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RECONNAISSANCE SURVEY
OF THE
POINT REYES HEADLAND
AREA OF
SPECIAL BIOLOGICAL SIGNIFICANCE
DRAFT NO. 2

BY

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A REPORT TO
THE CALIFORNIA DEPARTMENT OF FISH AND GAME and
THE STATE WATER RESOURCES CONTROL BOARD

JUNE, 1979

Foreword

A Standard Agreement for this report, Reconnaissance Survey of the Point Reyes Headland Area of Special Biological Significance, was entered into on November 1, 1978, between the California Department of Fish and Game and the contractor, the Point Reyes Bird Observatory, with Gordon L. Chan, Ph.D., as the Principal Consultant. The findings reported herein are therefore those of the principal consultant and do not necessarily reflect the opinion or policies of the California Department of Fish and Game or the State Water Resources Control Board.

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Acknowledgements

My students over the past twenty years have been the chief helpers in describing the marine invertebrates and fishes of the area. Special thanks are also extended to the staff of the Point Reyes Bird Observatory, Co-director Dr. Deborah A. Clark, who has managed and reviewed this report, and other Observatory staff members who reviewed the manuscript. My special gratitude goes to my wife Maxine who typed this manuscript.

The support of this study by the California Department of Fish and Game and the State Water Resources Control Board is gratefully acknowledged.

Abstract

The land site of the Point Reyes Headland ASBS is entirely within the Point Reyes National Seashore Park; the area is also designated as a California Department of Fish and Game marine reserve. The Headland is blessed with a large breeding population of Steller and California sea lions. In 1957, over 1,800 California sea lions were counted and photographed at Sea Lion Cove. About 3,500 murres breed on rocks at Lighthouse Point, making this locality the largest breeding rookery in Marin County. Large-sized red abalones inhabit the shallow water zones at Split Rock Cove. The marine life is highly diverse and abundant.

The water quality of the ASBS is good in comparison to marine waters closer to urban centers. The site is generally free from sewage and other water-related pollutants. The potential pollution threat to this ASBS could come from tanker oil spills as shipping lanes accelerate traffic between Valdez, Alaska and refineries in California. If offshore drilling for gas and oil occurs on the continental shelf, it will take place 24.1 km. (15 miles) beyond the boundary of the Point Reyes National Seashore Park. If accidental or chronic spills occur from such development, the marine life of the Headland ASBS could be seriously affected. A final threat could come from the radionuclides dumped on the continental slope south of the Farallon Islands.

The basic recommendation for this ASBS is to keep man, aircraft, and boats from encroaching and/or harrassing the marine mammals and birds in this unique locality.

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CONCLUSIONS AND RECOMMENDATIONS

The Point Reyes Headland ASBS is located in Marin County, California, entirely within the western portion of the Point Reyes National Seashore Park. The ASBS site is an area of 1,359 acres, basically encompassing an ancient massive granitic cliff facing in a southerly direction. Besides the protection afforded by the Point Reyes National Seashore Park, the Headland is a Fish and Game Marine Life Reserve. Under this reserve status, no form of marine life may be taken from the area within 305 meters (1,000 feet) of the high tide mark.

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.

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 2,000 meters (6,562 feet) south of the Farallon Islands could pose a hazard to the ASBS food chain if northward moving upwelling currents do carry these radionuclides to these waters.

The paramount marine organisms here at the Headland ASBS are the large year-around populations of California and Steller sea lions which inhabit and breed on the offshore rocks at Sea Lion Cove. At the Lighthouse Point on the western promontory of the Headland are the rocks where thousands of the Common Murre and other birds reside. The number of birds which breed here makes 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.

The diverse marine vertebrates and invertebrates stamp this ASBS locality as one of the most important marine habitats in California and most deserving of ASBS recognition. The following are three recommendations to enhance this vital marine ecosystem:

Recommendation No. 1

In 1972, the California Department of Fish and Game declared this area a marine reserve. This designation combined with the recognition of ASBS status, together with the National Seashore Park, should preserve this unique Headland for many generations. 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 harassment to these marine mammals. The only exception to the above entry rule is that scientific personnel with proper permits from the Point Reyes Seashore National Park and Fish and Game be allowed to study the biotic and abiotic features. In short, this initial recommendation is to continue the present

prohibition-entry rule that is currently in effect and enforced by the National Seashore Park.

Recommendation No. 2

Aircraft should be restricted by law from flying below an altitude of at least 912 meters (3,000 feet) in this area to prevent noise harrassment of the sea lions and birds.

Recommendation No. 3

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

I. INTRODUCTION

Reasons for Designating the Point Reyes Headland ASBS

On April 24, 1973, 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's 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 proposed as an ASBS for the protection of the above listed marine mammals and seabird as well as for the unique scientific value of the reserve."

California Regional Water Quality Control Board,
Executive Officer Summary Report, April 24, 1973

The description of the Point Reyes ASBS, Marin County:

"The area of ocean waters extending offshore 2000 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."

California State Water Resources Control Board
ASBS, July 1976

II. METHODS AND MATERIALS

The contract with the Department of Fish and Game required a qualitative reconnaissance survey of the physical, chemical and biological aspects of the subtidal and intertidal regions within and the land areas adjacent to the Point Reyes Headland ASBS. A further requirement was a description of the human land/water use and the actual or potential pollution threats within the ASBS, with indications of special water quality requirements of the biota.

A. Subtidal Methods

The subtidal description at Point Reyes Headland ASBS was based solely on the observations made by the principal consultant with his students over a period of 15 years, 1963 to 1978, in a total of 20 dives, averaging an hour per dive. After each dive, a log description of the physical and biological data was completed by the principal consultant; 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, as follows:

1. Underwater transect surveys. Eight transect sites were established by affixing subtidal markers, concrete blocks 20 cm. by 30 cm., 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 by the principal consultant.

High turbidity was generally encountered on most dives; the average underwater visibility was 1.2 meters (4 feet). In addition, large swells from the action of the Pacific northwesterly waves were generally present.

B. Intertidal Methods

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 with the aid of an Alvarez Rangefinder, then ten-meter perpendicular transect lines were employed from the baseline. Square meter quadrats were utilized to determine densities of marine organisms within each frame along the transect line. Information was logged on data sheets for each quadrat, beginning at the low minus intertidal zone 4 to the high intertidal zone 1 areas. 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.

C. Other Land Areas

Walks along the upper shoreline and bluffs enabled the principal consultant and his students 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.

D. Literature Methodology

Most of the information in this report is based on records of the

principal consultant's direct observations. Other sources 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.

The biological description was written in narrative terms, with the scientific name or genera as the basis for species identification. Common names, when appropriate, were utilized as a supplement.

III. DISCUSSION

A. PHYSICAL and CHEMICAL DESCRIPTION of the POINT REYES HEADLAND ASBS

1. Location and Size of the Point Reyes Headland ASBS

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). Its position is 123°00'W and 37°59'30"N on the USGS Drakes Bay, California, SW/4 Point Reyes 15' quadrangle, 1953.

"The proposed area includes the Point Reyes Headlands Reserve which is an ocean area extending 1000 feet (304.8 meters) from the high tide mark and bounded on the west by a line extending due west (true) from the Point Reyes Lighthouse and on the east by a line extending due east (true) from Chimney Rock. The proposed ASBS includes an additional 1000 feet offshore (total is 2000 feet offshore) from the Reserve as shown in Figure 2, Drawing No. 441A. The proposed area includes 3.5 miles (5.6 kilometers) of mainland shoreline."

California Regional Water Quality Control Board, 1973.

The total area of the Point Reyes Headland ASBS encompasses about 5.5 square kilometers, 1359 acres, or 550 hectares. The Headland site is 57 km. (3.1 miles) from the nearest town which is Inverness (Figure 1).

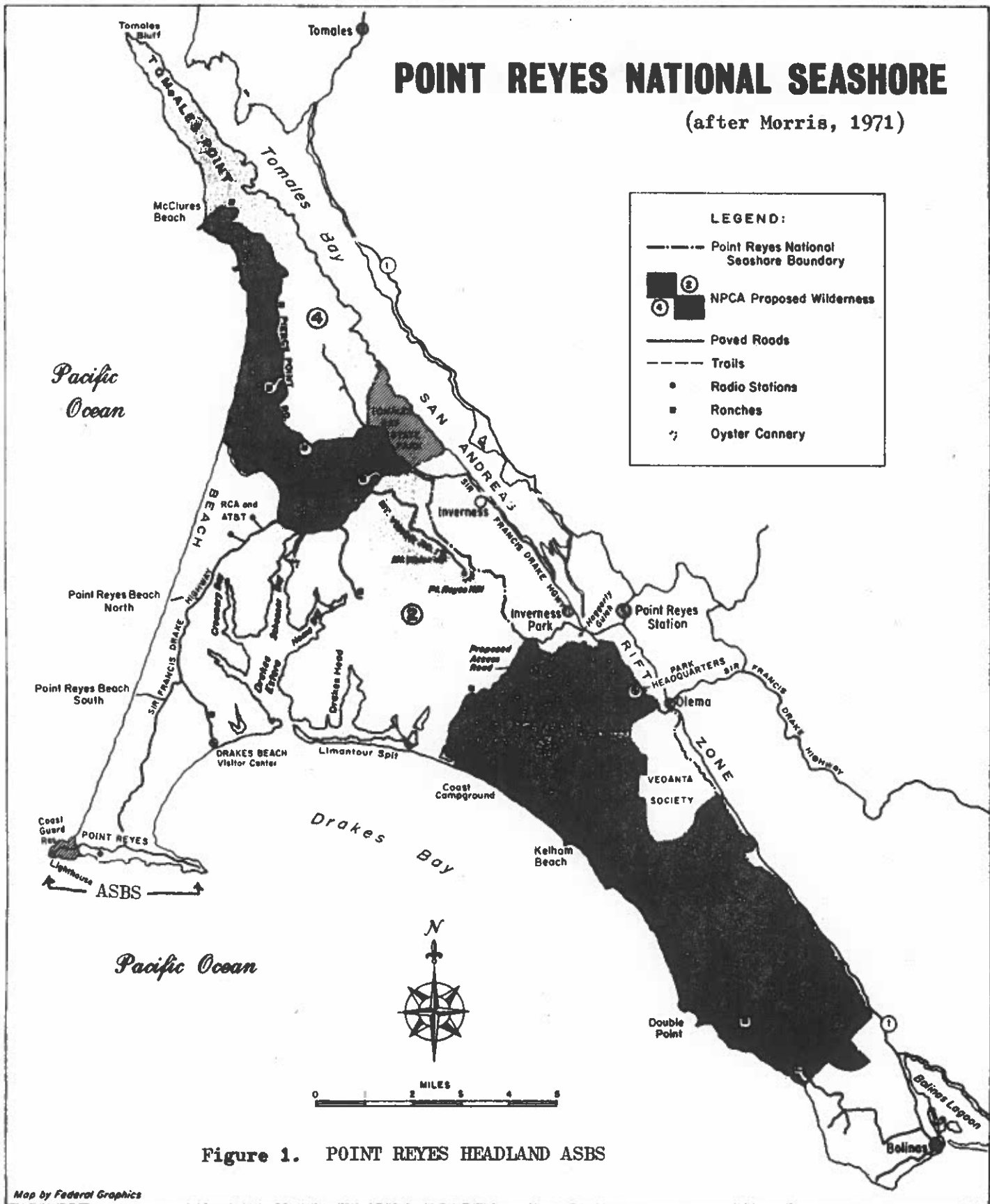
In 1972, the California Department of Fish and Game declared the Point Reyes Headlands as a Marine Life Reserve, Title 14, Division 1, Chapter 3, Article 1.57:

"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)."

Smith and Johnson 1972

POINT REYES NATIONAL SEASHORE

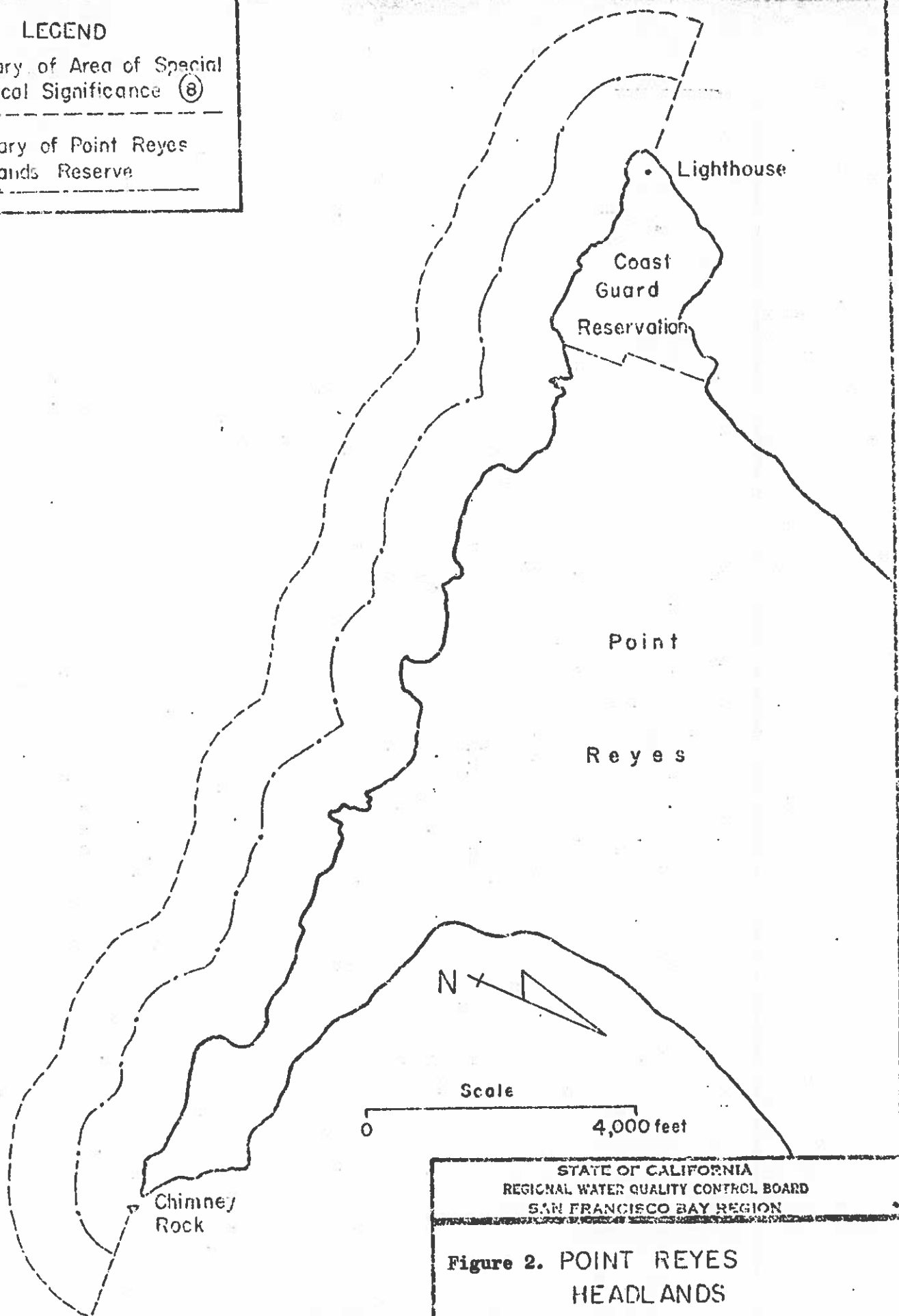
(after Morris, 1971)



LEGEND

Boundary of Area of Special
Biological Significance (8)

Boundary of Point Reyes
Headlands Reserve



STATE OF CALIFORNIA
REGIONAL WATER QUALITY CONTROL BOARD
SAN FRANCISCO BAY REGION

Figure 2. POINT REYES
HEADLANDS
RESERVE AND EXTENSION

DRAWN BY FJN DATE FEB. '73 DRWG. NO. 441A

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.

2. Climate

The general climate of the Point Reyes National Seashore Park is classified under the Evergreen Heath Etesian Climate (often referred to as Mediterranean) of the Köppen system (Schenk, 1970). Characteristics of this climate are moderate summers and cool, wet winters. The annual rainfall is about 49.5 cm. (19.5 inches) 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, records at the Point Reyes Lighthouse Station indicate the following conditions (Table 2). The area is buffeted by strong winds, with a maximum in the range of 64 to 80 km/hr (40-50 mph) in the winter while the summer average velocities range about 16 to 20 km/hr (10 to 13 mph). The maximum average temperatures ranged from 20° to 30°C (mid-60° to mid-80° F.) while the minimum average temperatures were 5° to 9°C. (40° F. range)(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 49.5 cm. (19.5 inches) per year (Figure 3), producing an annual runoff of approximately 15 cm. (6 inches)(Figure 4)(Biswell and Agee, 1973).

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

ANNUAL RAINFALL

inches

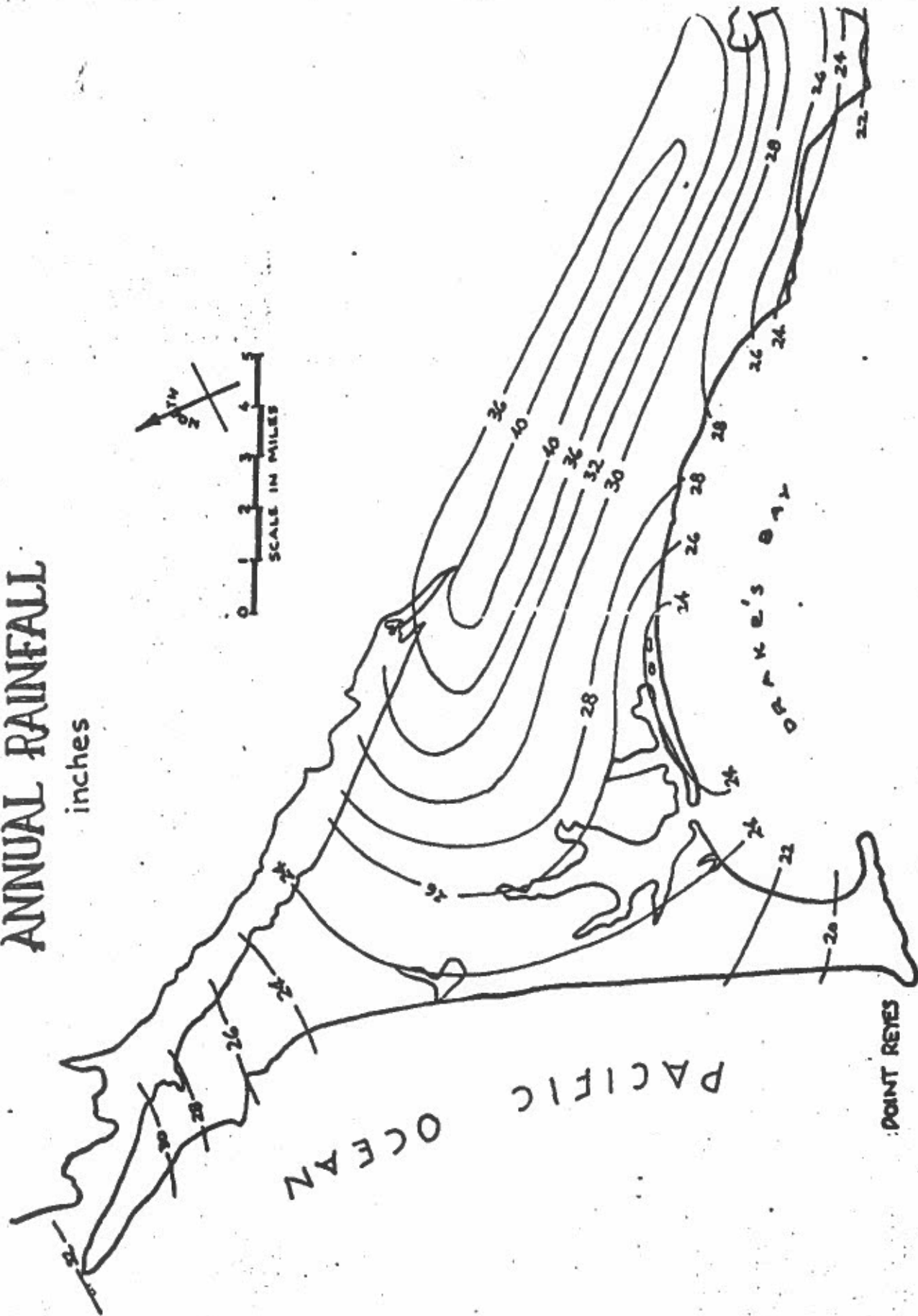


Figure 3. ANNUAL RAINFALL (inches), POINT REYES (Biswell and Agee, 1973)

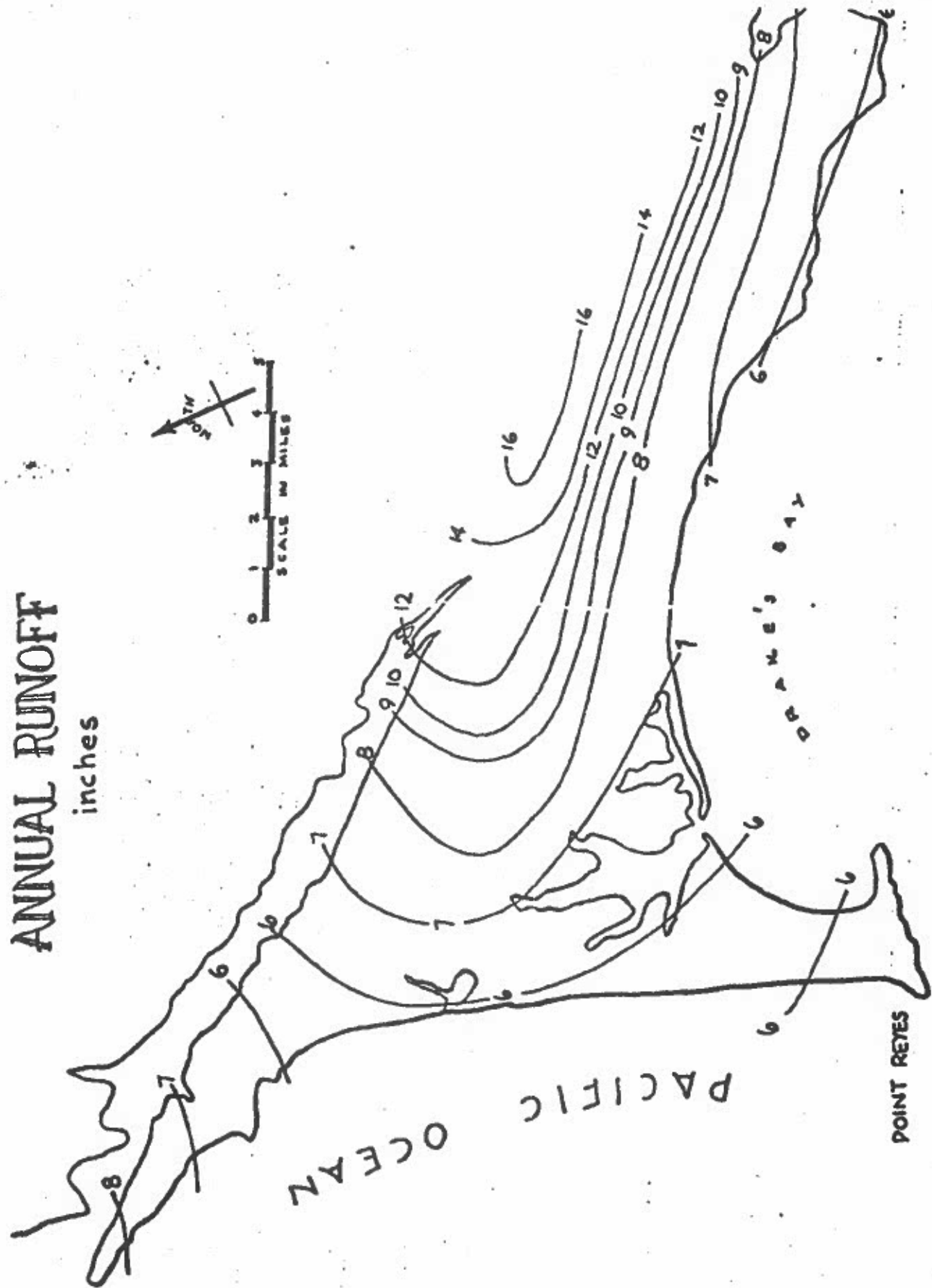


Figure 4. ANNUAL RUNOFF (inches), POINT REYES (Biswell and Agee, 1973)

3. Nearshore Waters

a. Submarine Topography

The Point Reyes Headland ASBS extends from the intertidal zone seaward for 609 meters (2000 feet). At the south face of this 609-meter line, the depth is about 30 meters (100 feet). However, at the western boundary of the ASBS zone, Lighthouse area, the depth probably is greater than 45 meters (150 ft.), while at the eastern boundary, at the Chimney Rock area, the depth is less than 18 meters (60 ft.) (Figure 6).

The submarine topography consists of large granitic boulders throughout the shallow water zones with large amounts of sand interspersed between the boulders. The sand continues to slope out beyond the ASBS boundary. At the west end, almost directly below the lighthouse, is "The Wall" — a vertical granitic face which drops 18 meters (60 feet) to the sloping sandy bottom at 26 meters (85 feet), Figure 5 below.

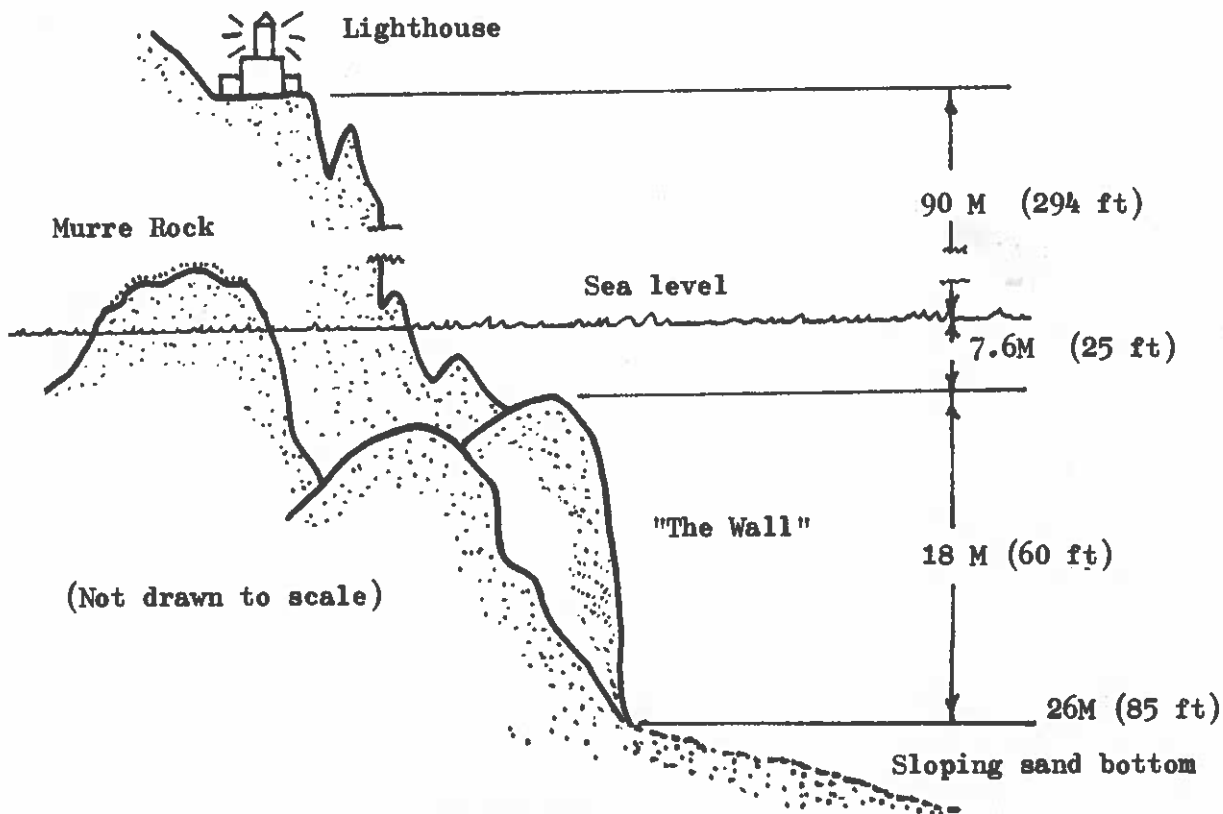


FIGURE 5. PROFILE OF "THE WALL"

In contrast to "The Wall" of the western side of the ASBS area, the submarine topography at Chimney Rock consists of large boulders 1 to 2.4 meters (3 to 8 feet) in diameter. Sand surrounds these boulders and gently slopes out to the 60-foot isobath line of the ASBS boundary (Figure 6). Large, vertical intertidal sea caves are also located amidst the conglomerate rocks about 50 meters east of the Lighthouse (Figure 6)(Appendix 11, Slide 15).

In summary, within the 5.5-meter (18-foot) contour line, the submarine topography consists of small and large boulders. Sand slopes out from these rocks to depths beyond the ASBS boundary. The most unique topography of the Point Reyes Headland ASBS is the 18-meter (60-foot) wall located under the Lighthouse on the west side of the ASBS area.

b. 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. Sea waves which are generated by the influence of the Pacific Northwest winds strike the Point Reyes Headland (Figure 7) and refract around the Point towards the inner beaches of Drakes Bay (Cherry, 1965). Cherry reported that in the summer months the wave trains approach from the west northwest with a wave period of 12 seconds. In the winter months, the refractory wave trains approach more from the west with a closer period of nine seconds (see Appendix 10B which illustrates the winter wave trains). Such waves carry much sediment from the Headlands to Drakes Bay where the sediments are sorted along the beach front. There is constant erosion of the Point Reyes Headland from the action of these wave trains.

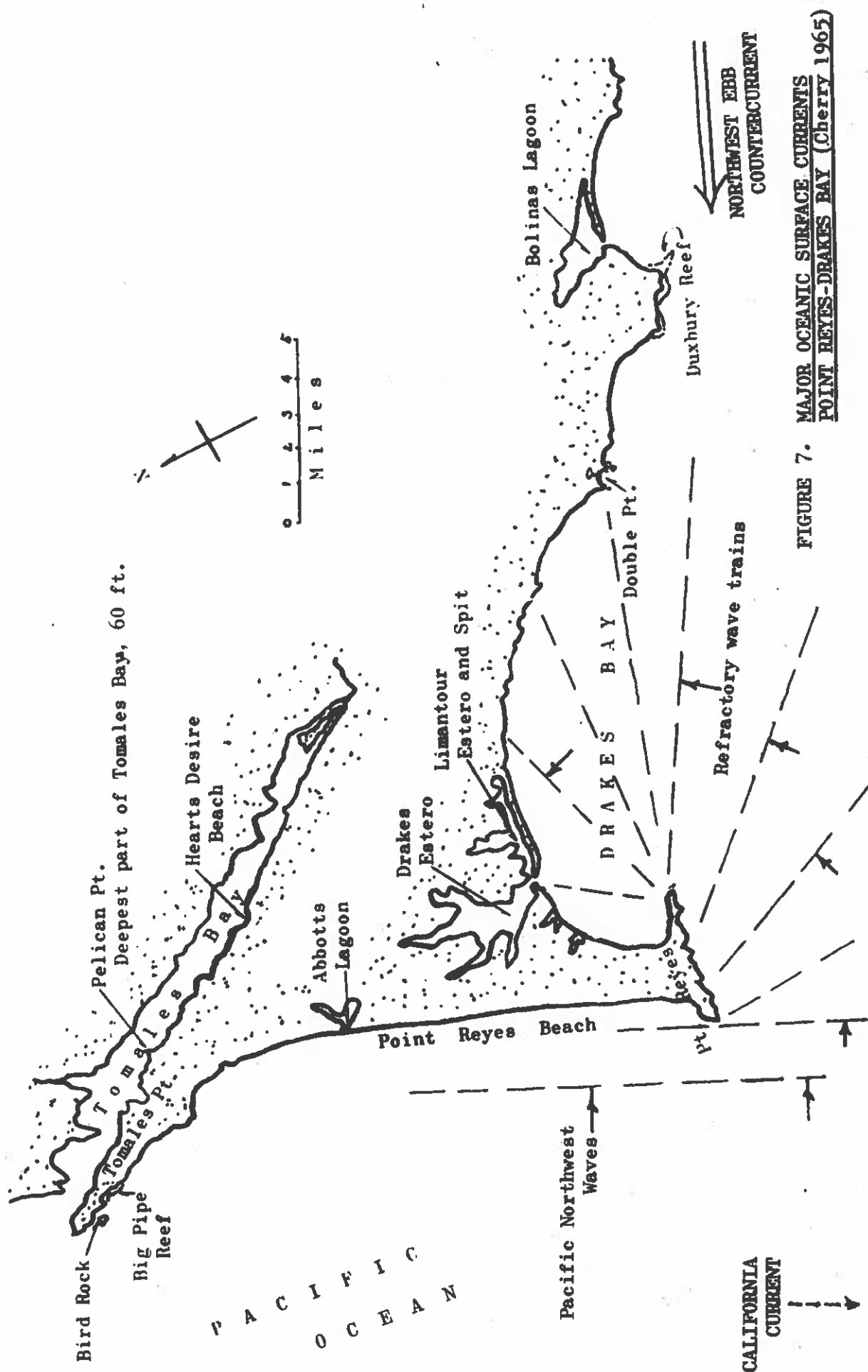


FIGURE 7. MAJOR OCEANIC SURFACE CURRENTS
POINT REYES-DRAKES BAY (Cherry 1965)

The waves which affect the littoral zone vary according to the patterns and influences by winds and other weather conditions which occur in this locality from day to day, month to month. The northwesterly winds generally accelerate the wave trains and the tidal currents associated with the Point Reyes Headland ASBS. In some areas of the ASBS, the waves strike intertidal zone with variable intensity. At Sea Lion Cove, the offshore sea stacks break up the velocity of the waves and the beaches in the cove are well-mixed, medium particle 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 10 to 40-centimeter (4 to 16-inch) cobbles. This beach does not have any sea stacks to break up the waves and the velocity of waves striking this beach is intense. The term "boulder beach" aptly describes the characteristics of this cove area.

In our dives at this ASBS site, no thermoclines were experienced; the water was consistently cold, averaging 10.5°C. (50.9°F.) (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 of "The Wall", just under the Lighthouse area. Dyer, in his 1975 study of the 47,500 cans of radioactive waste dumped southwest of the Farallon Islands, reported an upwelling current which seemed to head towards the Bolinas and Point Reyes Headlands (Figure 16). Whether this current reaches the ASBS site is not known at this time.

c. The Water Column

The clarity of the Point Reyes Headland ASBS waters ranges from 1 meter in the near shore area to about 4.5 meters at the 9-meter (30-ft.) contour line. Water clarity and visibilities are fairly

good for Marin County waters, averaging about 2.3 meters (7.4 feet) during the underwater dives (Table 3). Due to the intense wave actions of the area, there are many sediments which become suspended in the water column in close to the shore, and during summer months the planktonic blooms are the highest, thus contributing to the poor visibilities of the water column. During winter weeks when planktonic blooms are lowest, the visibilities of the near shore waters may have reached a maximum of about 3.0 meters (10 feet).

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 o/oo for this oceanic test station.

Water temperatures averaged about 10.5°C. (50.9°F.) for the diving activities conducted by the principal consultant 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 low levels, less than 0.01 ppm (Table 3). No trace metal data was available for this ASBS site.

4. Geomorphic Characteristics

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 1.3 cm. ($\frac{1}{2}$ in.) per year,

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)		meters(feet)	mg/l		
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	2.3 (7.4)	-	-	
Totals	25	21							
	Averages		10.5	(50.9)	32.1	2.3 (7.4)	8.9	< 0.01	

and has traversed northward hundreds of miles (Galloway, 1977).

a. Land Geomorphology of the ASBS Site (Figure 8)

The Point Reyes Headland ASBS is a rugged rock promontory composed basically of granitic rocks. Some geologists refer to the rock as "Point Reyes granodiorite", but Galloway (1977) simply states that it should be referred to as the "granitic rocks of the Point Reyes Peninsula". The age of the granitic rock is estimated as early Upper Cretaceous, or 83.9 million years old. Core borings have revealed that the granitic rocks extend 417 meters (1370 feet) below sea level. These plutonic rocks range in composition from quartz diorite to adamellite, containing more quartz and potash feldspar. Although most of the granitic rocks of the Point Peninsula are deeply weathered, geologists such as Galloway and others have examined these Point Reyes plutonic rocks and found much similarity to the granitic rocks of the 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 rounded 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 these conglomerates. Giant sea caves have been etched into the conglomerates at the surf zone (see Appendix slides of these sea caves). These conglomerates are younger Paleocene in age than the granitic rocks, and are found nowhere else on the Point Reyes Peninsula. The conglomerates interspersed with layers of fine grain sands were probably deposited underwater in a turbidity current and are similar

to the Paleocene conglomerates at Point Lobos in Monterey County. Galloway also reports that similar rocks were dredged up at the Cordell Banks, some 37 kilometers (20 miles) west of the Headland. Finally, the conglomerates are overlayed in an unconformed manner by basal glauconitic sand of the Drakes Bay Formation of early Pliocene Age. (All the preceding geology information was taken from Galloway's publication, 1977.)

The Point Reyes Headland ASBS is virtually in an east-west alignment with the massive 5.6 km (3 nautical miles) cliff facing in a southerly direction. The highest point of the Headland is at the western end, rising up to 186 meters (612 feet), while at the Chimney Rock area of the east side, the cliff is approximately 52 meters (173 feet)(see Figure 5 and Appendices photographs). Galloway (1977) suggests that this massive cliff is an eroded fault-line scarp, down thrust to the south. The submarine drop-off, Figure 5, "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 northwest-southwest. The ridges are harder layers of the Drakes Bay Formation and is folded into an anticline-syncline pattern. The valleys are remains of tributaries which drain into the down-valleys of Drakes Estero and Estero de Limantour (Figure 8)(Galloway, 1977).

b. 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 age of these rocks range from upper Cretaceous to Paleocene. A review of intertidal and subtidal geomorphology of the major sites of the ASBS will begin at the east portion of Chimney rock and move

west to the Lighthouse.

(1) Chimney Rock (Figure 9)

At the east end of the ASBS is a large granitic sea stack with a single 15-meter (50-foot) pinnacle that resembles an isolated chimney (see Appendix 11, Slide #1). This stack was a part of the main cliff during the past; erosion divided this section from this eastern promontory. Surrounding Chimney Rock are large boulders which make up the intertidal and subtidal configuration. Much sand surrounds these granitic rocks, and the sand continues in a gentle slope out beyond the 18-meter (60-foot) isobath area. Since the refractory waves sweep around the Chimney Rock area, there is much movement of sand throughout the year.

(2) Pelican Arch (Figure 9)

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

(3) Saddle Cove (Figure 9)(also see Appendix 11, #2)

The cliffs between Chimney Rock and Saddle Cove are nearly vertical in profile, rising from sea level to about 58 meters (190 feet). At Saddle Cove is a small beach which is at a base of a sloping grade which illustrates much erosion. In time, the water erosion of waves and wind may cut through this narrow saddle-like isthmus to the area of the old Coast Guard station, thus isolating a large island-sea stack formation.

(4) Split Rock (Figure 9)

Massive granitic rocks of past ages which have split off from the south cliffs provide the name of this area as Split Rock Cove.

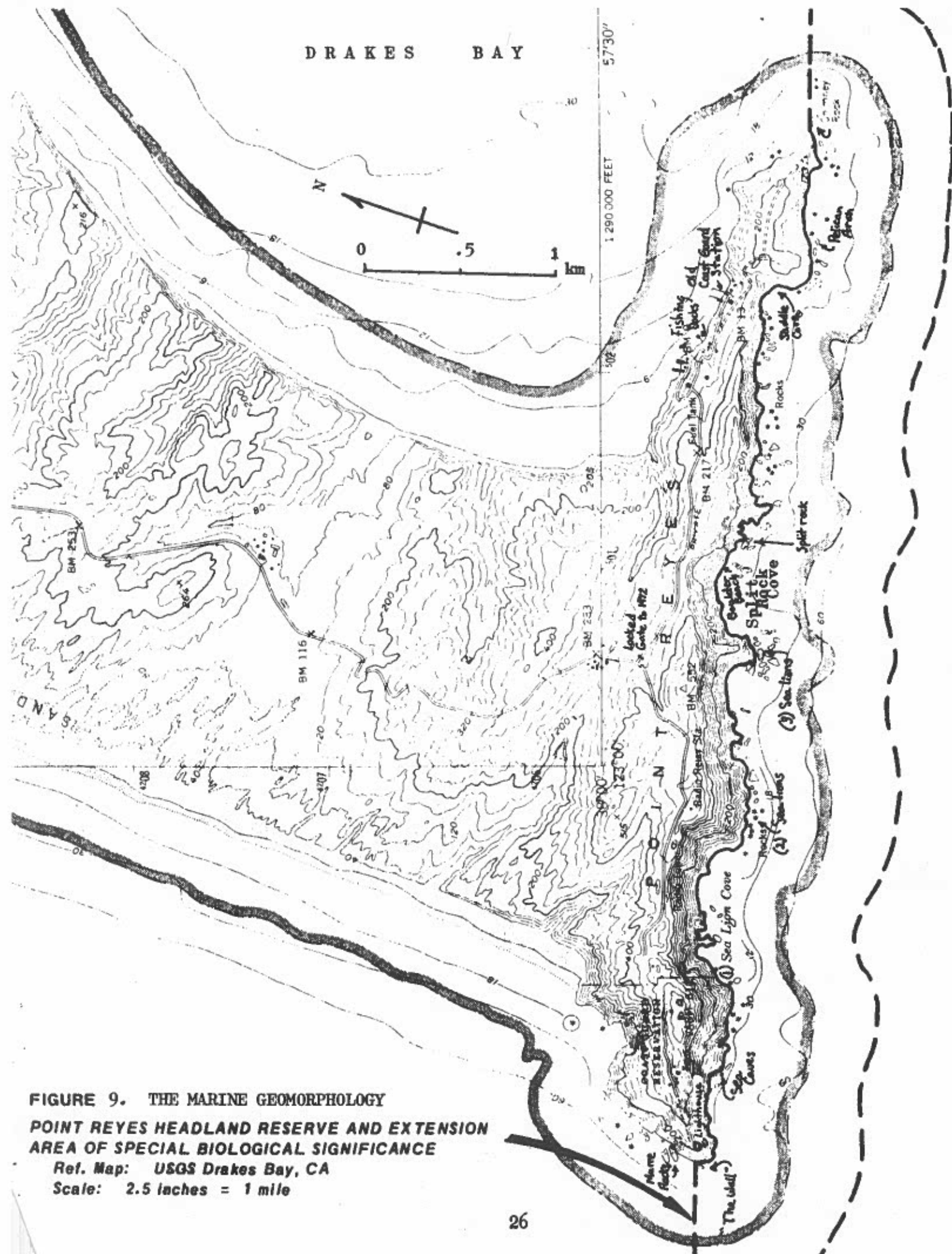


**FIGURE 9. THE MARINE GEOMORPHOLOGY
POINT REYES HEADLAND RESERVE AND EXTENSION
AREA OF SPECIAL BIOLOGICAL SIGNIFICANCE**

Ref. Map: USGS Drakes Bay, CA

Scale: 2.5 inches = 1 mile

The waters of this cove are much deeper than that of the major coves within these southern-facing cliffs. The 9-meter (30-foot) isobath bends deeply into the Split Rock Cove (Figure 9). The deep water enables large oceanic waves to come very closely to the beach area and thus dissipates great energy to Boulder Beach. The beach has a steep profile and is strewn with rounded cobbles and boulders, from 15 to 76 centimeters (6 to 30 inches) in diameter.

(5) 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 plutonic rocks enable many sea lions to haul out on these rocky platforms. The habitats are labeled "Sea Lions" (1), (2), and (3) in Figure 9. Coarse 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. (Appendix 11, slides #8-12)

(6) Sea Caves (Figure 9)

The conglomerates of the Point Reyes Headland ASBS extend from the highest point of the cliff at 186 meters (612 feet) to the surf zone where the depth is 9 meters (30 feet). The large Pacific Ocean waves erode these conglomerates, etching out giant sea caves (see Appendix 11, Slide #15). Large conglomerate boulders and coarse sand make up the benthic substrate at the base of these conglomerate cliffs. These cliffs are a favorite niche for the Common Murre, Uria aalge.

(7) "The Wall" (Figures 6 and 9)

As previously mentioned (Figure 5), "The Wall" is a granitic submarine 18-meter (60-foot) vertical cliff just below the Lighthouse at the western edge of this ASBS. The base of "The Wall" is 26 meters (85 feet) below sea level with sand and rocks sloping the benthic environment out beyond 30 meters (100 feet). This unique vertical wall to these depths is probably a result of the down-thrusting faulting action of this Headland ASBS.

The Principal Consultant has made two dives to this submarine site and in both instances, the dives were very hazardous. Ideal diving conditions are almost impossible to realize in this area as giant waves smash across this western promontory the year around. 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 50 centimeters (30 inches), both from the sediments stirred up by the wave-surges and by the darkness of these depths. With the threat of potential sharks in the area I certainly would not recommend other divers to explore this hazardous area.

(8) Murre Rock (Figure 9, Appendix 11, Slide #19)

Just west of the Lighthouse, at the surf line and north (outside) of the proposed ASBS, Figure 9, are two large granitic sea-stack rocks which are the main nesting sites of thousands of the Common Murre, Uria aalge (Appendix 11, Slides #17-19). I have observed that these birds reside here the year around.

B. BIOLOGICAL DESCRIPTION of the POINT REYES HEADLAND ASBS

The biota of the Point Reyes Headland ASBS will follow the outline below:

1. Plankton Samples
2. Benthic Shelf Communities
3. Subtidal Reefs
 - a. Plant Communities
 - b. Invertebrates
4. Intertidal Reefs and Beach
5. Vertebrates: Fish, Birds, Mammals
6. Land Vegetation
7. Unique Components

1. 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:

Plankton Net: 12 mesh, 120 microns

Length of tow: 100 meters

<u>Major Animals</u>	<u>July 6, 1970</u>		<u>July 22, 1976</u>	
	<u># in 1.6</u> <u>cm.³ grid</u>	<u>No. of</u> <u>organisms</u>	<u># in 1.6</u> <u>cm.³ grid</u>	<u>No. of</u> <u>organisms</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

TABLE 4. PLANKTON SAMPLE, POINT REYES HEADLAND ASBS

The plankton sample at the Point Reyes Headland ASBS appeared to be more oceanic in species sampling than in-shore littoral species. The calanoid copepods, the euphasiid shrimps, brachyuran crab larvae, and Sagitta sp. — Chaetognath worm—, all indicated oceanic species. The density of naupli-barnacle larvae is representative of in-shore littoral zone plankton. In 1970, the California Department of Fish and Game biologists collected oceanic plankton 11.2 km (6.0 miles) from the Point Reyes Headland ASBS (Brown & Caldwell, 1971) and the density and species list of organisms were very similar to my listing, Table 4. Since I was probably using a finer mesh net than the Fish and Game biologists, I gathered a greater amount of diatoms (Coscinodiscus sp. and Chaetoceros sp.) and dinoflagellates (Ceratium sp.).

On December 1, 1977, J. Doss, a student of mine, and I were diving off Split Rock (Figure 9) in 9 meters (30 feet) of water and observed a mother and calf grey whale, Eschrichtius robustus, feeding on a dense mass of Euphasiacea shrimps. This event illustrated that the deeper oceanic waters and their plankton forms are found within the Headland ASBS boundary, thus accelerating the high diversities and rich abundance of the foundational trophic organisms in the marine food pyramid of this special marine habitat.

2. Benthic Shelf Communities

Although dives were made between 18 to 30 meters (60 to 100 feet) at the Point Reyes Headland ASBS, no organisms were observed because of the turbidity of sand being moved by the strong wave surge off Chimney Rock and Split Rock (Figure 9).

Data on the benthic organisms on the continental shelf was obtained from the Brown and Caldwell Report, 1971. This engineering

firm established six benthic shelf stations ranging from about 9 to 13 km (5 to 7 miles) south of Point Reyes Headland ASBS (Appendix 1). 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.

3. Subtidal Reefs

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. The first discussion will center on the subtidal plants, then the invertebrates, and lastly the vertebrates, the fishes, birds and mammals.

a. The Plant Community

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 10, the outline of the rocky reefs 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. I have adopted some of Pequegnat's descriptions of zones with some modifications according to the type of marine plants which occupy the space. These plants have a

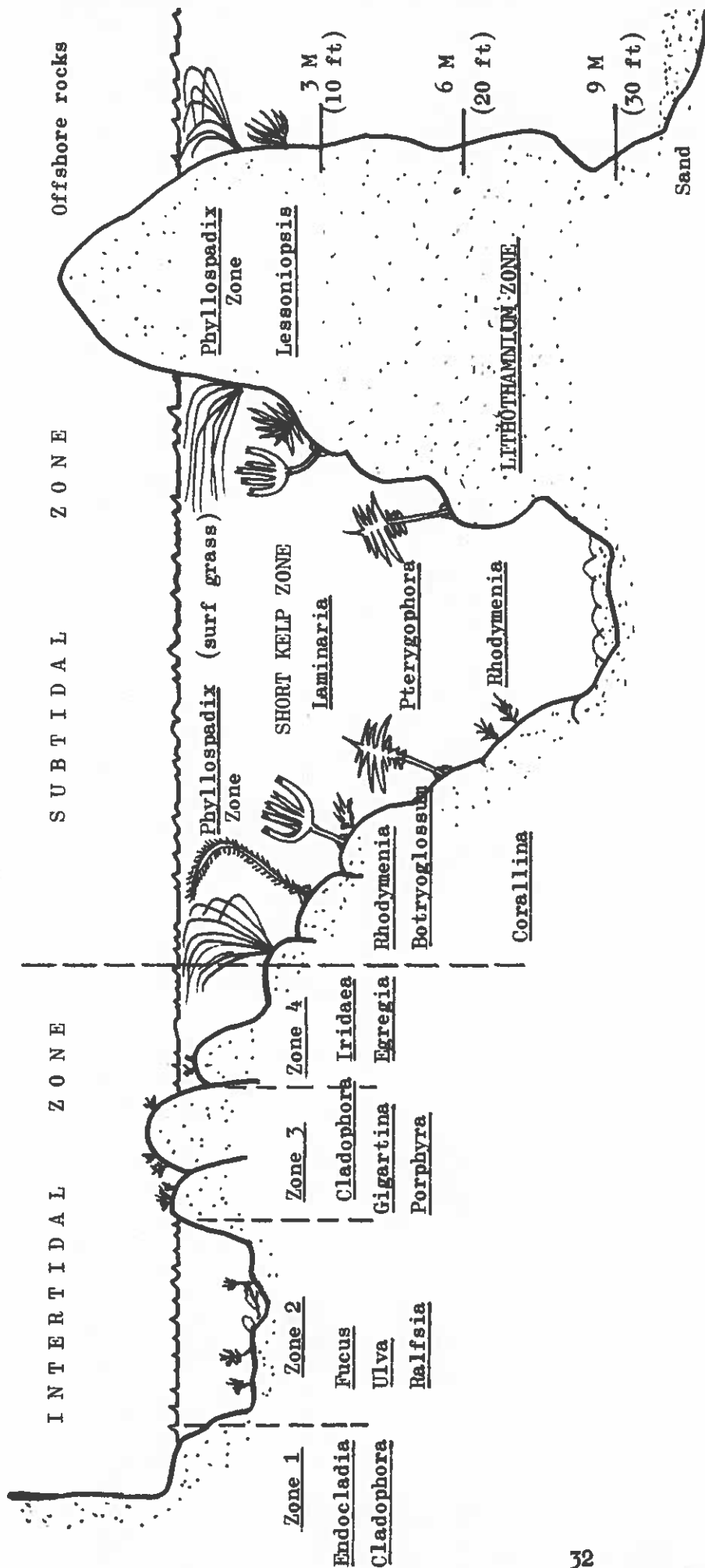


FIGURE 10. GENERAL DEPTH DISTRIBUTION OF INDEX PLANTS, POINT REYES HEADLAND (not drawn to scale)

specific selection zone depending on the 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. Around these plants are clustered the herbivore animals and the food chain is thus expanded because of the presence of the algal food and the detrital contribution of these plants.

Starting from the greatest depth, Table 5 describes the ecology of the general profile of the distribution of plants (Figure 10) in this 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 kelps 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 3 meters (10 feet) in length, growing on the sides and tops of the granitic rocks in the area.

Since the Chimney Rock sea stack protects a rather large intertidal zone 2 area, Figure 13, there are more zone 2 plants, Fucus distichus, Ulva spp., etc. (Appendix 2) here than in other areas of the Headland reefs.

- (2) The wave actions all along the south facing reefs of the Headlands are 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>Rhodymenia callophyllidoides</u> <u>Pterogophora 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> covers the rocks and mussels within this zone.
+3.5 MHLW	13	<u>Ralfsia pacifica</u> <u>Fucus distichus</u> <u>Ulva</u> spp. <u>Cladophora 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.

In the Split Rock Cove area (Figure 12), there are many protective rocks at both 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 Headland ASBS site, just below the Lighthouse, is buffeted constantly by strong oceanic waves, and with few offshore rocks for protection, the area has low plant species diversity, and is atypical of the plants listed by Table 5. Even the surf grass, P. torreyi, is short and sparse in this exposed promontory section.

b. The Subtidal Invertebrates

The general depth distribution of marine invertebrates at the Point Reyes Headland (Figure 11) is ideally applicable to the habitats of the Headland, with the exception of the western promontory under the Lighthouse. In general, sea stacks and offshore rocks provided a protective shield for many marine plants and animals to flourish in the lee of these plutonic rocks. Combining the general distribution of plants (Figure 10) with the general depth distributions of index invertebrates (Figure 11) will provide an approximate view of the marine habitats of the Point Reyes Headland ASBS. I shall first describe the subtidal habitat of the lower vertical zone and then proceed up through the intertidal regions. Habitat anomalies will be described within each vertical zone.

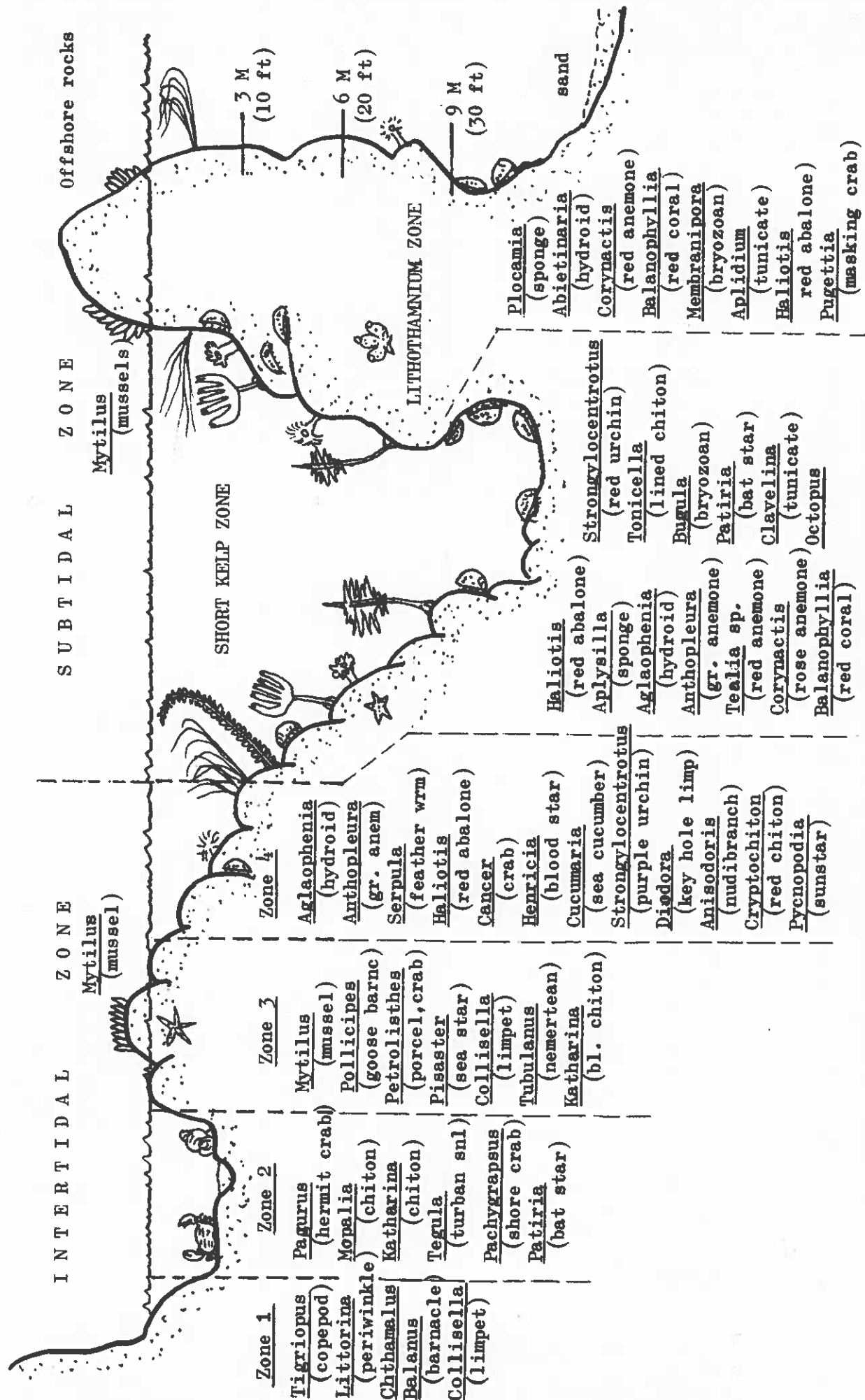


Figure 11. GENERAL DEPTH DISTRIBUTION OF INDEX INVERTEBRATES, POINT REYES HEADLAND

(not drawn to scale)

(1) The Lithothamnium or Coralline Algae Zone

In our deepest dives to the 30-meter (100-foot) isobath area, we encountered only coarse sand and no organisms were observed. The turbidity created by the wave surge at this depth hampered our underwater visibilities.

However, when we visited "The Wall", Figure 5, almost the entire surface of 18-meter (60-foot) submarine cliff was dominated by various species of the crustose algae, Lithothamnium sp. and Mesophyllum lamellatum, and Corallina spp. (Abbott and Hollenberg, 1976). Sub-surface rocks at this Lighthouse promontory area are nearly coated by these encrusting algae from the intertidal zone to the bottom of "The Wall" at 26 meters (85 feet). Swimming along this wall was quite difficult due to the periodic surge which would move the divers some 9 meters (30 feet) every few seconds. Only marine organisms that could withstand the surge were found on "The Wall". The following were the major index organisms which were abundant on the encrusted algal surface of this giant rock face:

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

Balanophyllia elegans, red solitary coral, very common

Metridium exilis, the cotton-top white anemone,
up to 30 cm. (1 ft.)

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

All of the above organisms were sprinkled amidst the encrusting algae, providing a very colorful wall when a flashlight is utilized to view these organisms in the dark waters of this vertical wall. One note of caution always entered the minds of the divers on this wall, and this was the possibility of encountering the white shark, Carcharodon carcharias, which is reported in these deep waters off this Marin County headlands (Follett, 1974). The combination of no safety boat anchorage, wave surge, darkness of the deep water, along with the potential danger of shark attacks in the area leads me to classify this diving site as extremely hazardous.

The general statement that the Lithothamnium sp. and other crustose algae cover the offshore subtidal rocks from surface to deeper depths holds true for other wash rocks and sea stacks throughout the Headland ASBS. However, the wash rocks east of "The Wall" have far greater amounts of marine plants due to less wave actions and thus provide a more diverse habitat for other invertebrates and fish.

With the appearance of kelp attached to these offshore rocks, the major herbivore that is found here is the red abalone, Haliotis rufescens. These large-sized gastropods are often found at the base of these offshore rocks and sea stacks (Figure 11). These abalones at the base of the rocks, about 9 meters (30 feet) below the surface, are much larger in size than the smaller red abalones nearer the surface, in among the surf grass, P. torreyi. The size of these abalones at the base of the rocks averaged close to 23 cm. (9 inches) in my subtidal transects at Split Rock Cove (Figure 11). These large abalones nestle under the overhangs of these rocks and their crowded shell-to-shell behavior allows only a sparse growth of the crustose algae, Lithothamnium sp.

(2) The Short-Kelp Canopy Zone

The water depths of the short-kelp canopy zone range from 7.6 to 3 meters (25 to 10 feet) and the kelp forms a dense canopy, particularly on the lee side of the offshore rocks and sea stacks, as illustrated by Figure 11. The primary kelps here are (from top to bottom):

Lessoniopsis littoralis, shredded kelp

Costaria costata, leaf kelp

Egregia menziessii, boa kelp

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

Pterygophora californica, tree kelp

The deepest of the kelp, P. californica, is particularly dense in this area with its thick stipe averaging about 1.2 meters (4 feet). These algae are attached to large boulders

throughout the lee side of these large offshore rocks and sea stacks. The major algae which covers these boulders are the coralline algae, Corallina officinalis var. chilensis, and the red algae, Rhodymenia pacifica and Botryoglossum farlowianum (Figure 10). With the abundance of kelp blades, the abalone, H. rufescens, has a flourishing population (see Appendix 11, Slide # 7) of abalones in this zone amidst the coralline algae).

The census of the populations of H. rufescens at the Point Reyes Headland has been one of my primary focuses since my first dive at Split Rock Cove in 1963 (Table 3). In July of 1970, my students and I made our first population census of abalones at Split Rock Cove and at Chimney Rock (Chan, 1971). Compass transects were established at fixed subtidal stations amidst the wash rocks at both areas (Figures 12 and 13).

Previous 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 304 meters (1,000 feet) of the high tide mark -- without a written permit from the Fish and Game Department (Smith and Johnson, 1972).

Populations of H. rufescens within the protective Headland Reserve has increased in numbers and size, as the latest census revealed in 1976 and 1978 (Table 6). In 1970, the population of abalones at Split Rock Cove (Figure 12) for transects A and B was an average 0.3 and 4.4 organisms per square

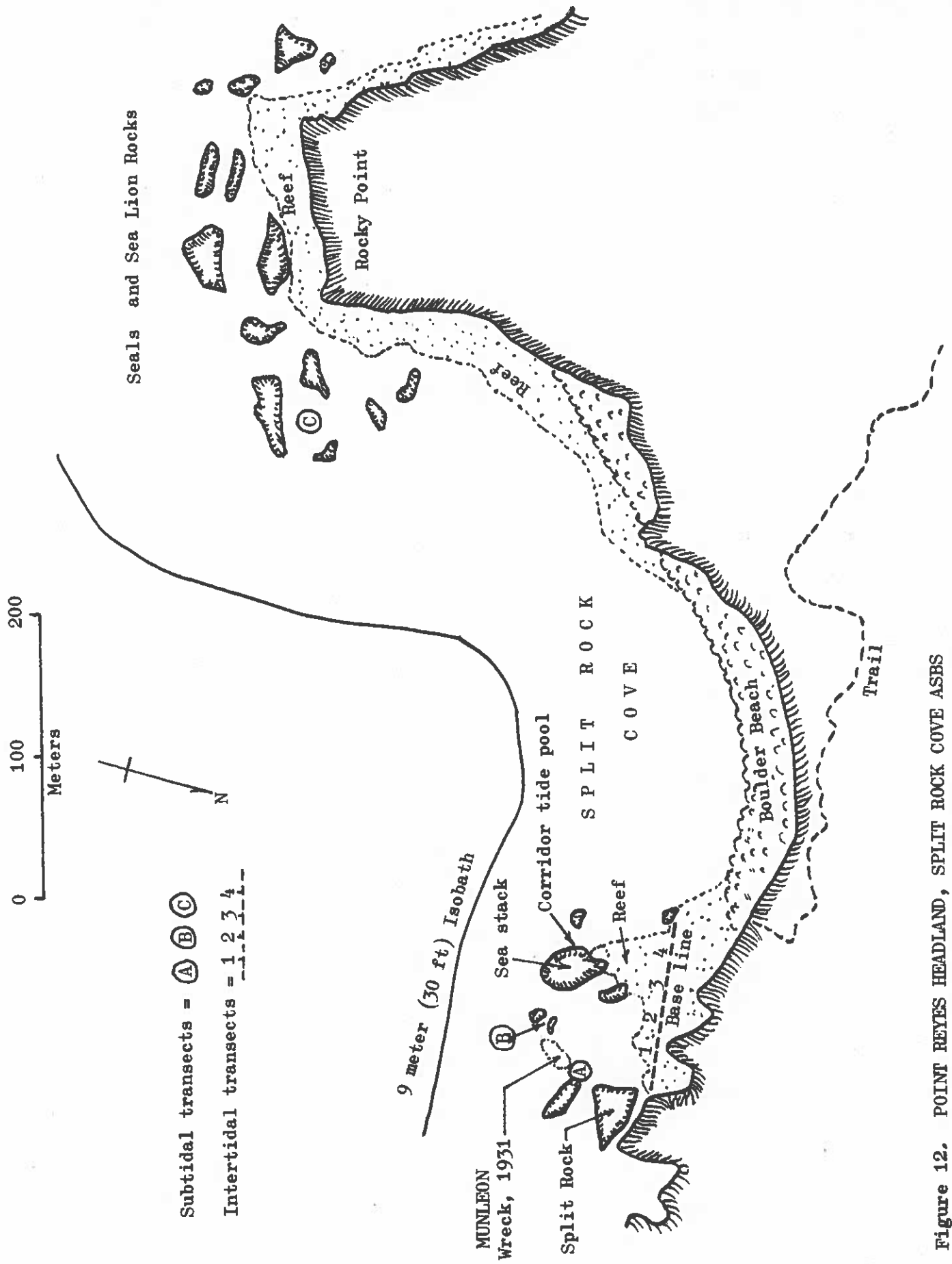


Figure 12. POINT REYES HEADLAND, SPLIT ROCK COVE ASBS

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

Intertidal transects = 1 2 3 4

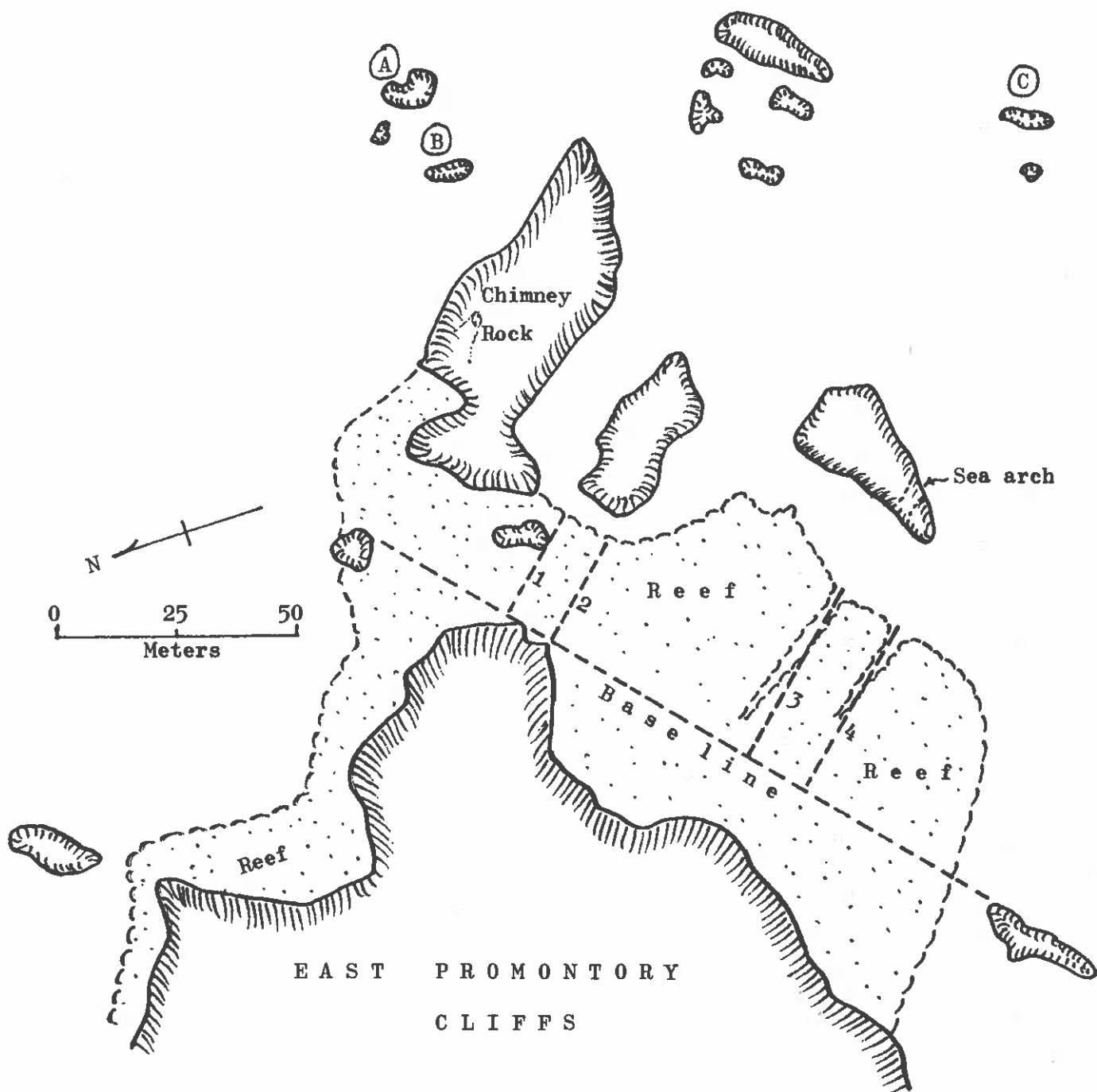


Figure 13. POINT REYES HEADLAND, CHIMNEY ROCK ASBS

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

<u>Subtidal Site</u>	<u>Transect</u>	<u>1970-1972 Avg. No./m.²</u>	<u>95% confidence limits</u>	<u>1979 Avg. No. per square meter</u>
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.
=====				
	<u>Transect</u>	<u>June 25, 1970 Avg. No./m.²</u>	<u>95% confidence limits</u>	<u>July 13, 1976 Avg. No./m.²</u>
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	

meter (Table 6). The average size for abalones at site B was 20.0 cm. (8.0 inches). In 1979, the populations 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 21.6 cm. (8.5 in.). These large-sized abalones are a direct result of the protective reserve system from the predation by man.

In contrast to Split Rock Cove, the abalones at two of the Chimney Rock transects (Figure 13) 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 1970. 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. In 1970, the average size of abalones at Chimney Rock was 14.9 cm. (5-7/8") while at Split Rock, they averaged 20.0 cm. (8.0") for the same year. The reasons for the small size abalones at Chimney Rock are probably two variables: the shallow subtidal environment which is constantly buffeted by shifting sand from waves sweeping across this area and the lack of short kelp, the primary food of the abalones. The subtidal rocks at Chimney Rock are covered with long strands of the surf grass, P. torreyi (Figure 10). At Split Rock Cove, the water is deep and in the lee side of the sea stacks, the short-kelp canopy is abundant.

By counting the growth layers of abalones at Split Rock Cove in 1970, I have estimated the age of these organisms to be 16 to 21 years old, while the samples at Chimney Rock were 10 to 15 years old. The abalones within my transect sites at Split Rock Cove are now probably close to 30 years old, and with the Reserve status in effect, these organisms will probably continue to grow and multiply in numbers. The largest abalone on record has been forwarded by me to the American Malacologists, Inc. (Wagner and Abbott, 1978) for official recognition as the world record size specimen.

This giant abalone is 29.4 cm. (11-9/16") and was found by Mr. Buzz Owens of Pigeon Point, California, while commercial diving off San Miguel Island in 1964. I have estimated the age of this specimen to be about 55 years old. With reserve status for invertebrates at Split Rock Cove, it is within reason that someday an abalone here may surpass the San Miguel record! Nevertheless, the large abalone populations of these waters remain as one of the prime assets of the Point Reyes Headland ASBS.

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

The following list, Table 7, illustrates the major and common subtidal invertebrates seen most abundantly in the subtidal short-kelp zone and the intertidal Zone 4 areas of the Point Reyes Headland ASBS (refers to Appendices 3, 5, and 7).

The partial list of Table 7 simply demonstrates the most common invertebrates observed in the short-kelp forest and up into the low intertidal zone. The diversity and abundance of organisms in these shallow waters form the foundation of a complex food web among the ASBS sites.

TABLE 7. MAJOR SUBTIDAL INVERTEBRATES, POINT REYES HEADLAND ASBS
(Appendix 2)

<u>SPECIES</u>	<u>ECOLOGY</u>
<u>Porifera</u>	
<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
<u>Cnidaria</u>	
<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 lefotensis</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
<u>Platyhelminthes</u>	
<u>Leptoplana chloranota</u> ,	polyclad flatworm in crevices, under rocks
<u>Nemertea</u>	
<u>Tubulanus polymorphus</u> ,	red ribbon worm in crevices and holdfasts of kelps
<u>Sipuncula</u>	
<u>Phascolosoma agassizii</u> ,	peanut worm in crevices, under rocks
<u>Annelida</u>	
<u>Platynereis bicanaliculata</u> ,	nerid polychaete in holdfasts, crevices
<u>Serpula vermicularis</u> ,	feather worm on sides of rocks
<u>Eudistylia polymorpha</u> ,	feather duster worm in sandy crevices
<u>Arthropoda</u>	
<u>Crustacea</u>	
<u>Balanus nubilus</u> ,	giant acorn barnacle among the sponges, tunicates
<u>Balanus glandula</u> ,	acorn barnacle on rock surfaces
<u>Idotea</u> spp.,	isopod among the red algae
<u>Metacaprella kennerlyi</u>	skeleton shrimp in hydroids
<u>Betaeus</u> sp.,	pistol shrimp in crevices
<u>Hemigrapsus nudus</u> ,	purple shore crab under rocks, crevices
<u>Pugettia richii</u> ,	masking crab among the red algae
<u>Cancer antennarius</u> ,	cancer crab in crevices, under ledges
<u>Pagurus</u> spp.,	hermit crabs among the red algae

Table 7 (continued)

Major Subtidal Invertebrates, Pt. Reyes Headland

Mollusca

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

Ectoprocta

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

Echinodermata

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

Urochordata

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

4. Invertebrates in the Intertidal Zones

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 here are very similar to species which reside in the subtidal kelp zone.

The kelps Laminaria spp., Alaria marginata, Costaria costata, along with the boa kelp Egregia menziesii, form a thick cover over this Zone 4 region. When the minus tides occur and depart from this area briefly, these algae are matted to the rocks and boulders. Lifting up the kelp reveals nearly the same species of organisms previously described in the short-kelp zone (Table 7). 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 at the western rocks at the Lighthouse area, the surf grass is sparse and shorter in length. The action of waves upon the intertidal rocks reaches such strong magnitude, especially under the Lighthouse area, that these waves may contribute to the decreased biomass of the surf grass community here. 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 coverage 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 intertidal 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, 10 years later, only

a few of these S. purpuratus were located in crevices, and they represented only a small percentage of the population explosion of urchins in 1968. The reasons for this unusual cycle of sea urchins in this area are unknown.

Intertidal Transects

Intertidal transects were established at Chimney Rock and at Split Rock Cove. At Chimney Rock, a 125-meter (410-foot) transect line was laid out (Figure 13) and perpendicular 10-meter transects were randomly selected for population counts. The major organisms at the Chimney Rock transects in 1970 (Chan, 1971) revealed (Table 8):

TABLE 8. MAJOR SPECIES, CHIMNEY ROCK TRANSECT, 1970

	<u>$\bar{X}/m.^2$</u>	<u>95% confidence limits</u>
<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, averaging 0.6 per square meter (Table 8). These small gastropods ranged from 5 to 17.7 cm. (2-7 inches) in length, supporting the observation that these reefs

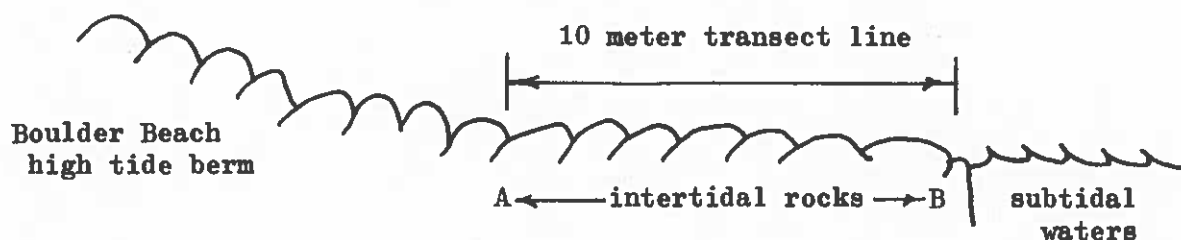
at Chimney Rock may be a nursery ground for young H. rufescens. Likewise, the data from the subtidal census of abalones (Table 6) also indicated that this promontory habitat supports a large, young population of these mollusks.

Another important organism seen in intertidally in 1970 was the gumboot chiton, Cryptochiton stelleri, with a mean of 0.5/m.² Moreover, the sunstar, Pycnopodia helianthoides, registered 0.2/m.² These two organisms are not common on local intertidal reefs, but their appearance here indicates the high diversity of invertebrates at Chimney Rock.

Two 1979 species lists were compiled on February 19 and March 4 to compare with those of the previous samplings of 1970 and 1973. The comparison information (Appendices #3 - 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. The only change noted was that 20 H. rufescens were observed in 1970 in the Chimney Rock intertidal transects, while only one specimen was observed in 1979. Certainly, the intertidal fluctuations of these abalones were not as numerically dramatic as the differences in sea urchin populations between the years of 1968 to 1978 at Chimney Rock, as previously described. The only parameter which might play a role in the reduction of abalones in the Chimney Rock area is the fact that man still is a predator of the mollusk in this subtidal and intertidal locality. Although our intertidal transects are inside the boundary of the California Department of Fish and Game Reserve (Smith and Johnson, 1972), individuals may still prey on available abalones which are easily accessible on these exposed reefs (see boundary, Figure 6).

The intertidal invertebrates in the Split Rock transects, Figure 12,

were very similar (Appendix 7) to those on the species list for Chimney Rock. The major difference is that the Zone 4 invertebrates in the Split Rock intertidal transects occupy a much larger area, far back towards the high tide berm area. The profile of these rocks is nearly horizontal, which helps to account for the similarity of organisms between points A and B, Figure 14.



(not drawn to scale)

Figure 14. 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 14) 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

As in the Chimney Rock habitat, a recent 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, Opa-lia chacei. This wentletrap snail was extremely numerous, 18 per dm.²,

around the root matrix of the surf grass, Phyllospadix torreyi. This snail is often observed under rocks or with sea anomones (Smith and Carlton, 1975), and its appearance in large numbers around the surf grass is but 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.

It seems over the years, my students and I record increasingly more and more species, and the probable reasons are more thorough examination by observers based on backup data, greater familiarity with the area by observers including myself, and valuable identification of species from the revised Light's Manual (Smith and Carlton, 1975).

At a site not in our Split Rock transects, my students and I thoroughly enjoy viewing the "corridor tidepool" on the north side of the major sea stack at the east side of Split Rock Cove (Figure 12). This oval granitic tidepool is shaped like a giant bowl, about 1.5 meters in all dimensions, and is probably a result of wave erosion in this particular site. 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-sized mussels, Mytilus californianus. Some of these mussels average around 21.3 cm. (8 inches), which is considered large for the Central California coast. The record size mussel for the Pacific Coast is 26 cm. (10-1/8 inches) from a Baja California seamount (Chan, 1973).

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, and waves move upon these areas throughout the mid-tidal range. In the wash rocks inhabited by the sea lions, there are zoned bands of surf grass, P. torreyi, and California mussel, M. californianus (Figure 15).

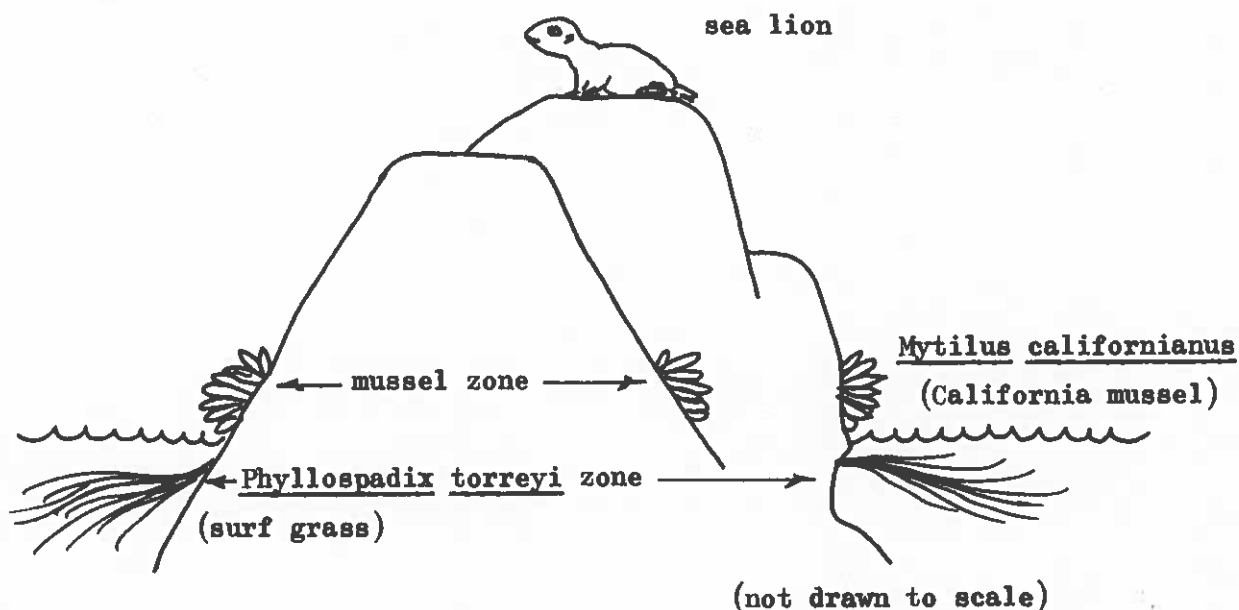


Figure 15. ZONATION of SURF GRASS AND MUSSELS around SEA LION WASH ROCKS

The marine invertebrates within the mussel-goose barnacle matrix are very similar to Hewatt's 1931 summary of organisms (Hedgpeth, 1968) from a square yard of mussel bed (Appendix 8).

The major organisms of these beds are:

Mytilus californianus, California sea 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 illustrated very coarse granitic sands during the winter months to medium grain size sands during summer months when the beaches have a more gentle slope. The waves during the winter months are very

intense and large, while during summer months the waves are more gentle; thus, finer particles of sand are deposited on these small beaches.

5. Vertebrates of Point Reyes Headland ASBS

a. The Fishes

The fishes of Point Reyes Headland are an important part of the food chain in this area. Due to the strong wave surge in this area, only a small number of fish species was observed in the shallow waters and intertidal zone. The fish are grouped into the habitats 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 violaceus</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>Oligocottus synderi</u> (P) (fluffy sculpin)

The fish, Table 9, are notated as to their feeding habits, following the work of Hobson and Chess (1976). The feeding behavior classifications are (1) hunting or stalking its prey, (2) picking or crushing its prey, and (3) plankton feeding.

Since the Point Reyes Headland ASBS does not have elongated kelps such as Nereocystis sp. and Macrocystis spp. due to strong wave actions of this headland area, there is no significant protective habitat for offshore fishes (Mitchell and Hunter, 1970). The fishes recorded in Table 9 were species observed in the short kelp and intertidal communities; nine species were recorded as part of the short kelp zone and ten species associated with the intertidal zone.

Of the twenty subtidal dives made here at the headland waters over a period of 23 years, an abundance of fish has not been observed as has been seen in other areas of Marin County. The copper rockfish, Sebastes caurinus, and the rock greenling, Hexagrammos superciliosus, were most often recorded in the short kelp zone, along with the lingcod, Ophiodon elongatus. With the large population of California sea lions, Zalophus californianus, in the area, I have sometimes wondered if these mammals play a role in keeping the numbers and diversities of near-shore fishes at a low profile. In their field study of fishes and drifting kelp, Mitchell and Hunter (1970) observed large Z. californianus prey on fish in the open seas and among the kelp beds. In October of 1975, while diving on Tanner Banks 185 kilometers (100 miles) west of San Diego, I observed several large Z. californianus feeding on fish above the Tanner Bank reefs. These reefs are about 111 kilometers (60 miles) from San Clemente Island, the natural habitat for these sea lions.

On the other hand, I have observed the California sea lions feed adjacent to island reefs in the Gulf of California. These mammals certainly do interact with the fish populations of our nearshore reefs and open ocean.

The intertidal fish population consists basically of sculpins and blennies. The most common sculpins are Clinocottus spp. and Oligocottus synderi. The blennies most abundant 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.

b. The Birds

The marine birds at the Point Reyes Headland ASBS site 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.

The data in 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. On four occasions, when I dove in the area, I observed that murres nearly blanketed these rocks

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

SPECIES	Number of Breeding Pairs per Breeding Site					
	Tomales Point	Bird Rock	Pt. Reyes Headland	Bear Valley	Double Point	Total
<u>Oceanodroma homochroa</u> (Ashy Storm-Petrel)		5				5
<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>Cepphus columba</u> (Pigeon Guillemot)	4	12	24		1	41
Breeding Site Totals	90	50	4604	225	962	5931

(see Appendix 11, slides 17 and 19, for a sea view of about 3,500 of these birds on September 25, 1975). 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. The cormorants occupy the lower portions of Murre Rock, Figure 5, as well as other sea stack rocks eastwardly to Chimney Rock.

Sarah Allen, a marine biologist from the Point Reyes Bird Observatory, has also recorded large numbers of murrees and cormorants at Double Point, 16.7 km. (9 nautical miles to the southeast of the

Point Reyes Headland (Map, Figure 1). In 1978, she estimated about 3,000 Common Murre, on the 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 by my students and myself over a period of sixteen years.

TABLE 11. MAJOR BIRDS SIGHTED FREQUENTLY, 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

c. The 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 this 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, page 9). Allen (1978) counted 594 P. vitulina at Double Point on May 12, 1977. 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 (Figure 9). A fourth marine mammal which has been reported at the Headland area is the elephant seal, Mirounga angustirostris. This seal has been known to visit the coast of British Columbia and Alaska (Pike and MacAskie, 1969). The seasonal relationships of both the harbor and elephant seals at Point Reyes are unknown at the present time.

On December 7, 1958, I observed and photographed more than 1800 California sea lions, Z. californianus, in Sea Lion Cove (Appendix 11, Slide 13). This may be one of the largest counts of the Z. californianus in Northern California (Allen, 1978). About 1,400 were counted at the Farallon Islands in 1974 and 1975 (Ainley et al, 1977). The populations at the Farallon Islands seem to sustain larger numbers than at the Point Reyes Headland, for on December 7, 1959, one year later at Sea Lion Cove, I counted only 105 sea lions (Appendix 11, Slide 14). I do not have any information as to the reasons for these seasonal fluctuations of sea lions at these Headland sites.

Likewise, populations of California sea lions in British Columbia undergo seasonal movements. Spaulding (1964) in his study of the distribution stated that sea lion migrations in his study areas are not fully understood. During the 1956-57 summer months, he reported, some 1300 adults were concentrated on two rookeries in British Columbia, but

he also found that 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. I have often wondered about the fluctuations of these large numbers of sea lions at Point Reyes Headland; do they migrate north to Oregon or south to Southern California? 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). Thus, the observations of 1800 sea lions in December of 1958 show a large, significant population of Z. californianus among Pacific Coast rookeries.

The feeding of hundreds of sea lions around the Point Reyes Headland remains an unknown factor. I have observed the limited shallow water feeding habits of sea lions in the littoral zone of this ASBS area. Hobson (1966) has also observed similar nearshore feeding habits of sea lions in both diurnal and nocturnal hours. However, I suspect that the feeding ecology of the Point Reyes sea lions is similar to that of sea lions occupying the waters of British Columbia. In Spaulding's analysis (1964) of these sea lions, the feeding begins late in the evening and reaches a peak during the hours of darkness. During some yearly seasons, the stomachs of sea lions reveal a dominance of rockfish, while in other seasons, herring and salmon dominate the intestinal contents. Although no stomach analysis of Point Reyes sea lions has taken place, it seems reasonable these continental shelf waters probably provide the

necessary fish supplies to sustain the hundreds of marine mammals which utilize Point Reyes Headland and adjacent areas as a habitat. At the Farallon Islands, the hake fish, Merluccius productus, was common during the peak productions of sea lion Zalophus, according to Ainley et al. (1977).

The second marine mammal dominating the Point Reyes Headland rocks is the giant northern or Steller sea lion, Eumetopias jubatus. Although the Federal Register (1975) prefers the common name "northern", I shall utilize the name "Steller" as used in the systematics by Orr and Poulter (1967) and Ainley et al. (1977). The Steller sea lion generally ranges from the Channel Islands in California to Alaska, with large population estimates off the coast of British Columbia, numbering 11,000 to 12,000 by aerial census (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 aerial census between 5,000 and 7,000 (Federal Register, 1975). The reports which I have read (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 highest estimate of Steller sea lions on the Point Reyes Headland which I have counted from an offshore skiff is 78 on December 12, 1967. My estimates of Steller sea lions in other years ranged from 49 to 70 throughout the seasons of 1955 to 1978, and the population seems to be steady within this numerical range. At the Farallon Islands the breeding population in June-July appears to be stabilized at about 130 mammals (Ainley et al., 1977). Observations by Orr and Poulter (1967) between 1961 and 1977, on Año Nuevo Island, showed counts of adult Stellers from 203 to 715. On

October 25, 1966, they counted a total of 1,140 adults, yearlings and pups. This island appears to be the largest rookery of Steller sea lions in Northern California.

The Steller sea lion, E. jubatus, favors isolated locations, occupying the offshore rocky reefs and sheltered rocky coves. At the Point Reyes Headland, the Stellers occupy the offshore rocks between Sea Lion Cove and Split Rock Cove (Figures 6 and 9). These 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 (Appendix 11, Slides 8 to 12). This population of E. jubatus has resided here at the Headland for many years, at least for the 23 years of my observations. An important reason for the longevity of the marine mammals here is the protection from human interference as provided by these rocks. When we first traversed our small boats to Sea Lion Cove in the early 1960's, we found that if we came within 100 meters (328 feet) of the rocks, the Stellers would begin to dive into the waters from their resting spots, some as high as 5 meters (16 feet) above the water. 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). In subsequent trips there, we always tried to keep a safe distance to avoid disturbing these sensitive mammals.

The sizes of these E. jubatus residing at the Headland appear to approach the statistics cited by the Federal Register, 1975, that adult males may grow to 3.0 meters (9.8 feet) in length and over 900 kg (1,984 lbs) in weight. Some of the adult males are very large (photographed in Appendix 11, Slides 10 and 11) and

may come close to the size scale cited above. Although their age is unknown, the Federal Register (1975) reports that some may live 17 years in the wild.

Although I have never seen an actual birth of E. jubatus or Z. californianus here at Point Reyes Headland, one can readily observe young pups with the dark chocolate-colored coat throughout the early summer months on the rocks and beaches of Sea Lion Cove. I am convinced that the Headland is a breeding rookery for both species of sea lions, very similar to the rookeries at the Farallon Islands (Ainley et al., 1977) and Año Nuevo Island (Orr and Poulter, 1967). In June 23, 1975, while tagging some abalones at area C of Split Rock Cove, Figures 6 and 9, I observed some very young pups on a nearby wash rock some 50 meters (164 feet) from our work area. We did not realize that we had intruded into their breeding and pupping time of June-July (Ainley et al., 1977)(Orr and Poulter, 1967): therefore, I was thoroughly stunned when a large-sized female rammed my backside, knocking me two meters (6.5 feet) at the water surface. I can still visualize that gigantic face of a female Steller sea lion, with half of her head in a molted stage, about 60 cm. (24 inches) from me. Somehow I slowly moved away and motioned to my diving companions to retreat back to shore. I have always been grateful that this female Steller gently nudged and warned me about honoring their habitat during their June and July breeding months.

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 Headland sites other than the observation 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 here 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, which migrates past the Lighthouse Point. The College of Marin has compiled partial data on this whale:

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 30 meters (100 ft) of outer rocks.
Jan. 1-Feb. 4, 1968	9	104	Whalers killed 2 mammals.
Jan. 15-29, 1969	3	18	Some within 457 meters (500 yds) of shore
	—	—	
	27	220	

Along with the data on the grey whale sightings off the Lighthouse Point in Table 12, I previously mentioned that on December 1, 1977, while diving at Split Rock we had observed a mother grey whale and her calf feeding on a dense mass of pelagic shrimps (Section B, Plankton data). The Point Reyes Headland ASBS locality seems to be an important landmark for these migrating E. robustus each year.

The only other mammal observed in and around the Point Reyes Headland over the 23 years has been the domesticated cows of the local rancher, some of which traverse down into the "slump-off" trails of the Split Rock Cove area (Figure 12).

6. Land Vegetation

The information for the Point Reyes upland vegetation description was compiled from Howell's work (1970).

Howell has listed over 750 species of plants in the Point Reyes National Seashore Park; this total represents more than 50% of the reported species in Marin County and about 15% of the total flora of California. He has also listed six plants which 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 vegetation of Point Reyes can be grouped into communities which are basically influenced by differences in the ecological tolerances of the flora and by the heterogeneity of the environment. The type of community which prevails here at Point Reyes Headland is the coastal scrub and grassland community. The dominant plants here 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 forementioned scrubs are common in the area mixed with an abundance of the annuals and perennial grasses such as barley, annual rye, California oatgrass and wild rye.

Scattered throughout the upland area where man has built some homes are the introduced cypress, mostly Cupressus macrocarpa.

7. 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, Figure 6. On December 7, 1958, one of the largest recorded populations of the California sea lion, 1800 (more or less) of these organisms, was counted on the winter beach here, Appendix 11, Slide 13. At the Farallon Islands, 1400 were counted in 1974 and 1975 (Ainley et al., 1977).

The large-size Steller sea lions, averaging 40 to 70 individuals throughout my years of study, also breed here in June-July. These Stellers require offshore rocks where there is no human disturbance. Harassment by man will drive these marine mammals away and force them to seek other permanent habitats (Federal Register, 1975).

The six listed sea birds all breed at the Point Reyes Headland ASBS (Ainley and Whitt, 1973). The Common Murre, Uria aalge, permanently resides on "Murre Rock" just below the Lighthouse at the western promontory. In 1973, Ainley and Whitt estimated some 3800 murrees breed here and over 3000 of these birds are illustrated in Appendix 11, Slide 19. 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 (Figure 2) 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 the state waters and it is here at Point Reyes Headland that this organism has grown to large sizes, some over 25.4 cm. (10 inches) 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 the Lighthouse Point.

The combination of the abalone and other invertebrates with the breeding sea lions and sea birds enables the Point Reyes Headland ASBS to have as many assets for a marine environment as any habitat on the California coast. Adding the diversity of marine organisms to the physical Headland features provides this ASBS locality with its unique components.

C. LAND AND WATER USE

Discussion of the land and water use of the Point Reyes Headland ASBS will be sub-divided under the following headings:

1. Marine Resource Harvesting
2. Historical Governmental and Recreational Use
3. Scientific and Educational Use

1. Marine Resource Harvesting

a. 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, crabs, 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, iced and trucked to San Francisco for sale and distribution. Occasionally, when fishing is good, albacore may also be landed for sale distributions. The Pacific oysters are raised commercially in nearby Drakes Estero (Smith, 1973).

In Marin County, the major local commercial fishing ports are Tomales Bay, Point Reyes (Drakes Bay), and Sausalito. Major commercial species landed for all Marin County ports are (Table 13):

TABLE 13. COMMERCIAL LANDINGS, MARIN COUNTY PORTS
Major Species, 1966-70 (Smith, 1973)

Species	Avg. Annual Landings Thousands of Pounds	Accumulated Landings Thousands	
		Pounds	Value
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
Oysters, giant Pacific	199	989	243

(There was no breakdown for landings in Drakes Bay)

Salmon and albacore tuna dominate the annual landings in pounds, with salmon drawing the highest dollar value as shown in Table 13. In combining the total commercial fish landings for all San Francisco Bay area counties, 1966-1970, Smith (1973) cites that the albacore tuna, the dover sole, English sole, petrale sole, salmon, and rockfish are the leading fish in poundage and dollar value.

For the impact on commercial fishing from Marin County ports, no breakdown of areas is provided other than the statement that salmon fishing is the primary activity in Marin County. In 1970, a total of 28,500 salmon were caught, bringing in a value of \$222,000 to the commercial fishing returns for Marin County (Appendix 9). In the assessment of potential oil drilling leases in Northern California, the Bureau of Land Management considers the Point Reyes Peninsula as "an important oyster culture, party-boat and commercial fishing area" (Bureau of Land Management, Pacific OCS Office, 1978).

b. 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 area was at Chimney Rock and at 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. There has been a 200% increase in diving days from Point Arguello to Oregon since 1960 with a 50% increase in catch (Burge et al., 1975).

As mentioned in the discussion involving Table 6, the population of abalones in the Point Reyes Headland Reserve has multiplied and the sizes of these abalones have increased, especially at Split Rock Cove.

2. 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 ($\pm$)	Inhabited by Coast Miwok Indians
1579	Sir Francis Drake may have sailed his vessel, GOLDEN HINDE, 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 27 km (15 miles) 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 82.8 km (44.7 miles) of ocean front and 68.6 km (37 miles) 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). By using a road traffic counter and employing a mathematical factor to separate out local traffic, Brock (1978) estimated that about 272,108 persons traveled to the Headland area in 1978, making it one of the most popular visitation areas. The park has set up signs warning visitors to keep away from the Headland cliffs and that hiking down to the south-facing reefs of the Headland is prohibited and dangerous.

In Table 14, the history of the 14 ship and aircraft wrecks at the Point Reyes Headland is recorded, especially during the early years when navigational equipment was not as efficient as present day models. The only shipwreck still present is the MUNLEON, with

its large hull plates scattered in about 6 meters (20 feet) of water in the eastern portion of Split Rock Cove, Figure 12.

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

3. Scientific and Educational Use

When the Point Reyes Headland Reserve was set up in 1972, there was much intention to promote scientific and educational use of the habitat. After seven 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 in the reserve lands has been the inaccessibility of the habitats for meaningful studies. The cliffs of granite 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% of the assigned times. Teachers and professors have taken

students to the more protected Chimney Rock area for intertidal educational field trips.

The research in ecological and behavioral studies of the marine mammals and sea birds within the Point Reyes Headland ASBS habitat 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.

D. POLLUTION THREATS TO POINT REYES HEADLAND ASBS

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 locality to have few pollution threats. The nearest town is Bolinas, about 30 km (16 nautical miles) from the Headland while San Francisco is about 59 km (32 nautical miles) away. I doubt if any of the municipal or industrial wastes of these communities could affect this ASBS site. 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 intestinal E. coli 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. Other potential pollution threats are as follows:

1. Dredging-Sedimentation

The only threat of dredging or sediment disposal activity might come from a source reported by McCampbell (1969), as follows. Based on the theory that the west side San Andreas fault is moving northward about 2.5 cm. (1 inch) 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 in the sands particles of flour gold, an extremely fine gold of the consistency of talcum powder in the samples, around 0.4 mm. (0.016 inches). 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 Lands 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. The following were conditions of the permit:

1. The Regional Water Quality Control Board stated that turbidity may not be created above the background at a distance beyond one-half mile from the operating equipment.
2. The Fish and Game Commission stated that operations must be more than one-half mile offshore and that sedimentation would not be permitted in the vicinity of the Headland in the kelp beds which are refuges for sea life.
3. The royalty to the State Lands Division for precious metals would be 5 and 6 percent at \$1/yd.³

All of the above information was taken from McCampbell's report (1969) and no action or operation on the 1968 permit has taken place. I seriously doubt if this gold project would ever materialize into a production basis.

2. 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, namely, the University of California Cyclotron, Hunter's Point naval facilities, and the Lawrence Livermore Laboratory, dumped over 47,500 barrels of radioactive waste southwest of the Farallon Islands (Figure 16). 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)

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

About 25% of the total of 47,500 barrels had imploded (Dyer, 1975). Current studies by Dyer indicate that for 27 days the vector plot for water movement from these sites was clearly northward, towards the Point Reyes Peninsula. Tidal currents, upwelling, and factors of irregular benthic topography are other variables which compound the problems of current movement. 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 2,000 meters (6,560 feet) and this concentration does exceed anticipated fallout levels. This potential pollution should warrant concern and attention from state and federal agencies.

3. Offshore Oil Development and Oil Discharge from Vessels

In January of 1971, two Standard Oil of California tankers collided under the Golden Gate Bridge. About 840,000 gallons of Bunker C fuel 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).

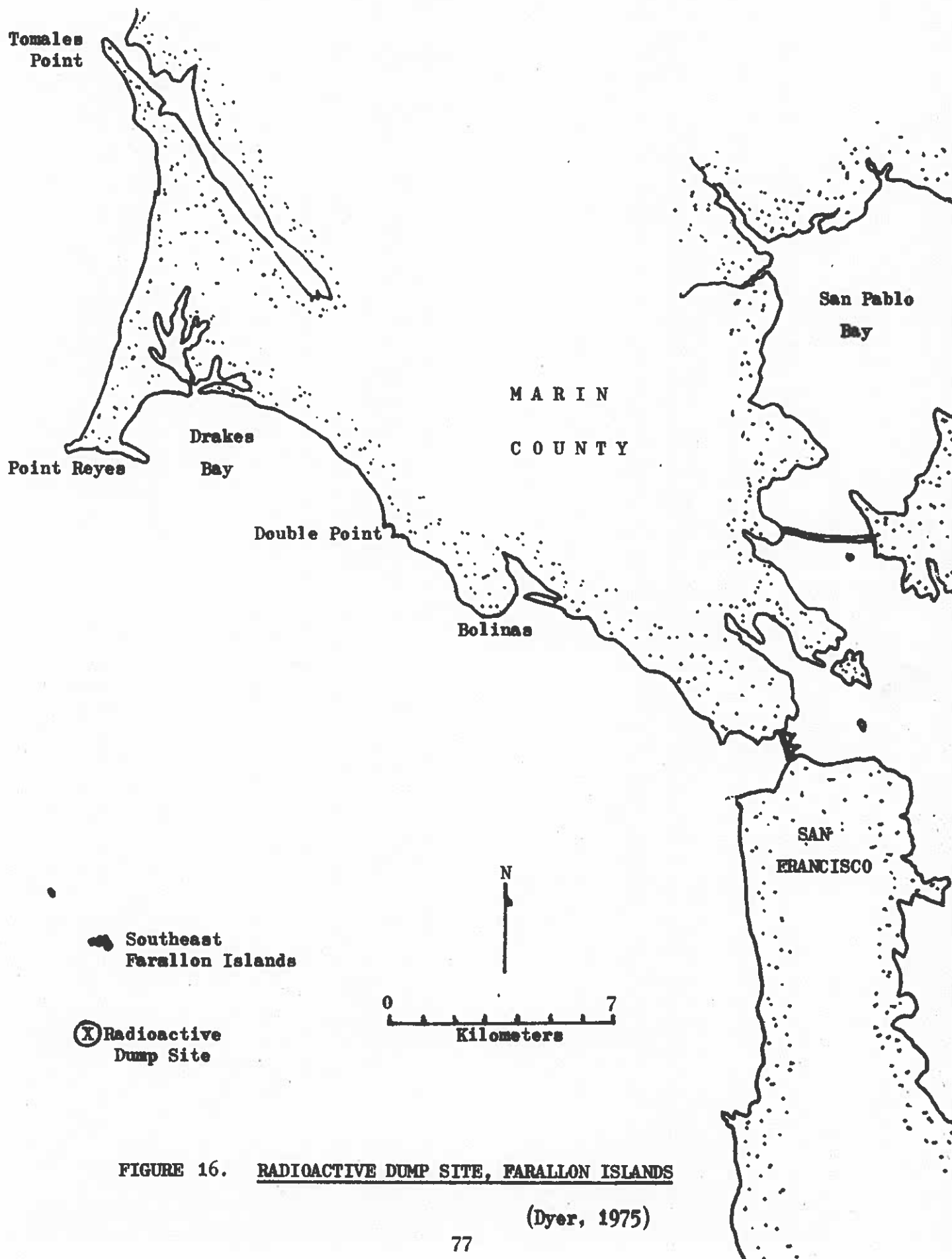


FIGURE 16. RADIOACTIVE DUMP SITE, FARALLON ISLANDS

(Dyer, 1975)

Others had estimated that the mortality may have been closer to 20,000 birds (Smail, et al., 1972). I had estimated (1972) that about 4.2 million invertebrates were smothered by the oil in my intertidal transect site areas around the Marin County coastline. With the increased oil tanker traffic between the Alaskan oil 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 under way, 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 28 km. (15 miles) of the Point Reyes National Seashore boundaries. This protected zone will not fully prevent the marine organisms from being affected by oil spills since sea birds are particularly vulnerable to such catastrophic and chronic 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

In summary, the major recognizable pollutant threat to the Point Reyes Headland ASBS seems to be from potential oil spills from tanker traffic moving up and down the Northern California waters. If the offshore continental shelf oil and gas drilling activities commence, then there are potential hazards to the marine organisms of the Headland ASBS. The recycling of plutonium at depths of 2,000 meters (6562 feet) south of the Farallon Islands could also pose a threat to the food chain if northward moving currents do carry these radionuclides to the Point Reyes waters. If mining permits were in operation, sediments from these marine activities could pose a hazard to the filter-feeders of the ASBS.

The following threats are low risk because they do not exist in significant proportions in the immediate Point Reyes Headland ASBS: municipal and industrial sewage wastes, cooling water effluents, dredging and spoil disposals, agricultural waste runoffs, lower salinities due to fresh water runoffs, and contaminants from marine harbor developments. The protection afforded by the Point Reyes National Seashore Park also enhances this ASBS locality from the terrestrial intrusion by man's environmentally damaging tendencies.

E. SPECIAL WATER QUALITY REQUIREMENTS

If a large community-composite sewage outfall system were to be constructed for the city of San Francisco and other bay area communities, and if the discharges were to be dumped into the Gulf of the Farallones where northwesterly tidal countercurrents (Figure 7) might carry the effluent to the Point Reyes ASBS, then the waters of this area should be closely monitored. Such discharge waters may cause the following problems:

1. Suspended and dissolved organics could nourish less favorable Monera (bacteria), Protista, and other organisms (sea urchins), thereby severely affecting the established food chain of this ASBS locality.
2. The discharged toxicants might affect nearby sensitive species (fish and crab larvae) within the ASBS.
3. Concentrations of effluents with slow biodegradable pollutants might increase algal organisms, thus causing eutrophication conditions.
4. Strange tastes or odors might cause pelagic fishes to shun the ASBS and thus remove important links in the ecological food web.

The monitoring of effluent waters should have a standard of dilutions greater than 100 to 1. Dilutions less than this ratio will have adverse effects on the market crab, Cancer magister, the pelagic shrimps such as Pandalus spp. and Mysis spp. (Brown & Caldwell, 1971). Effluent waters might also raise the temperature of waters near outflow systems; many of the coast rockfish, Sebastes spp., could have serious problems in waters greater than 15°C. (59° F.) (Brown & Caldwell, 1971).

Since large sewage discharge systems are not within the current list of viable projects for the San Francisco Bay area, the above effluent problems are remote. The water quality of the Point Reyes Headland ASBS is deemed quite good in comparison to the marine waters closer to urban centers.

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	Sample No.	1611	1613	1615	1617	1618
Km from Double Pt.	11.1	9.2	10.2	13.9	13.0	
Nautical miles from Double Pt.	6.0	5.0	5.5	7.5	7.0	
Total sample weight (grams)	268.0	497.0	233.0	1258.0	1214.0	
% of organic hard parts	0.4	0.2	2.8	0.5	10.5	
COLLECTED SPECIES		Numbers of Individuals				
PROTISTA						
Foraminifera						
<u>Elphidiella hannai</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			

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 barbarensis</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					
VERTEBRATA					
Vertebrae		1			1
Fish dermal plate					1

j = juvenile

Major Species ListA. CHLOROPHYTA (Green Algae)Codium fragileC. setchelliiCladophora columbianaUlva californicaU. lobataU. taeniataEnteromorpha intestinalisSpongomorpha coalitaBryopsis hypnoidesB. PHAEOPHYTA (Brown Algae)Ralfsia pacificaNereocystis luetkeanaDesmarestia ligulata var. ligulataLaminaria dentigera (L. andersonii)L. farlowiiLessoniopsis littoralisCostaria costataAlaria marginataEgregia menziesiiPterogophora californicaDictyoneurum californicumCystoseira osmundaceaPostelsia palmaeformisPelvetia fastigiataPelvetiopsis limitataFucus distichus endentatusC. RHODOPHYTA (Red Algae)Calliarthron tuberculosumBosiella californicaMesophyllum 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					

Appendix 2 (continued)

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

	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Deep Rocks	Short Kelp	4	3	2	1
	25'	15'				
<u>Lithothamnium</u> spp.	*x		x	x	x	
<u>Rhodomenia arborescens</u>	x					
<u>R. californica</u>	x	x				
<u>R. callophyllidoides</u>	*x	*x				
<u>Callophyllis pinnata</u>		x				
<u>C. violacea</u>		x				
<u>Fryxella gardneri</u>		x				
<u>Pterochondria woodii</u>		x				
<u>Botryoglossum farlowianum</u>		*x	x			
<u>Ceramium pacificum</u>		x				
<u>Callithamnion pikeanum</u>		x				
<u>Microcladia coulteri</u>		x				
<u>M. californica</u>			x			
<u>Rhodomenia pacifica</u>		x				
<u>R. palmata</u>			x			
<u>Corallina officinalis</u> var. <u>chilensis</u>		*x	*x			
<u>Bosiella orbigniana</u>		x				
<u>Lithophyllum imitans</u>		x				
<u>Gymnogongrus linearis</u>		x	x			
<u>Iridaea cordata</u> var. <u>splendens</u>		*x	*x			
<u>Porphyra pulchra</u>		x	x			
<u>P. perforata</u>			x	x	x	
<u>P. smithii</u>		x	x			
<u>Prionitis lanceolata</u>			x		x	
<u>Erythrophyllum delesserioides</u>		*x	x			
<u>Callophyllis linearis</u>			x			
<u>Plocamium violaceum</u>		x	x			
<u>Gracilaria sjoestedtii</u>		x	x			
<u>Neoptilota densa</u>			x			
<u>Rhodomela larix</u>				x		
<u>Cumagloia andersonii</u>					x	
<u>Odonthalia floccosa</u>				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
Hymeniacidon 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

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	
x	x				

* Major species

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 opisthopora</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>Phyllospadix</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

Cirripedia (Barnacles)

Balanus glandula

Balanus cariosus

Chthamalus dalli

Pollicipes polymerus

Copepoda

Tigriopus californicus

Isopoda

Idotea sp.

Idotea wosnesenskii

Amphipoda

Photis sp.

Ampithoe sp.

Caprellidea

Metacaprella kennerlyi

Caprella equilibra

Decapoda

Betaeus sp.

Pachygrapsus crassipes

Hemigrapsus nudus

Mimulus foliatus

Scyra acutifrons

Pugettia producta

Pugettia richii

Pugettia gracilis

Cancer productus

Cancer antennarius

Fabia subquadrata (in Mytilus)

Paraxanthias taylori

Spirontocaris sp.

Cryptolithodes sitchensis

Hapalogaster cavicauda

* Major species

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 hirsutiusculus

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)

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	

* Major species

Appendix 3 (continued)

Marine Invertebrates, Point Reyes Headland, 1955-1979

G. Chan

(MOLLUSCA)

Gastropoda (snails, slugs)

	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Base of Sea Stack Rocks 6m	Short Kelp Canopy 6m	4	3	2	1
<u>Acmaea mitra</u>		x	x			
<u>Collisella asmi</u>					x	
<u>Collisella digitalis</u>				*x	x	*x
<u>Collisella limatula</u>			x		x	
<u>Collisella pelta</u>					x	
<u>Collisella scabra</u>				*x	x	*x
<u>Notoacmea insessa</u>		x	x			
<u>Notoacmea persona</u>				x	x	
<u>Notoacmea scutum</u>				x	x	
<u>Opalia spp.</u>			x			
<u>Nucella spp.</u>			x			
<u>Calliostoma annulatum</u>	x	*x	x		x	
<u>Calliostoma canaliculatum</u>		x	x		x	
<u>Tegula brunnea</u>		x	x		x	
<u>Tegula funebris</u>				x	*x	
<u>Littorina planaxis</u>					x	x
<u>Littorina scutulata</u>				*x	x	*x
<u>Crepidula adunca</u>					x	
<u>Ceratostoma foliatum</u>	x	x	x			
<u>Acanthina spirata</u>				x	x	
<u>Searlesia dira</u>		x	x		x	
<u>Amphissa versicolor</u>		x	x		x	
<u>Trimusculus reticulatus</u>			x	x		
Opisthobranchia (sea slugs)						
<u>Acanthodoris nanaimoensis</u>		x	*x		x	
<u>Aeolidia papillosa</u>		x	x		x	
<u>Anisodoris nobilis</u>	x	*x	x			
<u>Antiopella barbarensis</u>			x		x	
<u>Archidoris montereyensis</u>	x	x	x		x	
<u>Cadlina sp.</u>		x	x		x	
<u>Coryphella trilineata</u>			x			

* Major species

Appendix 3 (continued)

Marine Invertebrates, Point Reyes Headland, 1955-1979

G. Chan

(MOLLUSCA, Gastropoda)

Opisthobranchia (sea slugs)

Diaulula sandiegensisDirona albolineataDirona pictaHermisenda crassicornisHopkinsia rosaceaPhidiana pugnaxRostanga pulchraTriopha carpenteriTriopha maculata

Bivalvia (Bivalves)

Mytilus californianusPenitella penitaHiatella arctica

Cephalapoda

Octopus sp.

ECTOPROCTA (Bryozoans)

Flustrellidra corniculataCrisia maximaBugula californicaBugula neritinaMembranipora membranaceaMembranipora fuscaTricellaria occidentalisHippodiplosia insculpta

ECHINODERMATA

Asteroidea (seastars)

Pycnopodia helianthoidesDermasterias imbricataHenricia leviusculaPatiria miniataLeptasterias hexactisLeptasterias pusilla

	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	*x		*x	
		x	x		x	
		x	x		x	

* Major species

Appendix 3 (continued)

Marine Invertebrates, Point Reyes Headland, 1955-1979

G. Chan

(ECHINODERMATA, Asteroidea — seastars)

Pisaster brevispinusPisaster ochraceus

Ophiuroidea (Brittle stars)

Amphiodia occidentalisOphiopholis aculeataOphiothrix spiculata

Holothuroidea (sea cucumbers)

Stichopus californicusEupentacta quinquesemitaCucumaria miniataLeptosynapta albicans

Echinoidea

Strongylocentrotus franciscanusStrongylocentrotus purpuratus

CHORDATA

Urochordata

Aplidium californicumAplidium propinquumDiplosoma macdonaldiClavelina huntsmaniArchidistoma molleDidemnum 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 lactucaSpongomorpha coalita

Phaeophyta (brown algae)

Costaria costataDesmarestia ligulataRalfsia pacificaEgregia menziesiiAlaria marginata

Rhodophyta (red algae)

Iridaea splendensCorallina officinalisMicrocladia coulteriGigartina canaliculataOdonthalia floccosaGigartina cristataPrionitis lyalliiInvertebrates

Cnidaria

Anthopleura elegantissimaAnthopleura xanthogrammicaEpiactis prolifera

Annelida

Glycera americanaSabella mediaSerpula vermicularisEudistylia polymorpha

Arthropoda

Cancer productusCancer antennariusPugettia productaBalanus glandulaBalanus nubilusPagurus hemphilliPagurus samuelisIdotea resicata

Mollusca

Pododesmus macroschismaTegula brunneaTegula funebrisCryptochiton stelleriHaliotis rufescensHaliotis cracherodiiHemissenda crassicornisHaliotis walallensisDiaulula sandiegensisAnisodoris nobilisCalliostoma ligatumCollisella sp.Hinnites multirugosus

Bryozoa

Bugula californica

Echinodermata

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

Chordata

Styela montereyensisAplidium californicumAplidium arenatumClavelina 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 greenieiAglaophenia 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 coalita
Codium fragile

Phaeophyta (brown algae)

Egregia menziesii
Laminaria dentigera
Alaria marginata

Rhodophyta (red algae)

Odonthalia floccosa
Corallina chilensis
Rhodomela larix
Gigartina cristata
Gigartina exasperata

Invertebrates

Platyhelminthes

Leptoplana chloranota

Cnidaria

Anthepleura elegantissima
Anthepleura xanthogrammica
Epiastis prolifera
Tealia sp.
Corynactis californica
Aglaophenia latirostris
Abietinaria greenei

Annelida

Platynereis sp.
Serpula vermicularis
Spirorbis sp.

Arthropoda

Pagurus samuelis
Pagurus hemphilli
Pagurus hirsutiusculus
Idotea resecata
Ligia occidentalis
Pollicipes polymerus
Balanus glandula
Balanus cariosus
Cancer antennarius
Cancer productus
Hemigrapsus nudus
Pachygrapsus crassipes
Pugettia producta
Petrolisthes cinctipes
Pachycheles rudis
Hapalogaster cavicauda

Mollusca

Mytilus californianus
Littorina planaxis
Littorina scutulata
Collisella persona
Acmaea mitra
Collisella digitalis
Collisella scabra
Collisella pelta
Thais emarginata
Thais lamellosa
Thais canaliculata
Diodora aspera
Tegula funebris
Tegula brunnea
Mopalia lignosa
Tonicella lineata
Cryptochiton stelleri
Haliotis rufescens
Octopus sp.

Echinodermata

Amphiodia sp.
Patiria miniata
Dermasterias imbricata
Leptasterias sp.
Pisaster ochraceus
Strongylocentrotus purpuratus

Chordata

Clavelina huntsmani
Aplidium 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 cordataPorphyra 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 macrohimaTegula 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 californicumAplidium arenatumClavelina huntsmani

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

<u>Species</u>	<u>Total</u> <u>Count</u>	+ = present at North Double Pt. 1975-78
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 Steelhead

Smith
(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.

APPENDIX 10**PHOTOGRAPHS, POINT REYES HEADLAND**

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A. Point Reyes Headland, Aerial View (U.S. Coast and Geodetic Survey, 1957)	107
B. Wave Trains, Chimney Rock, Point Reyes Headland (U.S. Fish & Wildlife, 1961)	108
C. Split Rock, Point Reyes Headland (Chan, 1957)	109
D. Sea Lion Cove, Point Reyes Headland (Chan, 1957)	110

APPENDIX 11.

Color 35 mm Slides, Point Reyes Headland

(Chan, 1957-1978)

Slide No.

1. Chimney Rock, 1975
2. Saddle Cove, 1968
3. Pelican Arch area, 1977
4. Abalone Shack, Split Rock Trail, 1957
5. Split Rock Cove, 1957
6. Split Rock, 1962
7. Abalones, Haliotis rufescens, July 1970
(Split Rock Transect)
8. Steller sea lions, July 1976
9. Steller sea lions, September 1975
10. Family of Steller sea lions, July 1976
(with young pups)
11. Steller sea lions, July 1976
12. Steller sea lions, July 1976
13. California sea lions, 1800±, December 7, 1958
14. California sea lions, 105, December 7, 1959
15. Sea Caves, Lighthouse Point, 1975
16. Conglomerate rocks, Lighthouse, 1975
17. Murre Rock, Lighthouse, September 1975
18. Lighthouse Point, September 1975
19. Murre Rock, Lighthouse Point, 3500± Murres, September 25, 1975
20. Wreck, Lelani Nalulani, Point Reyes Beach, October 1978

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