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California Marine Waters
Areas of Special Biological Significance
Reconnaissance Survey Report

BIRD ROCK

CALIFORNIA MARINE WATERS

AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

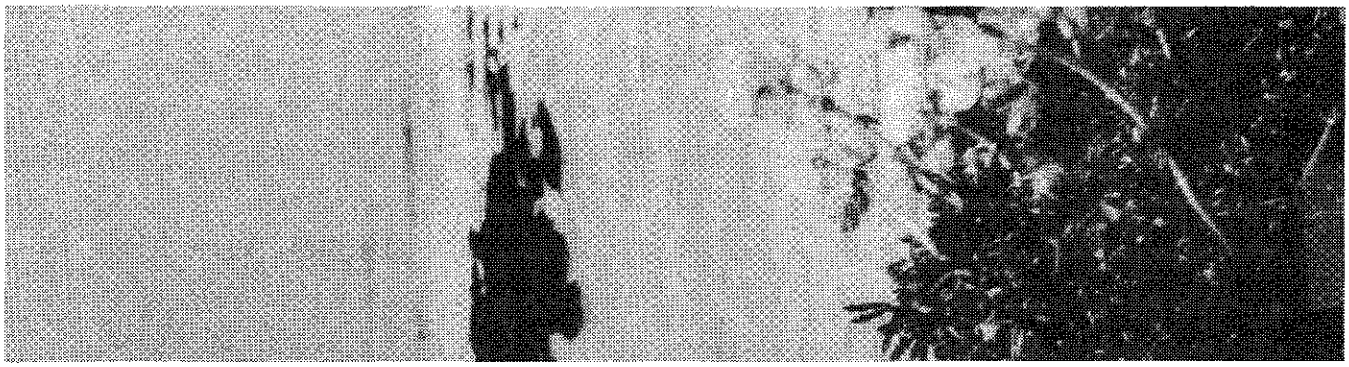
RECONNAISSANCE SURVEY REPORT

BIRD ROCK
MARIN COUNTY

STATE WATER RESOURCES CONTROL BOARD

SURVEILLANCE AND MONITORING SECTION

APRIL, 1980
WATER QUALITY MONITORING REPORT NO. 80-2



STATE WATER RESOURCES CONTROL BOARD

AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

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

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

ACKNOWLEDGEMENTS

This State Water Resources Control Board Report is based on a reconnaissance survey report submitted by Dr. Gordon L. Chan and Point Reyes Bird Observatory. Special thanks are extended to the staff of the Point Reyes Bird Observatory, especially Dr. Deborah A. Clark as the primary individual who has managed and reviewed this report. Appreciation is also directed to Biologist Richard Brown of the Point Reyes National Seashore Park who made available much material for this Area of Special Biological Significance study.

The chief contributors in describing the marine invertebrates and fishes of the Bird Rock area have been Dr. Chan's students over the past twenty years.

Dr. Chan's report was prepared in fulfillment of an agreement with the California Department of Fish and Game, which has coordinated the preparation of a series of Area of Special Biological Significance Survey Reports for the State Water Resources Control Board under an interagency agreement.

ABSTRACT

The Bird Rock ASBS is located in Marin County and within the northern boundary of the Point Reyes National Seashore Park. The total area encompasses 72 acres (35 hectares).

The dominant oceanic current is the California Current which moves southerly off northern and central California. At Bird Rock Bay, the primary waters entering this area come from waves funneling through the north channel. Waves also surge through the west channel and around the south tip of Blow-Hole Rock.

Bird Rock appears to be a large granitic sea stack that may have been an extension of the Tomales Point Peninsula, being connected by a series of intertidal rocks along the north channel reef.

The marine plant community forms a distinct ecological habitat for the invertebrates of the subtidal reef area. The plants form distinct habitat zones which are comprised of reef tops, reef sides, reef bases, and sand and gravel substrates. The extent of these zones depend on depth, wave action, amount of light, and exposure during ebb tide.

The marine habitat at Bird Rock has one of the most diverse invertebrate populations in northern California. There is a nursery population of red abalones within the ASBS and the sea urchin and sea cucumber populations are quite large. The marine environment is basically undisturbed and characterized by stable assemblages of invertebrates and marine plants.

The Bird Rock ASBS has a variety of unique components including the California sea lion, the harbor seal, several species of marine birds and invertebrates as well as the great white shark.

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FINDINGS AND RECOMMENDATIONS

Findings

1. The Bird Rock Area of Special Biological Significance is located within the northwest corner of the Point Reyes National Seashore Park. The ASBS site encompasses the large sea stack-island called Bird Rock and the surrounding smaller rocky pinnacles and reefs; all the rocks here are composed of granite.

2. Because Bird Rock ASBS is isolated some 1,000 feet (300 m) from the Tomales Point peninsula, and because of the remoteness of this area from urban towns, the waters are free from the pollutants of man. The water quality of this ASBS site is excellent in comparison to the marine waters of the San Francisco Bay region.

3. The only recognizable pollution threat to the ASBS locality may be from the potential oil spills from tanker traffic moving up and down the California waters. Another future threat may come from oil and gas development from offshore continental shelf drilling activities in the Bodega shelf and canyon to the north.

4. The major organisms which support the ASBS designation are the harbor seals and California sea lions which inhabit the east side reefs of Bird Rock. The harbor seals appear to use this site the year-round, and young pups provide evidence of a breeding population.

5. Four species of marine birds breed on the island, with the Ashy Storm-Petrel, *Oceanodroma homochroa*, breeding in the granitic crevices of Bird Rock as the most unusual species. The Black Oystercatcher, *Haematopus bachmani*, is often seen feeding from the intertidal reefs of this ASBS site. Large numbers of the White Pelican, *Pelecanus erythrorhynchos*, use this habitat in the fall season.

6. The marine habitat at Bird Rock contains one of the most diverse invertebrate populations north of Monterey County. The abalone, sea urchin, and sea cucumber populations are particularly numerous. There is a nursery population of red abalones in this ASBS locality. The marine environment is basically undisturbed and is characterized by relatively stable assemblages of invertebrates and marine plants.

7. Finally, the white shark, Carcharodon carcharias, frequently visits the ASBS and adjacent waters. Seven recorded shark attacks have occurred here with three of these attacks in the shallow waters of Bird Rock. Department of Fish and Game biologists regard this area as a "hot spot" for these marauding fish.

Recommendations

Such diversity of marine invertebrates, fish, birds, and mammals provides this ASBS locality with one of Northern California's most unique ecosystems, deserving of ASBS recognition. Three recommendations to enhance this ASBS are:

1. The California Department of Fish and Game should declare this site a marine reserve. The justification:

   a. The area is remote and not many abalone hunters make the effort to utilize the resources.

   b. The marine mammals and birds require protection from the harassment of men and boats.

   c. The menace of the white sharks in the area is reason enough to keep individuals out of these waters.

2. Humans should not be permitted on the rock-island unless by special research permit from the California Department of Fish and Game and the Point Reyes National Seashore Park. The remoteness of the site enhances this particular recommendation.

3. Aircraft should also be restricted by law from flying below an altitude of 3,000 feet (912 m) in this area to prevent noise harassment to the marine mammals and birds.

4. Boats should also keep at least 1,640 feet (500 m) from the marine mammal habitats.

5. Little is known about the invertebrates, fish, and marine birds and mammals of this area. Therefore, research is needed to document the population activities of the birds and mammals, as well as to investigate the ecology of the white shark which visits these waters.

INTRODUCTION

The California State Water Resources Control Board, under its Resolution No. 74-28, designated certain Areas of Special Biological Significance (ASBS) in the adoption of water quality control plans for the control of wastes discharged to ocean waters. The ASBS are intended to afford special protection to marine life through prohibition of waste discharges within these areas. The concept of "special biological significance" recognizes that certain biological communities, because of their value or fragility, deserve very special protection that consists of preservation and maintenance of natural water quality conditions to practicable extents (from State Water Resources Control Board's and California Regional Water Quality Control Board's Administrative Procedures, September 24, 1970, Section XI. Miscellaneous--Revision 7, September 1, 1972).

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

1. Discharge of elevated temperature wastes in a manner that would alter natural water conditions is prohibited.

2. Discharge of discrete point source sewage or industrial process wastes in a manner that would alter natural water quality conditions is prohibited.

3. Discharge of wastes from nonpoint sources, including but not limited to storm water runoff, silt and urban runoff, will be controlled to the extent practicable. In control programs for wastes from nonpoint sources, Regional Boards will give high priority to areas tributary to ASBS.

4. The Ocean Plan, and hence the designation of Areas of Special Biological Significance, is not applicable to vessel wastes, the control of dredging, or the disposal of dredging spoil.

In 1973, the California Regional Water Quality Control Board, San Francisco Bay Region, recommended the Bird Rock Area for Special Biological Significance (ASBS) designation, based on this rationale:

> "Primarily Bird Rock serves as a hauling-out ground for the California sea lion and the harbor seal. Although four species of seabirds nest on the rock, only the Black Oystercatcher feeds regularly in the immediate vicinity of the rock. A survey by the staff of the Point Reyes Bird Observatory relates that three breeding pairs existed on Bird Rock in July, 1972. Principally, the area is proposed as an ASBS to afford protection to the two species of marine mammals." (California Regional Water Quality Control Board, 1973).

ORGANIZATION OF SURVEY

The subtidal description at Bird Rock ASBS was based on the observations made by the principal consultant with his students over a period of twenty-two years, from 1957 to 1979, in a total of 15 dives, averaging about an hour per dive. After each dive, a log describing the physical and biological data was completed; these logs can be examined at the College of Marin. The appendices list a compilation of organisms observed. The dives involved two basic forms of observations:

Underwater transect surveys: One transect site was established by affixing subtidal markers, concrete blocks 20 cm. by 30 cm., with a yellow vinyl line attached to each block. The blocks were wedged in by placing other large boulders nearby. Divers used compass bearings to determine placement of transect lines at the site. A weighted square meter frame was moved along the marked transect line and counts of organisms were made within each square meter quadrat. This transect site is indicated by ST-1 and 2, Figure 5.

General reconnaissance underwater surveys: Observations of marine life were also noted by divers swimming along compass bearing transects parallel to the shore. Data from all underwater transects were recorded and later transferred to data sheets by the principal consultant. Underwater visibility was generally good in comparison to other dive localities within the Marin County shores, averaging about 8 feet (2.4 m) in this area.

In the 22 years of visits to the Bird Rock ASBS site, the principal consultant has made 24 intertidal excursions (Table 3). In 1970, an intertidal baseline was plotted along the mid-tide Zone 2 area of the reef at Bird Rock. The baseline was divided into equal segments and three perpendicular transect lines were randomly selected for observations, indicated by T-1, T-2, T-3 on Figure 5. Square meter frames were then moved along the marked transect line and counts of marine organisms were logged on data sheets for each quadrat from the low to high intertidal areas. Statistical analysis is patterned after the Simpson Index

method of calculating the presence of dominant organisms (Simpson, et al., 1970).

Walks along the upper shoreline and bluffs enabled the principal consultant to observe and record the geology and botanical makeup of the Bird Rock ASBS. Maps were utilized to determine the distances of roads and locations of towns and other important landmarks.

Most of the information in this report is based on the 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 institutions of 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.

PHYSICAL AND CHEMICAL DESCRIPTION

Location and Size

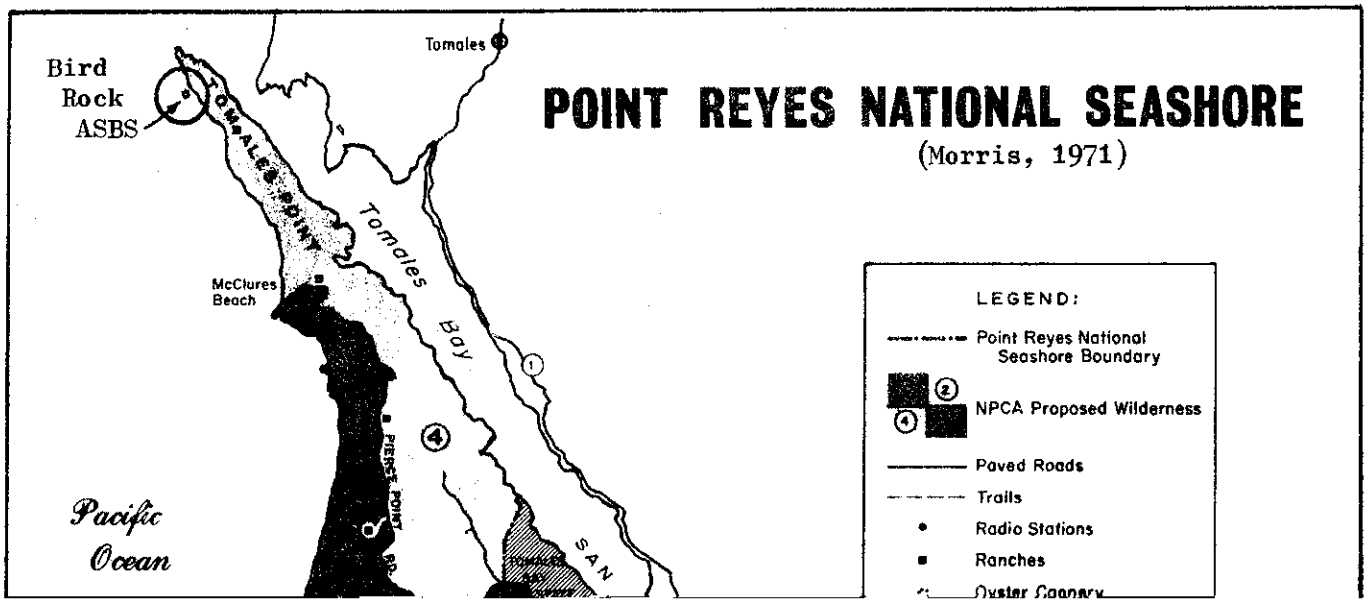
The Bird Rock Area of Special Biological Significance is located in Marin County, California. The area is situated entirely within the northern boundary of the Point Reyes National Seashore Park (Figure 1). Its position is 122°59'29" west longitude and 38°14'48" north latitude on the Bodega and Tomales Bay U.S. Coast and Geodetic Survey Chart. The ASBS perimeter extends 1,000 feet (305 m) from Bird Rock, which includes about 90 feet, (27 m) of the coastline of Tomales Point (Figure 2). The perimeter is bordered on the western side by the 30 foot (9.1 m) isobath, a line of equal depth below the water surface. The total area of Bird Rock ASBS encompasses 72 acres (35 hectares). The nearest town is Dillon Beach, 2 nautical miles (3.7 km) from Bird Rock (Figure 2).

Climate

The general climate of the Point Reyes National Seashore Park is classified as Mediterranean. Characteristic of this climate are moderate summers and cool, wet winters. The annual rainfall at Point Reyes is about 19.5 inches (49.5 cm) per year (Table 1). The rainfall at Tomales Point is higher than at other areas within the National Park, averaging about 30 inches (76 cm) (Figure 3). The annual runoff at Tomales Point from the rainfall is about 8 inches (20 cm) (Figure 4).

The ASBS is strongly influenced by the Pacific Ocean. The winds during the summer come from the northwest, averaging about 10 to 13 mph (16 to 20 km hr) at the Point Reyes Lighthouse site. During winter months, velocities may approach 40 to 50 mph (64 to 80 km) at the Lighthouse (Table 2).

During the summers the prevailing westerlies have high moisture content, thus accounting for the persistent fog which blankets the area; they are an important climatic variable for the Point Reyes Park area. The Lighthouse at the Point Reyes Headland is reported to be one of the foggiest lighthouses on the Pacific Coast.


POINT REYES NATIONAL SEASHORE
(Morris, 1971)
Bird Rock ASBS
Tomales
TOMALES POINT
Tomales Bay
McClures Beach
PIERCE POINT RD.
SAN
Pacific Ocean
LEGEND:
Point Reyes National Seashore Boundary
NPCA Proposed Wilderness
Paved Roads
Trails
Radio Stations
Ranches
Oyster Cannery

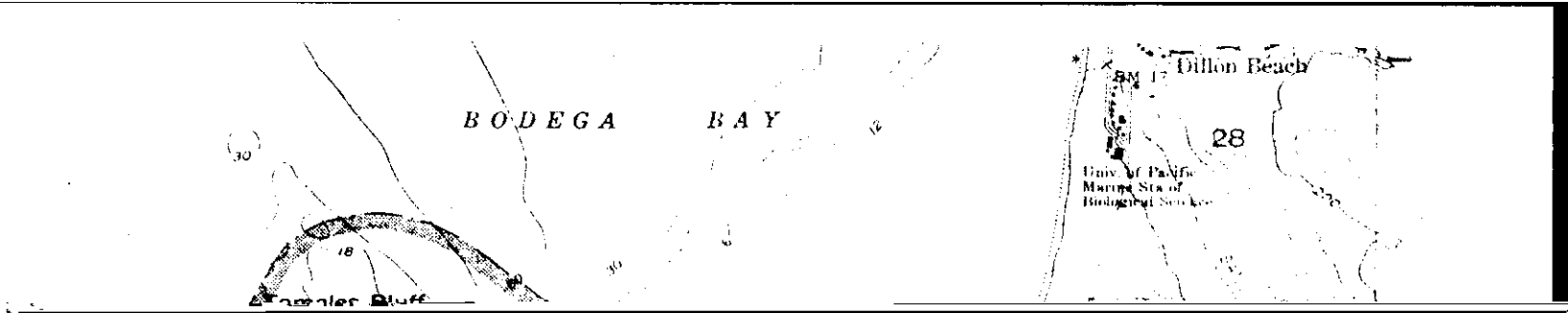

BODEGA BAY
Dillon Beach
28

TABLE 1

WEATHER DATA FOR POINT REYES
(No Date, After Felton: 1965)

	TEMPERATURE SUMMARY (in °F)					PRECIPITATION SUMMARY (in inches)
	HIGHEST	AVERAGE MAXIMUM	AVERAGE MINIMUM	RECORD MEAN	LOWEST	RECORD MEAN
MARCH	88	55.3	46.1	50.8	30	2.68
APRIL	83	55.6	46.6	51.1	36	1.50
MAY	85	56.0	47.3	51.7	38	0.84
JUNE	87	57.4	48.4	53.0	40	0.26
JULY	91	58.2	49.3	53.8	42	0.06
AUGUST	90	58.5	50.3	54.5	41	0.04
SEPTEMBER	98	61.3	51.7	56.5	45	0.47
OCTOBER	91	61.0	50.8	55.8	41	1.23
NOVEMBER	83	59.3	49.3	54.4	34	2.26
DECEMBER	73	55.8	46.6	51.1	27	3.31
JANUARY	78	54.3	45.3	49.7	29	3.86
FEBRUARY	78	54.8	46.2	50.4	31	3.04
ANNUAL	98	57.3	48.2	52.7	27	19.55

Average number of days with 0.01 inches or more precipitation = 73
Average growing season: 361 days.

TABLE 2

U. S. WEATHER BUREAU DATA FOR POINT REYES LIGHTHOUSE STATION
Summary of Averages for the Period 1949-53

	WIND VELOCITY		TEMPERATURE		WEATHER (days)			
	MAX	AV	MAX	MIN	BRIGHT	CLOUDY	FOGGY	RAINY
MARCH	47	14 Mph	71°	41°	18	7	1	5
APRIL	43	14	68	45	13	10	6	1
MAY	45	13	76	43	15	7	8	1
JUNE	45	13	80	46	15	8	6	1
JULY	34	11	77	48	9	5	17	0
AUGUST	37	10	77	49	7	7	16	1
SEPTEMBER	36	9	86	49	9	9	12	0
OCTOBER	42	10	81	47	13	4	12	2
NOVEMBER	51	11	74	46	13	6	8	3
DECEMBER	51	10	67	43	15	7	3	6
JANUARY	44	11	64	39	15	9	3	4
FEBRUARY	43	11	65	40	14	5	6	3

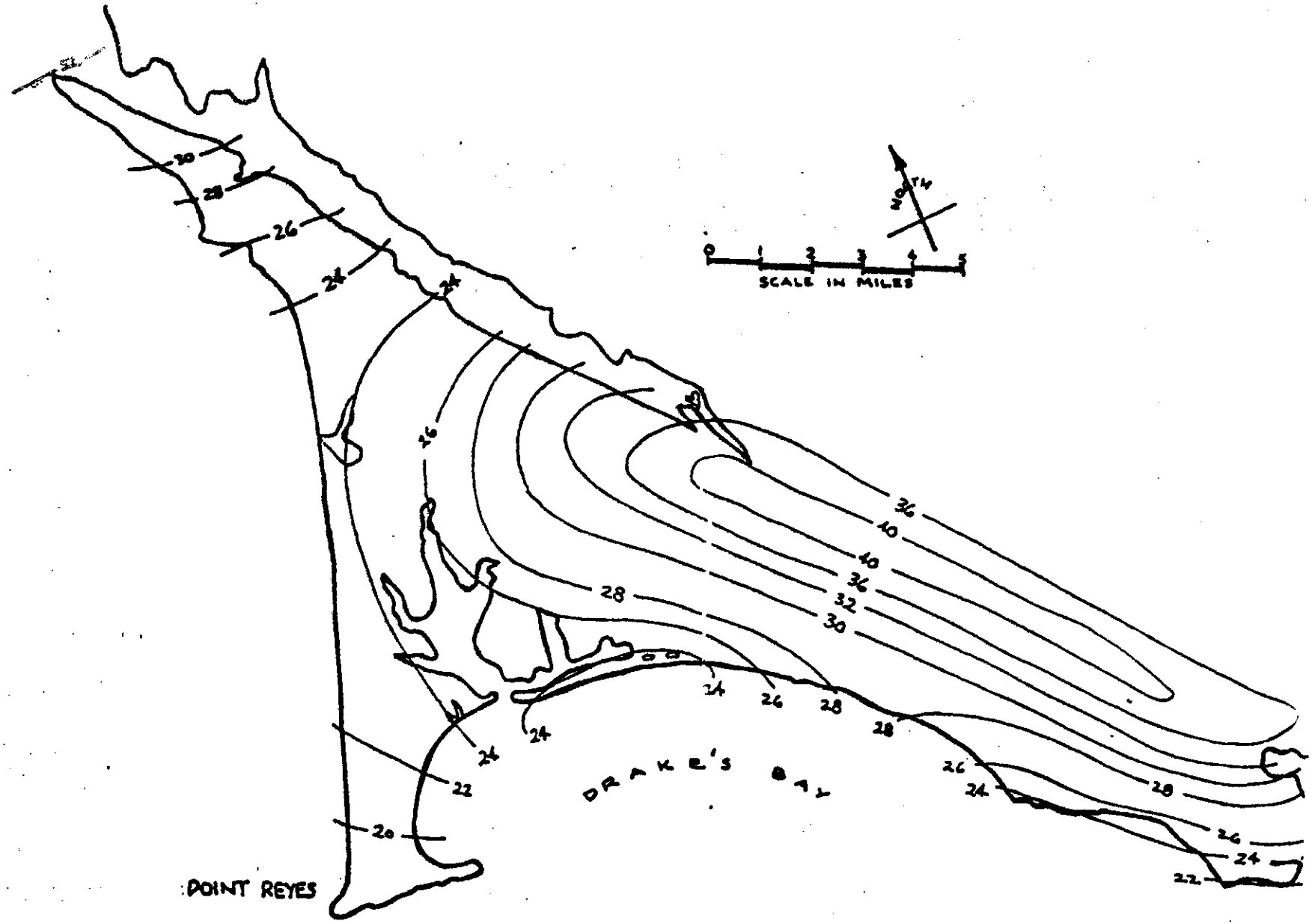
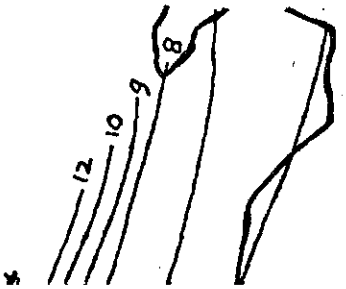


Figure 3. ANNUAL RAINFALL (inches), POINT REYES (Biswell and Agee, 1973)


12
10
9
8

With the coolness of the frequent fog, Point Reyes has recorded the lowest mid-summer temperature range of any observation station in the continental United States (Schenk, 1970). During the 1949-1953 period, there was an average range of 7°F. (3.9°C.) between the mean temperature of the coldest and warmest months of the year (Table 2).

Nearshore Waters

Submarine Topography: The perimeter of the Bird Rock ASBS stretches from the bluff of Tomales Point to about the 30 foot (9.1 m) isobath line. The western boundary of the ASBS perimeter extends 300 feet (91 m) to the west of the 30 foot (9.1) isobath line (Figure 5). The expanse beyond the 20-foot isobath line is composed of a sandy bottom. The area between Bird Rock and the Tomales Point shore is called Bird Rock Bay and is approximately 10 to 15 feet (3 to 4.5 m) deep. The submarine sites near the edges of the intertidal reefs are very rocky, while in the mid-zones of the Bay, there is a coarse-sandy bottom. The north channel is approximately 10 feet (3 m) deep, while the south channel is about 15 feet (4.5 m) deep. The west channel, between Bird Rock and Blow-Hole Rock is about 15 feet (4.5 m) deep, and is a granitic-lined channel (Figure 5). During high tides the exposed rocky pinnacles within the Bay are covered by water, making boat navigation somewhat hazardous.

The exposed intertidal reefs of the Bird Rock ASBS are of granite, with the largest reef exposure at the north portion of the ASBS site. Surge channels cut by waves approaching from the Pacific northwest side are quite large and prominent within these reefs (Figure 5).

Currents and Waves: The dominant oceanic current is the slow moving, southerly California Current off northern and central California. Surface waves generally approach from the northwest (Figure 6). The wave trains that strike Tomales Point refract towards the shallow sandy substrates of Tomales Bay and around the Bird Rock ASBS. At times, the waves at the mouth of Tomales Bay are quite severe, and over the years, a number of divers have been lost due to small boat accidents in and around this Tomales Point promontory.

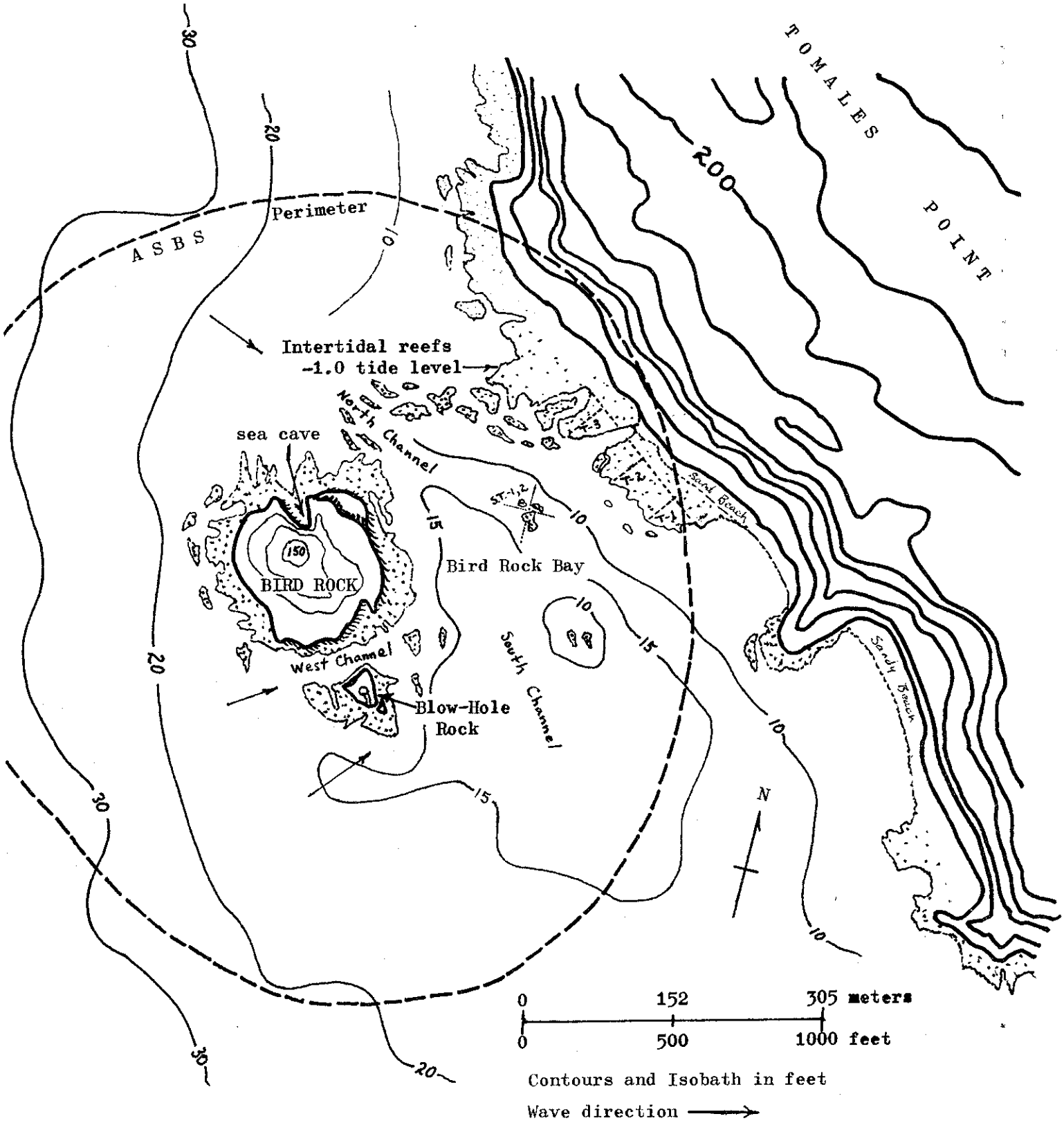


Figure 5. BIRD ROCK ASBS TOPOGRAPHY

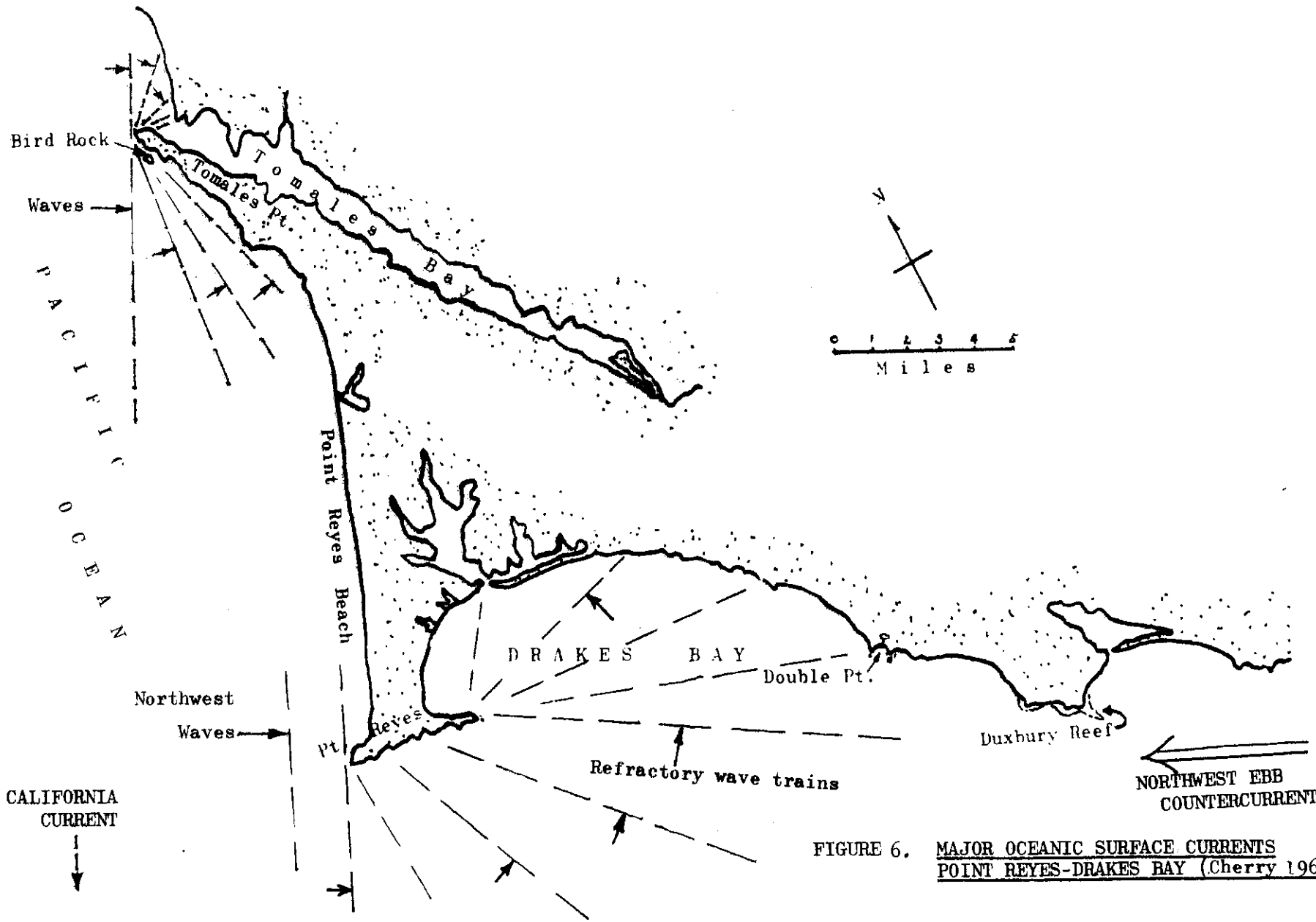


FIGURE 6. MAJOR OCEANIC SURFACE CURRENTS POINT REYES-DRAKES BAY (Cherry 1965)

During summer months the waves come more from the west northwest, while in winter months, the waves are predominantly from the west (Cherry, 1965). At Bird Rock Bay, the primary waters entering this area come from waves funneling through the mouth channel. Waves also cross through

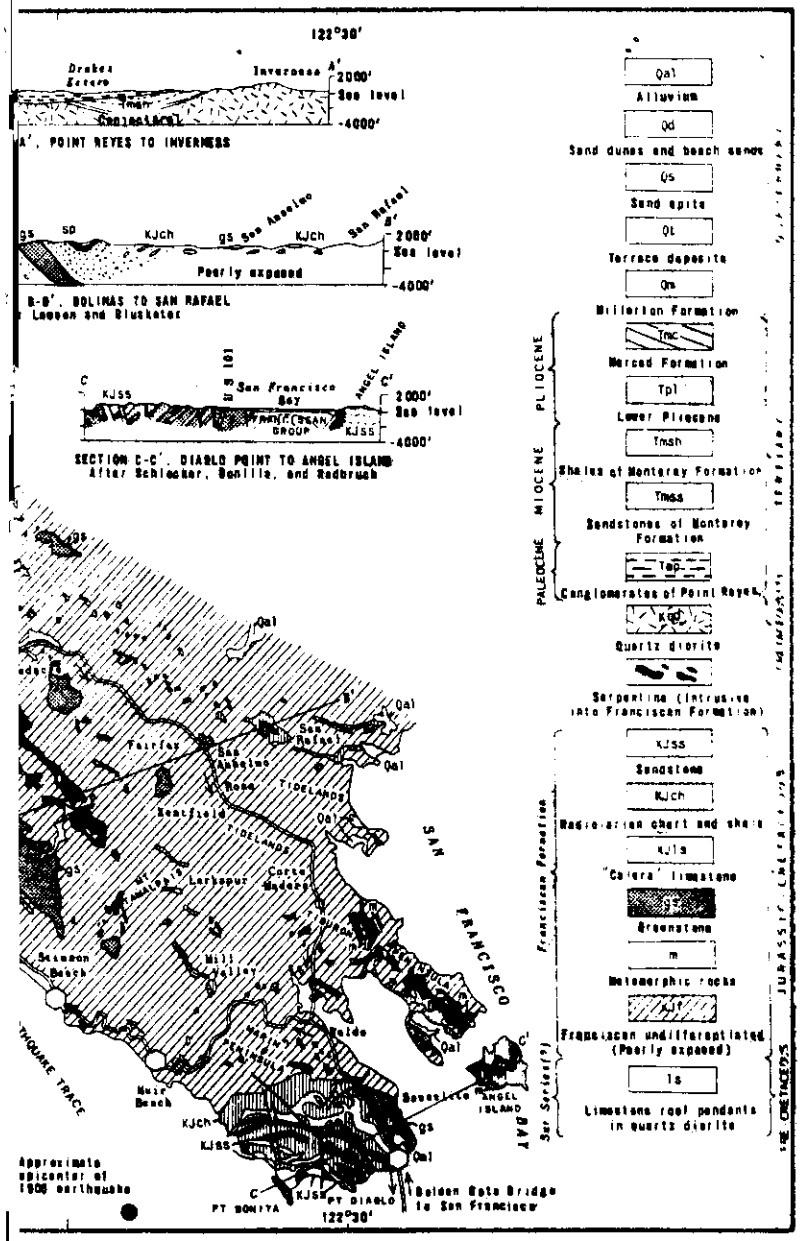
TABLE 3. SUMMARY OF ABIOTIC WATER PARAMETERS

BIRD ROCK, 1957- 1979, G. Chan

	Date	Activity: Inter-tidal	Activity: Div-ing	Surface Water Temperature	Surface Salinity o/oo	Water Visi-bility	Dissolved Oxygen mg/l	Nitrate Phosphates ppm
						feet		
1.	July 21, 1957	X						
2.	July 3, 1961	X						
3.	March 6, 1962	X		11.0°C (52°F)				
4.	Dec. 19, 1963	X						
5.	Dec. 18, 1964	X						
6.	Nov. 10, 1965	X						
7.	Dec. 20, 1965	X	X	10.0°C (50°F)		15		
8.	July 17, 1967	X						
9.	Nov. 6, 1969	X	X					
10.	May 5, 1970	X	X	10.5°C (51°F)	31	8		
11.	June 23, 1970	X	X	12.7°C (55°F)	32	20		
12.	July 24, 1970	X	X	12.2°C (54°F)	32	20		
13.	Nov. 25, 1970	X	X	11.6°C (53°F)	31	15		
14.	May 22, 1971	X	X			10		
15.	July 20, 1971	X						
16.	Nov. 24, 1971	X	X			15		
17.	June 19, 1972	X	X	12.2°C (54°F)	31	20		
18.	Apr. 28, 1973	X	X			10		
19.	Aug. 1, 1973	X	X					
20.	Dec. 9, 1974		X			10	8.0	∠0.01
21.	Mar. 28, 1975		X			12		
22.	July 1, 1976	X		12.7°C (55°F)	34			
23.	July 22, 1976	X	X	11.0°C (52°F)	33	20	9.0	∠0.01
24.	Nov. 25, 1977	X	X	10.5°C (51°F)	32	15		
25.	May 25, 1978	X						
26.	Apr. 28, 1979	X						
	Total =	24	15					
	Average =			11.5°C (52. °F)	32.0	15 ft (4.5 m)		

Topography and Geomorphology

The basic geomorphology of the Point Reyes National Seashore Park



A AND NEARBY AREAS (Galloway, 1977)

To the east of the Tomales Point Peninsula is the long and narrow Tomales Bay inlet which traces the rift zone of the San Andreas Fault (Figure 7). Tomales Bay, which has the appearance of a drowned valley, is about 7,000 feet (2,133 m) wide at its northern end, suggesting that the width of the San Andreas Fault Zone is also as wide (Galloway, 1977).

The subtidal geomorphology of the area west of Bird Rock is basically composed of sand with a few granitic rocky outcroppings along the 20-foot (6 m) isobath (Figure 5). The Continental Shelf continues westwardly for about 25 miles (40 km) before the continental slope appears, with the Bodega submarine canyon as the most formidable feature of the area (Jennings, 1975). Other notable subtidal and intertidal features (Figure 5) of Bird Rock ASBS are as follows:

Bird Rock Bay: A shallow embayment of sand and granitic rocks, averaging about 15 feet (4.5 m) in depth. There are several large pinnacle rocks which appear above the water surface during low tides.

North Channel Reef: These granitic rocks are scattered throughout the northern portion of Bird Rock Bay (Figure 5) which may indicate that at one time during lower sea levels, this reef connected Bird Rock to the Tomales Point Peninsula as a geological tombolo. Wave erosion has sliced the north channel to a depth of approximately 10 feet (3 m).

Sea Cave: There is a large sea cave on the north side of Bird Rock which penetrates about one-fourth of the way into the north portion of the rock.

Blow-Hole Rock: Just south of Bird Rock is a large rock which has a crevice which enables water to enter and create a "blow-hole" effect. At times, sprays of water may reach a height of 20 feet (6 m). The west channel between Bird Rock and Blow-Hole Rock is a vertical wall of about 15 feet (4.5 m).

Intertidal reefs: There are large expanses of granitic reefs around Bird Rock and on the Tomales Point portion of the ASBS site (Figure 5). These reefs have many crevices which are a result of wave erosion. Waves also have flattened the tops of these rocks forming a broad platform for seals to haul-out.

BIOLOGICAL DESCRIPTION

Subtidal Biota

Marine Plant Community: From the subtidal regions to the upper intertidal rocks, the marine plants form a distinct ecological habitat for the invertebrates of the reef area. In Figure 8, 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. The principal consultant has adopted some of Pequegnat's descriptions of zones with some modifications according to the type of marine plants which occupy the Bird Rock ASBS. These plants have a specific selection zone depending on the depth, wave action, amount of light, and exposure during ebb tide.

The major plants in both subtidal and intertidal areas of Bird Rock are listed in Appendix 1. The key plants which are most abundant and

Avg. Depth	Index Plant Zone	Ecology
	Nereocystis leutkeana	Bull kelp which attaches to the rocks within the Bird Rock Bay.
3 meters (10 feet)	*Pterygophora californica* *Laminaria dentigera*	Major brown alga which form the short kelp zone.
1.5 meters (5 feet) Zone 4	*Dictyoneurum californicum*	Low intertidal, yellowish-brown alga which is very abundant in Bird Rock Bay.
	Egregia menziesii	Boa kelp, low intertidal
	Iridaea cordata	Red alga of the low intertidal zone.
	Phyllospadix torreyi	Surf grass is abundant in this zone.
+1.5 MLLW (Hedgpeth, 1968) Zone 3	*Gigartina papillata*	Red alga — Algae of the mussel bed zone
	Cladophora sp.	Green alga
	Porphyra perforata	Red alga
+3.5 MHLW	*Ralfsia pacifica*	Zone 2 alga - protected from direct wave actions by extensive intertidal granitic rocks.
	Fucus distichus	
	Ulva spp.	
	Cladophora columbiana	
+5.6 MHW	*Endocladia muricata*	Zone 1 alga - small plants which can withstand dessication.
	Gigartina canaliculata	

The granitic rocks at the bottom of Bird Rock Bay are heavily encrusted with *Lithothamnium* sp. and other red algae. Even the north and west channel rock surfaces have much encrusting algae. The canopy algae of *Nereocystis*, *Egregia*, *Laminaria*, and *Dictyoneurum* are very abundant in close to intertidal rocks. In particular, the yellowish-brown clustered alga, *Dictyoneurum californicum*, is the thickest of all these canopy algae, forming a dense matrix of entangled blades just at the low intertidal water line (Figure 8). This species, although abundant at Bird Rock, is not common within Marin County waters. It is frequently seen in Monterey and along low intertidal rocks of Sonoma County (Abbott and Hollenberg, 1976).

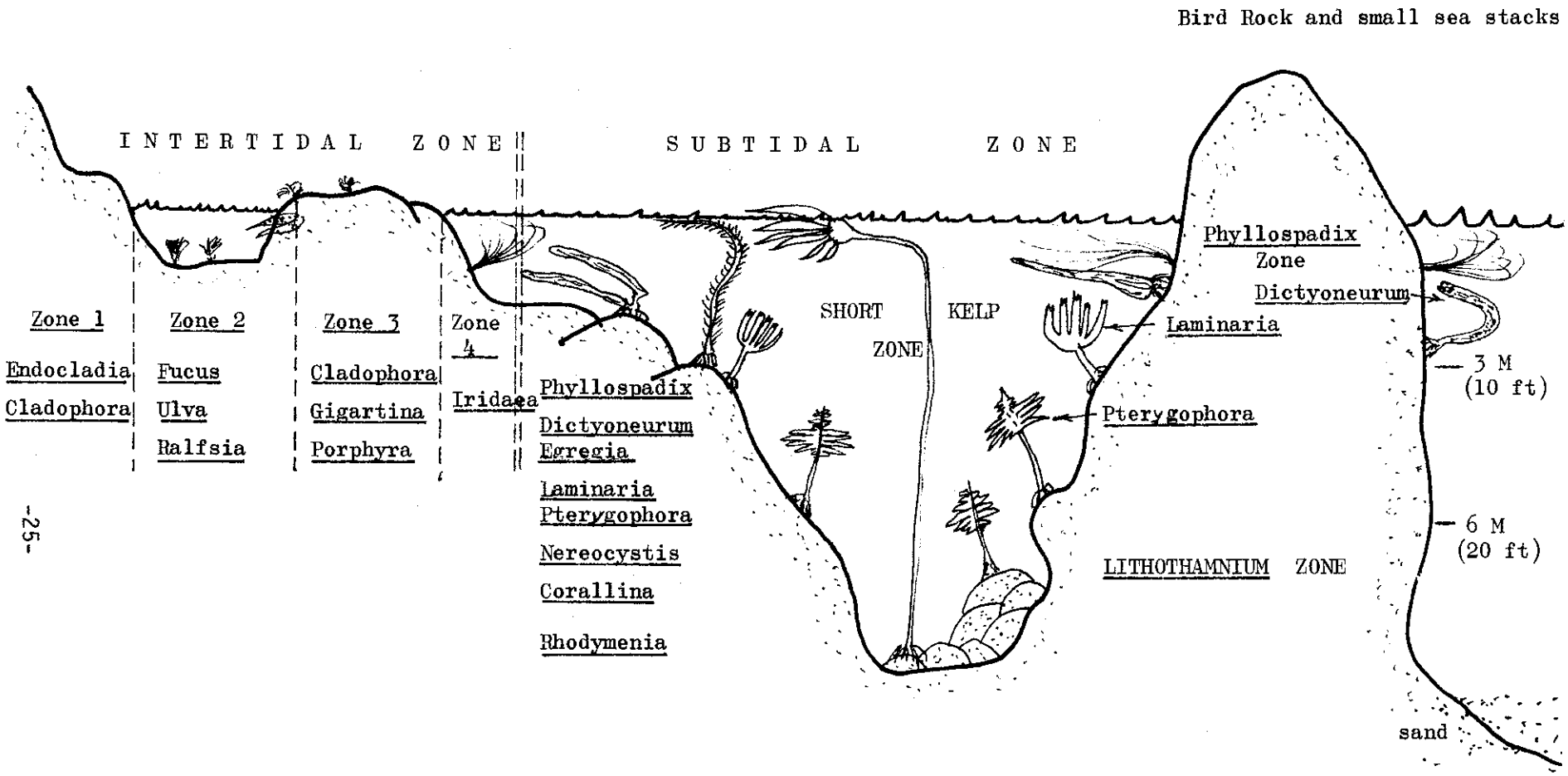


FIGURE 8. GENERAL DEPTH DISTRIBUTION OF INDEX MARINE PLANTS, BIRD ROCK ASBS (not drawn to scale)

Invertebrates: The general depth distribution of marine invertebrates (Figure 9) is ideally applicable to the Bird Rock ASBS. From the overview of Bird Rock ASBS, Figure 5, the [illegible]

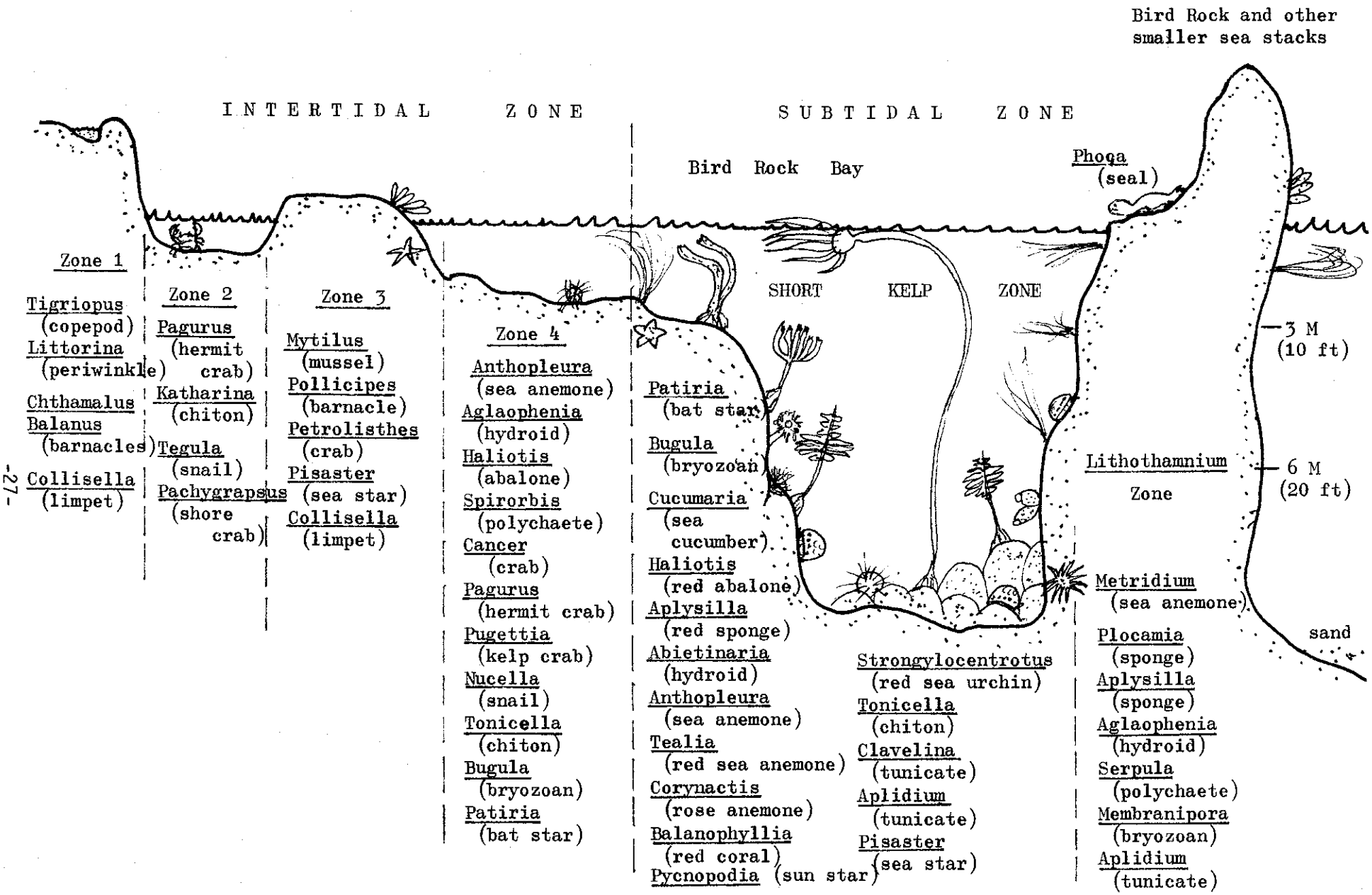


Figure 9. GENERAL DEPTH DISTRIBUTION OF MAJOR INVERTEBRATES, BIRD ROCK ASBS (not drawn to scale)

area. A more thorough listing of important invertebrate species is given in Appendix 2. On the east side of Bird Rock are long strands of surf grass, Phyllospadix torreyi, which extend from the water surface to approximately the 6 foot (1.8 m) depth. Below the surf grass are the short kelps, Laminaria dentigera and Pterygophora californica. There is also an abundance of small red abalones within the crevices of these rocky granitic boulders.

In the middle areas of Bird Rock Bay are scattered boulders and tall rocky pinnacles that are exposed during minus low tides. Coarse, granitic sand covers most of the benthic area of Bird Rock Bay down to a depth of 20 feet (6 m). The dominant invertebrate throughout the short kelp zone is the red sea urchin, Strongylocentrotus franciscanus. In 1970, two subtidal transects were set up on the eastern portion of Bird Rock Bay (Figure 5). In 40 square meter samples around two rock pinnacles, a mean of 73 S. franciscanus per each 10-meter transect line was counted.

For the same subtidal transect line, an average of 9 red abalone per 10-meter transect were calculated. Four of the red abalones were tagged (Chan, 1971) and in two years' time all tagged specimens had disappeared from the transect. With the large numbers of urchins and abalones in the area, the center portion of Bird Rock Bay is grazed clean of marine algae. Red abalones generally feed during night hours, but in this locality, they are moving and feeding during daylight hours in their search for the sparse algal food. These abalones will not stay put in one spot as will those in the Point Reyes Headland area. It has been found that if algal food is readily available, the abalones will remain in one spot for almost their entire life span. These stationary abalones will form an attachment "scar" on the rock surfaces. However, if food is sparse, the abalones will migrate readily as seen in these Bird Rock Bay specimens.

With so many urchins in the subtidal and low intertidal zones, there is an abundance of asteroids, in particular, the batstar, Patiria miniata, and the sunstar, Pycnopodia helianthoides. The sunstar has been seen

feeding on the large red sea urchins here as well as in the Sonoma-Mendocino coast habitats. The batstars are scavengers, eating most anything they can find in this habitat.

Along the north side of Bird Rock Bay is a large reef which spans the area between Tomales Point and Bird Rock. The brown alga, Dictyoneurum californicum, is extremely dense in this area. This yellow-brown alga will grow from the low intertidal Zone 4 region to about 6 feet (1.8 m) below the water surface. By brushing aside the long blades of this alga, divers can observe that the granitic crevices of the reef contain a large population of the sea cucumber, Cucumaria miniata. Some of the sea cucumbers can stretch out to 1 foot (30 cm) and their bright orange tentacles truly brighten these rocky reefs.

Intertidal Biota

The intertidal zone of the Bird Rock ASBS is extremely rich with invertebrate organisms and closely resembles the granitic intertidal reefs of the Monterey-Carmel area. Appendix 3 is the combined species list for the intertidal transects which were established in 1970 on the Tomales Point side of the ASBS zone (Figure 5). Table 5 provides the mean densities of the major invertebrates within the intertidal transects:

TABLE 5. MAJOR INVERTEBRATES, BIRD ROCK TRANSECT

Major Species	June 24, 1970 $\bar{X}/m.^2$	July 1, 1976 $\bar{X}/m.^2$
Anthopleura xanthogrammica, green sea anemone	25.7	26.0
Mytilus californianus, sea mussel	26.6	27.1
Tegula funebralis, black turban snail	18.3	12.4
Pollicipes polymerus, goose barnacle	12.3	14.3
Balanus spp., acorn barnacle	11.9	9.1
Petrolisthes cinctipes, porcelain crab	43.9	20.5
Strongylocentrotus purpuratus, purple sea urchin	3.4	9.0
Pisaster ochraceus, purple starfish	0.9	0.2

The intertidal transects were sampled on June 24, 1970 and again on July 1, 1976.

Benthic organisms, particularly the infauna and sessile and slow-moving epifauna, are very useful as indicator species for a marine area because they tend to remain in place. They can react to long-range environmental changes, and by their presence, generally reflect the nature of the substratum (Colonell, 1979). Consequently, benthic organisms such as sea cucumbers, barnacles, mussels, and sea anemones may be used to monitor long-term pollution effects. Some biologists feel that these sessile and slow-moving organisms reflect the health of a marine area (Pearson, 1971, 1972; and Rosenberg, 1973, for discussion on long-term usage of benthic organisms for monitoring pollution).

Plankton Sample

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. Only one plankton sample was taken for Bird Rock ASBS as seen in the following table.

TABLE 6. PLANKTON SAMPLE, BIRD ROCK ASBS, JULY 22, 1976

Major Animals	No. in 1.6 $cm.^3$ grid	Number of Organisms
Nauplii (barnacle larvae)	5	5.4×10^4
Calanus spp. (copepods)	3	1.0×10^4
Oikopleura sp. (larvacean)	1	0.7 x 104
Salpa sp. (Thaliacean)	1	0.3×10^4
Zoea (brachyuran crab)	1	0.2×10^4
Major Plants		
Chaetoceros spp. (diatom)	14	6.0×10^5
Lauderia sp. (diatom)	6	5.6×10^4
Biddulphia sp. (diatom)	3	1.0×10^4
Coscinodiscus sp. (diatom)	4	1.6×10^4
Ceratium spp. (dinoflagellate)	10	6.0×10^4
Peridinium sp. (dinoflagellate)	3	0.7×10^4

The plankton sample at the Bird Rock ASBS appears to be very similar to the numerous plankton samples which have been taken in Tomales Bay. The ocean currents and waves of the Bird Rock area probably carry the same planktonic species through the north end of Tomales Bay.

Vertebrates

Fishes of Bird Rock ASBS: The fishes of Bird Rock ASBS are an important and integral part of the food chain of this area. Although the finfish groups are by far the most important to this community, the Bird Rock waters along with Tomales Point have been given much publicity in

in the Bird Rock ASBS is a reality. The species which is involved in the shark attacks is the white shark, *Carcharodon carcharias*, Figure 10.

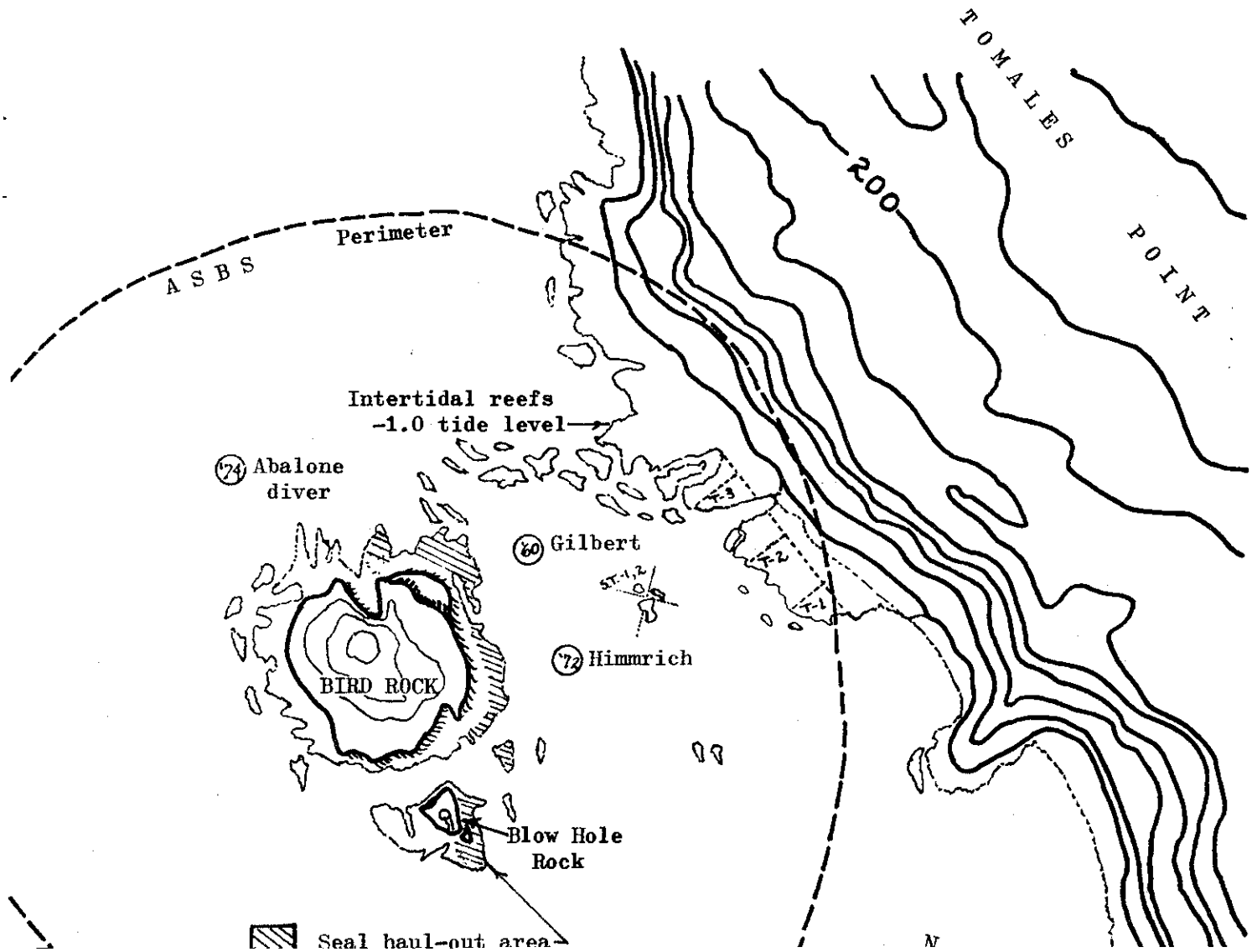

TOMALES
POINT
200
ASBS
Perimeter
Intertidal reefs
-1.0 tide level
'74 Abalone
diver
'60 Gilbert
ST-1,2
T-3
T-2
T-1
'72 Himmrich
BIRD ROCK
Blow Hole
Rock
Seal haul-out area
N

TABLE 7. DISTRIBUTION OF MAJOR FISH SPECIES IN BIRD ROCK ASBS

Short Kelp Community

Mustelus henlei (H)
(brown smoothhound shark)

Triakis semifasciata (H)
(leopard shark)

Sebastes atrovirens (H)
(kelp rockfish)

Sebastes auriculatus (H)
(brown rockfish)

Sebastes caurinus (H)
(copper rockfish)

Sebastes melanops (H)
(black rockfish)

Sebastes nebulosus (H)
(china rockfish)

Ophiodon elongatus (H)
(lingcod)

Hexagrammos decagrammus (Pl)
(kelp greenling)

Scorpaenichthys marmoratus (H)
(cabezon)

Hypsurus caryi (P)
(rainbow surfperch)

Damalichthys vacca (P)
(pile surf perch)

Phanerodon furcatus (P)
(white surf perch)

Gibbonsia elegans (Pl)
(spotted kelpfish)

Eopsetta jordani (H)
(petrale sole)

Anarrhichthys ocellatus (H)
(wolf eel)

Intertidal Zone

Cebidichthys violaceus (H)
(monkeyface blenny)

Xiphister atropurpureus (P)
(black prickleback)

Apodichthys flavidus (P)
(penpoint gunnel)

Gobiesox meandricus (P)
(northern clingfish)

Clinocottus analis (P)
(wooly sculpin)

Enophrys bison (P)
(buffalo sculpin)

Oligocottus synderi (P)
(fluffy sculpin)

(H) = hunts or stalks prey

(P) = picks or crushes prey

(pl) = plankton feeder

Marine Birds: The marine birds at the Bird Rock ASBS are regarded by the California Regional Water Quality Control Board (1973) as one of the primary reasons the area needs protection. The census and study of marine birds at Bird Rock are very sparse. Only the work of Ainley and Whitt (1973), Table 8, documents the importance of birds utilizing this habitat as a breeding site.

The bird which is of key importance is the Ashy Storm-Petrel, *Oceanodroma homochroa*. By observing rocky crevices, they estimated that perhaps the maximum possible breeding population on Bird Rock would be 10 to 12 pairs (Ainley and Osborne, 1972).

TABLE 8. 1971 CENSUS of the NUMBER OF BREEDING PAIRS of MARINE BIRDS at BIRD ROCK (Ainley and Whitt, 1973)

Species	No. of breeding pairs per breeding site	Nesting habitat
Oceanodroma homochroa (Ashy Storm-Petrel)	5	in rocky crevices

Marine Mammals: Little is known about the marine mammals which occupy the Bird Rock ASBS. The 1,000 foot (300 m) distance of Bird Rock from the Tomales Point view area makes it very difficult to study this location's marine birds and mammals. The California sea lion, *Zalophus californianus*, has been observed on the rocky reefs of Bird Rock on only a few occasions. However, the harbor seal, *Phoca vitulina*, has been observed on the many granitic reef outcroppings during every survey. The locality of haul-out sites can be seen on Figure 11. The counts of harbor seals recorded for the Rock are summarized in Table 9.

TABLE 9. HARBOR SEALS OBSERVED AT BIRD ROCK

Date	No. of Seals Observed	Source
June 1-3, 1965	35	*Carlisle, Alpin 1966
May 5, 1970	73	Chan
June 23, 1970	87	Chan (observed 18 pups)
July 3, 1972	42	*Ainley
July 1, 1976	85	Chan
April 16, 1977	70	*Sjogren
Nov. 25, 1977	67	Chan
Nov. 4, 1978	175	Allen

*(Ainley and Allen, 1977)

The incomplete data in Table 9 indicates that the harbor seals may occupy Bird Rock reefs the year-round and that they may utilize the area as a breeding site. The harbor seals also can be found in numbers ranging from 25 to 225 in Tomales Bay near Lawson's Landing and Hog Island (Allen, 1979).

Other marine mammals observed near this ASBS site are the elephant seal, *Mirounga angustirostris*, the migrating grey whale, *Eschrichtius robustus*, and the humpback whale, *Megaptera novaeangliae* (Allen, 1979).

Although Tomales Point has a variety of terrestrial mammals--rodents, rabbits, bobcats, deer, domesticated animals--none have ever been recorded for Bird Rock.

Land Vegetation

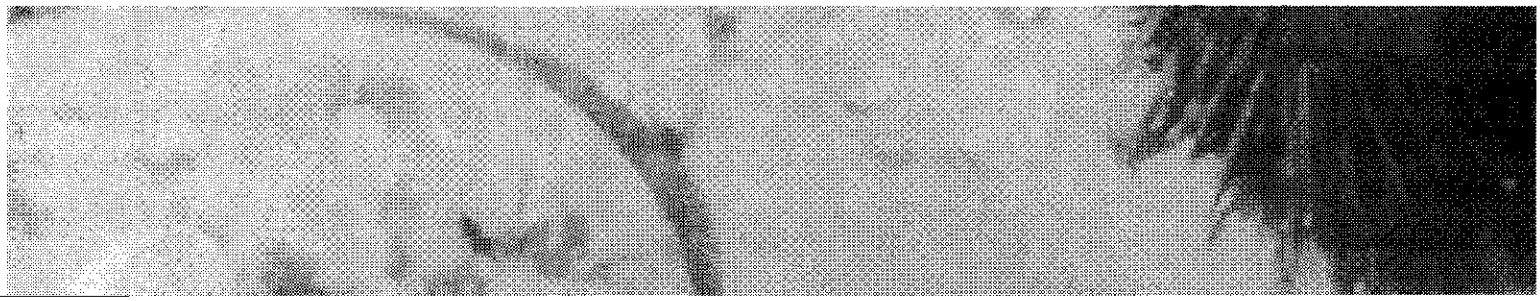
The information for the Tamalco Point upland vegetation description

Marine mammals: While the California sea lion, *Zalophus californianus*, utilizes Bird Rock occasionally, the harbor seal, *Phoca vitulina*, occupies the east reefs of Bird Rock in large numbers as a year-round haul-out site. Young harbor seal pups have been observed on these reefs during early summer months.

Marine birds: The Black Oystercatcher, *Haematopus bachmani*, has been observed feeding regularly from the reef rocks. Over 100 White Pelicans, *Pelecanus erythrorhynchus*, have been observed utilizing the rock as a habitat in late fall. The Ashy Storm-Petrel, *Oceanodroma homochroa*, the Western Gull, *Larus occidentalis*, the Pigeon Guillemot, *Cepphus columba*, and the Brown Pelican, *P. occidentalis*, have all been observed on Bird Rock.

Marine invertebrates: The subtidal area abounds with the red abalone, *Haliotus rufescens*, with most of the observed specimens being small. Bird Rock Bay is a nursery for these small abalones. The orange sea cucumber, *Cucumaria miniata*, is extremely abundant in subtidal rocky crevices and may be used as a benthic indicator for possible pollution effects. The marine invertebrate populations are one of the most diverse found in waters north of Monterey County (Figure 12).

Fish: The Bird Rock-Tomales Point locality has been termed a "hot spot" for the white shark, *Carcharodon carcharias*. There have been seven attacks in this area with three attacks within the ASBS.



LAND AND WATER USE DESCRIPTION

Marine Resource Harvesting

Ocean Fishing and Other Fisheries: The Bird Rock ASBS borders the Pacific Ocean fishing activities around the mouth of Tomales Bay and Bodega Bay. The heaviest fishing off these ocean waters is in pursuit of the king and silver salmon as these fish make their way to spawning areas in northern streams and estuaries during summer months. Most commercial trawlers fish further out at sea, but at times during the months of July and August, many commercial boats as well as sportfishermen in smaller boats are fishing the area between McClure's Beach and the mouth of Tomales Bay. Most of the commercial boats cover the area from Bodega Bay to the north of Bird Rock ASBS, and there is an estimate of the catch of salmon approaching a ton per day for about 10 to 15 fishing days (Worsley, 1972).

A second area of intense sport fishing activity is at the mouth of Tomales Bay where boats are engaged in the catch of flatfish such as sole, flounder, and the California halibut, the most sought-after fish in the area. Lingcod, perch, sea trout, and rockfish are also reportedly caught in this locality.

Within Tomales Bay are a wide variety of other fishing activities which range from commercial herring catches of around 7,800 tons in 1975-76 (Kelly, 1976) to commercial harvesting of smelt, perch, and even sharks. There is also an annual shark and stingray derby which nets about 30,000 pounds of fish for fertilizer use (Worsley, 1972).

The invertebrate fishing within Tomales Bay includes the hunt for gaper and Washington clams as well as for geoducks, cockles, littleneck clams, and soft shell clams. The oyster industry within the Bay has also accelerated within recent years.

Abalone Sportfishing: The major fishing activity within the Bird Rock ASBS is the hunt for the red abalone, *Haliotis rufescens*. For many

years, abalone hunters from Lawson's Landing have hiked over the Tomales Point peninsula and have spent their time seeking intertidal and subtidal abalone. Small boats also make their way to the ASBS site from Tomales and Bodega Bay ports; their anchorage is always within Bird Rock Bay. Before the coming of the National Seashore status, divers made their way to Bird Rock by a dirt road. This road is now closed to traffic.

Despite all the years of human predation on the red abalone, the mollusk still persists in adequate numbers. The transect counts of abalones between the years 1970 to 1977 have been reduced by 80%. This reduction may be due to fishing and perhaps to migration of the mollusk seeking additional algae. Since the area is blessed with the recruitment of juvenile abalones, the overall population seems to be holding its own against present fishing pressure. The threat of the white shark also tends to minimize the number of divers in the area.

Historical, Governmental, and Recreational Use

The brief chronology of the Bird Rock ASBS involves the use of Tomales Point peninsula by man. The land was occupied by the Coastal Miwok Indians about 1500 A.D. The ranching activities of the peninsula ranged from Solomon Pierce in 1858 to the McClure family in the 1900's and finally to the McDonald family of present days.

A major shipwreck on Bird Rock took place on November 20, 1903, when the 2,289-ton bark FRANCOIS COPPEE went aground on the Rock and eleven men died in the disaster (Point Reyes Historian, 1977).

In 1962 the Point Reyes National Seashore was established. Since then the governmental plan is to convert the peninsula to a Tule Elk range. In March of 1978, 17 Tule Elk were introduced to this area (Brown, 1978).

The number of visitors to this Tomales Point area in the year 1978 was reported to be 57,930 (Brock, 1978). To arrive at the Bird Rock view area, visitors now have to walk about four miles from their parked

vehicles. While some individuals involved with education groups still investigate the eastern intertidal reefs of the ASBS site, relatively few individuals swim across the Bird Rock Bay to visit the island. This trend of park visitors walking to the ASBS site and occasional divers fishing for abalones in the waters seems to be the major human activities for this area in the future.

Scientific and Educational Use

There is a need for ecological and behavioral research on the marine mammals and sea birds within the Bird Rock ASBS. Over the years, very few agencies or even individuals have attempted to use the ASBS

ACTUAL OR POTENTIAL POLLUTION THREATS

The geography of the Bird Rock ASBS together with the protection afforded to this locality by the Point Reyes National Seashore Park enables this ASBS site to have no direct pollution threats. There is no municipal sewage system in the general area of Tomales Point which might create problems. Tomales Point is now closed to cattle ranching so that the pollution threat is eliminated.

The only pollution threat which looms in the near future is the possibility of an oil discharge from vessels moving up and down the coast. The increased oil tanker traffic between the Alaskan port at Valdez and the refineries of central and southern California could accelerate the risk of an accident similar to the January, 1971 San Francisco oil spill. This spill resulted in deaths of about 7,000 sea birds and some 4.2 million invertebrates.

Another possible oil pollution threat could come from the proposed federal leasing of the Pacific Outer Continental Shelf (OCS) oil and gas lease Sale No. 53. This sale will include potential drilling in the Bodega Canyon by offering 27 tracts from 3 to 21 nautical miles (5 to 34 km) off Bodega Head and Tomales Point (Pacific OCS office, 1978).

With oil leasing arrangements under way, the Department of Interior announced in November, 1978, that in the OCS Amendments there will be no gas and oil drilling activities with 15 miles (24 km) of the Point Reyes National Seashore boundaries. This protected zone will not fully prevent the marine birds from being affected in the event of a catastrophic spill or chronic occurrence of spills. The Bureau of Land Management (Pacific OCS, 1978) has listed seven agents which could affect marine resources in the event OCS oil and gas development materializes:

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 which could lead to environmental degradation

SPECIAL WATER QUALITY REQUIREMENTS

If a large community-composite sewage outfall system were to be constructed for north Marin and south Sonoma County towns, and if the discharge were dumped north of Tomales Point, the northwesterly waves and currents could carry the effluent to the Bird Rock ASBS. Such discharged waters would affect the total food web of the marine organisms of the ASBS site and require special monitoring of water quality. The possibility of the development of such an outfall system is very remote. Thus, the water quality of the Bird Rock ASBS is deemed excellent in comparison to marine waters closer to urban centers, such as San Francisco Bay to the south.

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APPENDIX 1. MARINE PLANTS, BIRD ROCK ASBS 1957-1979 G. Chan

Major Species List	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Deep Rocks	Short Kelp	4	3	2	1
	25'	15'				
A. CHLOROPHYTA (Green Algae)						
Codium fragile	x					
C. setchellii		x	x			
Cladophora columbiana				x	*x	x
Ulva californica				x	x	
U. lobata					x	
U. taeniata			x			
Entermorpha intestinalis					x	
Spongomorpha coalita		x	x			
Bryopsis hypnoides		x	x			
B. PHAEOPHYTA (Brown Algae)						
Ralfsia pacifica					*x	
Nereocystis luetkeana	*x	*x				
Desmarestia ligulata var. ligulata	x					
Laminaria dentigera (L. andersonii)		*x	x			
L. farlowii		x				
Lessoniopsis littoralis		*x				
Costaria costata		x				
Alaria marginata		x	x			
Egregia menziesii		x	*x			
Pterygophora californica		*x	x			
Dictyoneurum californicum		*x				
Cystoseira osmundacea		x				
Postelsia palmaeformis			x			
Pelvetia fastigiata				x		
Pelvetiopsis limitata				x		
Fucus distichus endentatus					*x	
C. RHODOPHYTA (Red Algae)						
Calliarthron tuberculosum	x					
Bosiella californica	x					
B. orbigniana spp. dichotoma	x	x				
Mesophyllum lamellatum	x					

*Major plants

Appendix 1 (continued)

Marine Plants, Bird Rock ASBS, 1957-1979
G. Chan

Major Species List (continued)

	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Deep Rocks	Short Kelp	4	3	2	1
	25'	15'				
Lithothamnium spp.	*x		x	x	x	
Rhodymenia arborescens	x					
R. californica	x	x				
R. callophyllidoides	*x	*x				
Callophyllis pinnata		x				
C. violacea		x				
Fryeella gardneri		x				
Botryglossum farlowianum		*x	x			
Ceramium pacificum		x				
Callithamnion pikeanum		x				
Microcladia coulteri		x				
M. californica			x			
Rhodymenia pacifica		x				
R. palmata			x			
Corallina officinalis var. *chilensis*		*x	*x			
Lithophyllum imitans		x				
Iridaea cordata var. *splendens*		*x	*x			
Porphyra pulchra		x	x			
P. perforata			x	x	x	
P. smithii		x	x			
Prionitis lanceolata			x		x	
Erythophyllum delesserioides		*x	x			
Callophyllis linearis			x			
Plocamium violaceum		x	x			
Gracilaria sjoestedtii		x	x			
Neoptilota densa			x			
Rhodomela larix				x		
Cumagloia andersonii					x	
Odonthalia floccosa				x		
Gigartina corymbifera		x	x			
G. spinosa		x	x			
G. papillata					*x	
G. canaliculata				*x		*x

* Major plants

Appendix 1 (continued)

Marine Plants, Bird Rock ASBS, 1957-1979
G. Chan

Major Species List (continued)

	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Deep Rocks	Short Kelp	4	3	2	1
	25'	15'				
Endocladia muricata						*x
D. TRACHEOPHYTA (Vascular plant)						
Phyllospadix torreyi		*x	*x		x	

* Major plants

APPENDIX 2 MARINE INVERTEBRATES BIRD ROCK ASPS 1957-1970

Appendix 2 (continued)

Marine Invertebrates, Bird Rock ASBS, 1957-1979
G. Chan

Major Organisms by Phyla	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Base, Bird Rock	Short Kelp Canopy	4	3	2	1
PLATYHELMINTHES (Flatworms)						
Oregoniplana opisthopora			x			
Hoploplana californica	x			x		
Leptoplana chloranota		x	*x	x	x	
Notoplana sp.		x		x	x	
NEMERTEA (Ribbon worms)						
Tubulanus polymorphus		*x	*x	x		
Micrura verrilli (in *Phyllospadix*)		x	x		x	
Paranemertes peregrina (in *Mytilus* beds)			x	x		
SIPUNCULA (Peanut worms)						
Themiste pyroides (rock crevices)		x	x			
Phascolosoma agassizii		x	*x	x	x	
ANNELIDA (Segmented worms)						
Polychaeta (marine worms)						
Arctonoe fragilis (in starfish grooves)		x	x			
Halosydna brevisetosa		x	x	*x	x	
Harmothoe imbricata			x	x	x	
Eumida sanguinea		x	x			
Neanthes brandti			x		x	
Nereis latescens					x	
Platynereis bicanaliculata		*x	*x	x	x	
Cirriformia luxuriosus			x			
Polydora sp. (in sponges)	x	x				
Sabella crassicornis		x	x			
Serpula vermicularis	*x	*x	*x	x	*x	
Eudistylia polymorpha		*x				
Spirobis spp.		*x	x	x	x	
Dodecarcaeria fewkesi		x	x			
ARTHROPODA						
Crustacea						
Cirripedia (Barnacles)						
Balanus crenatus		x	x			

* Major species

Appendix 2 (continued)

Marine Invertebrates, Bird Rock ASBS, 1957-1979
G. Chan

Major Organisms by Phyla	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Base, Bird Rock	Short Kelp Canopy	4	3	2	1
(ARTHROPODA, Crustacea)						
Cirripedia (Barnacles)						
Balanus nubilus	*x	*x	x			
B. glandula		x	x	x	*x	*x
B. cariosus			x	x	x	
Chthamalus dalli				*x	x	*x
Pollicipes polymerus				*x		x
Copepoda						
Tigriopus californicus						*x
Isopoda						
Idotea sp.			x	x	x	
I. wosnesenskii		x	x			
Amphipoda						
Photis sp.		x	x		x	
Ampithoe sp.	x	x	*x	x	x	
Caprellidea						
Metacaprella kennerlyi		*x	*x		x	
Caprella equilibra		x	x			
Decapoda						
Betaeus sp.		*x	x			
Pachygrapsus crassipes				x	*x	
Hemigrapsus nudus		x	*x	*x	x	
Mimulus foliatus		x	x			
Scyra acutifrons	x	x				
Pugettia producta		x	*x		x	
Pugettia richii		*x	*x		x	
Pugettia gracilis		x	x			
Cancer productus			x			
Cancer antennarius		x	*x		x	
Fabia subquadrata (in *Mytilus*)				x		
Paraxanthias taylori			x			
Spirontocaris sp.			x		x	
Cryptolithodes sitchensis		x	x			
Hapalogaster cavicauda		x		x		

* Major species

Appendix 2 (continued)

Marine Invertebrates, Bird Rock ASBS, 1957-1979
G. Chan

Major Organisms by Phyla	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Base, Bird Rock	Short Kelp Canopy	4	3	2	1
(ARTHROPODA, Crustacean)						
Decapoda						
Pachycheles rudis		x		x	x	
P. pubescens		x		x	x	
Petrolisthes cinctipes				*x	x	
Pagurus samuelis		x	*x		*x	
P. hemphilli		x	*x		x	
P. hirsutiusculus		x	x			
Pycnogonida (sea spiders)						
Pycnogonum stearnsi (on sea anemones)			x		x	
Ammothella tuberculata		x	x			
Achelia sp.		x	x			
Phoxichilidium femoratum		x	x			
Halicarida sp. (mite)					x	
MOLLUSCA						
Polyplacophora (Chitons)						
Cryptochiton stelleri		*x	*x			
Katharina tunicata			x	*x	*x	
Tonicella lineata	*x	*x	*x		x	
Placiphorella velata				x		
Mopalia ciliata				x	*x	
M. lignosa				x	x	
M. muscosa			x	x		
Nuttallina californica				*x	x	
Cyanoplax dentiens			x			
Gastropoda (snails, slugs)						
Crepidula adunca			x		x	
Diodora aspersa		*x	x			
Megatobennus bimaculatus	x	*x	x			
Fissurella volcano	x	x				
Haliotis cracherodii (black abalone)			x		x	
H. kamtschatkana (pinto abalone)	x					
H. rufescens (red abalone)	*x	*x	x		x	

* Major species

Appendix 2 (continued)

Marine Invertebrates, Bird Rock ASBS, 1957-1979

G. Chan

Major Organisms by Phyla	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Base, Bird Rock	Short Kelp Canopy	4	3	2	1
(MOLLUSCA)						
Gastropoda (snails, slugs)						
Acmaea mitra		x	x			
Collisella asmi					x	
C. digitalis				*x	x	*x
C. limatula			x		x	
C. pelta					x	
C. scabra				*x	x	*x
Notoacmea insessa		x	x			
N. persona				x	x	
N. scutum			x	x	x	
N. fenestrata			x			
N. paleacea			x	x		
Lottia gigantea			x			
Opalia spp.			*x			
Nucella spp.			x			
Calliostoma annulatum	z	*x	x		x	
C. canaliculatum		x	x		x	
Tegula brunnea		x	x		x	
T. funebralis				x	*x	
Littorina planaxis					x	x
L. scutulata				*x	x	*x
Crepidula adunca					x	
Ceratostoma foliatum	x	x	x			
Acanthina spirata				x	x	
Searlesia dira		x	x		x	
Amphissa versicolor		x	x		x	
Trimusculus reticulatus			x	x		
Opisthobranchia (sea slugs)						
Acanthodoris nanaimoensis		x	*x		x	
Aeolidia papillosa		x	x		x	
Anisodoris nobilis	x	x	x			
Antiopella barbarensis			x		x	
Archidoris montereyensis	x	x	x		x	

* Major species

Appendix 2 (continued)

Marine Invertebrates, Bird Rock ASBS, 1957-1979
G. Chan

Major Organisms by Phyla	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Base, Bird Rock	Short Kelp Canopy	4	3	2	1
(MOLLUSCA)						
Gastropoda (snails, slugs)						
Cadlina sp.		x	x		x	
Coryphella trilineata			x			
Opisthobranchia (sea slugs)						
Diaulula sandiegensis		x	*x		x	
Dirona albolineata			x		x	
Dirona picta			x			
Hermissenda crassicornis	x	*x	x		x	
Hopkinsia rosacea	*x	*x			x	
Phidiana pugnax		x				
Rostanga pulchra	*x	*x	x		x	
Triopha carpenteri		x	x		x	
T. maculata		x	x			
Bivalvia (Bivalves)						
Mytilus californianus				*x	x	x
Penitella penita				x		x
Hiatella arctica		x	x		x	
Hinnites giganteus		x	x			
Cephelapoda						
Octopus sp.	x	*x	x		x	
ECTOPROCTA (Bryozoans)						
Flustrellidra corniculata	x					
Crisia maxima	*x					
Bugula californica	*x	*x	x		x	
B. neritina	*x	*x	*x		x	
Membranipora membranacea	*x	*x	*x		x	
M. fusca		*x				
Tricellaria occidentalis		*x	x		x	
Hippodiplosia insculpta	*x	x				
ECHINODERMATA						
Asteroidea (seastars)						
Pycnopodia helianthoides		*x	x			
Dermasterias imbricata		x	x			

* Major species

Appendix 2 (continued)

Marine Invertebrates, Bird Rock ASBS, 1957-1979
G. Chan

Major Organisms by Phyla

	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Base, Bird Rock	Short Kelp Canopy	4	3	2	1
(ECHINODERMATA)						
(Asteroidea, seastars)						
Henricia leviuscula	x	x	x		x	
Patiria miniata	*x	*x	*x		*x	
Leptasterias hexactis		x	*x		x	
L. pusilla		x	*x		x	
Pisaster brevispinus		*x	x		x	

APPENDIX 3. INTERTIDAL TRANSECT SPECIES LIST FOR BIRD ROCK G. Chan

(May 5, 1970; July 1, 1976; April 29, 1979)

ALGAE

Chlorophyta

Cladophora columbiana
Cladophora trichotoma
Enteromorpha sp.
Spongomorpha coalita
Ulva sp.

Phaeophyta

Alaria marginata
Costaria costata
Dictyoneurum californicum
Egregia menziesii
Fucus furcatus
Laminaria dentigera
Nereocystis leutkeana
Pelvetia fastigata
Postelsia palmaeformis
Ralfsia pacifica

Other

Phyllospadix torreyi

Rhodophyta

Agardhiella coulteri
Bossiella chiloensis
B. dichotoma
Callithamnion pikeanum
Callophyllis sp.
Corallina chilensis
C. gracilis
Endocladia muricata
Erthrophyllum delesserioides
Gastroclonium coulteri
Gigartina californica
G. canaliculata
G. corymbifera
G. cristata
G. spinosa
Halosaccion glandiforme
Iridaea cordata
I. flaccida
Lithothamnium sp.
Melobesia sp.
Microcladia coulteri
Odonthalia floccosa
Plocamium sp.
Porphyra perforata
Ptilota filicina
Prionitis lanceolata
Rhodomela larix
Smithora naiadum

INVERTEBRATES

PORIFERA

Aplysilla glacialis
Halichondria bowerbanki
Haliclona permolis
Leucosolenia eleanori
Ophlitaspongia pennata
Plocamia karykina

CNIDARIA

Aglaophenia struthionides
Anthopleura elegantissima
A. xanthogrammica
Clytia sp.
Epiactis prolifera
Tealia crassicornis
Velella velella (washed in)

Appendix 3 (continued)

Intertidal Transect Species List
for Bird Rock - G. Chan

(Invertebrates)

NEMERTEA

Paranemertes peregrina

SIPUNCULIDA

Phascolosoma agassizii

ANNELIDA

Arctonoe vittata
A. fragilis
Cirriformia luxuriosus
Glycera sp.
Nepthys sp.
Polydora sp.
Platynereis agassizii
Serpula vermicularis
Spirorbis spp.
larval form
polychaeta, two species, fragments

ARTHROPODA

Balanus cariosus
B. glandula
B. nubilus
Cancer antennarius
C. productus
Chthamalus dalli
Pachygrapsus crassipes
Pagurus hirsutiusculus
P. samuelis
Petrolisthes cinctipes
Phoxichilidium sp.
Pollicipes polymerus
Pugettia producta
P. richii
Tigriopus californicus

MOLLUSCA

Acmaea mitra
Calliostoma canaliculatum
Collisella digitalis
C. limatula
C. scabra

Appendix 3 (continued)

Intertidal Transect Species List
for Bird Rock - G. Chan

(Invertebrates)

(MOLLUSCA)

Diodora aspera
Haliotis rufescens
Hinnites giganteus
Littorina planaxis
L. scutulata
Lottia gigantea
Mytilus californianus
Mopalia ciliata
M. lignosa
M. muscosa
Notoacmea fenestrata
N. insessa
N. paleacea
N. persona
Nucella canaliculata
N. emarginata
Nuttalina californica
Katharina tunicata
Octopus sp.
Rostanga pulchra
Searlesia dira
Tegula brunnea
T. funebralis
Tonicella lineata

BRYOZOA

Bugula spp.
Membranipora sp.

ECHINODERMATA

Dermasterias imbricata
Henricia leviuscula
Leptasterias hexactis
L. pusilla
Ophiothrix spiculata
Patiria miniata
Pisaster ochraceus
Pycnopodia helianthoides
Strongylocentrotus franciscanus
S. purpuratus
Cucumaria curata
C. miniata

CHORDATA

Aplidium sp.
Clavelina huntsmani
Boltenia villosa