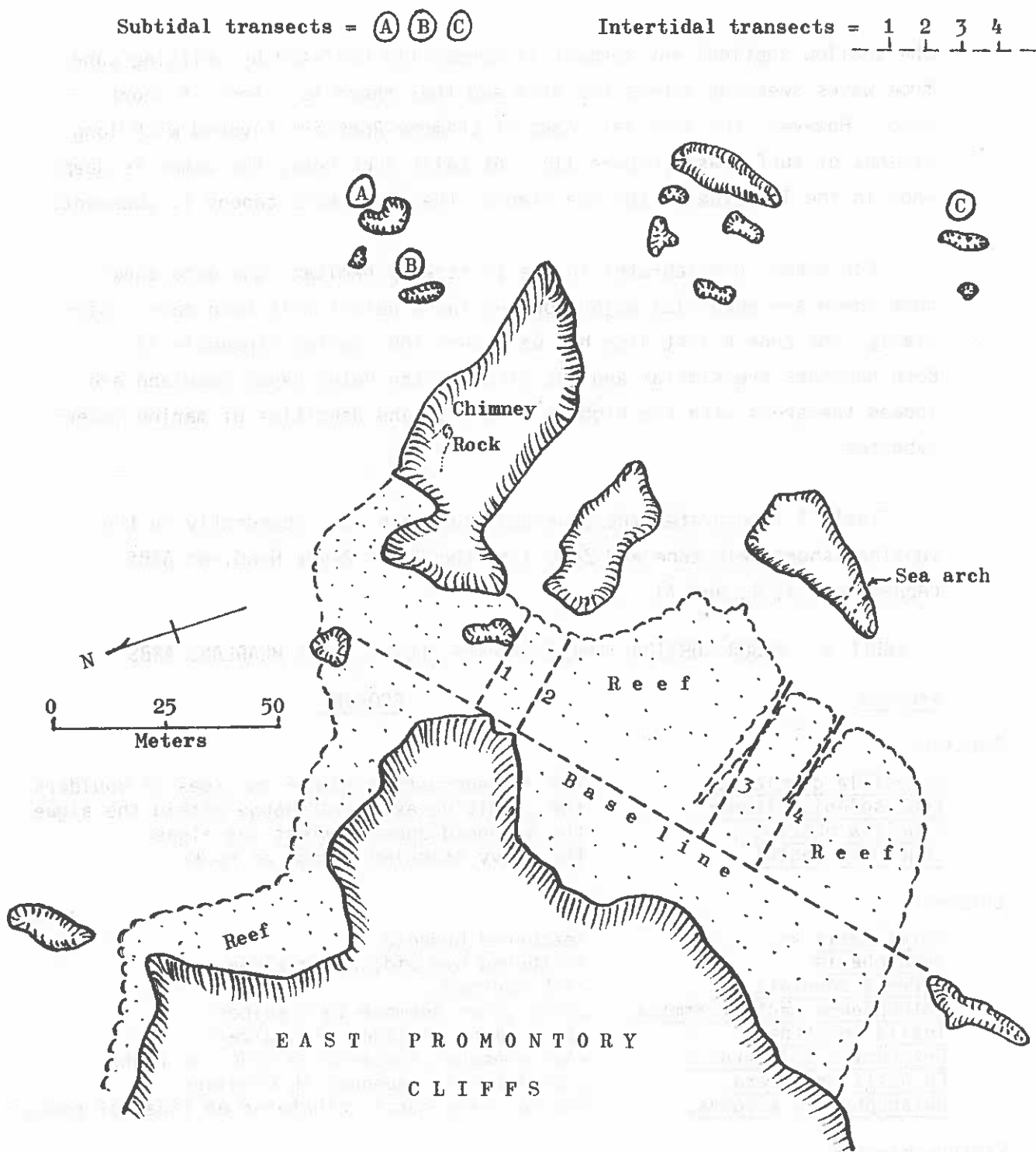


Figure 14. POINT REYES HEADLAND, CHIMNEY ROCK

the shallow subtidal environment is constantly buffeted by shifting sand from waves sweeping across the area and that there is a lack of short kelp. However, the subtidal rocks at Chimney Rock are covered with long strands of surf grass (Figure 11). At Split Rock Cove, the water is deep and, in the lee side of the sea stacks, the short-kelp canopy is abundant.

For other invertebrates in the short-kelp habitat, the data show that there are about 111 major species found amidst this kelp zone. Similarly, the Zone 4 list also has well over 100 species (Appendix 3). Both habitats are similar and the sites at the Point Reyes Headland are indeed the areas with the highest diversity and densities of marine invertebrates.

Table 7 illustrates the invertebrates seen most abundantly in the subtidal short-kelp zone and Zone 4 of the Point Reyes Headland ASBS (Appendices 3, 5, and 7).

TABLE 7. MAJOR SUBTIDAL INVERTEBRATES, POINT REYES HEADLAND ASBS

<u>SPECIES</u>	<u>ECOLOGY</u>
Porifera	
<u>Aplysilla glacialis</u> ,	the red encrusting sponge on sides of boulders
<u>Leucosolenia eleanor</u>	the primitive asconoid sponge within the algae
<u>Leucilla nuttingi</u> ,	the syconoid sponge amidst the algae
<u>Leucandra heathi</u> ,	the heavy spiculed sponge on rocks
Cnidaria	
<u>Abietinaria</u> sp.	feathered hydroid
<u>Aglaophenia</u>	feathered hydroid, among algae
<u>Garveia annulata</u> ,	club hydroid
<u>Anthopleura xanthogrammica</u> ,	giant green anemone in crevices
<u>Tealia lofotensis</u>	red anemone on sides of boulders
<u>Corynactis californica</u> ,	rose anemone clustered on sides of rocks
<u>Epiactis prolifera</u> ,	proliferating anemone, in crevices
<u>Balanophyllia elegans</u> ,	red solitary coral, clustered on sides of rocks
Platyhelminthes	
<u>Leptoplana chloranota</u> ,	polyclad flatworm in crevices, under rocks

Table 7. (Continued) Major Subtidal Invertebrates, Pt. Reyes Headland

Nemertea

Tubulanus polymorphus, red ribbon worm in crevices and holdfasts of kelps

Sipuncula

Phascolosoma agassizii, peanut worm in crevices, under rocks

Annelida

Platynereis bicanaliculata, nerid polychaete in holdfasts, crevices
Serpula vermicularis, feather worm on sides of rocks
Eudistylia polymorpha, feather duster worm in sandy crevices

Arthropoda

Crustacea

Balanus nubilus, giant acorn barnacle among the sponges, tunicates
Balanus glandula, acorn barnacle on rock surfaces
Idotea spp., isopod among the red algae
Metacaprella kennerlyi, skeleton shrimp in hydroids
Betaeus sp., pistol shrimp in crevices
Hemigrapsus nudus, purple shore crab under rocks, crevices
Pugettia richii, masking crab among the red algae
Cancer antennarius, cancer crab in crevices, under ledges
Pagurus spp., hermit crabs among the red algae

Mollusca

Cryptochiton stelleri, red gumboot chiton on rocks, crevices
Tonicella lineata, lined chiton on top of rocks
Katharina tunicata, black chiton
Diodora aspera, keyhole limpet amidst sponges, tunicates
Haliotis rufescens, red abalone under ledges, crevices
Calliostoma annulatum, red top shell among the red algae
Anisodoris nobilis, yellow dorid nudibranch among sponges
Hermisenda crassicornis, nudibranch feeding on hydroids
Hopkinsia rosacea, rose nudibranch in algae, tunicates
Rostanga pulchra, orange dorid on top of sponges, tunicates
Octopus sp., large octopus under ledges

Ectoprocta

Bugula californica, foliose bryozoan in crevices
Membranipora spp., encrusting bryozoan on kelp, rocks
Tricellaria occidentalis, bryozoan on rocks

Echinodermata

Pycnopodia helianthoides, sunstar among the sea urchins
Henricia leviuscula, blood star at the base of algae
Patiria miniata, common bat star on rock surfaces
Pisaster spp., ochre stars in crevices
Cucumaria miniata, orange sea cucumber in crevices
Strongylocentrotus purpuratus, purple sea urchin on benthic sand, rocks

Table 7. (Continued) Major Subtidal Invertebrates, Pt. Reyes Headland

Urochordata

<u>Aplidium</u> spp.,	encrusting tunicates on rock surfaces
<u>Clavelina</u> <u>huntsmani</u> ,	transparent tunicate under ledges, base of kelp
<u>Archidistoma</u> <u>molle</u> ,	tunicate hanging under ledges

Intertidal Biota

An extension of the short kelp zone is the intertidal Zone 4 region. This area does not have much exposure and is quickly covered by the sea. Thus, the organisms are very similar to species which reside in the subtidal kelp zone.

The kelps Laminaria spp., Alaria marginata, Costaria costata, along with the feather boa, Egregia menziesii, form a thick cover over this Zone 4 region. One of the primary marine plants in this area is the surf grass, Phyllospadix torreyi. This seed plant covers large areas of the low intertidal rocks and is quite long at Chimney Rock, while near the Lighthouse the surf grass is sparse and shorter in length. The action of waves upon the intertidal rocks reaches such magnitude, especially under the Lighthouse, that this may contribute to the decreased biomass of the surf grass community. Nevertheless, the root system of the grass provides a very thick matrix for many invertebrates, particularly marine worms, crustaceans, and bivalves. In the higher rocks of the Zone 4 region, the red algae, Prionitis lanceolata and Iridaea cordata var. splendens, provide additional habitat for a wide variety of invertebrates and sculpin fish.

In 1968, the intertidal Zone 4 region of the Chimney Rock area was blanketed by the purple sea urchin, Strongylocentrotus purpuratus. One square meter sample revealed about 280 of these small urchins. Since that year, the population of urchins has decreased dramatically. In sampling the same area in 1978, only a few urchins were located in crevices, and they represented only a small percentage of the 1968 population. The reasons for this unusual cycle of urchins are unknown.

Intertidal Transects: At Chimney Rock, a 410 foot (125 m) transect line was laid out with perpendicular, 10-meter transects randomly selected for population counts. The major organisms at the Chimney Rock transects in 1970 are listed in Table 8.

TABLE 8. MAJOR SPECIES, CHIMNEY ROCK TRANSECT, 1970 (Chan 1971)

	$\bar{X}/m.^2$	95% confidence limits
<u>Pagurus samuelis</u> , hermit crab	1.4	+ 1.1
<u>Pycnogonum stearnsi</u> , sea spider	0.8	+ 0.4
<u>Petrolisthes cinctipes</u> , porcelain crab	1.7	+ 1.3
<u>Balanus glandula</u> , acorn barnacle	105.6	+ 58.0
<u>Hemigrapsus nudus</u> , purple shore crab	0.5	+ 0.3
<u>Haliotis rufescens</u> , red abalone	0.6	+ 0.2
<u>Littorina planaxis</u> , littorine snail	78.5	+ 31.6
<u>Tegula funebris</u> , black turban snail	4.6	+ 1.7
<u>Cryptochiton stelleri</u> , gum boot chiton	0.5	----
<u>Thais emarginata</u> , rock snail	2.3	+ 1.8
<u>Patiria miniata</u> , bat starfish	0.3	+ 0.1
<u>Leptasterias</u> sp., small starfish	1.3	+ 0.4
<u>Strongylocentrotus purpuratus</u> , sea urchin	1.6	+ 0.8
<u>Pycnopodia helianthoides</u> , sunstar	0.2	+ 0.05
<u>Pisaster ochraceus</u> , purple starfish	0.3	+ 0.1

One of the most significant organisms present in the intertidal transects was the abalone in the quadrats. These small gastropods ranged from 2 to 7 inches (5 to 17.7 cm) in length, supporting the observation that these reefs may be a nursery ground for young H. rufescens. Likewise, the data from the subtidal census of abalones (Table 6) indicated that this promontory habitat supports a large, young population of these mollusks.

Two organisms seen intertidally in 1970 were the gumboot chiton, Cryptochiton stelleri, and the sunstar, Pycnopodia helianthoides. These two organisms are not common on local intertidal reefs, but their appearance indicates the high diversity of invertebrates at Chimney Rock.



Figure 15. Photograph of Starfish, Pisaster sp., found on the reefs at Point Reyes.

Species lists were compiled on February 19 and March 4, 1979 to compare with those of the previous samplings of 1970 and 1973. The comparison information (Appendices 3 through 7) revealed that speciation over a period of nine years had changed very little; these reefs have remained fairly constant in providing a habitat for invertebrates (Figure 15). The only change noted was that 20 red abalone were observed in 1970 in the Chimney Rock intertidal transects, while only one specimen was observed in 1979. The only parameter which might play a role in the reduction of abalones in the Chimney Rock area is that man still is a predator. Although the intertidal transects are inside the boundary of the California Department of Fish and Game Reserve, individuals may still prey on available abalones which are easily accessible on these exposed reefs (see boundary, Figure 6).

The intertidal invertebrates (Appendix 6) in the Split Rock transects were very similar to those on the species list for Chimney Rock. The major difference is that the Zone 4 invertebrates in the Split Rock transects occupy a much larger area, as far back as the high tide line. The profile of these rocks is nearly horizontal, which helps to account for the similarity of organisms from one end of the transect to the other, points A and B, Figure 16, below.

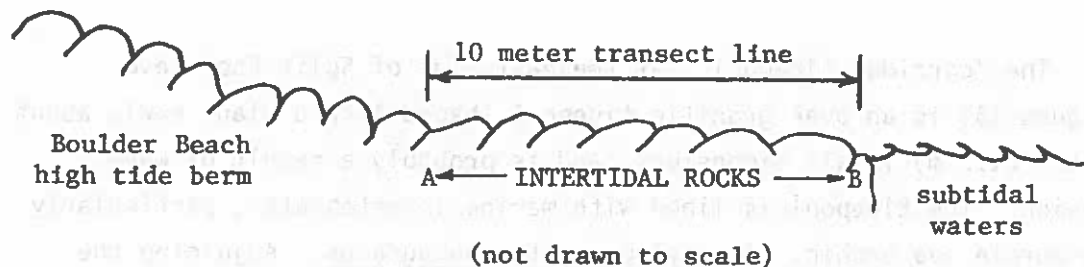


FIGURE 16. INTERTIDAL PROFILE, SPLIT ROCK INTERTIDAL TRANSECT

Although the following list of key organisms describes those found throughout the intertidal transect, the area at point B, Figure 16, certainly contained a greater density of these invertebrates:

Garveia annulata, hydroid
Aglaophenia sp., hydroid
Abietinaria sp., hydroid
Anthopleura xanthogrammica, green sea anemone
A. elegantissima, aggregating sea anemone
Epiactis prolifera, proliferating anemone
Membranipora spp. encrusting bryozoan
Bugula neritina, foliose bryozoan
Aplidium spp., tunicate

A review in March, 1979, of the Split Rock intertidal transects revealed that the marine plants and invertebrates are still highly diverse and abundant. The only major change in 1979, compared with the studies of 1970 and 1973, was the presence of hundreds of the Prosobranch gastropod, Opalia chacei. This wentletrap snail was extremely numerous around the root matrix of the surf grass, Phyllospadix torreyi. This snail is often observed under rocks or with sea anemones (Smith and Carlton, 1975), and its appearance is another of the unusual "blooms" of marine organisms observed in the intertidal zone of the Point Reyes Headland reefs. Some 98 species of marine plants and invertebrates were recorded in the 1979 review of the Split Rock transects.

The "corridor tidepool", at the east side of Split Rock Cove, (Figure 13) is an oval granitic tidepool shaped like a giant bowl, about 5 feet (1.5 m) in all dimensions, and is probably a result of wave erosion. The tidepool is lined with marine invertebrates, particularly the purple sea urchin, Strongylocentrotus purpuratus. Adjoining the eastern side of this tidepool is a large crevice or corridor which is lined with large California mussels, Mytilus californianus. Some of these mussels average around 8 inches (20.3 cm), which is considered large for the Central California coast.

Other intertidal reef areas west of Split Rock Cove are not extensive in size. The profile of the beach and rocky points is very steep, with waves breaking upon these areas throughout the mid-tidal range. In the wash rocks inhabited by the sea lions, there are zoned bands of surf grass and California mussel (Figure 17).

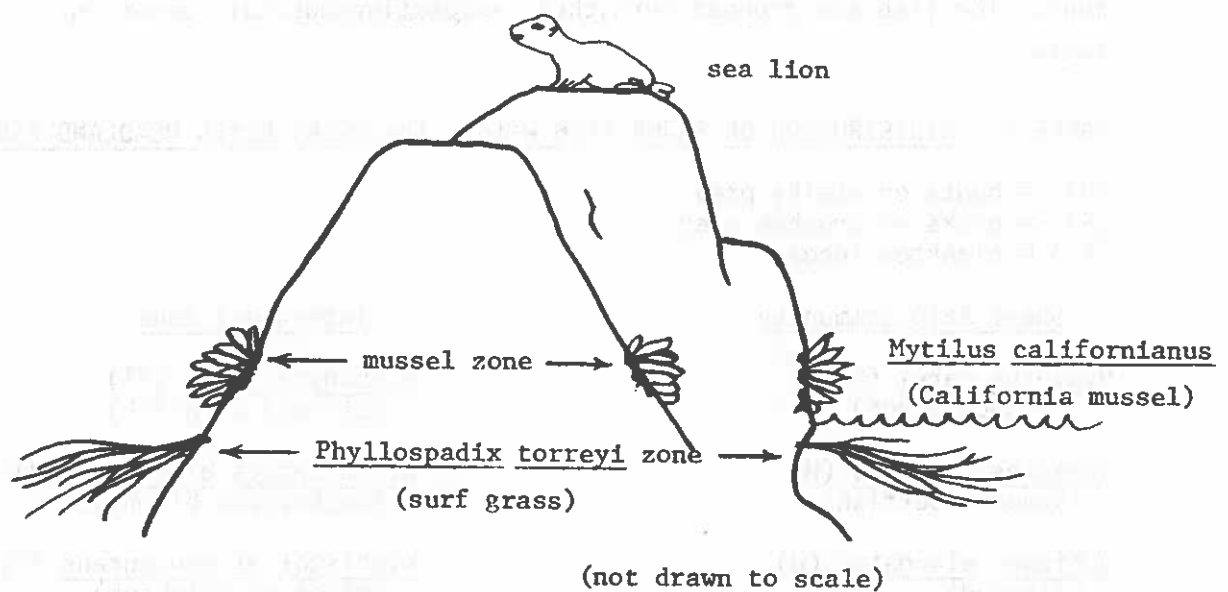


Figure 17. ZONATION of SURF GRASS AND MUSSELS around SEA LION WASH ROCKS

The major marine invertebrates from a square yard of mussel bed (Appendix 8) are:

Mytilus californianus, California mussel
Pollicipes polymerus, goose barnacle
Balanus spp., acorn barnacle
Petrolisthes cinctipes, porcelain crab
Cirolana harfordi, isopods; and a great variety of lower worms

No surveys of marine organisms were made for the small sandy beaches of the Point Reyes Headlands. These steep-profile beaches are composed of very coarse granitic sands during the winter months to medium-grain sands during summer months. The waves during the winter months are very intense, while during summer months the waves are more gentle; thus, finer particles of sand are deposited on these small beaches.

Vertebrates

Fishes: Due to the strong wave surge in this area, only a small number of fish species were observed in the shallow waters and intertidal

zone. The fish are grouped into their respective habitats shown in Table 9.

TABLE 9. DISTRIBUTION OF MAJOR FISH within the POINT REYES HEADLAND ASBS

(H) = hunts or stalks prey
(P) = picks or crushes prey
(Pl) = plankton feeder

<u>Short Kelp Community</u>	<u>Intertidal Zone</u>
<u>Hypsurus caryi</u> (P) (rainbow perch)	<u>Gibbonsia metzi</u> (Pl) (striped kelpfish)
<u>Sebastes caurinus</u> (H) (copper rockfish)	<u>Cebidichthys biolaceus</u> (H) (monkeyface blenny)
<u>Ophiodon elongatus</u> (H) (lingcod)	<u>Xiphister atropurpureus</u> (P) (black prickleback)
<u>Scorpaenichthys marmoratus</u> (H) (cabezon)	<u>Apodichthys flavidus</u> (P) (penpoint gunnel)
<u>Sebastes mystinus</u> (Pl) (blue rockfish)	<u>Gobiesox meandricus</u> (P) (northern clingfish)
<u>Sebastes goodei</u> (Pl) (chilipepper)	<u>Clinocottus analis</u> (P) (wooly sculpin)
<u>Hexagrammos superciliosus</u> (Pl) (rock greenling)	<u>Clinocottus recalvus</u> (P) (bald sculpin)
<u>Heterostichus rostratus</u> (Pl) (giant kelpfish)	<u>Enophrys bison</u> (P) (buffalo sculpin)
<u>Gibbonsia metzi</u> (Pl) (striped kelpfish)	<u>Clinocottus globiceps</u> (P) (mosshead sculpin)
	<u>Oligocotus synderi</u> (P) (fluffy sculpin)

Since the ASBS does not have elongated kelps such as Nereocystis sp. and Macrocystis spp., there is no significant protective habitat for offshore fishes (Mitchell and Hunter, 1970).

Over a period of 23 years, fewer fish have been observed in the ASBS waters than in other areas off Marin County. The copper rockfish and the rock greenling were most often recorded in the short kelp zone, along with the lingcod. With the large population of California sea lions,

Zalophus californianus, in the area, it is possible these mammals play a role in keeping the numbers and diversities of near-shore fishes at a low profile.

The intertidal fish population consists basically of sculpins and blennies. The most common sculpins are Clinocottus spp. and Oligocottus synderi. The most abundant blennies are Cebidichthys violaceus, Xiphister atropurpureus, and Apodichthys flavidus. The above species were quite abundant in the tidepools and crevice channels at the Chimney Rock and Split Rock reefs.

Birds: The marine birds at Point Reyes Headland ASBS are one of the great natural resources of this marine environment. Any casual or scientific visitor to this area cannot help being amazed at the great number of birds which nest on the Headland rocks and cliffs. However, there has been very little work done on the census and study of marine birds at the Headland, and only the work of Ainley and Whitt (1973), Table 10, documents the importance of birds using this habitat as a breeding site. From Table 10, the Point Reyes Headland is the largest site for breeding birds in Marin County.

Table 10 revealed 4,604 pairs of breeding marine birds at the Point Reyes Headland in 1971. The Common Murre, Uria aalge, numbered 3,820 breeding pairs or 83% of the total number of birds observed. Most of the Common Murres usually reside on two large rocks almost directly below the Lighthouse on the western promontory, Figure 5.

TABLE 10. 1971 CENSUS of the NUMBER OF BREEDING PAIRS OF MARINE BIRDS, MARIN COUNTY (Ainley and Whitt, 1973)

<u>SPECIES</u>	<u>Number of Breeding Pairs per Breeding Site</u>					
	<u>Tomales Point</u>	<u>Bird Rock</u>	<u>Pt. Reyes Headland</u>	<u>Bear Valley</u>	<u>Double Point</u>	<u>Total</u>
<u>Oceanodroma homochroa</u> (Ashy Storm-Petrel)		5				5

TABLE 10. 1971 CENSUS of the NUMBER OF BREEDING PAIRS OF MARINE BIRDS, MARIN COUNTY (Ainley and Whitt, 1973)
(Continued)

SPECIES	Number of Breeding Pairs per Breeding Site					Total
	Tomales Point	Bird Rock	Pt. Reyes Headland	Bear Valley	Double Point	
<u>Phalacrocorax penicillatus</u> (Brandt's Cormorant)			480	15	170	665
<u>Phalacrocorax pelagicus</u> (Pelagic Cormorant)	86		264	10	40	400
<u>Haematopus bachmani</u> (Black Oystercatcher)		3	3		1	7
<u>Larus occidentalis</u> (Western Gull)		30	13		50	93
<u>Uria aalge</u> (Common Murre)			3820	200	700	4720
<u>Cephus columba</u> (Pigeon Guillemot)	4	12	24		1	41
Breeding Site Totals	90	50	4604	225	962	5931

The murrees also reside in smaller numbers on the conglomerate cliffs east of the Lighthouse. The Brandt's Cormorant, Phalacrocorax penicillatus, with 480 breeding pairs, and the Pelagic Cormorant, P. pelagicus, with 264 breeding pairs (Table 10), are the species with the next highest numbers at the Headland.

Sarah Allen, a marine biologist from the Point Reyes Bird Observatory, has also recorded large numbers of murrees and cormorants at Double Point, 9 nautical miles (16.7 km) to the southeast of the Point Reyes Headland (Figure 1). Allen estimated about 3,000 Common Murre on Stormy Stack of Double Point, with many nests among the population.

Although no counts were made of marine birds of the area, the following list, Table 11, cites the birds observed during studies over a period of sixteen years.

TABLE 11. MAJOR BIRD SIGHTINGS, POINT REYES HEADLAND

G. Chan, 1962-1978

Aechmophorus occidentalis, Western Grebe
Buteo jamaicensis, Red-tailed Hawk
Cephus columba, Pigeon Guillemot
Corvus brachyrhynchos, Common Crow
C. corax, Common Raven
Falco peregrinus, Peregrine Falcon (occasionally)
Fratercula corniculata, Horned Puffin (?)
Haematopus bachmani, Black Oystercatcher
Larus occidentalis, Western Gull
Melanitta perspicillata, Surf Scoter
Melospiza melodia gouldii, Song Sparrow
Oceanodroma homochroa, Ashy Storm-Petrel (?)
Pelecanus erythrorhynchos, White Pelican
P. occidentalis, Brown Pelican
Petrochelidon pyrrhonota, Cliff Swallow
Phalacrocorax penicillatus, Brandt's Cormorant
P. pelagicus, Pelagic Cormorant
Puffinus griseus, Sooty Shearwater
Uria aalge, Common Murre

Marine Mammals: Along with the large bird populations, the marine mammals of the Point Reyes Headland are the principal rationale for the ASBS recognition for this locality. The two major species of marine mammals at the Headland are the northern or Steller sea lion, Eumetopias jubatus, and the California sea lion, Zalophus californianus. The third major marine mammal of this area is the harbor seal, Phoca vitulina. One of the major rookeries of harbor seals in Northern California is at Double Point (Figure 1). The population of harbor seals at the Point Reyes Headland is small; generally they occupy the rocks at the western tip of Split Rock Cove and at Chimney Rock. A fourth marine mammal which has been reported at the Headland area is the elephant seal, Mirounga angustirostris. The seasonal relationships of both the harbor and elephant seals at Point Reyes are unknown at the present time.

During December, 1958, more than 1800 California sea lions were observed in Sea Lion Cove by the principal consultant. This may be one of the largest counts of the sea lions in Northern California (Allen, 1978). One year later at Sea Lion Cove, only 105 sea lions were counted. At this time there are no reasons for these seasonal fluctuations of sea lions at the Headland site.

Likewise, populations of California sea lions in British Columbia undergo seasonal movements. Spaulding (1964) stated that sea lion migrations in his study areas are not fully understood. During the 1956-57 summer months, 1300 adults were concentrated on two rookeries in British Columbia, but over half of their population leave after pupping and breeding, moving south in the fall. The Federal Register (1975) cited that some 1,000 sea lions migrate through Oregon to the Canadian area (1968-70). The Register also reported that there was a minimum population of 34,322 California sea lions in the Channel Islands off Southern California in June of 1964. The total population of Z. californianus is about 60,000 with 20,000 in Baja-Mexico, and 40,000 in the United States (Federal Register, 1975). The feeding habits of the sea lions around the Point Reyes Headland remain unknown.

The second marine mammal dominating the Point Reyes Headland rocks is the giant northern or Steller sea lion, Eumetopias jubatus. The Steller sea lion generally ranges from the Channel Islands in California to Alaska, with population estimates off the coast of British Columbia numbering 11,000 to 12,000 (Federal Register, 1975, and Pike and MacAskie, 1969). The California population of Steller sea lions is estimated by the California Department of Fish and Game between 5,000 and 7,000 (Federal Register, 1975). Certain reports (Ainley et al., 1977; Federal Register, 1975; Spaulding, 1964; Pike and MacAskie, 1969) all state that the populations of the Steller sea lions are on a decline throughout the Pacific Coast.

The Steller sea lion favors isolated locations; at the Point Reyes Headland, the Stellers occupy the offshore rocks between Sea Lion Cove and Split Rock Cove (Figures 6 and 9). The Stellers with families reside on offshore rocks within the partial shelter of Sea Lion Cove while the young adults inhabit the rocks closer to the more exposed area of Split Rock Cove. This population has resided at the Headland for many years. An important reason for the longevity of the marine mammals is the protection from human interference as provided by these rocks. Human harassment, prompting the sea lions to dive into the water, can cause injury to these marine mammals and can drive them away from their permanent rookery site (Federal Register, 1975).

The sizes of these sea lions residing at the Headland appear to approach the statistics cited by the Federal Register, 1975; adult males may grow to 9.8 feet (3.0 m) in length and over 1,984 lbs (900 kg) in weight.

The Headland apparently is a breeding rookery for both species of sea lions, very similar to the rookeries at the Farallon Islands (Ainley et al., 1977) and Ano Nuevo Island (Orr and Poulter, 1967).

The harbor seal, Phoca vitulina, has also been observed on Chimney Rock and the west side of Split Rock Cove. No data is available about the harbor seals at these sites other than that their numbers and activities seem to constitute a minor role in comparison to the dominance of both species of sea lions at the Headland. The small population of harbor seals may be an extension of the large rookeries of seals located at Double Point, Drakes Estero, or Bird Rock (Allen 1978).

Another marine mammal which has been reported in the area is the grey whale, Eschrichtius robustus. The College of Marin has compiled partial data on this whale in Table 12, below.

TABLE 12. COLLEGE OF MARIN WHALE WATCHERS' STATISTICS
POINT REYES LIGHTHOUSE (A. Molina, 1978)

<u>Period</u>	<u>Number of Days, Observations</u>	<u>Number of Grey Whales</u>	<u>Comments</u>
Dec. 12-31, 1967	15	98	Headed south; some breached. Few within 100 ft (30 m) of outer rocks.
Jan. 1-Feb. 4, 1968	9	104	Whalers killed 2 mammals.
Jan. 15-29, 1969	3	18	Some within 500 yds (457 m) of shore
	27	220	

Along with the data on the grey whale sightings off the Lighthouse Point in Table 12, a mother grey whale and her calf were observed feeding on a dense mass of pelagic shrimp. The Point Reyes Headland ASBS locality seems to be an important landmark for these migrating whales each year.

Landside Vegetation

Howell (1970) has listed over 750 species of plants in the Point Reyes National Seashore Park; this total represents more than 50 percent of the reported species in Marin County and about 15 percent of the total flora of California. Howell notes the following six plants are endemic to the Point Reyes habitat:

<u>Species</u>	<u>Family Name</u>
<u>Agrostis aristiglumis</u>	Timothy grass tribe (bent grass)
<u>Lupinus layneae</u>	Lupine family
<u>Sidalcea rhizomata</u>	Mallow family
<u>Arctostaphylos cushingiana</u>	Heather family
<u>Castilleja leschkeana</u>	Figwort family
<u>Blennosperma nanum</u> var. <u>robustum</u>	Sneezeweed family

The type of community which prevails at Point Reyes Headland is the coastal scrub and grassland community. The dominant plants are:

<u>Species</u>	<u>Common Name</u>
<u>Artemisia californica</u>	California sage brush
<u>Salvia mellifera</u>	black sage
<u>Baccharis pilularis</u>	coyote brush
<u>Mimulus guttatus</u>	sticky monkeyflower
<u>Rhus diversiloba</u>	poison oak
<u>Rhamnus californica</u>	California coffeeberry
<u>Lupinus arboreus</u>	tree lupine

The aforementioned scrubs are common in the area mixed with an abundance of annual and perennial grasses such as barley, annual rye, California oatgrass and wild rye.

Scattered throughout the upland area where homes have been built are introduced cypress, mostly Monterey Cypress, Cupressus macrocarpa.

Unique Components

The Point Reyes Headland ASBS was so designated primarily because of the following organisms:

Zalophus californianus, California sea lion

Eumetopias jubatus, Steller sea lion

Uria aalge, Common Murre

Phalacrocorax penicillatus, Brandt's Cormorant

P. pelagicus, Pelagic Cormorant

Cephus columba, Pigeon Guillemot

Haematopus bachmani, Black Oystercatcher

Larus occidentalis, Western Gull

Both species of sea lions, the California and the Steller, breed at the Point Reyes Headland, with the greatest concentration at Sea Lion Cove. On December 7, 1958, one of the largest recorded populations (1800 more or less) of the California sea lion was counted.

The Steller sea lions also breed here in June-July. These Stellers require offshore rocks where there is no human disturbance.

The six listed sea birds all breed within the ASBS (Ainley and Whitt, 1973). The Common Murre permanently resides on "Murre Rock" just below the Lighthouse at the western promontory. In 1973, Ainley and Whitt estimated some 3800 murrees breed at this location. Besides the other breeding sea birds, the Brown Pelican, Pelecanus occidentalis, an endangered species, occupies the many rocks around Chimney Rock and Split Rock Cove. The Peregrine Falcon, Falco peregrinus, another endangered bird, has been sighted at least once every two years by students on field trips to the Headland sites.

Since 1972, the Point Reyes Headland has been declared a California Department of Fish and Game Reserve resulting in the protection of all invertebrates from the predation of man. Included under the protection is the red abalone, Haliotis rufescens. This mollusk is under constant

fishing pressure throughout state waters and it is here at Point Reyes Headland that this organism has grown to large sizes, some over 10 inches (25.4 cm) in length. At Split Rock Cove, this mollusk is abundant. Other marine invertebrates, such as the giant cotton-top anemone, Metridium exilis, can be found on the spectacular vertical wall under Lighthouse Point.

LAND AND WATER USE DESCRIPTION

Marine Resource Harvesting

Ocean Fishing: The Point Reyes Headland ASBS borders the western perimeter of Drakes Bay, Figure 1, which has been an important fishing ground for almost a century. The major fisheries have been in ocean salmon, crab, and bottom fish. During the past decades, the San Francisco fish dealers have maintained fish warehouses and fish barges on the Point Reyes Headland side of the Bay. Market crabs and salmon are now the only products landed in quantity. Occasionally, albacore may also be landed for distribution. The Pacific oyster is raised commercially in nearby Drakes Estero (Smith, 1973).

In Marin County, the major local commercial fishing ports are Tomales Bay, Drakes Bay, and Sausalito. Major commercial species landed for all Marin County ports are listed in the following table:

TABLE 13. COMMERCIAL LANDINGS, MARIN COUNTY PORTS

Major Species, 1966-70 (Smith, 1973)

<u>Species</u>	<u>Avg. Annual Landings Thousands of Pounds</u>	<u>Accumulated Landings Thousands</u>	
		<u>Pounds</u>	<u>Value</u>
Flounder	36	178	\$ 12
Herring, Pacific	20	100	24
Rockfish	51	255	17
Salmon	611	3,058	1,935
Tuna, albacore	707	3,537	774
Crab, market	161	815	282
Oyster, giant Pacific	199	989	243

Salmon and tuna dominate the annual landings in pounds, with salmon drawing the highest dollar value as shown in Table 13.

History of Abalone Sportfishing: Previous to the enactment of the California law which established Point Reyes Headland as a Marine Reserve in 1972 (Figure 2), the intertidal and shallow waters of the Headland were open to sportfishing for the red abalone, Haliotis rufescens. The

primary fishing areas were Chimney Rock and Split Rock Cove. However, there was limited access by road to these areas because a gate to these areas was kept locked by the local ranchers (Figure 9). Thus, the public abalone fisherman was not able to enter into these habitats and the fishing for these mollusks was performed by local individuals who had road access. Because of this restrictive entry, these beds of abalones were generally afforded protection from the type of over-harvesting commonly observed throughout public areas of California.

Historical, Governmental, and Recreational Use

A brief chronology of the major history of man at the Point Reyes Headland is as follows:

<u>Approximate Dates</u>	(Mason, 1972)
1500 (+)	Inhabited by Coast Miwok Indians
1579	Sir Francis Drake may have sailed his vessel, GOLDEN HIND, into Drakes Bay.
1817	Spanish-Mission influences over the Indians
1854	Granite Quarry, Chimney Rock area
1860's	Shafter Brothers ranches in the area
1870	Point Reyes Lighthouse in operation. With electricity came a 1000 watt light bulb, providing a million candle power beam; the beacon could be seen 24 miles at sea (Point Reyes Historian, 1977)
1900 to the present	Dairy and hereford ranching in the vicinity
1920's	U.S. Coast Guard Station at the east side of Point Reyes, on the Drakes Bay side. Closed in the 1960's.
1962	The Point Reyes National Seashore Park was established.
1967	The Lighthouse was closed to tourism, reopened to the public in 1977 by the Park Service.
1978	U.S. Dept. of Interior: no outer continental shelf oil and gas drilling permitted within 15 miles (24 km) of the Point Reyes National Seashore Park.

The most significant enhancement of the Point Reyes Headland was the establishment of the National Seashore Park in 1962. The park encompasses some 65,000 acres with 44.7 miles (72 km) of ocean front and 37 miles (59.5 km) of bay frontage. The park has a series of highly diverse wildlife habitats: upland Douglas fir forest, coastal scrub and grasslands, fresh and salt water marshes, bays and estuaries, sandy beaches and dunes, and a rocky coastline with all forms of marine life zones. The fauna and flora in these localities are among the most diverse on the Pacific Coast.

The Point Reyes National Seashore Park continues to attract more visitors each year:

<u>Year</u>	<u>Total visitors</u>	(Brock, 1978)
1974	1,333,708	
1975	1,576,246	
1976	1,637,416	About 70% of the visitors come during the summer months.
1977	1,810,968	
1978 (Nov.)	1,828,784	

The primary access to the Point Reyes Headland area is via State Highway 1 to Inverness, then by paved road to the Headland by Sir Francis Drake Highway (Figure 1). Brock (1978) estimated that about 272,108 persons traveled to the Headland area in 1978, making it one of the most popular visitation areas.

Table 14 lists the 14 ship and aircraft wrecks at the Point Reyes Headland. The only shipwreck still present is the MUNLEON, with its large hull plates scattered in about 20 feet (6 m) of water in the eastern portion of Split Rock Cove.

TABLE 14. SHIPWRECKS AT THE POINT REYES HEADLANDS (Mason, 1972)

1862 . . .	Monterey
1876 . . .	George P. Haub
1877 . . .	Selma
1895 . . .	Rachel
1898 . . .	J. Eppinger
1910 . . .	Annie E. Smale
1910 . . .	Selja
1913 . . .	John D. Spreckels
1926 . . .	Yosemite
1927 . . .	Henrietta
1929 . . .	Hartwood
1930 . . .	Richfield
1931 . . .	Munleon (ship plates still present in Split Rock Cove)
1938 . . .	DC-3 United Airlines

Scientific and Educational Use

When the Point Reyes Headland Reserve was set up in 1972, there was intention to promote scientific and educational use of the habitat. After eight years of reserve status, there have been almost no scientific papers published on information from the area and educational use has been very limited. A primary reason for the lack of activity has been the inaccessibility of the habitats for meaningful studies. The cliffs are very dangerous for climbing activities, and severe ocean conditions can rise up in a short period to prevent diving and intertidal work. Because of the hazardous nature of the cliffs, the National Park and the Fish and Game officials have been hesitant to promote scientific and educational studies. Although the College of Marin has subtidal and intertidal transects located within the reserve, the chances of having a "good day" for work are only about 50 percent of the assigned times. Field trips are usually to the more protected Chimney Rock area for intertidal research.

The research in ecological and behavioral studies of the marine mammals and sea birds within the Point Reyes Headland ASBS has been very sparse. Much work needs to be recorded so that these marine organisms might provide information as to how man can assist them to maintain their vitality throughout the years. The research and educational studies should never encompass any form of harassment to these creatures.

ACTUAL OR POTENTIAL POLLUTION THREATS

The geography of the Point Reyes Headland together with the protection afforded to the area by the Point Reyes National Seashore Park enables this ASBS to have few pollution threats. The nearest town is Bolinas, about 16 nautical miles (30 km) from the Headland while San Francisco is about 32 nautical miles (59 km) away. It is unlikely that any of the municipal or industrial wastes of these communities could affect the ASBS. There is little or no pollution threat from any large scale sewage system. Since the upland ranches are involved in dairy and cattle ranching, there is a potential of accelerating coliform bacteria into surrounding waters. However, the uplifted topography of the Point Reyes Headland causes the terrestrial runoffs to slope towards Drakes Bay or to the Pacific Ocean side of the peninsula.

Point Sources

Dredging-Sedimentation: The only threat from dredging or sediment disposal activity might come from a source reported by McCampbell (1969), as follows. Based on the theory that the west side of the San Andreas fault is moving northward about 1 inch (2.5 cm) per year, the Point Reyes Peninsula would have been in the vicinity of the Golden Gate opening about one million years ago. The drainage of the Sierra Nevada mountains flowed westward, thus forming the hypothesis that placer gold may be in the sands around the Point Reyes Headland area. In 1966, the University of California Department of Geology collected sand samples around the peninsula and found particles of flour gold, an extremely fine gold the consistency of talcum powder in the samples. The expected cost of processing the sands in 1966 was about 50 cents per cubic yard. The concentration of flour gold in the Point Reyes area was 0.3 to 3.0 parts per million. McCampbell (1969) felt the quantity of gold in this area could be significant. A prospecting mineral rights state permit was signed in March 1968 with the State Land Division encompassing 5,800 acres, specifying that McCampbell would have rights to gold, silver, platinum, uranium, and yttrium. This was the first offshore mineral permit issued in California. No action or operation on the 1968 permit has taken place.

Nonpoint Sources

Radioactive Waste Disposal Site: From 1946 to 1965, under the direction of the Atomic Energy Commission, the three major producers of radioactive materials in the San Francisco Bay Area dumped over 47,500 barrels of radioactive waste southwest of the Farallon Islands (Figure 18). The waste was stored in 55-gallon barrels and other concrete containers (Table 15).

TABLE 15. RADIOACTIVE MATERIALS DUMPED at the FARALLON ISLANDS
(Dyer, 1975)

<u>Site</u>	<u>Depth</u>	<u>Distance from Land</u>	<u>Years</u>	<u>No. of 55-gal. barrels</u>	<u>Radionuclides released from barrels</u>
37!38'N	900 m	60 km	1951-53	3,500	238 _{Pu} 239,249 _{Pu} and 137 _{Cs} (both sites)
37!37'N	1700 m	77 km	1946-65	44,000	
to 123!08'W					

About 25 percent of the total of 47,500 barrels has imploded (Dyer, 1975). Ocean current studies by Dyer indicated that for 27 days the water movement from these sites was clearly northward, towards the Point Reyes Peninsula. Whether the released radioactive plutonium 238, 239 and 249 plus cesium 137 pose any danger to the Point Reyes ASBS waters is uncertain. The total plutonium and cesium released from these barrels were within global fallout levels and considered insignificant by Noshkin et al., (1978). However, they did report that plutonium 238 is being remobilized at 6,560 feet (2,000 m) and this concentration does exceed anticipated fallout levels.

Offshore Oil Development and Oil Discharge from Vessels: In January, 1971, two Standard Oil of California tankers collided under the Golden Gate Bridge. About 840,000 gallons of Bunker C fuel oil was spilled and in succeeding days the California Department of Fish and Game estimated that about 7,000 sea birds were injured by the oil and less than ten percent survived (Chan, 1972). Smail, et al., (1972) estimated that the mortality may have been closer to 20,000 birds. The principal consultant (1972) estimated that about 4.2 million invertebrates were smothered by

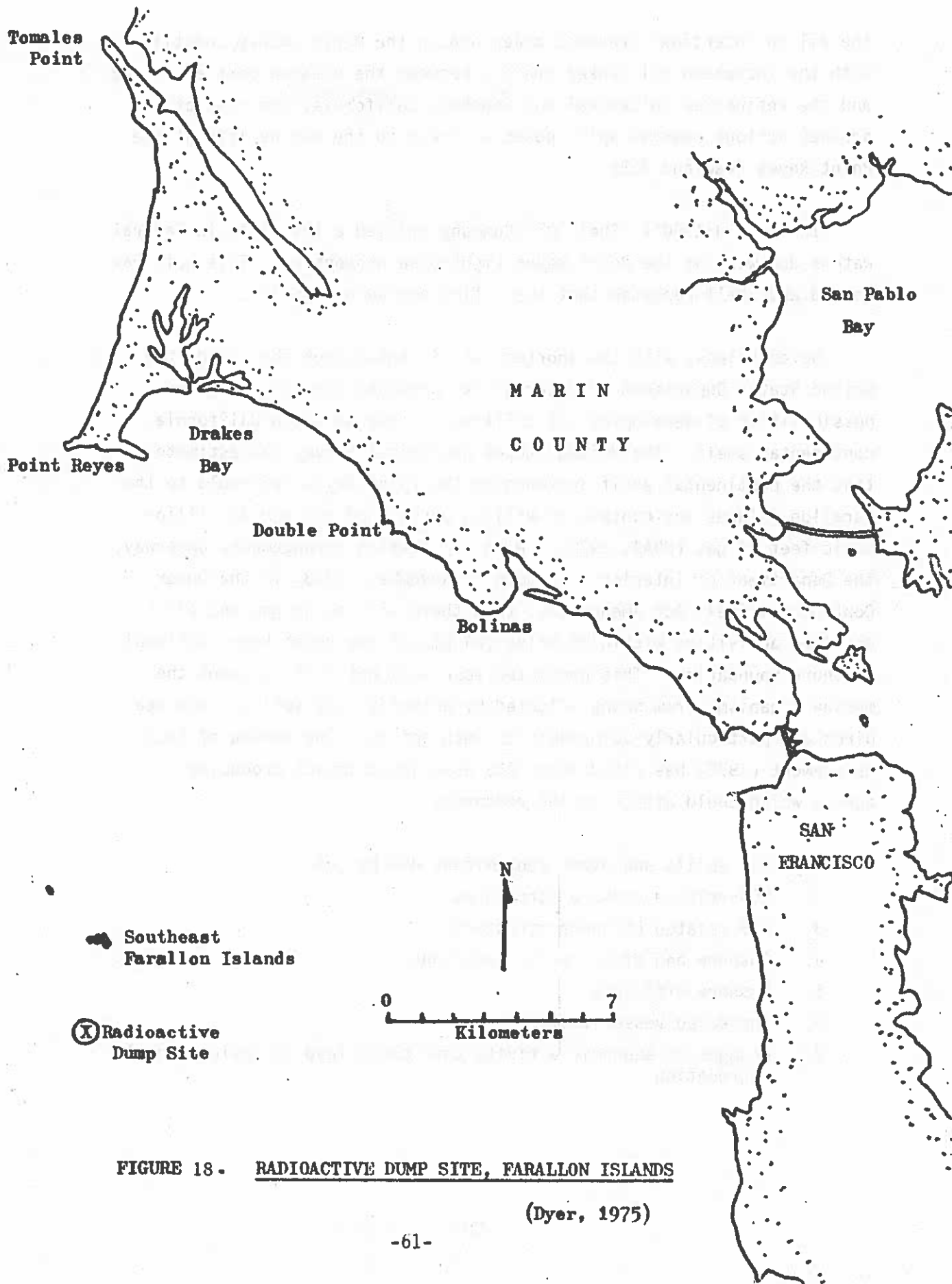


FIGURE 18. RADIOACTIVE DUMP SITE, FARALLON ISLANDS

(Dyer, 1975)

the oil in intertidal transect areas around the Marin County coastline. With the increased oil tanker traffic between the Alaskan port at Valdez and the refineries in Central and Southern California, the risk of another serious coastal spill poses a threat to the marine life at the Point Reyes Headland ASBS.

In the mid-1960's, Shell Oil Company drilled a test hole in federal waters due west of the Point Reyes Lighthouse promontory. This hole was capped and Shell reported that their findings were negative.

Nevertheless, with the shortage of oil throughout the world, the United States Department of Interior has proposed investigating the possibilities of developing oil drilling off the Northern California continental shelf. The United States Geological Survey has estimated that the continental shelf surrounding the Point Reyes Peninsula to the Farallon Islands may contain 70 million barrels of oil and 70 billion cubic feet of gas (NOAA, 1978). With oil leasing arrangements underway, the Department of Interior announced in November, 1978, in the Outer Continental Shelf Act Amendments, that there will be no gas and oil drilling activities within 15 miles (24 km) of the Point Reyes National Seashore boundaries. This protected zone will not fully prevent the marine organisms from being affected by potential oil spills since sea birds are particularly vulnerable to such spills. The Bureau of Land Management (1978) has cited seven OCS associated impact producing agents which could affect marine resources:

1. Oil spills and other contaminant discharges
2. OCS-related onshore structures
3. OCS-related offshore structures
4. Onshore and offshore air emissions
5. Onshore effluents
6. Increased vessel traffic
7. Changes in economic activity that could lead to environmental degradation

SPECIAL WATER QUALITY REQUIREMENTS

The water quality of the Point Reyes Headland ASBS is deemed quite good in comparison to the marine waters closer to urban centers. The inclusion of the Headland ASBS within the protective boundary of the Point Reyes National Seashore Park reduces the likelihood of pollutants injuring the marine habitat. However, if a large sewage outfall system were to be constructed for several Bay Area communities, and if the discharge were to be dumped into the Gulf of the Farallons, then the waters of the ASBS should be closely monitored.

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	Sample No.	1611	1613	1615	1617	1618
Km from Double Pt.	11.1	11.1	9.2	10.2	13.9	13.0
Nautical miles from Double Pt.	6.0	6.0	5.0	5.5	7.5	7.0
Total sample weight (grams)	268.0	268.0	497.0	233.0	1258.0	1214.0
% of organic hard parts	0.4	0.4	0.2	2.8	0.5	10.5
COLLECTED SPECIES		Numbers of Individuals				
PROTISTA						
Foraminifera						
<u>Elphidiella hannah</u>		7	50	60	17	85
<u>Nonionella sp.</u>			1			
<u>Haplophragmoides sp.</u>				60		
<u>Massilina sp.</u>				6		1
<u>Poroeponides sp.</u>				4		
<u>Triloculina sp.</u>				8		
<u>Rotorbinella sp.</u>				2		
ARTHROPODA						
Crustacea						
<u>Mutilus sp.</u> (Ostracoda)						1
<u>Pseudophilomedes sp.</u> (Ostra.)		2	5		1	
<u>Rutiderma sp.</u> (Ostracoda)			1			
<u>Balanus sp.</u> (Barnacle)				9	5	2
<u>Cancer sp.</u> (Crab)		1	1	5	1	1
MOLLUSCA						
Bivalvia						
<u>Nuculana taphria</u>				7	2	
<u>Mysella tumida</u>		12	55	26	3	2
<u>Siliqua sp.</u>			1			
<u>Tellina bodegensis</u>						1
<u>Tellina carpenteri</u>			6			
<u>Spigular sp.</u>		1				
<u>Chlamys hastatus</u>				1		1
<u>Hinnites multirugosus</u>				2		
<u>Modiolus sp.</u>				4		
<u>Transennella tantilla</u>				4	45	4
<u>Kellia sp.</u>				1		
<u>Glans carpenteri</u>				1		
<u>Protothaca staminea</u>				6j	9	2
<u>Clinocardium fucanum</u>				1	2	
<u>Clinocardium nuttallii</u>					2	2
<u>Mya truncata</u>				6	3	1
<u>Spisula catilliformis</u>				2		
<u>Macoma secta</u>				3	1	
<u>Macoma inconspicua</u>				1		
<u>Nettastomella rostrata</u>				8		
<u>Ostrea lurida</u>					1	
<u>Kellia laperousii</u>						1
<u>Axinopsida sericata</u>		1	1			

j = juvenile

Appendix 1 (continued)

Benthic Shelf Communities
Brown & Caldwell, 1971

Sample No.	1611	1613	1615	1617	1618
(MOLLUSCA)					
Gastropoda					
<u>Nassarius perpinguis</u>		1			1
<u>Nassarius mendicus</u>			15	12	6
<u>Mitrella gouldii</u>	1	4		1	
<u>Odostomia sp.</u>		1j	6		1
<u>Turbonilla sp.</u>		2			
<u>Crepidula sp.</u>			1		
<u>Ocenebra sp.</u>			1	1	
<u>Bittium eschrichtii</u>			1		
<u>Amphissa sp.</u>			1		
<u>Turbonilla sp.</u>			2	1	1
<u>Alvania acutilviata</u>			4	12	5
<u>Cypraeolina pyriformis</u>			1		
<u>Crepidatella sp.</u>				2	
<u>Margarites sp.</u>				4	
<u>Homalopoma sp.</u>				1	
<u>Epitonium sp.</u>				1	1
<u>Balcis sp.</u>				1	
<u>Polytropa lamellosa</u>					3
<u>Olivella baetica</u>					3
<u>Mangelia barbarentis</u>					1
<u>Acteon sp.</u>					1
Scaphopoda					
<u>Cadulus fusiformis</u>				1	
"WORMS" Calcareous tubes	few	abundant			
BRACHIOPODA					
<u>Terebratulina unguicula</u>			2		
BRYOZOAN					
present					
VERTEBRATA					
Vertebrae		1			1
Fish dermal plate					1

j = juvenile

Major Species List

A. CHLOROPHYTA (Green Algae)

Codium fragile

C. setchellii

Cladophora columbiana

Ulva californica

U. lobata

U. taeniata

Enteromorpha intestinalis

Spongomorpha coalita

Bryopsis hypnoides

B. PHAEOPHYTA (Brown Algae)

Ralsia pacifica

Nereocystis luetkeana

Desmarestia ligulata var. **ligulata**

Laminaria dentigera (L. andersonii)

L. farlowii

Lessoniopsis littoralis

Costaria costata

Alaria marginata

Egregia menziesii

Pterogophora californica

Dictyoneurum californicum

Cystoseira osmundacea

Postelsia palmaeformis

Pelvetia fastigiata

Pelvetiopsis limitata

Fucus distichus endentatus

C. RHODOPHYTA (Red Algae)

Calliarthron tuberosum

Bosiella californica

Mesophyllum lamellatum

* Major plants

SUBTIDAL ZONE		INTERTIDAL ZONE			
Deep Rocks	Short Kelp	4	3	2	1
25'	15'				
X					
	X	X			
			X	*X	X
			X	X	
				X	
		X			
				X	
	X	X			
	X	X			
				*X	
*X	*X				
X					
	*X	X			
	X				
	*X				
	X				
	X	X			
	X				
	X				
		X			
			X		
			X		
				*X	
X					
X					
X					

Appendix 2 (continued)

Marine Plants, Point Reyes Headland, 1955-1979
G. Chan

<u>Lithothamnium</u> spp.
<u>Rhodymenia arborescens</u>
<u>R. californica</u>
<u>R. callophyllidoides</u>
<u>Callophyllis pinnata</u>
<u>C. violacea</u>
<u>Fryxella gardneri</u>
<u>Pterochondria woodii</u>
<u>Botryoglossum farlowianum</u>
<u>Ceramium pacificum</u>
<u>Callithamnion pikeanum</u>
<u>Microcladia coulteri</u>
<u>M. californica</u>
<u>Rhodymenia pacifica</u>
<u>R. palmata</u>
<u>Corallina officinalis</u> var. <u>chilensis</u>
<u>Bosiella orbigniana</u>
<u>Lithophyllum imitans</u>
<u>Gymnogongrus linearis</u>
<u>Iridaea cordata</u> var. <u>splendens</u>
<u>Porphyra pulchra</u>
<u>P. perforata</u>
<u>P. smithii</u>
<u>Prionitis lanceolata</u>
<u>Erythrophyllum delesserioides</u>
<u>Callophyllis linearis</u>
<u>Plocamium violaceum</u>
<u>Gracilaria sjoestedtii</u>
<u>Neoptilota densa</u>
<u>Rhodomela larix</u>
<u>Cumagloia andersonii</u>
<u>Odonthalia floccosa</u>

SUBTIDAL ZONE		INTERTIDAL ZONE			
Deep Rocks	Short Kelp	4	3	2	1
25'	15'				
*x		x	x	x	
x					
x	x				
*x	*x				
	x				
	x				
	x				
	*x	x			
	x				
	x				
	x				
		x			
	x				
		x			
			x		
	*x	*x			
	x				
	x				
	x	x			
	*x	*x			
	x	x			
	x	x	x		
	x	x			
		x			
			x		
				x	
		x			

* Major plants

Appendix 2 (continued)

Marine Plants, Point Reyes Headland, 1955-1979

G. Chan

Gigartina corymbifera

G. exasperata

G. papillata

G. canaliculata

Endocladia muricata

D. TRACHEOPHYTA (Vascular plant)

Phyllospadix torreyi

* Major plants

SUBTIDAL ZONE		INTERTIDAL ZONE			
Deep Rocks	Short Kelp	4	3	2	1
25'	15'				
	x	x			
	x	x			
				*x	
			*x		*x
					*x
	*x	*x		x	

Major Organisms
by Phyla

PORIFERA (Sponges)

Aplysilla glacialis
Haliclona sp.
Ophlitaspongia pennata
Lissodendoryx sp.
Plocamia karykina
Halichondria panicea
Hymeniacion sp.
Polymastia pachymastia
Cliona sp.
Tethya aurantia
Leucosolenia eleanor
Leucandra heathi
Leucilla nuttingi
Prosuberites sp.

CNIDARIA (animals with stinging cells)

Hydrozoa

Tubularia marina
Abietinaria sp.
Aglaophenia sp.
Plumularia sp.
Garveia annulata
Sertularia sp.
Obelia sp.

Anthozoa

Anthopleura elegantissima
Anthopleura xanthogrammica
Tealia lofotensis
Corynactis californica
Balanophyllia elegans
Epiactis prolifera
Metridium exilis

* Major species

SUBTIDAL ZONE		INTERTIDAL ZONE			
Base of Sea Stack Rocks 6m	Short Kelp Canopy 6m	4	3	2	1
x	*x	x			
	x	x		x	
	x	x			
x					
*x	x	x		x	
	x	x		x	
*x					
*x					
	x	x			
x	x				
	*x				
*x	*x				
	*x	x			
		x			
x	x	x		x	
	x	x		x	
	x	*x		*x	
*x	*x	*x		x	
x	*x				
*x	*x				
*x	*x				
	*x	*x		x	
x	x				

Appendix 3 (continued)

Marine Invertebrates, Point Reyes Headland, 1955-1979

G. Chan

	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Base of Sea Stack Rocks 6m	Short Kelp Canopy 6m	4	3	2	1
PLATYHELMINTHES (Flatworms)						
<u>Oregonioplana opisthopera</u>			x			
<u>Hoploplana californica</u>	x			x		
<u>Leptoplana chloranota</u>		x	*x	x	x	
<u>Notoplana</u> sp.		x	x	x	x	
NEMERTEA (Ribbon worms)						
<u>Tubulanus polymorphus</u>		*x	*x	x		
<u>Micrura verrilli</u> (in <u>Hyllospadix</u>)		x	x		x	
<u>Paranemertes peregrina</u> (in <u>Mytilus</u> beds)			x	x		
SIPUNCULA (Peanut worms)						
<u>Themiste pyroides</u> (rock crevices)		x	x			
<u>Phascolosoma agassizii</u>		x	*x	x	x	
ANNELIDA (Segmented worms)						
Polychaeta (marine worms)						
<u>Arctonoe fragilis</u> (in starfish grooves)		x	x			
<u>Halosydna brevisetosa</u>		x	x	*x	x	
<u>Harmothoe imbricata</u>			x	x	x	
<u>Eumida sanguinea</u>		x	x			
<u>Neanthes brandti</u>			x		x	
<u>Nereis latescens</u>					x	
<u>Platynereis bicanaliculata</u>		*x	*x	x	x	
<u>Polydora</u> sp. (in sponges)	x	x				
<u>Sabella crassicornis</u>		x	x			
<u>Serpula vermicularis</u>		*x	*x	x	*x	
<u>Eudistylia polymorpha</u>		*x				
<u>Spirobis</u> spp.			x	x	x	
<u>Dodecarceria fewkesi</u>		x	x			
ARTHROPODA						
Crustacea						
Cirripedia (Barnacles)						
<u>Balanus crenatus</u>		x	x			
<u>B. nubilus</u>	x	*x	x			

* Major species

G. Chan

* Major species

SUBTIDAL ZONE			INTERTIDAL ZONE			
Base of Sea Stack Rocks 6m	Short Kelp Canopy 6m		4	3	2	1
	x		x	x	*x	*x
			x	x	x	
				*x	x	*x
				*x		x
						*x
			x	x	x	
	x		x			
	x		x			
	x		x	x	x	
			*x		x	
	x		x			
	*x		x			
				x	*x	
	x		*x	*x	x	
	x		x			
x	x					
	x		x		x	
	*x		*x		x	
	x		x			
			x			
	x		*x		x	
				x		
			x			
			x		x	
	x		x			
	x			x		

Appendix 3 (continued)

Marine Invertebrates, Point Reyes Headland, 1955-1979

G. Chan

(ARTHROPODA, Crustacean)

Decapoda

Pachycheles rudis

Pachycheles pubescens

Petrolisthes cinctipes

Pagurus samuelis

Pagurus hemphilli

Pagurus hirsutiunculus

Pycnogonida (sea spiders)

Pycnogonum stearnsi (on sea anemones)

Ammothella tuberculata

Achelia sp.

Phoxichilidium femoratum

Halicarida sp. (mite)

MOLLUSCA

Polyplacophora (Chitons)

Cryptochiton stelleri

Katharina tunicata

Tonicella lineata

Placiphorella velata

Mopalia ciliata

Mopalia lignosa

Mopalia muscosa

Nuttallina californica

Cyanoplax dentiens

Gastropoda (snails, slugs)

Crepidula adunca

Diodora aspersa

Megatebennus bimaculatus

Fissurella volcano

Haliotis cracherodii (black abalone)

Haliotis kamtschatkana (pinto abalone)

Haliotis rufescens (red abalone)

* Major species

SUBTIDAL ZONE		INTERTIDAL ZONE			
Base of Sea Stack Rocks 6m	Short Kelp Canopy 6m	4	3	2	1
	x		x	x	
	x		x	x	
			*x	x	
	x	x		*x	
	x	*x		x	
	x	x			
		x		x	
	x	x			
	x				
					x
	*x	*x			
		*x	x	x	
x	*x	*x		x	
			x		
			x	*x	
			x	x	
		x	x		
			x	x	
		x			
					x
x		x			
	x				
x	x				
		x		x	
x					
x	*x	*x		x	

Appendix 3 (continued)

Marine Invertebrates, Point Reyes Headland, 1955-1979

G. Chan

(MOLLUSCA)

Gastropoda (snails, slugs)

Acmaea mitra

Collisella asmi

Collisella digitalis

Collisella limatula

Collisella pelta

Collisella scabra

Notoacmea insessa

Notoacmea persona

Notoacmea scutum

Opalia spp.

Nucella spp.

Calliostoma annulatum

Calliostoma canaliculatum

Tegula brunnea

Tegula funebris

Littorina planaxis

Littorina scutulata

Crepidula adunca

Ceratostoma foliatum

Acanthina spirata

Searlesia dira

Amphissa versicolor

Trimusculus reticulatus

Opisthobranchia (sea slugs)

Acanthodoris nanaimoensis

Aeolidia papillosa

Anisodoris nobilis

Antiopella barbarensis

Archidoris montereyensis

Cadlina sp.

Coryphella trilineata

* Major species

SUBTIDAL ZONE		INTERTIDAL ZONE			
Base of Sea Stack Rocks 6m	Short Kelp Canopy 6m	4	3	2	1
	x	x			
				x	
			*x	x	*x
		x		x	
				x	
			*x	x	*x
	x	x			
			x	x	
			x	x	
x	*x	x		x	
	x	x		x	
	x	x		x	
			x	*x	
				x	x
			*x	x	*x
				x	
x	x	x			
			x	x	
	x	x		x	
	x	x		x	
		x	x		
			x	x	
x	*x	x		x	
		x		x	
x	x	x		x	
	x	x		x	
		x			

Appendix 3 (continued)

Marine Invertebrates, Point Reyes Headland, 1955-1979

G. Chan

(MOLLUSCA, Gastropoda)

Opisthobranchia (sea slugs)

Dianulula sandiegensis

Dirona albolineata

Dirona picta

Hermisenda crassicornis

Hopkinsia rosacea

Phidiana pugnax

Rostanga pulchra

Triopha carpenteri

Triopha maculata

Bivalvia (Bivalves)

Mytilus californianus

Penitella penita

Hiatella arctica

Cephalopoda

Octopus sp.

ECTOPROCTA (Bryozoans)

Flustrellidra corniculata

Crisia maxima

Bugula californica

Bugula neritina

Membranipora membranacea

Membranipora fusca

Tricellaria occidentalis

Hippodiplosia insculpta

ECHINODERMATA

Asteroidea (seastars)

Pycnopodia helianthoides

Dermasterias imbricata

Henricia leviuscula

Patiria miniata

Leptasterias hexactis

Leptasterias pusilla

* Major species

SUBTIDAL ZONE		INTERTIDAL ZONE			
Base of Sea Stack Rocks 6m	Short Kelp Canopy 6m	4	3	2	1
	x	x		x	
		x		x	
		x			
x	*x	x		x	
*x	*x			x	
	x				
*x	*x	x		x	
	x	x		x	
	x	x			
			*x	x	x
			x		x
	x	x		x	
x	*x	x		x	
	*x	x		x	
	*x				
	*x	x		x	
*x	x				
	*x	x			
	x	x			
x	x	x		x	
*x	*x	*x		*x	
	x	x		x	
	x	x		x	

Appendix 3 (continued)

Marine Invertebrates, Point Reyes Headland, 1955-1979

G. Chan

(ECHINODERMATA, Asteroidea — seastars)

Pisaster brevispinus

Pisaster ochraceus

Ophiuroidea (Brittle stars)

Amphiodia occidentalis

Ophiopholis aculeata

Ophiothrix spiculata

Holothuroidea (sea cucumbers)

Stichopus californicus

Eupentacta quinquesemita

Cucumaria miniata

Leptosynapta albicans

Echinoidea

Strongylocentrotus franciscanus

Strongylocentrotus purpuratus

CHORDATA

Urochordata

Aplidium californicum

Aplidium propinquum

Diplosoma macdonaldi

Clavelina huntsmani

Archidistoma molle

Didemnum carnulentum

SUBTIDAL ZONE		INTERTIDAL ZONE			
Base of Sea Stack Rocks 6m	Short Kelp Canopy 6m	4	3	2	1
	*x	x		x	
	*x	*x	*x	x	
	x	x		x	
	x	x		x	
	x	x			
	x				
	x	x		x	
	*x	*x		x	
				x	
	*x	x			
	*x	*x		x	
*x	*x	*x		x	
	*x	x		x	
*x	x	x			
*x	*x	*x		x	
	*x	*x			
*x	*x	x			

* Major species

Algae

Chlorophyta (green algae)

Ulva lactuca
Spongomorpha coalita

Phaeophyta (brown algae)

Costaria costata
Desmarestia ligulata
Ralfsia pacifica
Egregia menziesii
Alaria marginata

Rhodophyta (red algae)

Iridaea splendens
Corallina officinalis
Microcladia coulteri
Gigartina canaliculata
Odonthalia floccosa
Gigartina cristata
Prionitis lyallii

Invertebrates

Cnidaria

Anthopleura elegantissima
Anthopleura xanthogrammica
Epiactis prolifera

Annelida

Glycera americana
Sabella media
Serpula vermicularis
Eudistylia polymorpha

Arthropoda

Cancer productus
Cancer antennarius
Pugettia producta
Balanus glandula
Balanus nubilus
Pagurus hemphilli
Pagurus samuelis
Idotea resicata

Mollusca

Pododesmus macroschisma
Tegula brunnea
Tegula funebris
Cryptochiton stelleri
Haliotis rufescens
Haliotis cracherodii
Hermisenda crassicornis
Haliotis walallensis
Diaulula sandiegensis
Anisodoris nobilis
Calliostoma ligatum
Collisella sp.
Hinnites multirugosus

Bryozoa

Bugula californica

Echinodermata

Pisaster ochraceus
Pisaster brevispinus
Pisaster giganteus
Pycnopodia helianthoides
Patiria miniata
Dermasterias imbricata
Solaster dawsoni
Leptasterias aequalis
Henricia leviuscula
Strongylocentrotus franciscanus
Strongylocentrotus purpuratus
Cucumaria miniata
Stichopus californicus
Ophiothrix spiculata

Chordata

Styela montereyensis
Aplidium californicum
Aplidium arenatum
Clavelina huntsmani

Algae

Chlorophyta (green algae)

Spongomorpha coalita

Phaeophyta (brown algae)

Pterygophora californicaNereocystis leutkeanaLaminaria dentigeraCytoseria osmundaceaAlaria marginataEgregia menziesiiDesmarestia mundaCoilodesme californicaCostaria costataLessoniopsis littoralisPostelsia palmaeformisMacrocystis integrifolia

Rhodophyta (red algae)

Iridaea cordata var. splendensPorphyra perforataHalosaccion glandiformeGigartina exasperataGigartina canaliculataAlso: Phyllospadix torreyi
(surf grass)Invertebrates

Porifera

Rhabdodermella nuttingiLeucosolenia eleanorCliona celata

Cnidaria

Anthopleura elegantissimaAnthopleura xanthogrammicaEpiactis proliferaAurelia auritaCorynactis californicaAbietinaria greeneiAglaophenia latirostrisChrysaora melanasterPolyorchis penicillatusVelella lata

Arthropoda

Pagurus samuelisPagurus hirsutiusculusPugettia productaPycnogonum stearnsiCancer antennariusPetrolisthes cinctipesHapalogaster cavicaudaBalanus glandulaIdotea resecataHemigrapsus nudus

Mollusca

Haliotis rufescensLittorina planaxisLittorina scutulataTegula funebrisTegula brunneaCollisella limatulaCollisella digitalisCollisella scabraAcmaea mitraCryptochiton stelleriMopalia lignosaThais emarginataCeratostoma foliatumHinnites multirugosusTonicella lineataThais canaliculataCrepidula aduncaThais lamellosa

Echinodermata

Patiria miniataLeptasterias aequalisStrongylocentrotus purpuratusPycnopodia helianthoidesPisaster ochraceus

Chordata

Aplidium spp.Clavelina huntsmani

Algae

Chlorophyta (green algae)

Spongomorpha coalitaCodium fragile

Phaeophyta (brown algae)

Egregia menziesiiLaminaria dentigeraAlaria marginata

Rhodophyta (red algae)

Odonthalia floccosaCorallina chilensisRhodomela larixGigartina cristataGigartina exasperataInvertebrates

Platyhelminthes

Leptoplana chloranota

Cnidaria

Anthopleura elegantissimaAnthopleura xanthogrammicaEpiactis preliferaTealia sp.Corynactis californicaAglaophenia latirostrisAbietinaria greenei

Annelida

Platynereis sp.Serpula vermicularisSpirorbis sp.

Arthropoda

Pagurus samuelisPagurus hemphilliPagurus hirsutiunculusIdotea resecataLigia occidentalisPollicipes polymerusBalanus glandulaBalanus cariosusCancer antennariusCancer productusHemigrapsus nudusPachygrapsus crassipesPugettia productaPetrolisthes cinctipesPachycheles rudisHapalogaster cavicauda

Mollusca

Mytilus californianusLittorina planaxisLittorina scutulataCollisella personaAcmaea mitraCollisella digitalisCollisella scabraCollisella peltaThais emarginataThais lamellosaThais canaliculataDiodora asperaTegula funebrisTegula brunneaMopalia lignosaTonicella lineataCryptochiton stelleriHaliotis rufescensOctopus sp.

Echinodermata

Amphiodia sp.Patiria miniataDermasterias imbricataLeptasterias sp.Pisaster ochraceusStrongylocentrotus purpuratus

Chordata

Clavelina huntsmaniAplidium sp.

Algae

Chlorophyta (green algae)

Spongomorpha coalita

Phaeophyta (brown algae)

Pterygophora californicaNereocystis leutkeanaLaminaria dentigeraCystoseira osmundaceaAlaria marginataEgregia menziesiiDesmarestia munda

Phaeophyta - continued

Coilodesme californicaCostaria costataLessoniopsis littoralisPostelsia palmaeformis

Rhodophyta (red algae)

Iridaea sordataPorphyra perforataHalosaccion glandiformeGigartina californicaGigartina canaliculataInvertebrates

Porifera

Rhabdodermella nuttingiLeucosolenia eleanorCliona celata

Cnidaria

Anthopleura elegantissimaAnthopleura xanthogrammicaEpiactis proliferaAurelia auritaCorynactis californicaAbietinaria greeneiAglaophenia latirostris

Ctenophora

Pleurobrachia bachei

Annelida

Serpula vermicularisEudistylia polymorpha

Arthropoda

Cancer productusCancer antennariusPugettia productaBalanus glandulaBalanus nubilusPagurus samuelisPagurus hemphilliIdotea resicata

Mollusca

Pododesmus macrochismaTegula brunneaTonicella lineataCryptochiton stelleriHaliotis rufescensHermisenda crassicornisDiaulula sandiegensisAnisodoris nobilisCalliostoma ligatumCollisella paleaceaHinnites multirugosus

Bryozoa

Bugula californica

Echinodermata

Pisaster ochraceusPisaster brevispinusPisaster giganteusPycnopodia helianthoidesPatiria miniataDermasterias imbricataLeptasterias aequalisHenricia leviusculaStrongylocentrotus franciscanusStrongylocentrotus purpuratusCucumaria miniataStichopus californicusOphiothrix spiculata

Chordata

Styela montereyensisAplidium arenatumAplidium californicumClavelina huntsmani

APPENDIX 8 ORGANISMS FROM A SQUARE YARD, Hewatt, 1931 (Hedgpeth, 1968)

<u>Species</u>	<u>Total Count</u>	<u>+= present at North Double Pt. 1975-78</u>
Algae		
<u>Collisella</u> spp.	319	+
<u>Amphissa</u> <u>veriscolar</u>	39	+
<u>Balanus</u> <u>glandula</u>	872	+
<u>Cirolana</u> <u>harfordi</u>	926	+
<u>Leptasterias</u> <u>aequalis</u>	6	+
<u>Lottia</u> <u>gigantea</u>	10	
<u>Mytilus</u> <u>californianus</u>	1612	+
<u>Nuttallina</u> <u>californica</u> (later present)		
<u>Pachygrapsus</u> <u>crassipes</u>	14	+
<u>Petrolisthes</u> <u>cinctipes</u>	416	+
<u>Phascolosoma</u> <u>agassizii</u>	327	+
<u>Pollicipes</u> <u>polymerus</u>	356	+
<u>Tegula</u> <u>brunnea</u>	17	+
<u>Tetraclita</u> <u>squamosa</u>	78	
<u>Thais</u> <u>emarginata</u>	218	+
TOTAL	5210	plus many worms

APPENDIX 9

Anadromous Fisheries - Salmon and SteelheadSmith
(1973)ESTIMATES OF MARIN COUNTY COMMERCIAL
SPORTFISHING EFFORT AND ECONOMIC VALUES*

<u>Fishery</u>	<u>Catch</u>	<u>Est. Angler Days</u>	<u>Expendi- ture per Angler Day</u>	<u>Total Expendi- ture</u>	<u>Net Bene- fit per Angler Day</u>	<u>Total Net Benefit</u>
<u>1970</u>						
SALMON						
Party boat	26,000	33,500	\$20.00	\$ 670,000	\$6.00	\$ 201,000
Private boat	<u>2,000</u>	<u>2,000</u>	"	<u>40,000</u>	"	<u>12,000</u>
Ocean Total	28,000	35,500		\$ 710,000		\$ 213,000
River	<u>500</u>	<u>2,000</u>	20.00	<u>40,000</u>	4.50	<u>9,000</u>
Total Salmon	28,500	37,500		\$ 750,000		\$ 222,000
STEELHEAD	1,100	4,600	22.00	\$ 101,000	5.00	\$ 23,000
<u>1980</u>						
SALMON						
Ocean		44,500	20.00	\$ 890,000	6.00	\$ 267,000
River		<u>2,500</u>	"	<u>50,000</u>	4.50	<u>11,000</u>
Total Salmon		47,000		\$ 940,000		\$ 278,000
STEELHEAD		5,800	22.00	\$ 128,000	5.00	\$ 29,000

* See explanation of county figures.

STATE WATER RESOURCES CONTROL BOARD

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