ARCHIVE COPY
OFFICE OF LEGISLATIVE
AND PUBLIC AFFAIRS

California Marine Waters

Areas of Special Biological Significance

Reconnaissance Survey Report

STATE WATER RESOURCES CONTROL BOARD

AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

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

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

CALIFORNIA MARINE WATERS

AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

RECONNAISSANCE SURVEY REPORT

DOUBLE POINT
MARIN COUNTY

STATE WATER RESOURCES CONTROL BOARD

DIVISION OF PLANNING AND RESEARCH

SURVEILLANCE AND MONITORING SECTION

WATER QUALITY MONITORING REPORT NO. 79-15

ACKNOWLEDGEMENT

This State Water Resources Control Board Report is based on a reconnaissance survey report submitted by Dr. Gordon L. Chan and the Point Reyes Bird Observatory. The latter report was prepared in fulfillment of an agreement with the California Department of Fish and Game, which has coordinated the preparation of a series of Area of Special Biological Significance Survey Reports for the Board under an interagency agreement.

ABSTRACT

The Double Point Area of Special Biological Significance (ASBS) encompasses 86 acres which include two promontory headlands. The ASBS is situated entirely within the southern boundaries of the Point Reyes National Seashore Park in Marin County, California. There are no roads in the area, just hiking trails.

Double Point is part of the geological Monterey Formation, Miocene to Pliocene in age. The geomorphology of the area was primarily caused by massive landslides within the past 10,000 years. Geologists believe these slides are still occurring.

The climate is basically Mediterranean with foggy summer conditions and cool, wet winters. The northwesterly winds dominate the weather patterns, giving rise to a chaparral scrub and grassland community.

The subtidal reef consists of large boulders behind the Stormy Stack rock, and a large bed of bull kelp, Nereocystis luetkeana, forms an upper canopy, while short kelps covering the rocks form a lower canopy for a wide diversity of marine invertebrates and fish. There are extensive intertidal reefs at both North and South Points with lush algal and marine life.

Stormy Stack at the North Point is a breeding rookery for thousands

site, the Point Reyes National Seashore Park provides excellent protection for this marine habitat from potential pollution threats.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENT	i
ABSTRACT	ii
LIST OF TABLES	iv
LIST OF FIGURES	v
FINDINGS, CONCLUSION AND RECOMMENDATIONS	1
INTRODUCTION	6
ORGANIZATION OF SURVEY	8
PHYSICAL AND CHEMICAL DESCRIPTION	10
Location and Size	10
Nearshore Waters	10
Topography and Geomorphology	18
Climate	26
BIOLOGICAL DESCRIPTION	31
Subtidal Biota	31
Intertidal Biota	40
Plankton Samples	45
Benthic Shelf Communities	48
Vertebrates	49
Land Vegetation	55
Unique Components	57
LAND AND WATER USE DESCRIPTION	61
Marine Resource Harvesting	61
Governmental Designated Open Space and Recreational Uses	65
Scientific and Educational Uses	66
ACTUAL OR POTENTIAL POLLUTION THREATS	68
Point Sources	68
Non-Point Sources	68
SPECIAL WATER QUALITY REQUIREMENTS	72
ANNOTATED BIBLIOGRAPHY	73

APPENDICES

		Page
1.	Marine Plants, Double Point 1957-1978	78
2.	Marine Invertebrates, Double Point 1957-1978.	80
3.	Bethnic Shelf Communities	87
4.	Distribution of Fish within the Double Point ASBS	89
5.	Harbor Seals at Double Point: January 1976 through May 1977.	90
6.	Marin County Commercial Fish Landings, Pounds and Value for Years 1966-1970	94
7.	San Francisco Bay Area Counties Commercial Fish Landings and Shipments, Pounds and Value for Years 1966-1970	97
8.	Estimates of Marin County Commercial Sportfishing Effort and Economic Values	100

LIST OF TABLES

Table		Page
1.	Summary of Abiotic Water Parameters, Double Point, 1957-78. .	17
2.	Weather Data for Point Reyes.	27
3.	U.S. Weather Bureau Data for Pt. Reyes Lighthouse Station . .	27
4.	Description of Major Plants, Double Point	32
5.	Data on *Haliotis rufescens*.	37
6.	Intertidal Animals, South Double Point.	41
7.	Organisms from a Square Yard, Monterey, California.	42
8.	Plankton Sample, Double Point, 1965	46
9.	Bolinas Bay Plankton Sample, 1967	46
10.	Plankton Samples, Farallon Islands to Double Point, 1970. . .	47
11.	1971 Census of Number of Breeding Pairs of Marine Birds, Marin County.	51
12.	Breeding Pairs of Birds at Double Point	53
13.	Summary of Data on Harbor Seals, *Phoca vitulina*	54
14.	Radioactive Materials Dumped at the Farallon Islands.	68

LIST OF FIGURES

Figure		Page
1.	Double Point Proposed ASBS.	3
2.	Double Point at Point Reyes National Seashore Park.	11
3.	Double Point ASBS	12
4.	Double Point Submarine Topography	13
5.	Major Oceanic Surface Currents, Point Reyes-Drakes Bay. . . .	15
6.	Geology of the Pt. Reyes Peninsula and Nearby Areas	19
7.	Landslide at Double Point	21
8.	Major Slide Blocks in Southern Pt. Reyes National Seashore. .	22
9.	Sectional View of a General Landslide	23
10.	Cross-sectional area of Double Point Slides	23
11.	Geomorphology of Double Point	25
12.	Annual Rainfall, Point Reyes.	29
13.	Annual Runoff, Point Reyes.	30
14.	General Depth Distribution of Index Plants, Double Point. . .	33
15.	General Depth Distribution of Index Invertebrates, Double Point.	35
16.	Double Point Transect Stations, Subtidal-Intertidal	38
17.	Intertidal Zone Transect, North Point, Double Point	43
18.	Photograph of harbor seals, *Phoca vitulina*, found at Bolsa Beach of Double Point	58
19.	Energy Food Chain, Double Point ASBS.	60
20.	Fishing Beds of *H. rufescens*, History of the Lake Areas . . .	64
21.	Radioactive Dump Site, Farallon Islands	69

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Findings

The Double Point ASBS is located in Marin County, entirely within the boundaries of the Point Reyes National Seashore Park. The ASBS site is a small area of 86 acres, with two unique points or promontories jutting out into Drakes Bay.

This ASBS is protected by the Park boundaries and by its distance from urban centers; the Double Point ASBS has been found to be relatively unaffected by pollutants. The water quality of the area is good in comparison to areas adjacent to the San Francisco Bay region which have been impacted by man. A discussion of the geomorphology of the ASBS is necessary to understand the natural resources of the area.

The Monterey shale-sandstones make up the geological rocks of the area. Landslides, both ancient and recent, have formulated the hills and valleys in this locale; with lakes occupying the depressions. Pelican Lake bisects the ASBS, with a creek flowing down to the beach. The toes of these landslides have been eroded by the ocean waves, thus shaping the ASBS shore site with high cliffs; North Point rises 420 feet (128 m). Surrounding both North and South Points are intertidal and subtidal reefs. At North Point, 1,312 feet (400 m) from the intertidal zone is a large sea stack called Stormy Stack. This solitary rock is one of the major bird feeding and breeding sites in Marin County. During the summer months thousands of cormorants, murres, pelicans, and grebes aggregate on Stormy Stack. South Point, which has a smaller stack, also is a major rookery site during summer months.

Below these rookeries is a reef that is lush in marine kelp and teems with marine invertebrates. Abalones, once abundant in the area, are now very sparse within the ASBS waters. Only the kelp beds south of Double Point have a remnant population large encough to support a sport fishing activity.

Most notable among all organisms at Double Point are the harbor seals, Phoca vitulina, which permanently reside on Bolsa Beach, the area between North and South Points (Figure 1). During the pupping months of April to June, the population often numbers over 500 mammals, making this herd one of the largest permanent populations in the world.

The hundreds of seals, thousands of birds, and their interaction with the diverse invertebrates and fish of the area make this locality a unique and important ASBS site in California.

CONCLUSION

Water quality in the ASBS appears to be adequately protected as a result of the remoteness of the area from discharges and population centers. Added protection is afforded by the Point Reyes National Seashore Park encompassing the land area adjacent to the ASBS. It appears that the most significant threats to water quality are oil spills, such as the 1971 Standard Oil spill, and the unconfirmed impacts of radioactive wastes disposed at the Farallon Island site.

RECOMMENDATIONS

1. It is the principal investigator's recommendation that the State Board consider enlargement of the Double Point ASBS to include both promontory headlands of North and South Points and Stormy Stack and the large bird population on this rock. The following statement is proposed as the description for the recommended enlarged ASBS:

> The Double Point ASBS is located in Marin County, California, within the southern boundaries of the Point Reyes National Seashore Park. Its position is 122°47'00"W and 37°56'45"N on the Double Point U.S.G.S. 7.5 minute series quadrangle. The eastern or land boundary follows the concave shoreline area, including the entire North and South Points with their intertidal and

subtidal reefs. In the ocean, the proposed area is enclosed by the 12.2 meter (40-foot) isobath, a line of equal depth below the water surface connecting the S45°W line extending outside of the North and South Points. The ASBS area includes both Stormy Stack at the North Point and Pinnacle Stack on the South Point. The total area of the Double Point ASBS encompasses 1.1 square kilometers or 272 acres (110 hectares).

The primary reason for enlarging the ASBS site is to include the bird rookeries of Stormy Stack and South Point by forming a larger buffer zone against disturbances to Double Point birds and mammals.

2. Consideration should be given to closing the Bolsa Beach area to general visitors and establishing a minimum altitude for aircraft in this area.

Because the key organism in the ASBS is the harbor seal, the focus on preventing the human harassment of these mammals should be accentuated. The human disturbance on Bolsa Beach will drive the seals into the water and prevent their return to the beach. Such harassment should definitely not be permitted during the pupping months, and perhaps not even at all. The justification for human access to the Bolsa Beach area is marginal; total prohibition of man in the area is within the purpose of the Marine Mammal Protection Act of 1972. Individuals or organizations with special reserach interest should be able to secure permits to visit the beach area. Aircraft should be restricted by law from flying below an altitude of at least 3,000 feet (912 m) in this area to prevent noise harassment of these seals and birds.

3. Consideration should be given to the long-term monitoring of the populations and ecological activities of the harbor seal and bird rookery at Stormy Stack. Efforts to determine their ecological dynamics would greatly enhance the understanding of the biology of these marine organisms in Central and Northern California.

4. As there are very few young red abalones, Haliotis rufescens, in the ASBS waters, this locality would be an ideal site on which to initiate a reseeding of juvenile abalones. A monitoring program for this activity should be established under the auspices of the California Department of Fish and Game.

INTRODUCTION

The California State Water Resources Control Board, under its Resolution No. 74-28, designated certain Areas of Special Biological Significance (ASBS) in the adoption of water quality control plans for the control of wastes discharged to ocean waters. 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 quality conditions is prohibited.

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

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

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

In order for the State Water Resources Control Board to evaluate the status of protection of Double Point ASBS, a reconnaissance survey integrating existing information and additional field study was performed by Dr. Gordon L. Chan and Point Reyes Bird Observatory. The survey report was one of a series prepared for the State Board under the direction of the California Department of Fish and Game and provided the information compiled in this document.

Double Point was designated an ASBS based on the rationale that a section of the designated area, commonly referred to as Bolsa Beach, is an established harbor seal rookery containing up to more than 500 individuals. It must also be pointed out that the Double Point area is the second most important site for marine birds in Marin County (Ainley and Witt, 1973).

ORGANIZATION OF SURVEY

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 Double Point ASBS. A further requirement was a description of the land/water use and the actual or potential pollution threats within the ASBS, with indications of any special water quality requirements of the biota.

Subtidal Methods: The subtidal description at Double Point ASBS was based solely on the observations made by the principal consultant with his students over a period of 11 years, from 1967 to 1978, in a total of 17 dives, averaging an hour per dive. After each dive, a log describing the physical and biological data was completed by the principal consultant; these logs can be examined at the College of Marin. The appendices list a compilation of organisms observed.

The dives involved two basic aspects of observation:

1. Underwater transect surveys: Four transect sites were established by affixing subtidal markers, concrete blocks 20 cm. by 30 cm., with a yellow vinyl line attached to each block. Divers used compass bearings to determine placement of transect lines at these sites.

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

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

High turbidity was encountered on nearly all dives, cutting the visibilities to an average of about 1.3 feet (40 cm); in addition, large swells from the action of the Pacific northwesterly waves were often present. Maintaining compass bearings under such conditions was very difficult.

Intertidal Methods: Intertidal baselines were plotted along the high tide, Zone 1, area of the reefs at Double Point. Some permanent landmarks were scratched onto the shale rocks. The baseline was divided into five equal segments; one of the ten-meter perpendicular transect lines, selected at random, was used to delineate the study area. Square meter quadrats were then utilized to determine densities of marine organisms within each frame along the transect line. Information was then logged on the data sheet for each quadrat, beginning at the low minus intertidal Zone 4 to the high intertidal Zone 1 areas. Some unknown 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.

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 Double Point ASBS. Maps were utilized to determine the distances of roads and locations of towns and other important landmarks.

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.

PHYSICAL AND CHEMICAL DESCRIPTION

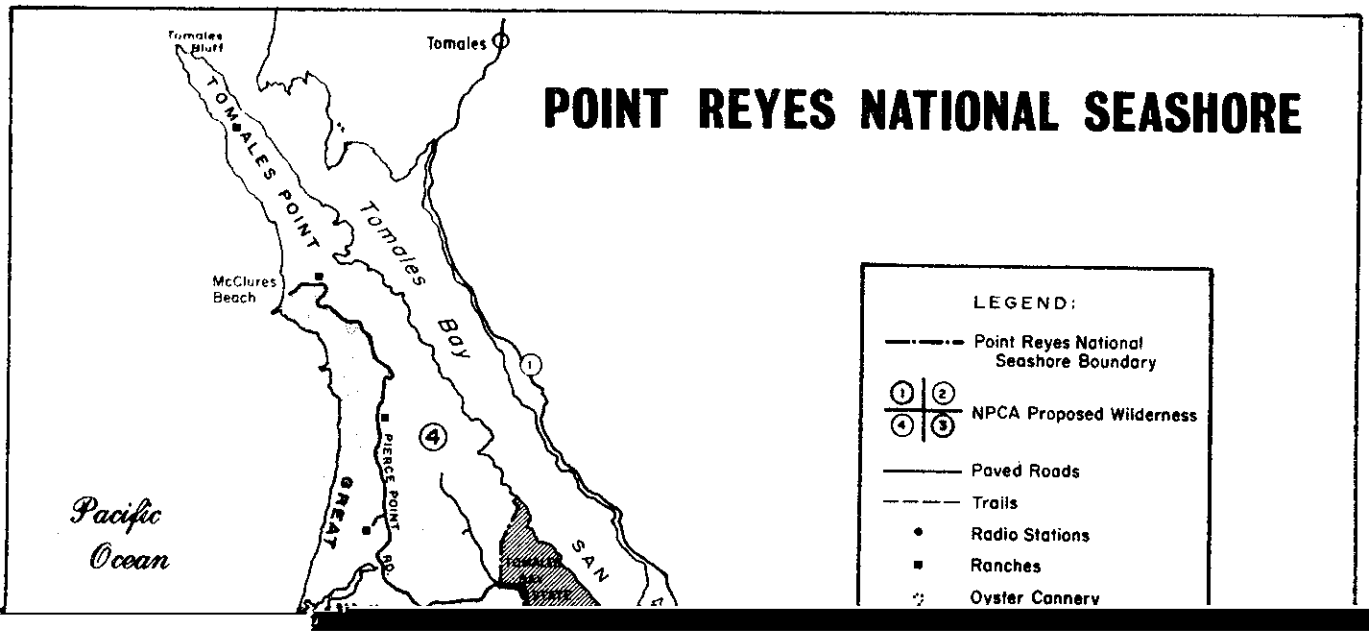
Location and Size

The Double Point Area of Special Biological Significance (ASBS) is located in Marin County, California. The area is situated entirely within the boundary of the Point Reyes National Seashore Park (Figure 2). Its position is 122°47'00"W and 37°56'45"N on the Double Point U.S.G.S. 7.5 minute series quadrangle map. Near the midpoint of the concave double points is the creek outlet from Pelican Lake (Figure 3). From the creek outlet, there are 3,700 ft. (1,128 m) of northern shoreline; the southern shoreline has 1,900 ft. (579 m). The proposed area is enclosed by the 30 ft. (9.1 m) isobath, a line of equal depth below the water surface connecting the S45°W lines extending from North and South Double Point. The total area of the Double Point ASBS encompasses 86 acres (35 hectares). Double Point is about 6 miles (9.6 km) from Bolinas, the nearest town, and 21 nautical miles (34 km) from San Francisco if one were to travel along the coast.

Nearshore Waters

Submarine Topography: The Double Point ASBS extends from the intertidal zone seaward to the 30 ft. (9.1 m) isobath line (Figure 3). The intertidal zone at both North and South Points consists of shale and sandstone. Very large boulders, about 3 to 8 ft. (1 to 2.4 m) in diameter, comprise the submarine topography around each point. The underwater area between Stormy Stack and the intertidal zone of North Point is filled with these large shale boulders. The 20 ft. (6.1 m) isobath line delineates the approximate average depth of these boulders between Stormy Stack and North Point (Figure 4).

Beyond the North and South Points is a gently sloping sandy profile leading from the Pelican Lake Creek outward past the 30 ft. (9.1 m) isobath line. The sand continues in a gentle slope towards the southwesterly direction. At approximately 3,281 ft. (1 km) from the Pelican Lake Creek


POINT REYES NATIONAL SEASHORE
Tomales Bluff
Tomales
TOMALES POINT
Tomales Bay
McClures Beach
PIERCE POINT RD.
GREAT
SAN
Pacific Ocean
LEGEND:
Point Reyes National Seashore Boundary
NPCA Proposed Wilderness
Paved Roads
Trails
Radio Stations
Ranches
Oyster Cannery

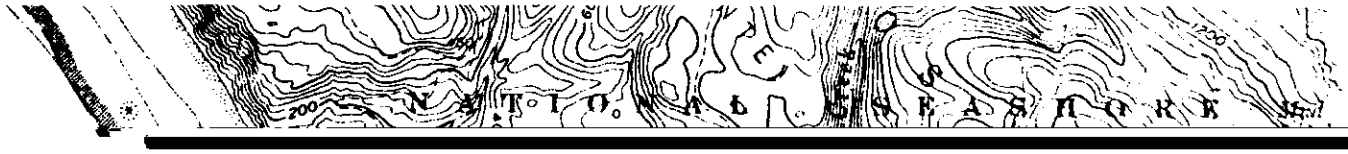

200
NATIONAL SEASHORE
1000

FIGURE 4. DOUBLE POINT

SUBMARINE TOPOGRAPHY

exit, a 1969 dive by the principal consultant revealed a continuous sandy bottom at 100 ft. (30.3 m) depth.

In summary, the submarine topography around both promontory points at the Double Point ASBS consists of large and small boulders. Between the North and South Points is a gradually sloping sandy bottom which probably dominates the relief of this area.

Currents: Two major current patterns influence the Double Point ASBS area.

One dominant oceanic surface current is the southerly moving California current off Northern and Central California. When the sea waves reach the Point Reyes Headlands (Figure 5), the waves are refracted 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 9 seconds. Such waves carry much sediment from the Point to Drakes Bay where the sediments are sorted along the beach front. There is constant erosion of the Double Point ASBS from the force of these refractory wave trains.

The second important current pattern affecting this area is the Northwest ebb tidal countercurrent which has been described by Dr. Pat Wilde of the University of California (Brown and Caldwell, 1971).

These offshore currents of the littoral zone vary according to the patterns and influences by winds and other weather conditions which occur in this locality. The northwesterly winds seem to accelerate the wave trains and tidal currents associated with the Double Point area. It was not uncommon to experience 1 to 2 meter waves at this site from a combination of strong winds and large swells. On rare days, calm seas are experienced.

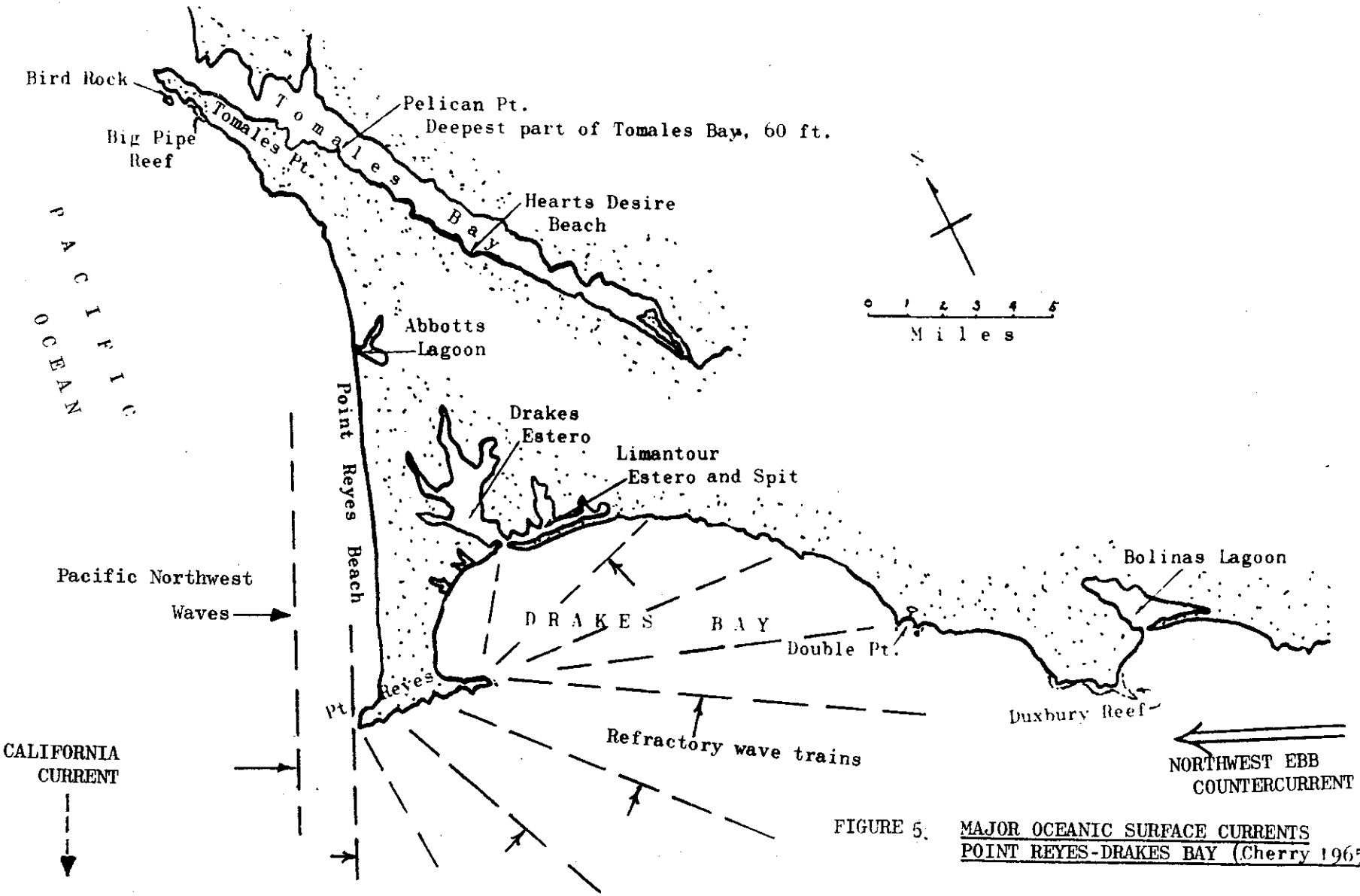


FIGURE 5. MAJOR OCEANIC SURFACE CURRENTS POINT REYES-DRAKES BAY (Cherry 1965)

At the Double Point beach area, the waves accumulate and strike the coarse sand beach at the Pelican Lake beach outlet. The massive amount of water which piles up in this little cove creates a strong undertow at the center of the beach. Divers at this area have experienced the outward "ride" which the undertow can create. The seals which inhabit this beach area also seem to take advantage of this undertow to hastily exit from the beach habitat. No thermoclines were experienced in the principal consultant's diving activities around these ASBS waters.

An unknown factor is the influence of upwelling at the Double Point ASBS. Dyer, in his 1975 study of the 47,000 cans of radioactive waste dumped southwest of the Farallon Islands, reported an upwelling current which seemed to head towards the Bolinas Headlands. Whether this current reaches the ASBS site is not known at the present time.

The Water Column: The clarity of water within the 86 acre ASBS varies from zero, close to the center beach area, to about 6.5 ft. (2 m) beyond the Stormy Stack area. Water clarity and visibilities during dives averaged about 2.8 ft. (0.9 m) (Table 1). During winter months, a large runoff of water from the higher elevations causes the lowest visibility for dives made in close proximity to the reefs. During the early summer months when the planktonic blooms are at their highest, the visibility is also poor. The clarity of water may improve slightly in late fall, but visibility for diving is generally less than 3 ft. (1 m). Most of the turbidity results from the suspended sediments which are moved about by wave surges. Surface salinities averaged 31 parts per thousand (^{o}/oo) (Table 1). This figure coincides with the average salinities in the coastal waters near the Golden Gate Bridge; the Brown and Caldwell report of 1971 shows 31.5 ^{o}/oo for many of the oceanic stations tested.

Water temperatures averaged about 52.9°F (11.6°C) for diving activities conducted by the principal consultant over a period of 21 years of observations at Double Point (Table 1).

Dissolved oxygen levels were in the optimum range of 7.7 to 8.9 mg/l. Nitrates and phosphates were at low levels, less than 0.01 ppm. (Table 1).

TABLE 1. SUMMARY OF ABIOTIC WATER PARAMETERS

DOUBLE POINT, 1957-1978, G. CHAN

DATE	ACTIVITY Intertidal	ACTIVITY Diving	SURFACE WATER TEMPERATURES	Surface Salinity o/oo	WATER VISIBILITY Meters	WATER VISIBILITY Feet	Dissolved Oxygen mg/l	Nitrates/Phosphates ppm
1. July 20, 1957	X							
2. Feb 3, 1962	X							
3. Feb 13, 1965	X	X	10.5°C (51°F)		0.3m	1.0		
4. July 1, 1965	X	X	10.0°C (50°F)		0.9m	3.0		
5. Aug 2, 1965	X	X	12.7°C (55°F)		0.15m	0.5		
6. July 8, 1966	X	X	10.5°C (51°F)		1.2m	4.0		
7. Oct 3, 1966	X							
8. July 20, 1967	X							
9. Dec 27, 1967	X	X	12.7°C (55°F)	31	2.0m	6.5		
10. June 10, 1968	X							
11. Jan 12, 1969		X	10.0°C (50°F)		1.5m	5.0		
12. July 3, 1969	X	X						
- - - - - - - -								
13. June 23, 1970		X	13.0°C (56°F)	32	0.77m	2.5		
14. July 7, 1970	X	X						
15. Aug 1, 1971		X	13.0°C (56°F)	32	0.6m	2.0		
16. Aug 5, 1972	X							
17. Aug 6, 1973	X							
18. June 4, 1974	X	X		29	1.5m	5.0		
19. Dec 31, 1975		X	11.6°C (53°F)		[illegible]	[illegible]	[illegible]	[illegible]

Topography and Geomorphology

The shoreline of the Double Point ASBS includes two headland promontories and a concave sandy beach in between the headland points (Figure 4). The basic geology of the Point Reyes National Seashore Park is based on the famous San Andreas Fault on its eastern boundary; the Double Point area is composed of sandstones of the Monterey Formation which overlays the quartz diorite granites, exposed on top of the Inverness Ridge (Figure 6).

Land Geomorphology: The following excerpt from Alan J. Galloway's The Geology of the Point Reyes Peninsula, Marin County (1977) summarizes the basic geology of this Peninsula:

ABSTRACT

The Point Reyes Peninsula is a triangle of land about 100 square miles in area in western Marin County, California, bounded on the east by the valley of the San Andreas fault zone and on the remaining sides by the Pacific Ocean. This report describes the geology of the land west of the San Andreas fault zone on this peninsula. The principal topographic features are the linear depressions of the Olema Valley, Bolinas Lagoon, Tomales Bay, the high land of Inverness Ridge immediately west of these depressions, and the promontory of Point Reyes.

The oldest rocks of the area are the metamorphosed limestones and schists which occur as roof-pendants in the granitic rocks of Inverness Ridge. Overlying the granitic rocks at Point Reyes is the Paleocene Point Reyes Conglomerate. At Inverness Ridge the granitic rocks are overlain by Miocene Monterey Shale of Relizian to Mohnian age. The Pliocene Drakes Bay Formation lies between Point Reyes and Inverness Ridge. These beds lie unconformably on the Monterey Shale and overlap onto the granitic basement of Point Reyes. The Pliocene Merced Formation, close to Bolinas, is very similar to that of the type section of the Merced Formation 20 miles to the southeast. These beds lie on rocks of the Franciscan Formation which are involved in the fault zone. The Pleistocene Olema Creek Formation lies on rocks of the Franciscan Formation in the fault zone near Olema.

Pleistocene non-marine terrace deposits overlie wave-cut platforms of Miocene rocks in several places. Old beach deposits of Pleistocene age are found at McClure's Beach on the west side of Tomales Point and along Point Reyes Beach. A very large area of ancient landsliding is found near Double Point.

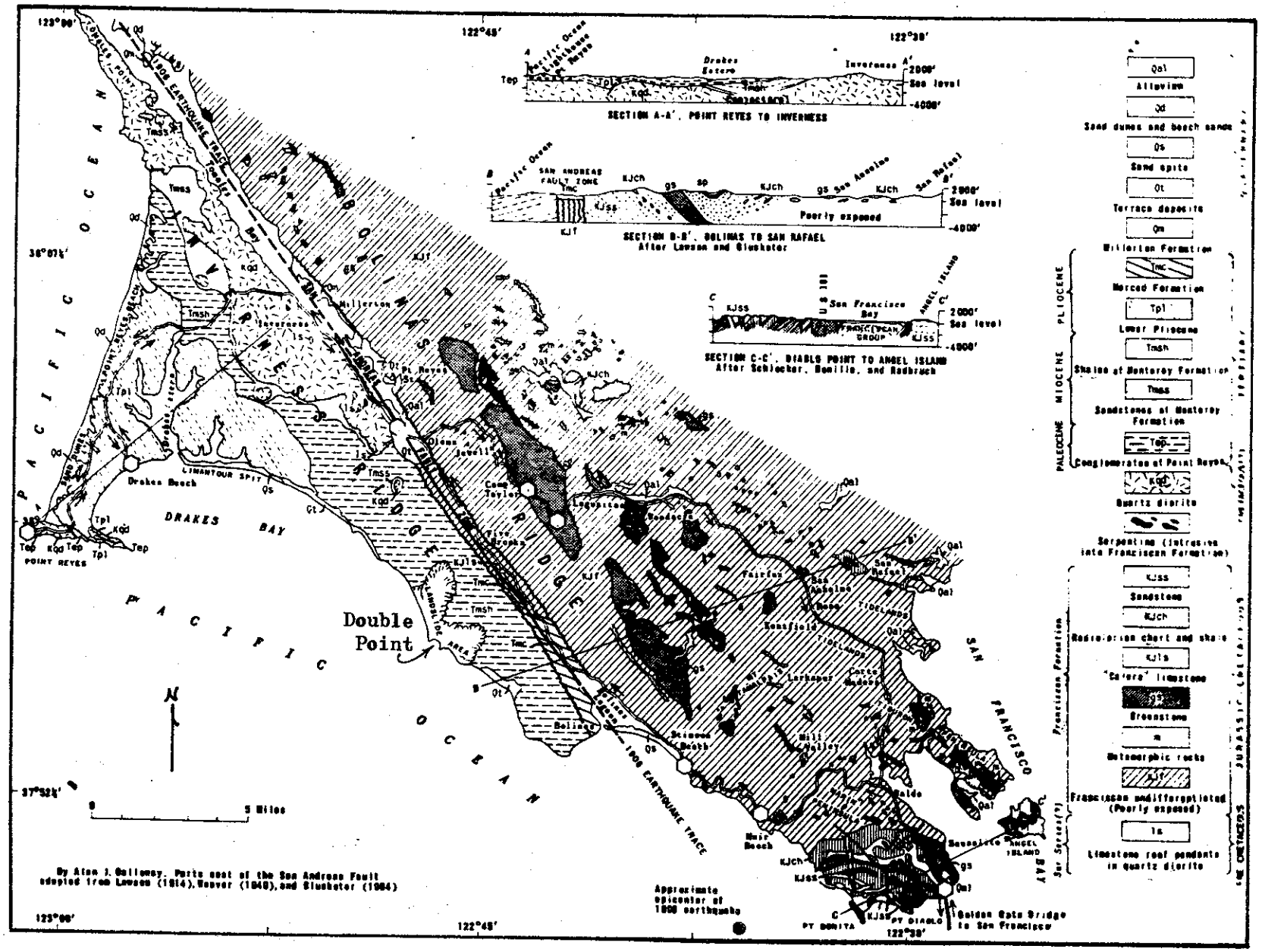


Figure 6. GEOLOGY OF THE POINT REYES PENINSULA AND NEARBY AREAS (Galloway, 1977)

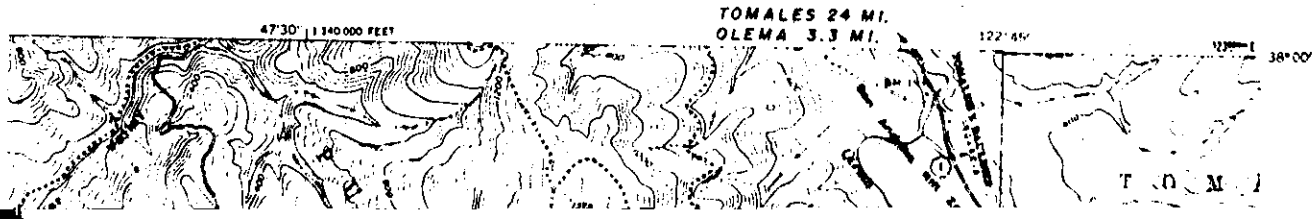
The structure of the area is dominated by the San Andreas fault zone which is about a mile and a half wide and traverses the Franciscan, Miocene, and granitic rocks. The surface rupture of the 1906 San Francisco earthquake lies toward the center of the fault zone at the south end of the Olema Valley, but lies closer to the west side of the fault zone at the north end. There is abundant topographic evidence of numerous earlier fault-traces within the fault zone. The zone here occupies a line of uplift, the blocks on each side tilting away from the fault zone. Indirect evidence suggests that the amount of lateral movement on the San Andreas fault has been on the order of 100 miles or more.

There are no active commercial operations for the extraction of minerals in the area at the present time. Oil and gas showings are abundant in Miocene and the Pliocene sediments, and a few exploratory wells have been drilled to test the prospects of the area. No commercial production has been found; the area has not been thoroughly explored for petroleum, but the prospects for any large accumulations of petroleum underlying the land area are not good.

The Double Point land formations resulted from a series of ancient landslides (Clague, 1969). The rocks involved in the landslides are shale, chert, and sandstone of the Miocene and Pliocene ages, and includes the Monterey shale. The landslides extend about 5 mi. (8.0 km) along this coastal area (Figure 7) and about 2 mi. (3.2 km) inland. The Double Point area was termed as a younger landslide, occurring about 10,000 years ago, after the cutting of the marine terrace as seen at the Bolinas mesa. Clague stated that these landslides are caused by erosion of the cliffs or toe of the landslides and the high permeability of the jointed shales and cherts displaced by earthquakes in the area. Certainly the proximity to the San Andreas Fault has contributed to these slides.

According to Clague (1969), the Double Point slide covers 1.7 sq. mi. (4.4. sq. km) and resulted in the formation of Pelican, Crystal, and Bass Lakes. At least three large blocks make up the Double Point slides, and many fresh scarps can still be observed in the old Lake Ranch area (Figure 8).

The Double Point area resembles a large slide with the toe of the slide being eroded by the ocean waves. A generalized picture of this slide is illustrated in Figure 9 by Clague (1969). In a reconstruction of the actual Double Point slide block, Clague has redrawn the area and its bedding planes and geomorphology (Figure 10). With the wave erosion


TOMALES 24 MI.
OLEMA 3.3 MI.
47'30"
1 340 000 FEET
122°45'
38°00'

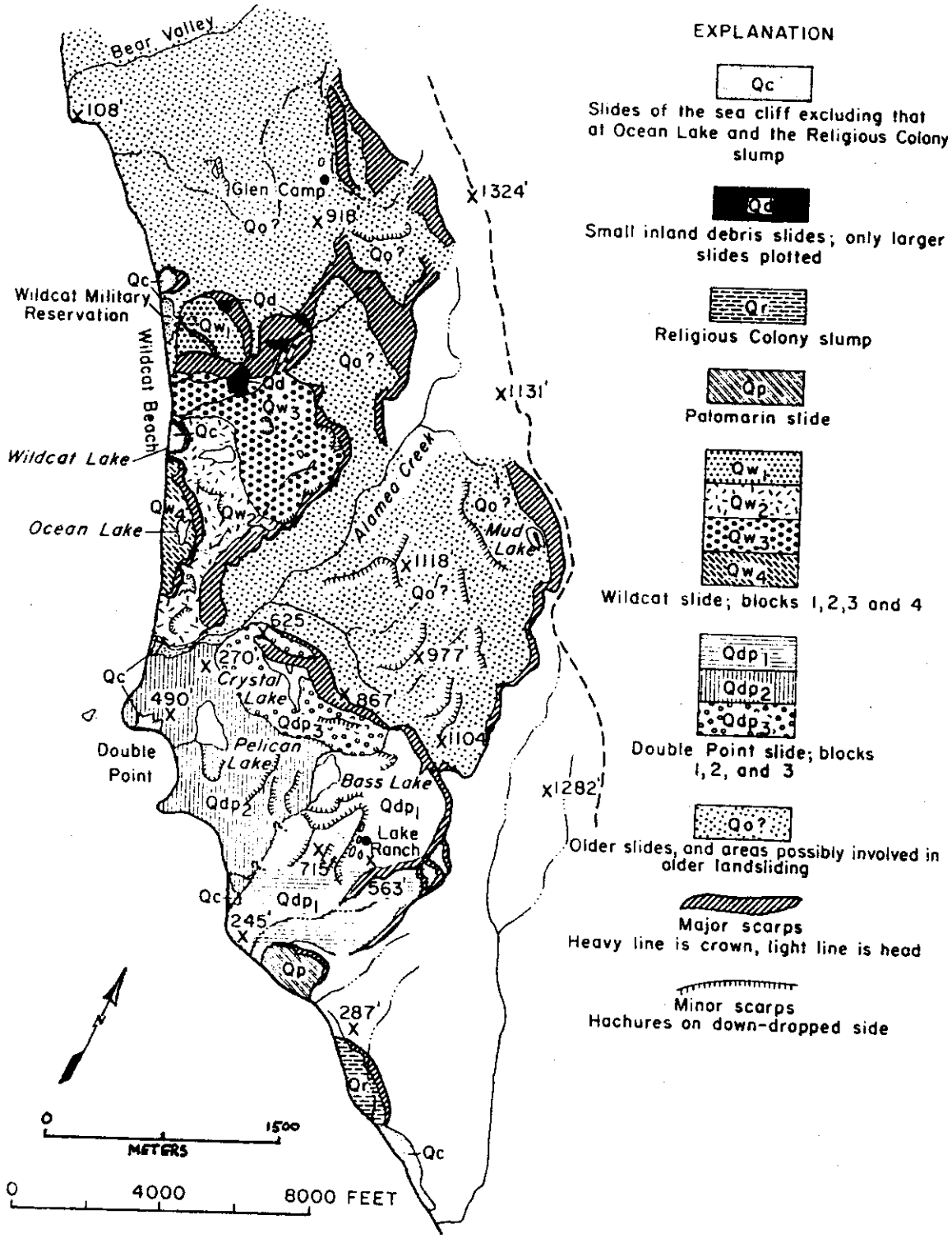


Figure 8. Map showing major slide blocks in southern Point Reyes National Seashore. (Clague, 1969)

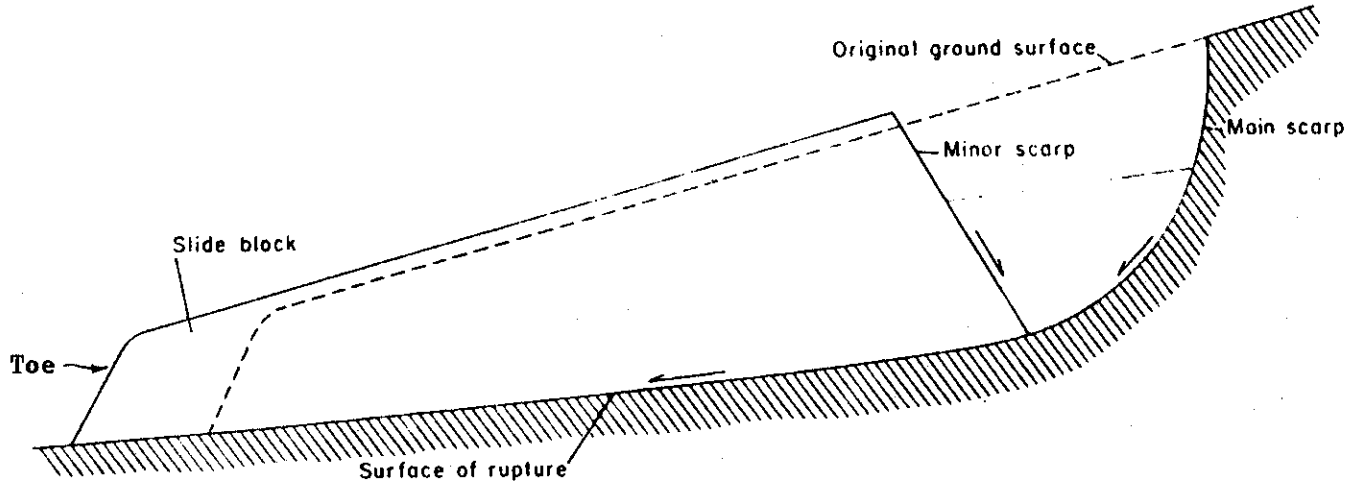


Figure 9. Section through a generalized slide showing origin of reverse-facing scarps by lateral spreading. **(Clague, 1969)**

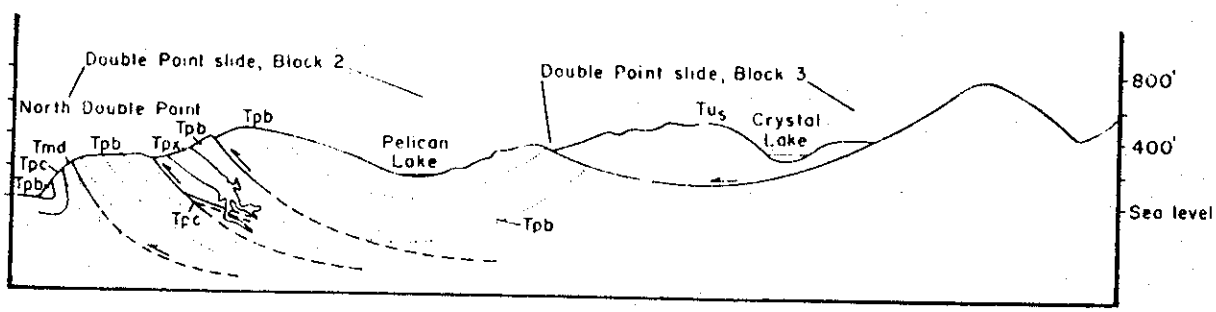
Tpd – Pliocene shale and mudstone

Tpc – Basal Pliocene glauconitic sandstone

Tpx – Sandstone mobilized into clastic injections

Tmd – Shale and cherty shale of the Monterey Formation

Tu_s – Undifferentiated shale



Bedding indicated by dotted lines. Surfaces of rupture indicated by lines with arrows showing the direction of movement; lines are dashed where rupture surfaces are inferred.

Horizontal and vertical scales: 1:10,000

0 1000 2000 FEET

Figure 10. *Cross-section showing area of Double Point slides.* **(Clague, 1969)**

still occurring, both Galloway (1977) and Clague (1969) have concluded that sliding is still taking place.

An interesting side note to the geomorphology of the area is that the area was once considered to be quite stable. Knowledge in regard to these sites as an active landslide area was probably limited. Thus, under the high peak of the North Point (400-foot contour line), the U.S. Army built some large subterranean concrete rooms to support its coastal artillery units here during World War II (1944). The entrances to these fortifications have now been filled and covered by the National Park Service, and there is very little trace of these structures at the present time (Figures 4, 11). It is very possible that as erosion and slides continue to chip away at the cliffs of North Point, these concrete structures will become exposed.

Further information on the geology of this area can be found in reports by Galloway (1977) and Clague (1969).

Intertidal and Subtidal Geomorphology: The shale, chert, and sandstone of the Monterey Formation make up the intertidal and offshore rocks at Double Point ASBS. These rocks are Miocene and Pliocene in age (Galloway, 1977), and are similar to other Monterey Formations exposed elsewhere along the Marin County coastline.

At North Point, the white chert and light-brown shale of the Monterey Formation form stratified folds. These folds are tightly banded into small chevron-like layers all along the exposed cliffs (Figures 4, 11). Clague reported that cores drilled in the area showed the Monterey Formation to be about 4,700 ft. (1,410 m) below sea level.

Most of the rocks which form the subtidal and intertidal mass at North Point consist of yellowish-brown and dark green glauconitic sandstones. The subtidal and intertidal rocks at the South Point are mostly chert and shale of the Monterey Formation. Large boulders, 5 ft. (1 1/2 m) in diameter, are very common in the subtidal habitat around the projection of South Point.

Wildcat
Lake
200
400
600
600
800
E

Both North and South Points represent the eroded face of synclines. The rocky islands, Stormy Stack at the North, and the pinnacle at the South Point are anticlinal rock masses, suggests Clague (1969). Clague also concludes that the areas between North Point and Stormy Stack and between South Point and the South Pinnacle are synclinal areas, the result of tectonic activities or landslides (Figure 11). Pelican Lake is a result of a synclinal depression caused by landslide activities (Clague, 1969) (Figures 10 and 11).

Between both points, the beach area, sometimes known as Bolsa Beach, consists of medium to coarse sands, ranging from 1 to 3 mm. The subtidal sands from Bolsa Beach out to the 100 ft. (30 m) line also appear to be medium to coarse sands. All of the sands seem to be poorly sorted, probably due to the constant mixing process from the strong waves affecting this beach area.

Climate

The general climate of the Point Reyes National Seashore Park is characterized as a Mediterranean type with moderate summers and cool, wet winters.

The annual rainfall is about 19.5 in. (49.5 cm) per year. There is very little rainfall during the summer months; most of the precipitation occurs in the winter months, November to March (Table 2).

The winds during the summer come from the northwest, averaging about 10 to 13 mph (16 to 20 km/hr). During the winter months velocities may approach 40 to 50 mph (64 to 80 km/hr) (Table 3).

During the summers the prevailing westerlies have high moisture content, thus accounting for the persistent fog which blankets the area and is an important climatic variable for the Point Reyes Park area. With the coolness of the frequent fog, Point Reyes has recorded the lowest mid-summer temperature range of any observation staion in the continental

TABLE 2.

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 3.

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

United States (Schenk, 1970). During 1949-1953 there was an average range of 7°F (3.9°C) between the mean temperatures of the coldest and warmest months of the year (Table 3). The principal consultant has encountered temperatures at Double Point as low as 50°F (10°C) in January 1968, and as high as 86°F (30°C) in September 1976.

As a precise example of weather for this Double Point area, Halliburton (1973) reported that fog was very common throughout the year at the Point Reyes Bird Observatory, located 1.5 mi. (2.4 km) south of the Double Point ASBS. Also, between November, 1972 and March, 1973, there was a rainfall range of 2 to 10 in. (5 to 25 cm). These data correspond closely to the rainfall map (Figure 12) which indicates an annual amount of 24 in. (60 cm) per year (Biswell and Agee, 1973). These authors also concluded that the Double Point area has about an annual 6 in. (15 cm) of land surface water runoff, based on the yearly rainfall information (Figure 13). The winter temperatures ranged from 30 to 55°F (-1° to 12.7°C), and summer temperatures from 45 to 80°F (7.2 to 26.6°C).

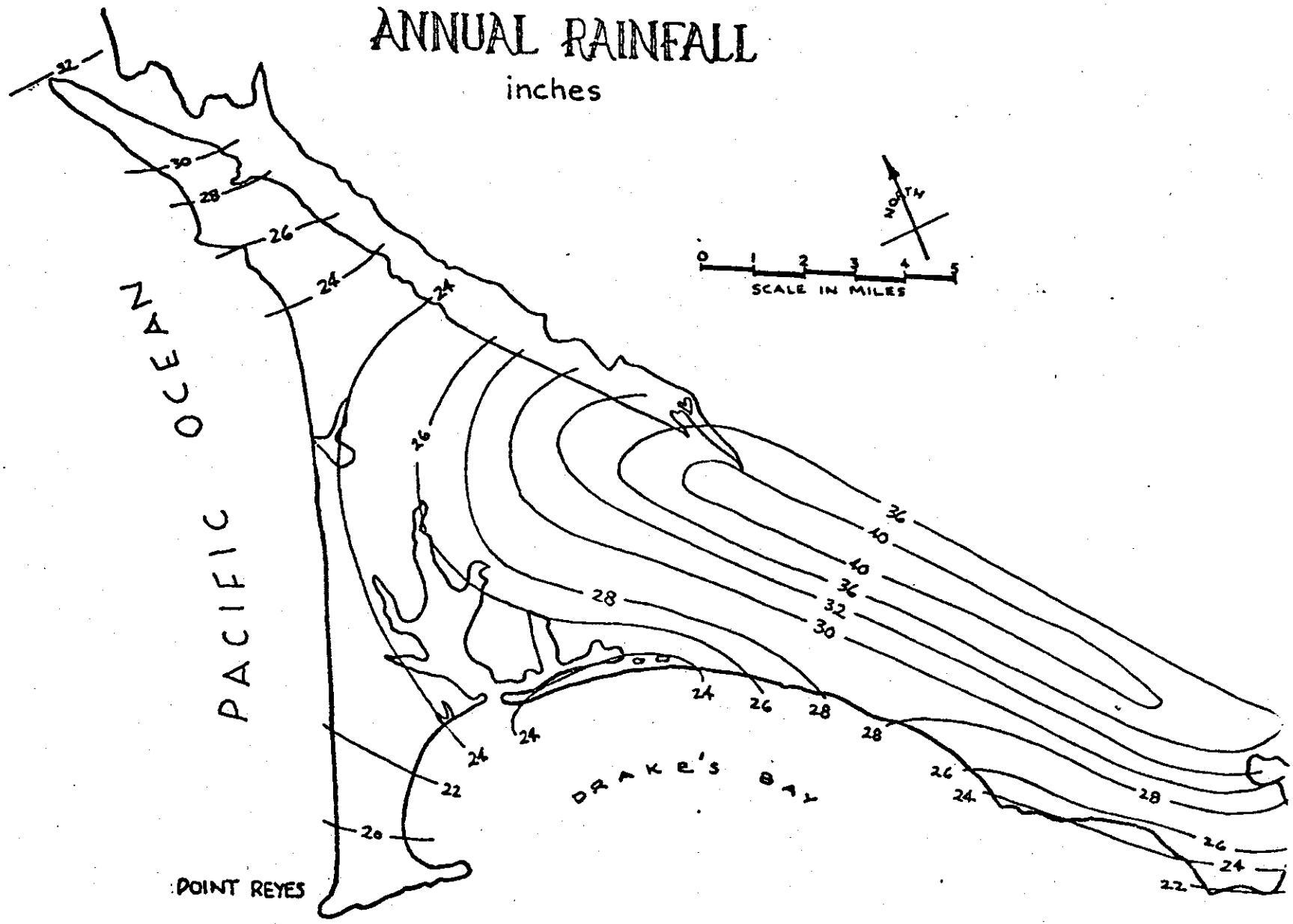


Figure 12. ANNUAL RAINFALL (inches), POINT REYES (Biswell and Agee, 1973)

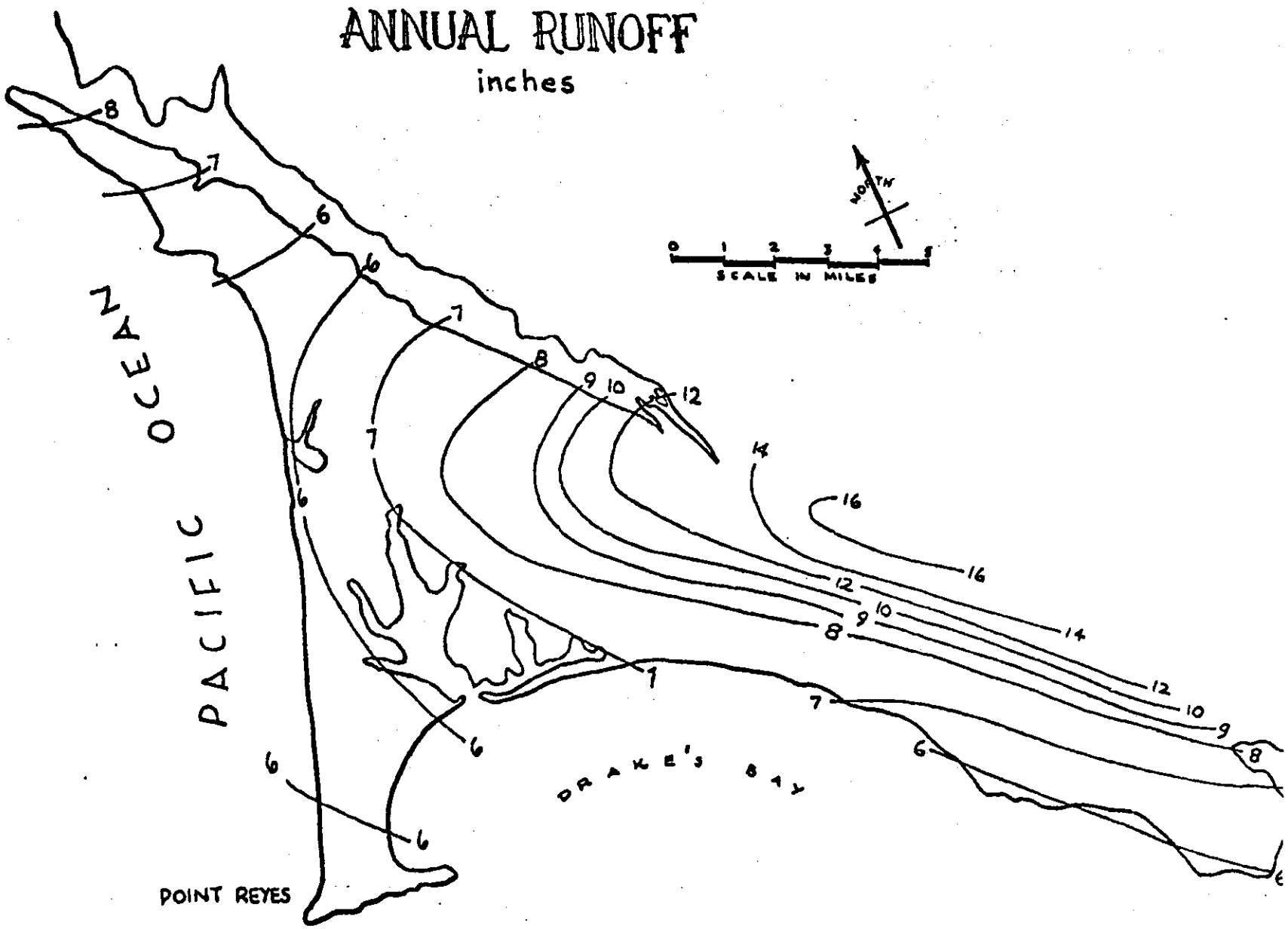


Figure 13. ANNUAL RUNOFF (inches), POINT REYES (Biswell and Agee, 1973)

BIOLOGICAL DESCRIPTION

Subtidal Biota

The subtidal community of Double Point abounds with a high diversity of plants and animals (Appendices 1-4). Better visibility and diving conditions over the years would undoubtedly increase the number of observations. Nevertheless, the community is extremely diverse within a very special habitat. The principal habitats are the reef areas surrounding both North and South Points and the rocky and sandy environment between both promontories.

Plant Community: From the subtidal regions to the upper intertidal rocks, the marine algae form a distinct ecological habitat for the invertebrates of the reefs. In Figure 11, the outline of the rocky reefs are delineated and within this region of algal growth, the plants form distinct habitats.

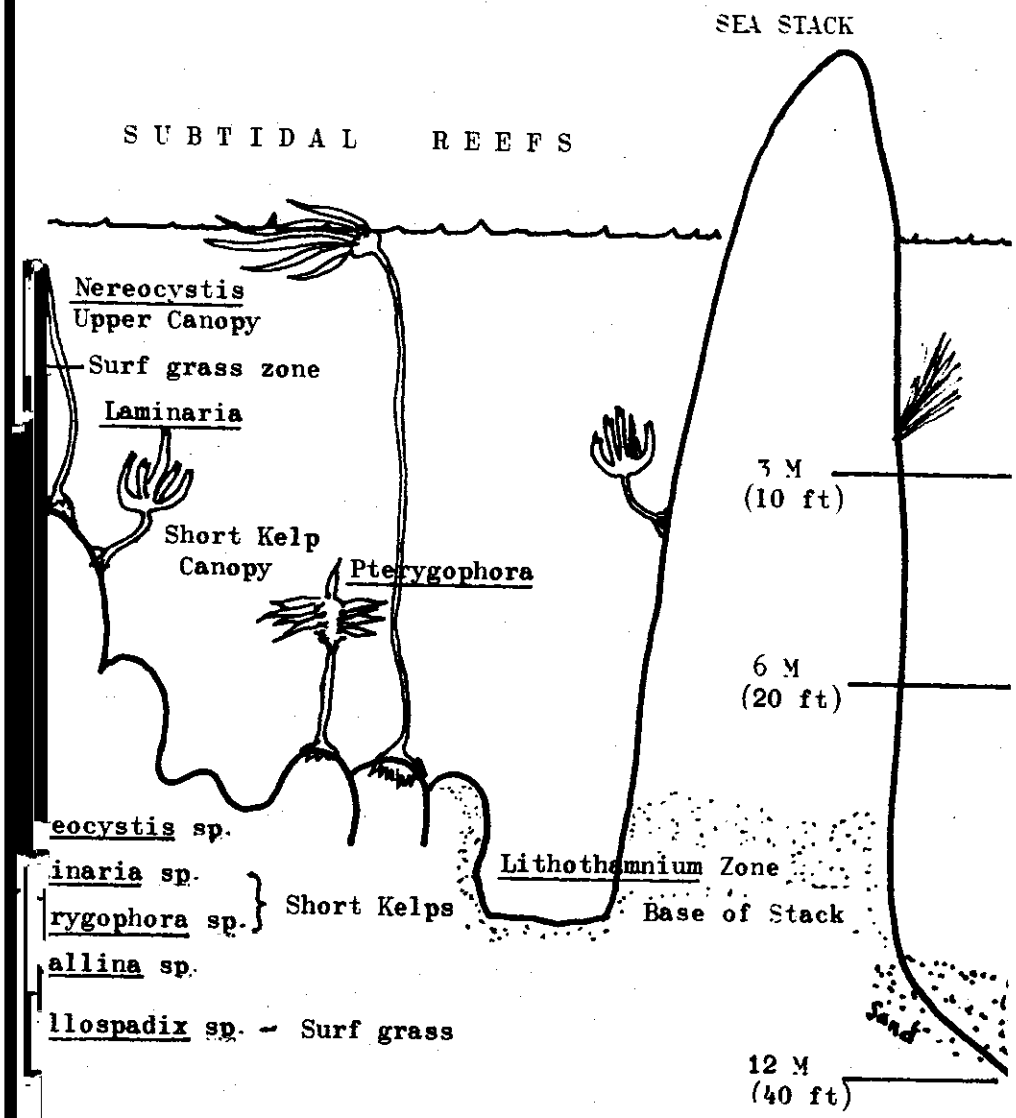
Pequegnat (1964) divided the offshore reefs of California into distinct layers: reef tops, reef sides, reef bases, and sand and gravel substrate. With some modifications according to the type of marine plants that occupy the space, Pequegnat's description of zones has been adopted for this survey. Marine plants have a specific selection zone depending on the depth, currents, amount of light, and exposure during ebb tides.

A total of 70 major plants in both subtidal and intertidal areas at Double Point are listed in Appendix 1. The key plants which are most abundant, and which dominate the specific zones, are called "index plants"; these are itemized in Table 4. 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, the following outline describes the ecology of the general profile (Figure 14) of the distribution of plants in this area:

TABLE 4. DESCRIPTION OF THE MAJOR PLANTS, DOUBLE POINT

Avg. Depth	No. of Major Plants	Index Plant Zone	Ecology
7 meters (25 feet)	8	*Lithothamnium* spp. and other encrusting red algae	This encrusting red algae zone covers the sides of the large rocks and sea stacks down to the sand level at 12 meters (40 ft).
		Nereocystis luetkeana The haptera of these plants have an optimum depth of about 7 meters (25 feet).	Rising from the tops of rocks between the sea stack and shallow reefs are large beds of the bull kelp *Nereocystis*. These giant kelp form an upper surface canopy for many fish and invertebrates.
4.5 meters 15 feet	23	*Laminaria dentigera* *Pterygophora californica* Short *Nereocystis* are also abundant here.	This is known as the short kelp zone. These heavy stiped kelps form a dense cover over the large rocks and boulders. Many animal herbivores (abalones, etc.) are found in this niche, second in population densities to the Zone 4 area below.
4.5 meters (15 feet)	20	*Egregia menziesii* *Phyllospadix torreyi* *Iridaea cordata*	At the interface of subtidal waters to the Zone 4 or low intertidal area are the boa kelp, *Egregia* sp., and the surf grass, *Phyllospadix* sp. The density of marine animals which occupy this niche is the highest at Double Point.



INDEX PLANTS, DOUBLE POINT (Not drawn to scale)

Invertebrates: The general depth distribution of marine invertebrates at Double Point (Figure 15) is ideally applicable to the habitat of North Point, with Stormy Stack as the pictured sea stack. At South Point, the sea stack-pinnacle is entirely exposed on the lee or east side of the stack. However, surrounding the pinnacle on the windward or west side are the typical algal communities previously described (Figure 14). Using the profile of the general distribution of invertebrates (Figure 15), the subtidal habitat of the lowest vertical zone will be described first; then moving up to the intertidal regions.

The Lithothamnium or Coralline Algae Zone: The depth of this zone ranges down to 40 ft. (12 m) which is at the base of the Stormy Stack (Figure 4). This niche is constantly swept by currents coming from the wave trains moving north-eastward. The visibility in this area is extremely poor, averaging about 1 foot (30 cm) during the dives. On each dive to the base of the sea stacks, an attempt was made first to search the sandy areas surrounding the stack for the distribution of sand-based organisms. However, for such dives (6 in total), the visibility was so poor, one could only record that detritus was moving with the wave surge

Thus, no organisms are described in this report for the benthic sands surrounding the sea stacks.

However, the Lithothamnium or Coralline-algae zone is profuse with marine life. When approaching the sea stack, the algae, sponges, and other colorful attached organisms show up remarkably well in the turbid waters. The pink crustose algae, Lithothamnium spp. and Mesophyllum lamellatum, cover the exposed rocky surfaces. Mixed in with the algae are dense masses of the sponges, Porifera. The red sponge, Plocamia karykina, has a discernible dull red color when spaced with the coralline algae. The yellow tubercles of the raised sponge, Polymastia pachymastia, are also spotted in the area along with the grey balled sponge, Hymeniacidon sp. This latter sponge with its long projecting spicules is quite numerous in the habitat.

Spaced throughout the sponges are large sheets of tunicates, Aplidium californica and Diplosoma macdonaldi. The upright ascidian, Clavelina

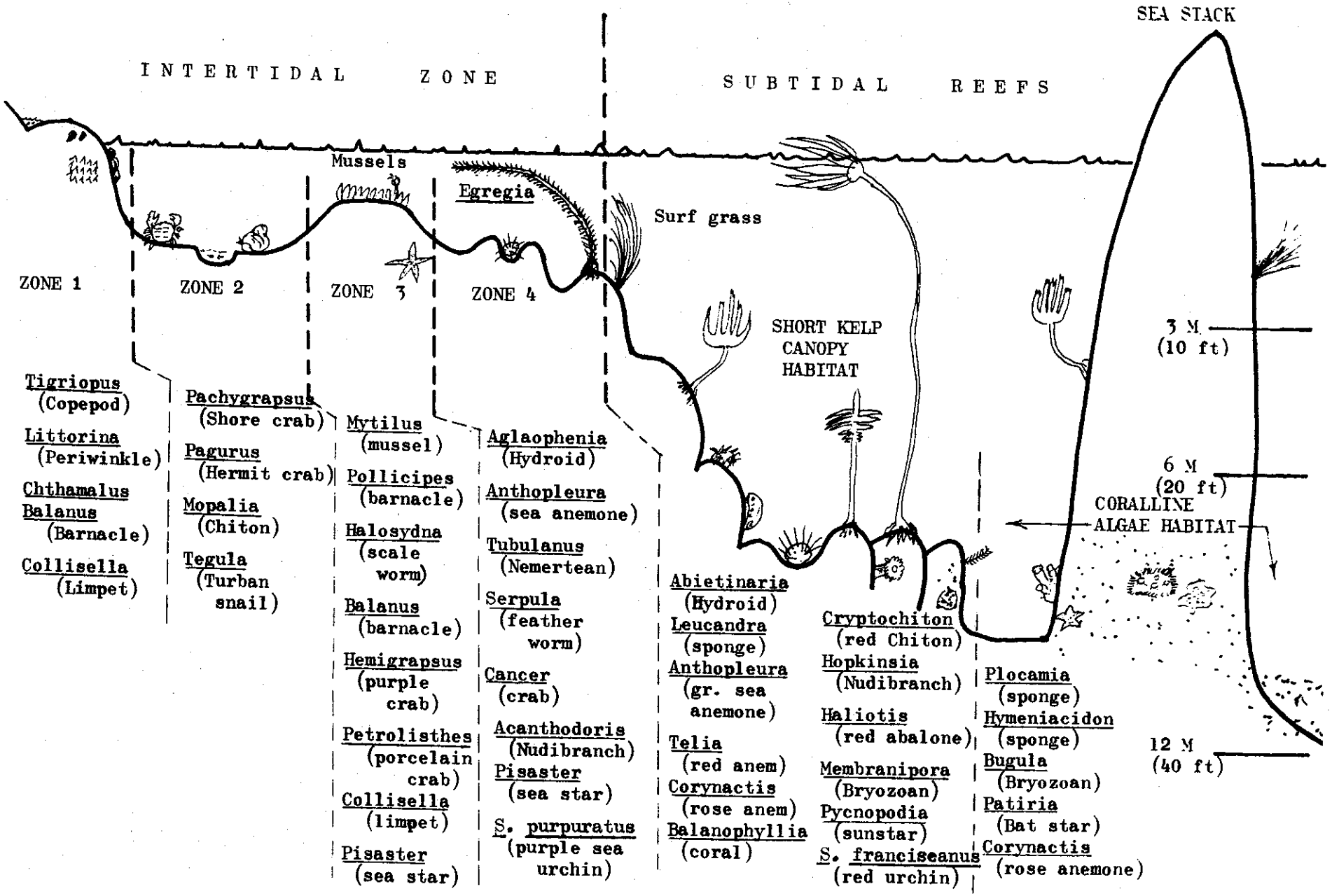


FIGURE 15. GENERAL DEPTH DISTRIBUTION OF INDEX INVERTEBRATES, DOUBLE POINT (Not drawn to scale)

huntsmani, with its brilliant red viscera, is easily distinguishable. The hydroids, Abietinaria sp. and Aglaophenia sp., are very abundant as well as the masses of ectoprocts. Membranipora [illegible]

From the underwater surveys, the data show that this short-kelp canopy area may be the most heavily populated habitat. The data on itemized species (Appendix 2) revealed that this area, along with the Zone 4 location, has the highest diversity and densities of organisms. Of the major species recorded, 110 were ascribed to the short-kelp canopy area and 101 to the intertidal Zone 4 location.

Key index invertebrates in this area are the sponges, cnidarians, crustaceans, gastropods, bryozoans, echinoderms, and tunicates. Over the years, a primary interest of this investigator was to record the populations of the red abalone, Haliotis rufescens, in this area. H. rufescens is much more dense in population at the South Point subtidal rocks than at the North Point area (Table 5). Four subtidal transects were observed, two at South Point, and two at North Point (Figure 16), primarily to record the activities of H. rufescens.

TABLE 5. DATA ON HALIOTIS RUFESCENS (Red Abalone)

Size of each transect = 5 square meters

Number of Abalones

24
12
400

In the rocks and boulders of the short kelp canopy zone are a myriad of other marine invertebrates. The sponges are abundant, particularly the heavy spiculed Leucandra heathi. Abietinaria sp., Aglaophenia sp. and Garveia annulata are among the many specimens of hydrozoans. The anthozoans are extremely plentiful. Large sized anemone A. xanthogrammica, T. lofotensis, and M. exilis are scattered throughout the locality. Likewise, the rose anemone, C. californica and the coral B. elegans abound in large numbers all over the rocky-boulder surfaces.

In the holdfasts of the kelps and red algae live a number of worms. Particularly abundant are the flatworms Leptoplana chloranota and Micura verilli, the flat ribbon worm found in the root matrix of surf grass, Phyllospadix torreyi. Other worms in the holdfast community are the polychaetes Harmothoe imbricata, Platynereis bicanaliculata, Polydora sp., found in sponges, and serpulid worms encrusting on rock surfaces.

Among the barnacles, the large Balanus nubilus is seen here. The amphipods, Ampithoe sp., and skeleton shrimp, Metacaprella kennerlyi, are very thick in the matrix of hydroids. Many masking crabs remain sessile and still among the sponges and hydroids, particularly Pugettia richii. The rocky crevices and ledges are coated with the ectoprocts Membranipora spp., Bugula spp., and Tricellaria occidentalis. Among the gastropods, the key-hole limpets Megatebennus bimaculatus, Diodora aspera, and Fissurella volcano are sessile among the sponges and tunicates. Likewise, many of the nudibranchs are sponge eaters, so many dorids are present: Acanthodoris nanaimoensis, Archiodoris montereyensis, Rostanga pulchra, and Ansiodoris nobilis. The most numerous of the nudibranchs is Hopkinsea rosacea; it is very colorful when found on the sponge-tunicate matrix.

With a surplus of kelp and other algae, the giant red urchins have much food to eat. The population of these sea urchins is not as dense as that of the Bird Rock area to the north, about 6 per 5 m^2 at those transect sites. Fortunately, there is a predator present which can consume 2 to 4 urchins a day--the sunflower star, Pycnopodia helianthoides (Chan, 1971). The batstar, P. miniata, and the pink skinned seastar and the ochre seastar are also very numerous among the echinoderms.

Near the upper surface of the short kelp community is the mat of surf grass, Phyllospadix torreyi. Mixed into the roots and thallus of this plant are many worms, including the flatworm Notoplana sp., the ribbon worms M. verrilli and Tubulanus polymorphus, the peanut worm Phascolosoma agassizii and the polychaetes H. brevisetosa, H. imbricata, Eumida sanguinea, P. bicanaliculata, and Polydora sp. Many crabs are in this surf grass habitat: Mimulus foliatus, Scyra acutifrons, Pugettia gracilis, P. richii, Paraxanthias taylori, and the stone crabs Hapalogaster cavicaunda and Pachycheles rudis.

The short kelp community also exists on the windward or west side of the sea stacks (Figure 15), but the diversity and density of marine invertebrates there do not match that of the lee or protected side of the stack. Algae, protected from the wave fronts and surges, grows to thick densities on the lee side.

Intertidal Biota

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

The kelps Laminaria spp., Pterogophora californica, Alaria marginata, along with the feather 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 subtidal short kelp zone. The surf grass community of Phyllospadix torreyi adds to the high diversity of organisms here. Moreover, there is an abundance of red algal species (Appendix 1) which also contributes to the food web complexities. A definite extension of the short kelp zone are the tidepools of the Zone 4 region. Coralline algae, C. officinalis var. chilensis, line most of the tidepools. With the other available reds, Prionitis lanceolata and Iridaea cordata var. splendens,

these pools offer much habitat to a wide variety of invertebrates and sculpin-type fish.

One additional species to grace this area is Strongylocentrotus purpuratus, the purple sea urchin. Throughout Northern California, observations have shown this species is definitely zoned above its counterpart, the giant red urchin; on Marin County shores it occupies the windward side of exposed reefs. These urchins nestle into crevices by the hundreds, and with the abundance of algae, their existence seems assured on the Double Point reefs.

Two intertidal transects were surveyed, one each at the North and South Points. At the South Point, Figure 16, a base line transect 175 yds. (160 m) ran parallel to the shore: a 10-meter perpendicular line constituted the counting transect in the intertidal zone. The line ran across the habitats from Zone 2 to 4.

Table 6 illustrates the sample mean of organisms from the South Point transect counts.

Table 6. INTERTIDAL ANIMALS, SOUTH DOUBLE POINT. Chan, 1970

Major Transect Species (10 meters)	Sample Mean* $\bar{X}/m.^2$
Anthopleura xanthogrammica	5.0
Cancer antennarius	1.4
Pagurus samuelis	2.9
Petrolisthes cinctipes	4.7
Leptasterias equalis	1.2
Pisaster ochraceous	1.0
Amphiopholis pugettana	2.0
Mopalia muscosa	2.0
Balanus glandula	74.0
Collisella digitalis	1.3

*Mean number per square meter of transect.

The sample transect did not have any California mussels, Mytilus californianus, as these are generally higher in the rocky zones closer

to the wave fronts. At the South Pinnacle, a large intertidal sea stack at the South Point, a dense cluster of California mussels exists around the +2.0 tidal levels.

At North Point, a longer transect of 105 ft. (32 m) was surveyed in 1975 and reviewed periodically for any changes in major organisms. No density samples were taken; only a species list was recorded. The last census in 1978 revealed very little in diversity had taken place (Figure 17). Some of the migratory invertebrates show more fluctuations in counts within the various zones, in particular the nudibranchs Acanthodoris nanaimoensis, Hermissenda crassicornis, and Hopkinsea rosacea. Crabs such as Hemigrapsus nudus, Cancer antennarius, and Pachygrapsus crassipes are quite mobile within the transect area.

One stable group with dependable population counts are the organisms associated with the Zone 3 mussel bed. The dominant organisms are the California mussel and the gooseneck barnacle, Pollicipes polymerus. Adhering to the shells of mussels and barnacles are the extremely abundant populations of acorn barnacles, Balanus sp. and Chthamalus spp., along with the limpets Collisella spp. The mussels form a canopy for many species of worms, amphipods, and decapods. Ricketts, Calvin and Hedgpeth (1968) described the work of Hewatt in 1931-32 involving the population succession of a Mytilus-Pollicipes bed in Monterey, California. A total of 5,210 invertebrates were taken from a square yard quadrat, summarized in the table below:

TABLE 7. ORGANISMS FROM A SQUARE YARD (Hewatt, 1931)

Species	Total Count	+ = present at North Double Pt. 1975-78
Algae		
Collisella spp.	319	+
Amphissa veriscolar	39	+
Balanus glandula	872	+

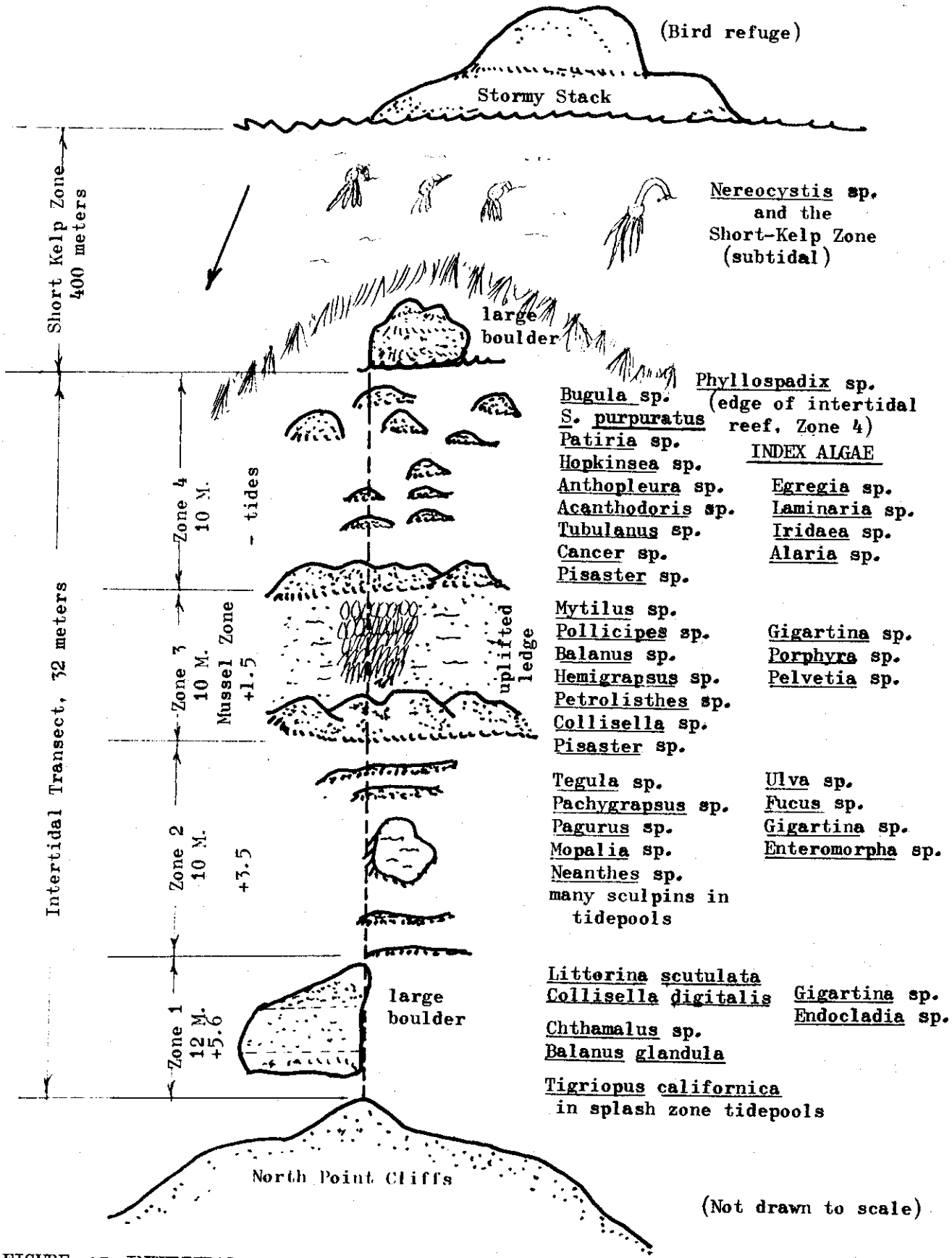


FIGURE 17. INTERTIDAL ZONE TRANSECT, NORTH POINT, DOUBLE POINT

Cirolana harfordi	926	+
Leptasterias aequalis	6	+
Lottia gigantea	10	
Mytilus californianus	1612	+
Nuttallina californica	(later present)	
Pachygrapsus crassipes	14	+
Petrolisthes cinctipes	416	+
Phascolosoma agazzizi	327	+
Pollicipes polymerus	356	+
Tegula brunnea	17	+
Tetraclita squamosa	78	
Thais emarginata	218	+
TOTAL	5210	plus many worms

In addition to those species found in the North Point mussel bed, as noted in Figure 17, there is a wide variety of worms and amphipods (Appendix 2):

Platyhelminthes:	Hoploplana californica
	Leptoplana chloranota
	Notoplana sp.
Nemertea:	Tubulanus polymorphus
	Paranemertes peregrina
Polychaeta:	Halosydna brevisetosa
	Harmothoe imbricata
	Platynereis bicanaliculata
	Serpula vermicularis
Amphipoda:	Ampithoe sp.

Moreover, within the cavities of many of the mussels are the commensal pea crabs, Fabia subquadrata.

On the lee or east side of the mussel bed zone is the protected intertidal shale reef which indicates Zone 2 organisms (Figure 17). Among the sea lettuce and rockweed algae live the black turban snail, Tegula funebralis, the lined shore crab, Pachygrapsus crassipes, found in crevices, the chitons, Mopalia spp., on the reef flats, and the nereid worm, Neanthes sp., in the sandy crevices, all of which are index species.

Finally, in Zone 1, the high zonated rocks of +5.6 MHW, are the populations of (Figure 17) acorn barnacles, the limpet Collisella digitalis, and the periwinkle Littorina scutulata.

In the high splash zone tidepools live the red chili-pepper copepod, Tigriopus californica, and a wide variety of gammaridea-amphipods. These organisms can withstand a wide range of temperatures and salinities.

In summary, the intertidal zones represent a ladder: those organisms which can withstand dessication and high temperatures are selected as the species that will live in these upper levels of the ladder system. The great majority of marine organisms tend to remain in the water habitat of the lower zone.

The beach area between the two points, sometimes referred to as Bolsa Beach, consists of extremely unstable sand-gravel particles, due to the constant erosive wave-surge which strikes this beach area, creating much suspended sediment in the water column. In our survey dives, attempts to record living specimens in this area were hampered by poor visibility, with average "seeing distance" of 6 inches (15 cm). Furthermore, the outgoing rip-tide from the center of this cove has also made diving difficult in this area. Therefore, it was not possible to record or observe any living organisms. Obviously as one moves closer to the rocky reefs on both sides of the promontories, one encounters many of the invertebrates already mentioned in the previous pages on the short kelp and intertidal communities.

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 immediate area of the Double Point ASBS, one littoral zone sampling for plankton, taken on August 2, 1965, produced the following:

TABLE 8. PLANKTON SAMPLE, DOUBLE POINT
August 2, 1965, G. Chan

Plankton net: 12 mesh, 120 microns
Length of tow: 100 meters

Major animals	No. in 1.6 $cm.^3$ grid	Number of Organisms
Nauplii (barnacle larvae)	3	5.4×10^4
Calanus spp. (copepods)	1	1.8×10^4
Bougainvillia sp. (anthomedusae)	2	3.0×10^4
Carcinus sp. (Brachyuran larvae)	2	3.2×10^4
Major diatoms		
Coscinodiscus spp.	3	2.4×10^4
Chaetoceros spp.	14	6.0×10^5

The phytoplankton *Coscinodiscus* spp. and *Chaetoceros* spp. were the most abundant diatoms, while the nauplii barnacle larvae had the highest density among the zooplankton (Table 8).

Comparing the Double Point plankton sample to eight plankton tows taken in 1967 from Bolinas Bay, it can be seen that the diatom, *Chaetoceros* spp. and the Nauplii larvae were again the most numerous organisms (Table 9).

TABLE 9. BOLINAS BAY PLANKTON SAMPLE, Chan, 1967

	Major Organisms	Numbers in tows
1.	*Chaetoceros* spp.	1.59×10^6
2.	Nauplii larvae	8.72×10^5
3.	*Coscinodiscus* spp.	4.44×10^5
4.	Rotifers	3.30×10^5
5.	Copepods	2.74×10^5
6.	*Noctiluca* sp.	2.70×10^5

Another plankton comparison appears in Table 10. Three samples were taken in 1970 by the California Department of Fish and Game and compiled by Brown and Caldwell (1971). The samples were taken at three stations:

Station	Distance from Double Point	
FG-6	13.8 miles	25.6 km
FG-7	8.2 miles	15.2 km
FG-8	6.0 miles	11.1 km

TABLE 10. PLANKTON SAMPLES FARALLON ISLANDS TO DOUBLE POINT, 1970
(Brown and Caldwell, 1971)

	NUMBER OF ORGANISMS PER CUBIC METER		
	Date = 4/1/70 Station = FG-6	4/2/70 FG-7	4/2/70 FG-8
Calanoid copepod	75	380	1,384
Annelid larvae	5		
Chaetognath	15	4	16
Brachyuran larvae	5	9	439
Gastropod larvae	5		4
Larvaceans (Oikopleura)	15	4	8
Fish eggs	1,150	48	8
Fish larvae	5		8
Cyclopoid copepods		4	24
Amphipods		4	
Porcellanid		1	5
Medusa			4
Siphonophore			4
Barnacle larvae			8
Barnacle nauplii			8
Euphausid			36
Mysids			12
Totals	1,275	454	1,936

The most distant sample from Double Point to the Farallon Islands was taken at station FG-6, showing fish eggs and copepods as the most numerous of organisms (Table 10). The sample at station FG-7 revealed similar proportions. At station FG-8, which was only 6.0 miles (11.1 km) from Double Point, populations of barnacle larvae appeared in the sample, long with a higher diversity of organisms. Such high diversities were also found in samples at Double Point and Bolinas Bay collected by the principal investigator, and probably can be attributed to the richness of plant productivity and density of animals at the nearshore reefs, especially for barnacle larvae.

In the plankton samples taken by the author, phytoplankton as well as zooplankton was being sought, whereas the samples by Brown and Caldwell (1971) were probably made with a coarse mesh zooplankton sampler net.

Since most of the reef animals are suspension feeding organisms, an understanding of the role of plankton in the Double Point water column is vital; it is the basic food source for the sponges, hydroids, barnacles, bivalves, bryozoans, tunicates, and the juvenile fish of the area. Plankton forms the base of the energy levels of the food pyramid, the beginning of the food chain, and the core of the marine food web.

Benthic Shelf Communities

In the immediate vicinity of Double Point ASBS, dives to 100 ft. (30 m) were made to the sandy substrate to observe benthic communities. Due to high turbidity, no organisms were observed in three abbreviated efforts in 1969 and 1978.

Data on the benthic organisms on the continental shelf were obtained by Brown and Caldwell (1971) at six benthic stations in 1970, ranging from 5 to 7 1/2 miles (9.2 to 13.2 km) southeast of Double Point (Appendix 3). The major organisms recovered from these six sites by the use of Petersen grabs and benthic nets were:

Foraminifera: Elphidiella hannai
Bivalves: Mysella tumida
Gastropod: Nassarius mendicus
Plus numerous calcareous tubes from various worms.

The species list (Appendix 3) is very extensive, with the Molluscan bivalves and gastropods making up the most species. Such data may indicate the types of organisms which live in closer proximity to the Double Point benthic regions.

Vertebrates

The Fishes: The fishes of Double Point are an integral part of the food chain in this area. Due to the low visibility of the waters, few fishes were observed in the open waters; however, 22 fishes were identified (Appendix 4). The fish are discussed in relation to their habitat and according to feeding habits.

Only two open water species were observed beyond the Double Point ASBS: the northern anchovy, Engraulis mordax, and the jack smelt, Atherinopsis californiensis. It is presumed that these fish enter the horseshoe cove of Double Point.

Within the sea stacks, there are at least nine species of fish which move in and out of the bull kelp canopy at both ends of the promontories. There were five perches identified by divers with the rainbow perch, Hypsurus caryi, the most common species observed under the long kelps. The black rockfish, Sebastes melanops, was the most frequently observed of the three rockfish species. The copper rockfish, Sebastes caurinus, was often observed resting on the bottom between boulders. Likewise, the lingcod, Ophiodon elongatus, was seen on nearly every dive to the area.

Many of the upper canopy fish were observed hiding in large caves formed by the shale boulders of the short kelp canopy habitat. Besides

the aforementioned lingcod, the cabezon, Scorpaenichthys marmoratus, was very common among the benthic rocks. In 1972, a large wolf eel, Anarrhichthys ocellatus, was spotted in a South Point cave.

Finally, under the shallow water feather boa canopy and among the higher intertidal tidepools are a number of blennies, sculpins, and clingfish. The most common blennies

TABLE 11. 1971 CENSUS OF THE NUMBER OF BREEDING PAIRS OF MARINE BIRDS,

MARIN COUNTY (Ainley and Witt, 1973)

SPECIES	Number of Breeding Pairs per Breeding Site					
	Tomales Point	Bird Rock	Pt. Reyes Headland	Bear Valley	Double Point	Total
Oceanodroma homochroa (Ashy Storm-Petrel)		5				5
Phalacrocorax penicillatus (Brandt's Cormorant)			480	15	170	665
Phalacrocorax pelagicus (Pelagic Cormorant)	86		264	10	40	400
Haematopus bachmani (Black Oystercatcher)		3	3		1	7
Larus occidentalis (Western Gull)		30	13		50	93
Uria aalge (Common Murre)			3820	200	700	4720
Cepphus columba (Pigeon Guillemot)	4	12	24		1	41
Breeding Site Totals	90	50	4604	225	962	5931

In all of Marin County, the Pt. Reyes Headlands about 9 nautical miles (16.7 km) to the west of Double Point, is the largest bird breeding rookery; Double Point - Stormy Stack is second. The Ainley and Whitt (1973) data show a total of 962 pairs of breeding marine birds in 1971 for Double Point; 73% of these (700 pairs) were the Common Murre, *Uria aalge*.

Allen, a marine biologist studying the seals at Double Point, has also observed large numbers of breeding birds at Stormy Stack; see Table 12 (Allen, 1978). She has confirmed Ainley and Whitt's work (1971) that the Common Murre, *U. aalge*, utilizes Stormy Stack as a breeding site. In recent communication (1978), Allen has indicated that there was a large population of cormorants at Stormy Stack in July of 1976. Besides the cormorant and common murre, other estimates of marine birds observed at Double Point ASBS are:

Aechmophotud occidentalis = + 2,000± for each summer, 1976 and 1977
(Western Grebe)

Pelecanus occidentalis = 100± for each summer, 1976 and 1977
(Brown Pelican, endangered list)

Melanitta perspicillata = 5,000± in April of 1977
(Surf Scoter)

Allen's estimated census of breeding birds at Double Point also includes other terrestrial species (Table 12), in particular the Cliff Swallow, Petrochelidon pyrrhonota, which has built hundreds of nests between the years of 1976-78.

An Osprey, Pandion haliaetus, was observed in 1962 in a nest in the Z-shaped crevices of the Monterey Formation on South Point. This osprey occupied this site for two seasons. Moreover, Allen has also observed the Peregrine Falcon, Falco peregrinus, (on endangered list) during the winter months of 1976 to 1978.

In summary, Double Point's Stormy Stack is extremely important for the thousands of marine birds which utilize it as a seasonal residence for roosting and the other birds which use it as a breeding site. The presence of marine birds at this locality has been very consistent over a period of 20 years.

Marine Mammals: The major rationale for the Double Point ASBS has been the recognition of the Bolsa Beach area as a major harbor seal, Phoca vitulina, rookery. By federal law, the seals of this area are protected under the provisions of the Marine Mammal Protection Act of 1972.

Most of the data on the harbor seals have come through the work of biologist Sarah Allen (1976-78) who has spent hundreds of hours observing and counting these mammals (Table 13 and Appendix 5). Allen's major conclusions from her three years of observations are:

TABLE 12. BREEDING PAIRS OF BIRDS AT DOUBLE POINT* Allen (1976-78)

SPECIES	Abalone Point So. of Double Pt	South Point	Stormy Stack
Phalacrocorax pelagicus (Pelagic Cormorant)	1	3	many nests
Phalacrocorax penicillatus (Brandt's Cormorant)			25 nests (1978)
Haematopus bachmani (Black Oystercatcher)			2 (1976-77) nest in 1978
Cepphus columba (Pidgeon Guillemot)	6	10	nest present
Uria aalge (Common Murre)			many nests (±3000 birds in 1978)
Petrochelidon pyrrhonota (Cliff Swallow)	hundreds of nests (1976-78)	hundreds of nests (1976-78)	
Corvus corax (Common Raven)		1 pair (77&78)	
Corvus brachyrhynchos (Common Crow)		present in 1978	
Salpinctes obsoletus (Rock Wren)		1 (1978)	
Carpodacus mexicanus (House Finch)		1 nest (1978)	
Aeronantes saxatalis (White Throated Swift)		2 (1977)	
Tachycineta thalassima (Violet-green Swallow)		2-10 (1977-78)	

* Sample estimates

(1) The day count of seals has ranged from a low of 20 to a high of 594 (May 12, 1977). The peak population census occurs each year during April-May when the number of seals may total over 500 for the beach area.

(2) For the 132 sample observations made during the 3-year study, there was an overall mean of 227 seals on the beach. During April-August, which includes the pupping season, the mean was 298 seals. The beach has the fewest seals during September-December; the mean was 70 seals per observation.

(3) The pupping season is from April through June. The number of pups ranged from a low of 1 on April 2, 1977, to a high of 175 on May 18, 1977. Observed pup mortality was 3 in 1976 and 13 in 1977, about 7.4% of the population.

(4) The harbor seals also haul out at the South Pinnacle as well as at the inner North Point beach.

(5) Hikers on the beach are the greatest disturbance to the seals, often preventing them from rehauling at a later time. Low flying aircraft and boats are another form of harassment to the rookery.

TABLE 13. SUMMARY OF DATA ON HARBOR SEALS, *Phoca vitulina*

(Allen, 1976-78)

Period	Number of Observations	Total Seals Observed	Average number per observation
1976 Jan-Mar	7 (days)	1,110	158.6 seals
Apr-Aug	19	3,874	203.9
Sep-Dec	10	751	75.1
1977 Jan-Mar	16	2,199	137.4
Apr-Aug	41	13,048	318.2
Sep-Dec	8	647	80.8
1978 Jan-Mar	7	1,156	165.1
Apr-Aug	20	6,940	347.0
Sep-Dec	4	278	69.5
	132 total	30,003 total	227.3 overall average

These harbor seals, *P. vitulina*, play an important role in the food web of Double Point, and probably feed on the fish of Drake's Bay. Their

major food is primarily fish, squid, and crustaceans; a single adult seal eats about 8.8 lbs. (4 kilograms) of fish per day (Federal Register, 1975). The eye-sight of harbor seals is reported to be one of the sharpest among all mammals; visualizing their prey is the key method of locating and capturing their food (Hobson, 1966).

Besides harbor seals, other mammals visit the Double Point ASBS (Allen, 1976-78), including the grey whale, Eschrichtius robustus, (each winter and spring), the California sea lion, Zalophus californica, (each spring), California sea otter, Enhydra lutris, and the humpback whale, Megaptera novaengliae.

Other mammals which come down to the beach are the coastal deer, raccoons, and grey foxes of the upland habitat.

Land Vegetation

The information for the Double Point 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:

Species	Common Name
Agrostis aristiglumis	Timothy grass tribe (bent grass)
Lupinus Layneae	Lupine family
Sidalcea rhizomata	Mallow family
Arctostaphylos Cushingiana	Heather family
Castilleja Leschkeana	Figwort family
Blennosperma nanum var. robustum	Sneezeweed tribe

The vegetation of Point Reyes can be grouped into communities which are basically influenced by differences in the environment. The type of community which prevails high on the Inverness Ridge above the Double Point coast is the Douglas fir forest which consists of the following major plants:

Species	Common Name
Pseudotsuga taxifolia	Douglas fir
Ceanothus thyrsiflorus	blue blossum
Mimulus guttatus	sticky monkeyflower
Rhamnus californica	California coffeeberry
Lithocarpus densiflora	tan oak
Arbutus menziesii	madrone
Umbellularia californica	California laurel

Below the Douglas fir forest is the coastal scrub and coastal grassland community which occupies the landslide area just above the Double Point ASBS. The dominant plants here are:

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

The coyote brush, *Baccharis pilularis*, seems to dominate the coastal scrub community. This scrub is a summer growing plant, and it thrives on moisture from the ocean fog. Over time, the coyote brush plants will spread and move into the new grasslands, at a rate of about 1 foot (30 cm) per year (Biswell and Agee, 1973). The grasslands are composed mostly of annuals and prennials including barley, annual rye, California oatgrass, and wild rye.

Clustered around the lakes (Pelican, Bass, and Crystal Lakes) of this Double Point area are thick growths of the coast willow, *Salix* spp.

Within the water's edge of the lakes are dense growths of the following dominant plants: common tule, Scirpus acutus, California bulrush, Scirpus californicus, cat-tail, Typha latifolia, sedge, Carex senta and Carex sp.

Unique Components

The Double Point ASBS was designated primarily because of the harbor seals, Phoca vitulina, which inhabit the inner Bolsa Beach of Double Point the year around (Figure 18). As previously mentioned, during the pupping months of April-July, the count of seals on a single day may number well over 500 on this beach (Allen, 1978). An estimated total number of 750,000 seals inhabit the Northwestern Pacific Coast (Federal Register, Vol. 40, No. 141, 1975); the Double Point sample of 500, which would then constitute about 0.07% of the total, seems miniscule. However, the sample, compared to other rookeries in California, is significant in size (Allen, 1978).

The Marine Mammal Act of 1972 requires that these mammals be protected. The National Park Service has taken some steps, through signs and literature, to warn visitors of the problems dealing with these mammals. The establishment of the Double Point ASBS does indeed enhance the population of the harbor seals by protecting the water quality and other beneficial uses, such as the invertebrate-fish community which is part of the food chain for these seals.

The other unique components of this ASBS are the nesting and breeding birds at this double promontory headland. Stormy Stack at the North Point, about 23 acres, is the second largest marine bird refuge in Marin County. Allen (1978) has observed an estimated 3,000 cormorants and 5,000 Common Murres on Stormy Stack. Ainley and Whitt (1972) [illegible]

Beach of Double Point.

Allen (1978) has also recorded that hundreds of Cliff Swallows, Petrochelidon pyrrhonota, have nested in the South Point rocky cliffs.

Therefore, these vertebrates, the birds and seals, occupy this Double Point area as a roosting or haul-out site. The feeding range of these vertebrates probably encompasses a much larger area of the Drakes Bay complex.

Figure 19 is an illustration of the author's suggested concept of the food and energy pathways at this Double Point habitat. The ultimate energy is the sun which provides the catalyst for the system of imported energy and the production of the primary producers. In this dual food chain, the grazing food chain, is the most visible, where the primary producers are grazed upon by first order consumers, the microscopic zooplankton, small invertebrates (crustaceans), and some fish and shore birds. The higher order consumers, such as crabs, fish and larger zooplankters, may eventually be consumed by the top order consumers, the marine birds and seals.

In the meantime, there are anaerobic and aerobic bacteria acting on all intertidal and subtidal organisms. Some small infauna organisms, Protista, feed on the bacteria.

All organisms eventually contribute to the residential energy vault which in turn is recycled back to the Double Point ASBS or exported into the Drakes Bay environment.

Thus, the unique components of this ASBS are really intertwined between the invertebrates and vertebrates of the Double Point ecosystem.

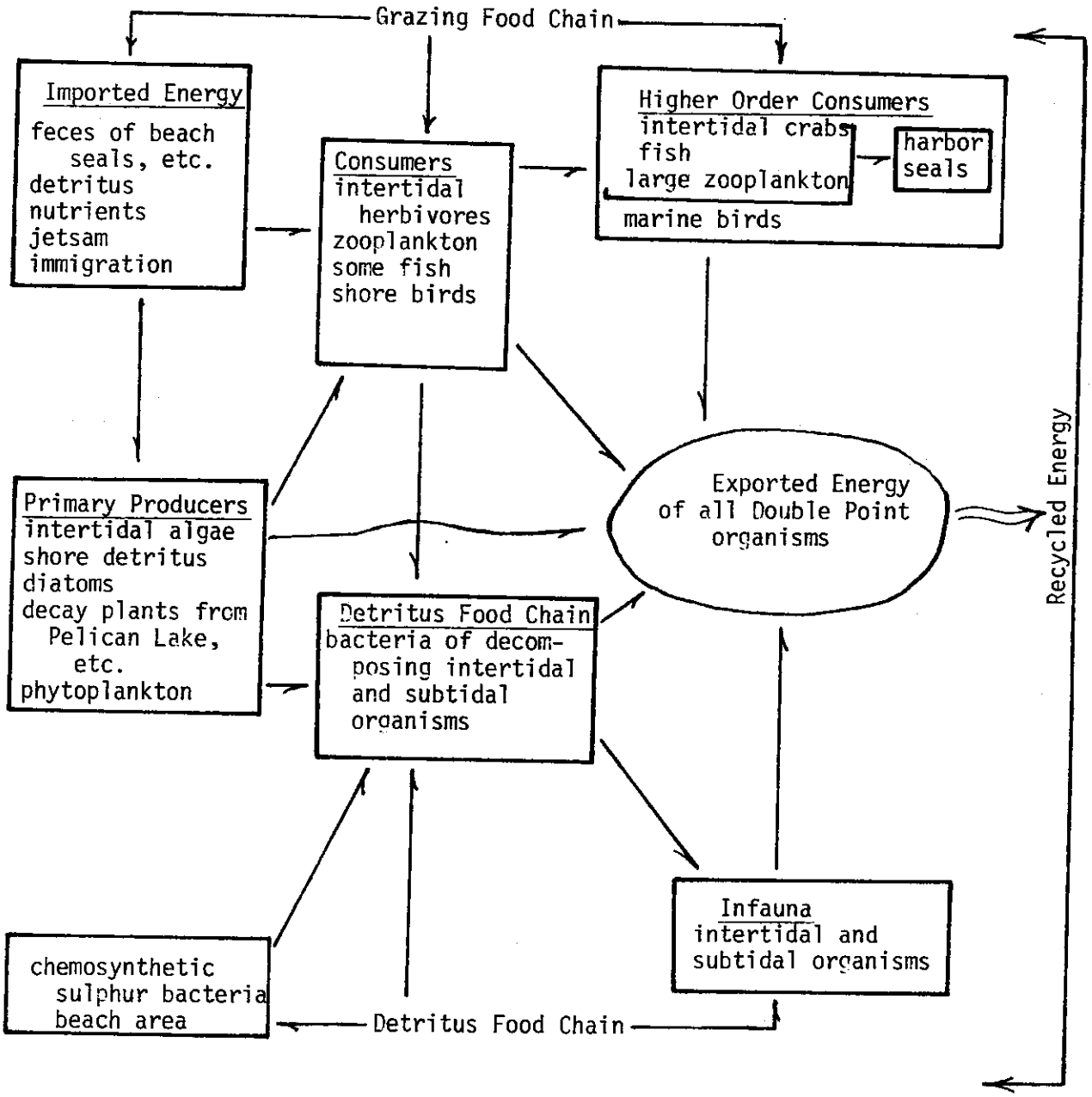


Figure 19: Energy Food Chain, Double Point ASBS.

LAND AND WATER USE

Marine Resource Harvesting

Commercial Fishery: The Double Point ASBS fronts Drakes Bay which has been an important fishing grounds for almost a century. The major

The estimates of Marin County commercial sportfishing landings and economic values are given in Appendix 8.

Abalone Sportfishing: However important the commercial fisheries in Drakes Bay may be, it is the abalone sportfishing activities which most directly affect the Double Point ASBS. The red abalone, *Haliotis rufescens*, is the only abalone fished in this locality by sports fishermen.

Some general information pertaining to the abalone fishery in central and northern California (Burge, Schultz, and Odemar, 1975) is:

(1) The catch of red abalone, *H. rusfescens*, in total California landings has been steadily decreasing since 1967, from 2,691,610 lbs. (in shell) to just 764,185 lbs. in 1974.

(2) Sportfishing pressure in central and northern California is steadily increasing, and there are strong indications that some stocks are overharvested. There has been a 200 percent increase in diving days from Point Arguello to Oregon since 1960, with a 50 percent increase in catch. However, for the same time period, the catch per hour has dropped from 3.04 abalones to 2.67 in Marin, Sonoma, and Mendocino counties. The total number of red abalones taken since 1960 for the three counties was 65,153, all caught by freedivers (SCUBA is illegal in Northern California). The intertidal stocks are now fully exploited and depleted in many areas. The bag limit is four abalones.

(3) For Marin County in 1972, the California Department of Fish and Game data showed that 996 red abalones were taken, representing only 1.2% of the total catch in Northern California.

(4) As previously stated in this report, the investigator concluded that with such pressure on this mollusk, that the population of *H. rufescens* at Double Point ASBS has been severely reduced to nearly zero in transects surveyed.

The investigator has been observing the abalone populations in Marin County for 23 years. Where the kelp is abundant, the abalones will be sessile in one spot, forming an algae-free attachment scar on the rock face. However, where kelp is sparse, such as at Bird Rock-Tomales Point,

about 7.5 nautical miles (14 km) to the northwest, the abalones will migrate to seek out their food. Since the kelp is abundant at Double Point transects surveyed, lack of food cannot be the reason for the depletion of subtidal abalones; there must be other reasons. Although the sea otter, Enhydra lutris, has been spotted on occasion at Double Point (Allen, 1978), the major reason for the demise of the abalones is probably the abalone harvesting activities, legal and illegal, of the sport diver in this area.

A brief chronology of man's fishing for abalones in the area has been:

(1) Removal of intertidal abalones by members of the Old Bolema Club, north of Double Point in the Wildcat Lake area and the old Lake Ranch at the Double Point area (Figure 20).

(2) A hermit lived at the South Point Beach, 1955-1965; when his shack (Figure 20) burned down in 1965, 550 shells of H. rufescens were found in the ruins (Chan, 1971).

(3) Many boatloads of divers continue to traverse up the coast from San Francisco Bay ports to secure abalones in the shallow reefs around Abalone Point, south of Double Point (Figure 20).

(4) Illegal harvesting of abalone plagues the area. For instance, on January 15, 1975, two divers using SCUBA took over 600 abalones from this area. These poachers were caught by state authorities (Brock, 1978). The illegal activities of poaching divers will probably continue to plague the authorities of this area, and certainly will not help in the natural recruitment of abalone in these shallow reefs.

Finally, if the sea otter does return in large numbers to this area in permanent residency, the population of abalone will be reduced even in subtidal areas to low levels as in the Monterey area. A natural state of balance will exist where predator and prey interact in the natural selection process. In this case, the abalone will be smaller in size and will be restricted to living in crevices and underneath narrow ledges.

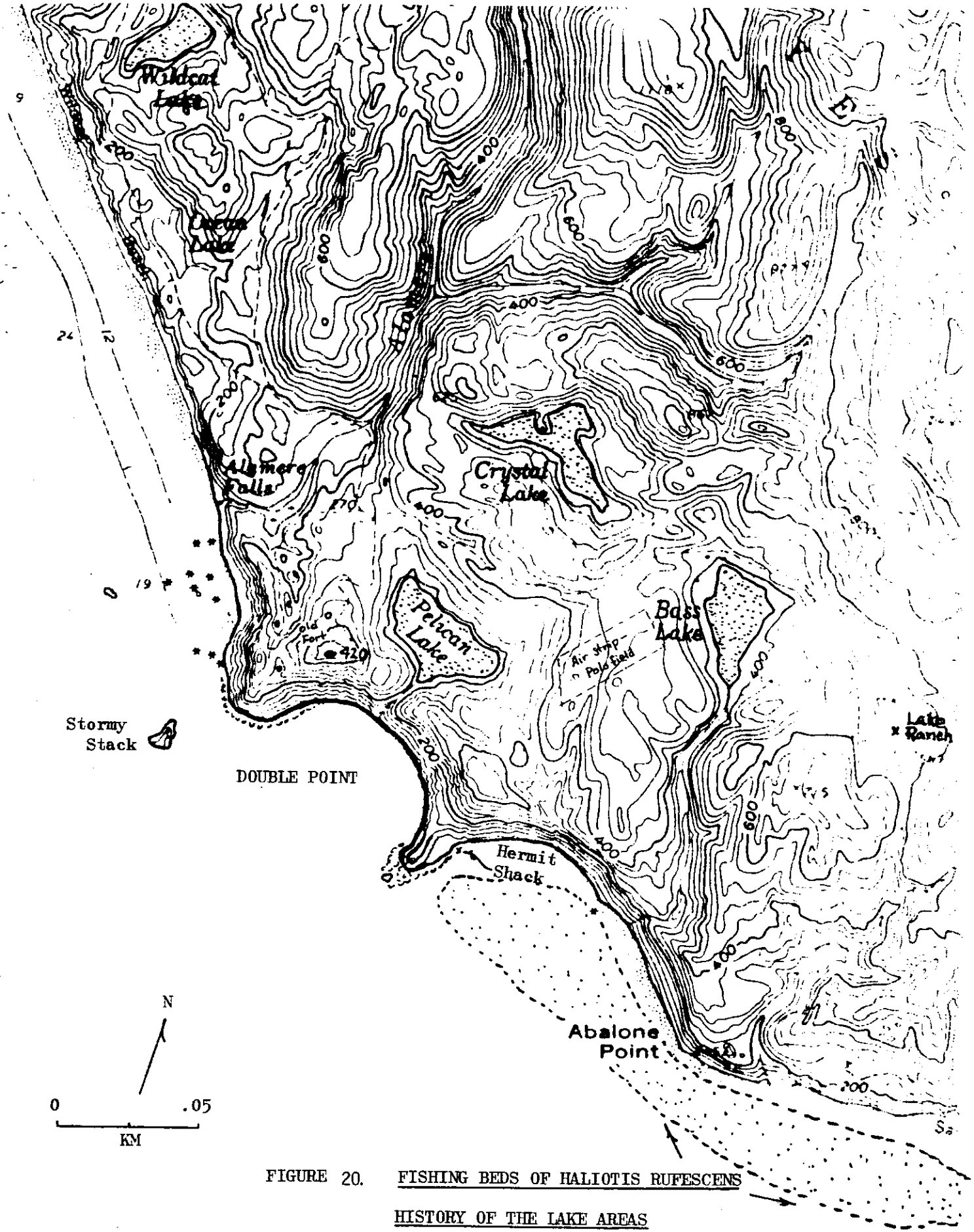


FIGURE 20. FISHING BEDS OF HALIOTIS RUFESCENS

HISTORY OF THE LAKE AREAS

Governmental Designated Open Space and Recreational Use

Before Congress established the Point Reyes National Seashore Park in 1962, the Double Point area was utilized in the following manner:

The U.S. Army had a coast artillery fort in the 1940's at North Double Point. The barracks were located at Bass lake.

William Tevis operated a cattle activity at the Lake Ranch (1950's), using his airstrip as a polo field (Figure 20).

The Bolema Club, north of Double Point, was operated as a pheasant-hunting club (1950's).

South of Double Point, the Church of the Golden Rule had a colony of people who had a cattle operation, farming and nursery activities (1950's). The Point Reyes Bird Observatory now exists on this site.

The Point Reyes National Seashore Park encompasses some 65,000 acres, with 44.7 miles (71.5 km) of ocean coast and 37 miles (59.2 km) of bay frontage. The Park has 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 geographical habitats. The wildlife in these areas is among the most diverse on the Pacific Coast.

For the Double Point area (the former Lake Ranch area), there are nine small lakes or ponds, most of which were formed by the accumulation of water in a closed depression behind landslide blocks some 10,000 years ago (Clague, 1969). Bass Lake (Figure 20) is the largest lake, with a surface area of about 7.4 acres (3 ha) with a maximum depth of 54 feet (16.5 m) (Strohschein, 1972). Pelican Lake, at the intersection of North and South points, was 30 feet (11 m) deep in July of 1969. The lake continues to drain through the "Pelican notch" between the two points to the beach. Both Bass and Pelican Lakes are slightly saline, slightly alkaline, warm monomietic lakes, and demonstrate slight eutrophic characteristics in terms of water chemistry (Widmer, 1976). Both lakes have been stocked with warm water game fish and offer a fine natural setting for recreational activities such as fishing, back packing, and nature study.

The National Seashore Park continues to have accelerated visitor growth each year:

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

The primary access to the Double Point area is via State Highway 1 and visitors have to traverse 3 to 4 miles of trails to arrive at the old Lake Ranch area. Brock (1978) estimated about 83,526 visitors to the Point Reyes Bird Observatory area north of Double Point from January to November of 1978. The number of visitors hiking out to the Double Point area is unknown. Access to the Double Point Bolsa Beach is down through the Pelican Lake notch or Creek. However, the Park has now posted a "no trespassing" sign at this creek to discourage visitors during the April to July months of the harbor seal's pupping season. Hiking down to the rocky points from the high cliffs is dangerous and should be discouraged. The number of visitors to the intertidal zone of Double Point remains small in comparison to that of visitors to other habitats of the park system.

Scientific and Educational Use

The potentials of utilizing the Double Point ASBS for scientific and educational use are yet to be fully realized. With the unique situation of thousands of marine birds and hundreds of harbor seals residing as neighbors, the use of this site for research could be expanded. The Point Reyes Bird Observatory has performed the major studies to date on the harbor seals, *Phoca vitulina* (Allen, 1976-78). There is still an important need to expand the census and study of the behavior of the marine birds on Stormy Stack and on South Point. The College of Marin has conducted invertebrate studies over the years and these transect observations should be continued. Unique pristine lakes adjacent to the ASBS should

bear further research from aquatic biologists. The flora certainly needs much clearer taxonomy and ecological considerations, as do the upland birds and mammals. Finally, the mixture of these geological landslides, still very active, should warrant constant surveillance and reporting.

ACTUAL OR POTENTIAL POLLUTION THREATS

Point Sources

Municipal and Industrial Discharge: Being isolated by the Point Reyes National Seashore Park, the Double Point ASBS has had few pollution threats. The nearest town, Bolinas, about 6 miles (9.6 km) away, seems to have an efficient waste disposal system. From Bolinas, or other communities further south, there appears to be little direct pollution threat to this area from municipal or industrial sewage systems. Likewise, there does not appear to be any threat from dredging or sediment disposal sites; none are in the immediate Drakes Bay area.

Non-Point Sources

Radioactive Waste: From 1946 to 1965, under the direction of the Atomic Energy Commission, three major producers of radioactive materials in the San Francisco Bay area dumped over 47,500 barrels of radioactive waste southwest of the Farallon Islands (Figure 21). The waste was stored in 55-gallon barrels and other concrete containers (Table 14).

TABLE 14. 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	900 m	60 km	1951-53	3,500	^{238}Pu $^{239,249}Pu$
37°37'N to 123°08'W	1700 m	77 km	1946-65	44,000	and ^{137}Cs (both sites)

About 25% of the total 47,500 barrels had imploded when surveyed in the mid-1970's (Dyer, 1975). Ocean current studies by Dyer indicated that for 27 days during the study period the vector plot for water movement from the disposal site was clearly northward. Tidal currents, upwelling,

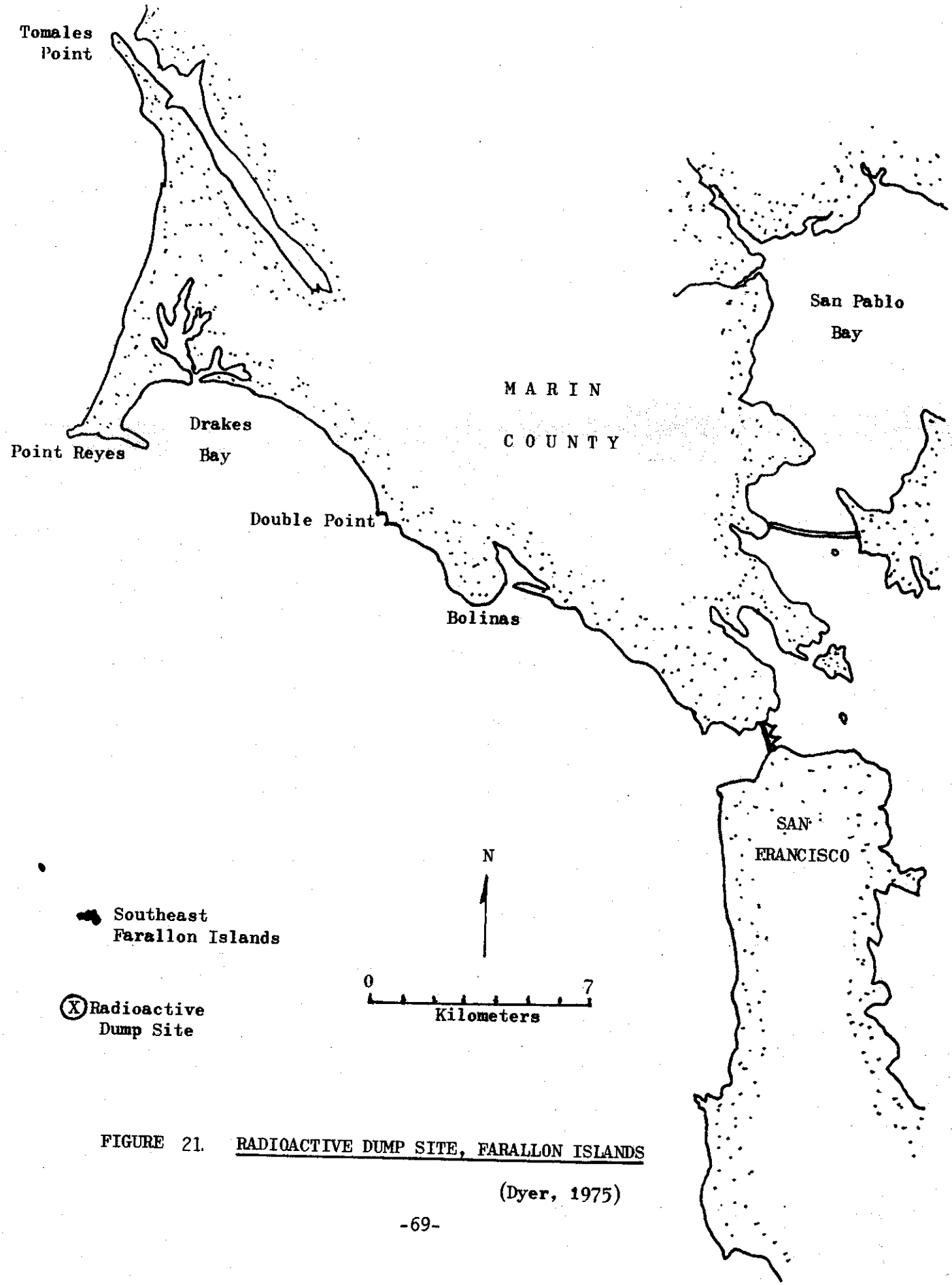


FIGURE 21. RADIOACTIVE DUMP SITE, FARALLON ISLANDS

(Dyer, 1975)

and factors of irregular benthic topography and other variables compound the problem of defining net water movement. Whether any released radioactive plutonium 238, 239 and 249 and cesium 137 pose any danger to the Double Point ASBS is uncertain. The total plutonium and cesium released from these barrels is within global fallout levels and considered insignificant by Noshkin, et al. (1978). However, they did report that ^{238}Pu is being remobilized at the disposal site in 2,000 meters of water. The concentration of plutonium measured in that area does exceed anticipated fallout levels. This situation could bear some attention and concern from State and federal agencies.

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 seabirds were injured by the oil and less than 10 percent survived (Chan, 1972). Others have estimated that the mortality may have been closer to 20,000 birds (Smail, et al., 1972). The principal investigator estimated that about 4.2 million organisms were smothered in intertidal transect sites around the Marin County coast (Chan, 1972).

With the increased oil tanker traffic between the Alaskan oil port at Valdez and the refineries in the San Francisco Bay system, the risk of another serious coastal oil spill similar to 1971 has been accelerated. Marine organisms, such as those at Double Point, are extremely vulnerable to such catastrophies.

There are small natural oil seeps and gas leaks on Duxbury Reef, about 5 miles (9.2 km) south of Double Point. Oil and gas seeps have also been observed at Double Point (Galloway, 1977). With such reported seepage, 14 exploratory wells have been drilled in and around the Bolinas Headlands between 1865 and 1954 (Galloway, 1977). In 1951, Standard Oil Company drilled through the Monterey Formation at Double Point, but gas and oil recovery in all of these wells has been unsuccessful (Galloway, 1977). If other such exploratory wells are ever to be drilled, either onshore or on the continental shelf offshore, these activities must be

closely monitored by federal and state agencies to determine the impact on the environment.

In summary, the only recognizable pollutant threat to the Double Point ASBS seems to be potential oil spills from tanker traffic moving up and down the Northern California waters. The recycling of plutonium from depths of 2,000 meters south of the Farallon Islands could also pose a threat to the food chain if the northward moving currents do carry these radionuclides to the Point Reyes shores. The protection afforded by the Point Reyes National Seashore Park truly enhances the safety of the Double Point ASBS in terms of most environment damaging pollutants.

SPECIAL WATER QUALITY REQUIREMENTS

As previously mentioned, the inclusion of Double Point ASBS within the protective boundary of the Point Reyes National Seashore Park naturally reduced the likelihood of pollutants injuring the marine habitat. If a large sewage outfall system were to be constructed for San Francisco and other Bay Area communities, and if the discharge were to be dumped into the Gulf of the Farallones where northwesterly tidal countercurrents might carry the effluent to the Double Point area, then the waters of this ASBS should be closely monitored.

ANNOTATED BIBLIOGRAPHY

Abbott, Isabella A. and George J. Hollenberg. Marine Algae of California, Stanford University Press, 1976.

A complete revision of Gilbert Smith's text, The Marine Algae of Monterey Peninsula. This new text offers a complete description and ecology of the algae of California. It has become the standard "bible" for marine algologists.

Ainley, David G. and Michael C. Whitt. "Numbers of Marine Birds Breeding in Northern California", Western Birds, Vol. 4, Number 3, 1973: 65-70.

One of the few articles which describes the numbers of breeding marine birds from the Farallon Islands to the Northern California Del Norte Coast. Species and densities of marine birds are specifically given for the Farallons, Marin County areas, Sonoma, Mendocino, Humboldt, and Del Norte counties. A very important summary report on breeding birds.

Allen, Sarah. "The Marine Birds and Harbor Seals of Double Point", unpublished data, 1976-1978.

The most valuable ecological information on the harbor seals in Northern California is described in several reports, to be published. The number of birds is also recorded.

Allen, Sarah. "Birth of a Harbor Seal", Oceans, Vol. 11, No. 5, Sept-Oct. 1978.

A photographic review of a birth of a pup from a harbor seal, Phoca vitulina on Double Point Beach. Photographs by Chriss Poulsen.

Bane, Gilbert W. and Annerka W. Bane. Bay Fishes of Northern California, Mariscos Publications, 1971.

A fine field book of local fishes, describing their morphological and ecological characteristics. Bane states that some 938,655 pounds of lingcod were landed in California in 1967 with most of the total coming from the Eureka area.

Biswell, Harold H. and James K. Agee. Description of the Terrestrial Environment, Point Reyes National Seashore, Berkeley, CA., October, 1973.

A general ecological report on the seashore park covering the climate, topography, geology, soils, hydrology, flora and fauna, and pollution problems. A good environmental report.

Brock, Leroy. Personal communications about the apprehension of two abalone poachers, Federal Incident No. 00012, 1975. Mr. Brock is the chief ranger at the Point Reyes National Seashore Park, 1978.

Brown and Caldwell. Marine Waste Disposal, Vol. II, San Francisco, September, 1971.

This report is a data supplement of this consulting engineering firm in San Francisco. The report illustrates the ebb countercurrents of Wilde. Also there are other extensive oceanographic planktonic, marine biology, and fishery reports of the Farallon Gulf just west of San Francisco Bay.

Burge, Richard, Steve Schultz and Melvyn Odemar. Draft Report on Recent Abalone Research in California with Recommendations for Management. California Fish and Game, unpublished paper, Jan. 15, 1975.

Much data on commercial and sport fishing of abalone, with recommendations to enhance the fishery.

California Regional Water Quality Control Board, San Francisco Bay Region, "Designation of Ocean Areas of Special Biological Significance along the San Francisco, San Mateo, and Marin Counties Coast", Item 4, Executive Officer Summary Report, April 24, 1973.

A summary report of the proposed ASBS areas with the retionale designating each area as ASBS. Includes location, description, and map for each ASBS.

Chan, Gordon L. A Survey of Marine Life on the Point Reyes National Seashore Park, College of Marin, Kentfield, February 10, 1971.

A survey of marine organisms, intertidal and subtidal, from Double Point to Tomales Point. Population data and partial species lists are included for 8 localities on the Point Reyes National Seashore coast.

Chan, Gordon L. "Subtidal Mussel Beds in Baja California with a New Record Size for Mytilus californianus", The Veliger, Vol. 16, No. 2, October 1, 1973.

A report on the giant sea mussels from a seamount, 80 feet deep, 180 miles below San Diego.

Chan, Gordon L. Population Studies of Marine Animals in Bolinas Lagoon, College of Marin, November, 1967.

An early attempt to describe the invertebrates and plankton populations in Bolinas Lagoon. Birds and mammals were also discussed.

Chan, Gordon L. A Study of the Effects of the San Francisco Oil Spill on Marine Organisms, 1972.

A review on the kill of marine organisms from the spill.

Cherry, John. Sand Movement Along a Portion of the Northern California Coast. U.S. Army Coastal Engineer Research Center, Washington, 1965.

A description of longshore currents and littoral drift from oceanic waves and the sediments which are deposited from the effects of these waves. A good report on the Point Reyes waves.

Clague, John J. "Landslides of the Southern Point Reyes National Seashore", Vol. 22, No. 7, California Division of Mines and Geology, July 1969.

From his master's thesis, the author fully describes the ancient landslides which have formed the land masses in and around the Double Point ASBS.

Dyer, Robert S. A Survey of the Farallon Islands, 500 Fathoms, Radioactive Waste Disposal Site. EPA, Washington D.C., Dec., 1975.

A report on the status of the 47,500 barrels of radioactive waste dumped at the Farallon Islands from 1946 to 1965.

Federal Register, Vol. 40, No. 141, Tuesday, July 22, 1975.

A summary from the office of the Secretary of Commerce of the 1972 Marine Mammal Act. A full description of the laws pertaining to marine mammals and a brief review of the biology-ecology role of each marine mammal.

Felton, E. California Many Climates, Pacific Books, Palo Alto, 1965.

A general description of the California localities with a glimpse of specific climate-years. The Point Reyes data is well presented.

Galloway, Alan J. Geology of the Point Reyes Peninsula, Marin County, California, California Division of Mines and Geology, 1977.

An excellent review of the geological history and geomorphology of the Point Reyes Peninsula. The coverage is very complete.

Halliburton, Richard. Studies of the Population Ecology of the Marin Song Sparrow. A M.A. thesis, Department of Biological Sciences, California State University at San Jose, June 1973.

Discussed the ecology of the song sparrow, Melospiza melodia gouldii at the Palomarin-Point Reyes Bird Observatory area. Shrubs and weather data was presented along with the ecology of the song sparrow.

Hedgpeth, J.W. (Rev.) Between Pacific Tides, Stanford University Press, 1968.

The famous Ricketts and Calvin text which was revised by Joel Hedgpeth is still the standard natural history text for marine biology on the Pacific Coast. The ecological description of marine invertebrates is outstanding.

Hobson, Edmund S. "Visual Orientation and Feeding in Seals and Sea Lions", Nature, Vol. 210, No. 5033, pp 326-327, April 16, 1966.

A good discussion on his experience with how seals and sea lions visualize to catch their prey. Vocalizing does not seem to be more important than the eyesight sense.

Hobson, Edmund S. and J.R. Chess. "Trophic Interactions among Fishes and Zooplankters nearshore at Santa Catalina Island, California", Fishery Bulletin, 74: 567-598.

A detailed study of the behavior of fish in the nearshore environment, describing their diurnal and nocturnal feeding habits.

Howell, J.T. Marin Flora, U.C. Press, Berkeley, 1970.

The flora of Point Reyes has been compiled from Howell's complete text on the plants of Marin.

Noshkin, Victor, et al. Radionuclides in the Marine Environment near the Farallon Islands, Lawrence Livermore Laboratory, Jan. 6, 1978.

The total 239 and 240_{Pu} and 137_{Cs} released at the Farallons is within global levels, but 238_{Pu} released at 2,000 meters exceeds fallout levels.

Pequegnat, W.E. The Epifauna of a California Siltstone Reef, Ecology, 45: 272-283, 1964.

Off Southern California, the author divided the reef off Corona de Mar into four zones, which are dictated by water depth and currents. The epifauna is distributed along these zones.

Schenk, Robert E. (Ed.) Contributions to the Archaeology of Point Reyes National Seashore, Treganza Museum Papers, No. 6, San Francisco State University, 1970.

A highly diverse report on the archaeological research at the National Seashore Park. It also briefly covers the abiotic and biotic influences of the park's terrestrial habitats.

Smail, John, David G. Ainley and Helen Strong. Notes on Birds Killed in the 1971 San Francisco Oil Spill, California Birds, Vol. 3, No. 2, 1972.

A review of the mortality and cleaning station events of birds affected by the 1971 San Francisco oil spill.

Smith, Emil J. Coastal County Fish and Wildlife Resources and their Utilization, California Dept. of Fish and Game, Aug. 1, 1973, pp. 67-105.

A review of the fishery resources of the San Francisco Bay area, with emphasis on commercial and sport catches.

Smith, Ralph I. and James T. Carlton. Light's Manual: Intertidal Invertebrates of the Central California Coast, 3rd Ed., University of California Press, 1975.

This famous Light's manual has been the guide for the marine invertebrates for four decades, and this new revision is now the standard reference for students of marine biology along the entire Pacific Coast.

Strohschein, W.E. "Preliminary Survey and Management Plan for Point Reyes National Seashore Area Waters", California Fish and Game, Region 3, 1972.

A good description of the geography of the Lake Ranch area.

Tepley, Lee. A film maker from Lockheed Missile and Space Company in Sunnyvale, California. I saw excerpts of a film he has made on the scavenger feeding habits of Patira miniata off California waters, 1972.

Widmer, Carl. "A Limnological Survey of Bass Lake, Point Reyes National Seashore", Elbert Covell College, University of the Pacific, 1976.

An unpublished student paper on the physical parameters of Bass Lake.

APPENDIX 1. MARINE PLANTS, DOUBLE POINT 1957-1978 G. Chan

Major Species List *Index Plants

	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Deep Rocks	Short Kelp	4	3	2	1
	25'	15'				
A. CHLOROPHYTA (Green Algae)						
Codium fragile	x					
Cladophora columbiana				x		x
Ulva lactuca				x	x	
Ulva lobata					x	
Enteromorpha intestinalis					x	
B. PHAEOPHYTA (Brown Algae)						
Nereocystis luetkeana	*x	*x				
Desmarestia ligulata var. ligulata	x					
Laminaria dentigera (L. andersonii)		*x	x			
Laminaria farlowii		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)						
Rhodymenia arborescens	x					
Calliarthron tuberculosum	x					
Bosiella californica	x					
Mesophyllum lamellatum	x					
Lithothamnium sp.	*x					
Callophyllis violacea		x				
Callophyllis pinnata		x				
Fryeella gardneri		x				
Pterochondria woodii		x				
Botryoglossum farlowianum		*x	x			

Appendix 1 (continued)

Marine Plants, Double Point, 1957-1978
G. Chan

SUBTIDAL ZONE		INTERTIDAL ZONE			
Deep Rocks	Short Kelp	4	3	2	1

APPENDIX 2. MARINE INVERTEBRATES, DOUBLE POINT, 1957-1978 G. Chan

Major Organisms by Phyla	*Index species	SUBTIDAL ZONE		INTERTIDAL ZONE			
		Base of Sea Stack Rocks 6m	Short Kelp Canopy 6m	4	3	2	1
PORIFERA (Sponges)							
Aplysilla glacialis		x		x			
Haliclona sp.			x	x			
Ophlitaspongia pennata			x	x			
Lissodendoryx sp.		x					
Plocamia karykina		*x	x				
Halichondria panicea			x	x			
Hymeniacidon sp.		*x					
Polymastia pachymastia		*x					
Cliona sp.			x	x			
Tethya aurantia		x	x				
Leucosolenia eleanor			x				
Leucandra heathi		*x	*x				
Leucilla nuttingi			x	x			
CNIDARIA (animals with stinging cells)							
Hydrozoa							
Tubularia marina		x	x	x			
Abietinaria sp.		*x	*x	x			
Aglaophenia sp.		*x	*x	*x			
Plumularia sp.		x	x	x			
Garveia annulata			*x	*x			
Sertularia sp.		x	x	x			
Obelia sp.			x	x			
Anthozoa							
Anthopleura elegantissima			x	x		x	
Anthopleura xanthogrammica		*x	*x	x			
Telia lofotensis		x	*x				
Corynactis californica		*x	*x				
Balanophyllia elegans		*x	*x				
Epiactis prolifera			x	x			
Metridium exilis		x	x				

Appendix 2 (continued)

Marine Invertebrates, Double Point, 1957-1978
G. Chan

*Index species	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Deep Rocks	Short Kelp	4	3	2	1
	25'	15'				
PLATYHELMINTHES (Flatworms)						
Oregoniplana opisthopora			x			
Hoploplana californica	x			x		
Leptoplana chloranota		x	x	x		
Notoplana sp.		x	x	x		
NEMERTEA (Ribbon worms)						
Tubulanus polymorphus		x	*x	x		
Micrura verrilli (in *Phyllospadix*)		x	x			
Paranemertes peregrina (in *Mytilus* beds)			x	x		
SIPUNCULA (Peanut worms)						
Themiste pyroides (rock crevices)		x	x			
Phascolosoma agassizii		x	x	x		

Appendix 2 (continued)

Marine Invertebrates, Double Point, 1957-1978
G. Chan

*Index species

	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Deep Rocks	Short Kelp	4	3	2	1
	25'	15'				
(ARTHROPODA, Crustacean)						
Copepoda						
Tigriopus californicus						*x
Isopoda						
Idotea sp.			x	x	x	
Idotea wosnesenskii		x	x			
Amphipoda						
Photis sp.		x	x			
Ampithoe sp.	x	x	x	x		
Caprellidea						
Metacaprella kennerlyi						

Appendix 2 (continued)

Marine Invertebrates, Double Point, 1957-1978
G. Chan

*Index species	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Deep Rocks	Short Kelp	4	3	2	1
	25'	15'				
(ARTHROPODA)						
Pycnogonida (sea spiders)						
Pycnogonum stearnsi (on sea anemones)			x		x	
Ammothella tuberculata		x	x			
Achelia sp.		x	x			
Phoxichilidium femoratum		x	x			
MOLLUSCA						
Polyplacophora (Chitons)						
Cryptochiton stelleri		*x	x			
Katharina tunicata				x		
Tonicella lineata	x	x	x			
Placiphorella velata				x		
Mopalia ciliata				x	*x	
Mopalia lignosa				x	x	
Mopalia muscosa			x	x		
Nuttallina californica				x		
Cyanoplax dentiens			x			
Gastropoda (snails, slugs)						
Crepidula adunca			x		x	
Diodora aspera		x	x			
Megatebennus bimaculatus	x	*x				
Fissurella volcano	x	x				
Haliotis cracherodii (black abalone)			x			
Haliotis kamtschatkana (pinto abalone)	x					
Haliotis rufescens (red abalone)	x	*x				
Acmaea mitra		x	x			
Collisella asmi					x	
Collisella digitalis				*x		*x
Collisella limatula			x		x	
Collisella pelta					x	
Collisella scabra				*x		*x
Notoacmea insessa		x	x			
Notoacmea persona				x	x	
Notoacmea scutum				x	x	

Appendix 2 (continued)

Marine Invertebrates, Double Point, 1957-1978
G. Chan

*Index species	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Deep Rocks	Short Kelp	4	3	2	1
	25'	15'				
(MOLLUSCA, Gastropoda)						
Calliostoma annulatum	x	x				
Calliostoma canaliculatum		x				
Tegula brunnea		x	x			
Tegula funebralis				x	*x	
Littorina planaxis					x	x
Littorina scutulata				*x		*x
Crepidula adunca					x	
Ceratostoma foliatum	x	x				
Acanthina spirata				x	x	
Searlesia dira			x		x	
Amphissa versicolor			x			
Trimusculus reticulatus			x	x		
Opisthobranchia (sea slugs)						
Acanthodoris nanaimoensis		x	*x			
Aeolidia papillosa		x	x			
Anisodoris nobilis	x	x	x			
Antiopella barbarensis			x			
Archiodoris montereyensis	x	x	x			
Cadlina sp.		x	x			
Coryphella trilineata			x			
Diaulula sandiegensis		x	x			
Dirona albolineata			x			
Dirona picta			x			
Hermissenda crassicornis	x	*x	x		x	
Hopkinsia rosacea	*x	*x				
Phidiana pugnax		x				
Rostanga pulchra	*x	*x	x			
Triopha carpenteri		x	x			
Triopha maculata		x	x			
Bivalvia (Bivalves)						
Mytilus californianus				*x		
Penitella penita				x		

Appendix 2 (continued)

Marine Invertebrates, Double Point, 1957-1978
G. Chan

*Index species	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Deep Rocks	Short Kelp	4	3	2	1
	25'	15'				
(MOLLUSCA)						
Cephelapoda						
Octopus sp.	x	x				
ECTOPROCTA (Bryozoans)						
Flustrellidra corniculata	x					
Crisia maxima	x					
Bugula californica	*x	x	x			
Bugula neritina	x	x	x			
Membranipora membranacea	*x	*x	x			
Membranipora fusca		*x				
Tricellaria occidentalis		*x	x			
Hippodiplosia insculpta	*x	x				
ECHINODERMATA						
Asteroidea (seastars)						
Pycnopodia helianthoides		*x	x			
Dermasterias imbricata		x	x			
Henricia leviuscula	x	x	x			
Patiria miniata	*x	*x				
Leptasterias hexactis		x	x			
Leptasterias pusilla		x	x			
Pisaster brevispinus		*x	x			
Pisaster ochraceus		*x	*x	*x	x	
Ophiuroidea (Brittle stars)						
Amphiodia occidentalis		x	x			
Ophiopholis aculeata		x	x			
Ophiothrix spiculata		x				
Holothuroidea (sea cucumbers)						
Stichopus californicus		x				
Eupentacta quinquesemita		x	x			
Cucumaria miniata		*x	x			
Echinoidea						
Strongylocentrotus franciscanus		*x				
Strongylocentrotus purpuratus		x	*x			

Appendix 2 (continued)

Marine Invertebrates, Double Point, 1957-1978
G. Chan

*Index species	SUBTIDAL ZONE		INTERTIDAL ZONE			
	Deep Rocks	Short Kelp	4	3	2	1
	25'	15'				
CHORDATA						
Urochordata						
Aplidium californicum	*x	x				
Aplidium propinquum		*x				
Diplosoma macdonaldi	*x	x				
Clavelina huntsmani	*x	*x	x			
Archidistoma molle		x				
Didemnum carnulentum	*x	*x				

APPENDIX 3. BENTHIC SHELF COMMUNITIES Brown & Caldwell 1971

j = juvenile

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					
Elphidiella hannai	7	50	60	17	85
Nonionella sp.		1			
Haplophragmoides sp.			60		
Massilina sp.			6		1
Poroeponides sp.			4		
Triloculina sp.			8		
Rotorbinella sp.			2		
ARTHROPODA					
Crustacea					
Mutilus sp. (Ostracoda)					1
Pseudophilomedes sp. (Ostra.)	2	5		1	
Rutiderma sp. (Ostracoda)		1			
Balanus sp. (Barnacle)			9	5	2
Cancer sp. (Crab)	1	1	5	1	1
MOLLUSCA					
Bivalvia					
Nuculana taphria			7	2	
Mysella tumida	12	55	26	3	2
Siliqua sp.		1			
Tellina bodegensis					1
Tellina carpenteri		6			
Spigular sp.	1				
Chlamys hastatus			1		1
Hinnites multirugosus			2		
Modiolus sp.			4		
Transennella tantilla			4	45	4
Kellis sp.			1		
Glans carpenteri			1		
Protothaca staminea			6j	9	2
Clinocardium fucanum			1	2	
Clinocardium nuttallii				2	2
Mya truncata			6	3	1
Spisula catilliformis			2		
Macoma secta			3	1	
Macoma inconspicua			1		
Nettastomella rostrata			8		
Ostraea lurida				1	
Kellia laperousii					1
Axinopsida sericata	1	1			

Appendix 3 (continued)

Benthic Shelf Communities
Brown & Caldwell, 1971

j = juvenile

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

APPENDIX 4. DISTRIBUTION OF FISH within the DOUBLE POINT ASBS

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

MAJOR SPECIES	Open Water, beyond Double Pt.	Under *Nereocystis*	Bottom, Short Kelp	Under *Egregia* & tidepools
Engraulis mordax (Pl) (Northern Anchovy)	x			
Atherinopsis californiensis (Pl) (Jack Smelt)	x			
Phanerodon furcatus (P) (White Perch)		x		
Hypsurus caryi (P) (Rainbow Perch)		x		
Embiotoca jacksoni (P) (Black Perch)		x		
Brachyistius frenatus (P) (Kelp Perch)		x		
Hyperprosopon argenteum (Pl) (Walleye Surf Perch)		x		
Sebastes melanops (H) (Black Rockfish)		x		
Sebastes mystinus (Pl) (Blue Rockfish)		x		
Sebastes caurinus (H) (Copper Rockfish)		x	x	
Ophiodon elongatus (H) (Lingcod)		x	x	
Scorpaenichthys marmoratus (H) (Cabezon)			x	x
Anarrhichthys ocellatus (H) (Wolf Eel)			x	
Cebidichthys violaceus (H) (Monkeyface Blenny)			x	x
Xiphister atropurpureus (P) (Black Prickleback)			x	x
Apodichthys flavidus (P) (Penpoint Gunnel)				x
Gobiesox maeandricus (P) (Northern Clingfish)				x
Clinocottus analis (P) (Wooly Sculpin)				x
Clinocottus recalvus (P) (Bald Sculpin)				x
Enophrys bison (P) (Buffalo Sculpin)			x	x
Oligocottus maculosus (P) (Tidepool Sculpin)				x
Oligocottus synderi (P) (Fluffy Sculpin)			x	

APPENDIX 5. Harbor seals at Double Point: January 1976 through May 1977

Allen. 1978

Date	Time of Observation	Tide	Total #	Pup #
1-24-76	1105-1145	.5 at 1145	200	
1-30-76	1510-1540	-.7 at 1700	123	
2-7-76	1015-1120	1.4 at 1101	348	
2-20-76	1240-1415	.4 at 0901	20-30	
2-28-76	1520-1625	-.1 at 1610	114	
3-20-76	0828-1020	-.4 at 0830	42	
3-29-76	1410-1625	.9 at 1620	258	2
4-2-76	0705-0930	.2 at 0810	45	1
4-6-76	0810-1025	.3 at 1000	224	3
4-10-76	1120-1500	.1 at 1345	185	12
4-13-76	1445-1610	.5 at 1516	127	13
4-17-76	0730-1100	-1.1 at 0742	132	17
4-21-76	1030-1130	.1 at 1127	221	36
4-23-76	1300-1410	.6 at 1313	203	28
5-2-76	0830-1000	-.4 at 0800	112	43
5-7-76	1200-1325	.2 at 1203	273	85
5-16-76	0900-1000	-1.4 at 0803	267	51
5-19-76	1015-1100	-.2 at 1040	164	54
6-3-76	1000-1200	-.3 at 0949	140	38
6-11-76	0800-0830	-1.6 at 0546	150	16
6-16-76	0900-0945	-.4 at 0913	320	38
7-7-76	0915-1020	4.1 at 0928	408	41
7-14-76	0800-0845	-.4 at 0818	329	68
7-15-76	0800-1000	.4 at 0833	329	37
7-22-76	0828-1245	4.0 at 1024	252	29
7-29-76	0730-0815	-.3 at 0726	221	25
7-31-76	0920-0935	.6 at 0907	Fog too thick for observation	
8-13-76	0709-0745	.8 at 0755	70	1
8-26-76	0700-0815	-.1 at 0609	111	1
9-9-76	0830-1000	.8 at 0611	79	
9-15-76	1140-1400	2.5 at 1420	69	
9-22-76	1525-1600	.9 at 1648	64	
9-29-76	1345-1430	5.7 at 1615	30	
1013-76	1015-1115	3.0 at 0829	176	
10-22-76	1540-1610	-.7 at 1721	28	
11-5-76	1530-1600	.6 at 1620	26	
12-3-76	1145-1245	0.0 at 1531	153	
12-15-76	1135-1320	1.0 at 1228	59	
12-17-76	1350-1430	-.5 at 1420	67	
1-5-77	1545-1600	-.7 at 1727	36	
1-7-77	1200-1300	5.7 at 1140	45	
1-12-77	1210-1315	1.3 at 1055	50	
1-25-77	1035-1150	1.8 at 0951	183	
2-3-77	1445-1530	-.6 at 1655	212	
3-1-77	1350-1430	0.0 at 1455	176	
3-3-77	1350-1430	-.2 at 1608	185	
3-4-77	1435-1530	-.2 at 1645	50	
3-12-77	1100-1200	-.1 at 1110	137	

Appendix 5 (continued)

Date	Time of Observation	Tide	Total #	Pup #
3-16-77	1406-1500	-.2 at 1507	160	
3-18-77	1420-1525	.2 at 1645	252	
3-19-77	1500-1600	.6 at 1700	53	
3-23-77	1030-1200	.5 at 0745	136	
3-25-77	0840-1015	.6 at 0906	179	
3-28-77	1125-1230	.5 at 1204	173	
3-30-77	1330-1520	.3 at 1345	172	
4-1-77	1320-1500	.2 at 1506	132	
4-2-77	1320-1515	.4 at 1545	128	1
4-4-77	1320-1620	.9 at 1705	175	2
4-6-77	0700-0720	-.8 at 0641	57	1
4-8-77	0845-0935	-.7 at 0836	110	4
4-9-77	0750-1020	-.5 at 0942	139	5
4-13-77	1335-1500	.2 at 1348	109	15
4-14-77	1325-1520	.5 at 1431	314	29
4-15-77	1355-1605	.8 at 1513	266	32
4-19-77	0835-1140	-.1 at 0545	321	56
4-21-77	0708-0930	-.1 at 0700	240	65
4-22-77	0755-1300	0.0 at 0738	350	83
4-23-77	0916-1120	.1 at 0815	245	77
4-26-77	1050-1310	.4 at 1207	364	104
4-27-77	1310-1520	.4 at 1300	442	126
4-29-77	1340-1510	.6 at 1437	478	146
5-6-77	0920-1100	-1.4 at 0811	446	127
5-7-77	0918-	-1.1 at 0918	259	not counted
5-10-77	1225-1325	.1 at 1218	449	147
5-12-77	1345-1520	.8 at 1406	594*	175
5-18-77	0700-0815	-.5 at 0623	210	86
5-20-77	0815-0915	-.5 at 0734	278	115
5-23-77	0900-1050	-.1 at 0938	330	111
5-25-77	1000-1200	.3 at 1103	340	106
5-27-77	1300-1340	.9 at 1300	428	105
6-7-77	1000-1130	-.1 at 1040	350	38
6-8-77	1020-1140	.5 at 1132	315	30
6-10-77	1135-1310	1.4 at 1317	385	51
6-15-77	0900-1010	[illegible]	[illegible]	[illegible]

Appendix 5 (Continued)

Date	Time of Observation	Tide	Total #	Pup #
8-3-77	0840-0940	.5 at 0836	278	2
8-8-77	1245-1435	2.7 at 1247	196	2
8-13-77	1115-1415	4.8 at 1206	90	
8-23-77	1255-1410	2.7 at 1239	116	
8-27-77	1230-1500	5.4 at 1132	81	
8-30-77	0815-1000	.3 at 0636	88	
9-3-77	1200-1310	2.2 at 0918	54	
9-7-77	1345-1500	2.9 at 1325	183	
9-14-77	1005-1035	.6 at 0612	60	
9-21-77	1305-1500	2.7 at 1246	68	
10-5-77	1250-1425	3.1 at 1152	80	
10-7-77	1200-1335	2.5 at 1400	81	
10-10-77	1420-1530	.9 at 1606	72	
11-6-77	1435-1500	.2 at 1500	49	

Appendix 5 **(continued)**

HARBOR SEALS AT DOUBLE POINT: January through November 1978 — **Allen, 1978**

Date	Time of Observation	Tide level		Total #	# Pups	Disturbance
1-26-78	1230-1515	5.4 at	1202	83		Unknown
2-3	1415-1530	-.5 at	1400	22		Sonic boom
2-21	1530-1610	-.2	1633	203		
3-7	1305-1420	-.6	1600	309		Planes
3-17	1135-1320	.6	1215	114		
3-23	1505-1630	.4	1624	296		Unknown
3-29	1020-1230	-.2	0849	129		Unknown
4-11	1230-1420	.0	0743	231	13	
4-17	1315-1430	.6	1304	273	32	
4-19	1250-1500	.7	1420	365	56	
4-25	1500-1800			513	105	
4-27	1040-1400	-.8	0831	556	150	
5-2	1255-1440	.4	1432	528	176	
5-9	1000-1245	-.5	0735	441	173	
5-13	1015-1130	.2	1031	358	136	
5-11	0850-1050	-.2	0857	304	123	
5-16	1130-1330	.8	1304	464	151	Cliff degradation
5-27	1008-1200	-.8	1011	318	96	
6-5	1100-1400	-.7	0602	359	51	
6-8	0916-1030	-.5	0748	197	25	
6-12	1030-1210	.4	1031	220	21	
6-23	0820-0920	-1.4	0803	311	26	
7-1	1100-1430	2.4	1500	511	18	Sailboat off S.P.
7-20	1300-1430	5.3	1300	467		Campsite at S.P.
7-25	0930-1100	.8	1000	333	5	Campsite at S.P.
8-10	1355-1525	5.4	1637	116		Unknown
8-22	1300-1400	5.8	1521	75		
9-1	1100-1300	5.0	1204	110		
9-28	1230-1330	2.0	1535	38		
10-23	1200-1400	3.1	1429	90+		Boat off S.S.
11-7	1130-1230	2.7	1035	40		

Total observation hours: 54.5 hours
Total number of separate observations: 31
Total number of disturbances: 5 knowns and 4 unknowns; plus 2 possible
Percentage of disturbances to total number of observations: 16.1% known, 29.0% if one includes the unknowns and 35.4% including the possible disturbances. Of the 5 known disturbances 4 were human related.

MARIN COUNTY COMMERCIAL FISH LANDINGS
POUNDS AND VALUE* FOR YEARS 1966 - 1970

SPECIES	1966	1967	1968	1969	1970
ANCHOVY	50,158	32,404	51,463	95,099	217,720
Value	$2,241	$4,695	$2,573	$8,559	$21,772
Average Price	.045	.145	.050	.090	.100
CRAB, MARKET (lbs.)	60,548	195,122	154,325	252,252	158,029
Value	$22,358	$55,726	$52,228	$98,727	$54,708
Average Price	.369	.286	.338	.391	.346
FLOUNDER (lbs.)	22,810	59,415	42,595	33,580	...
Value	$1,579	$4,088	$2,865	$2,199	...
Average Price	.069	.069	.067	.066	...
HALIBUT, CALIF. (lbs.)	7,294	18,223	10,068	6,492	61
Value	$1,845	$4,531	$2,382	$1,654	$17
Average Price	.253	.249	.236	.255	.279
HERRING, PACIFIC (lbs.)	7,750	10,902	48,480	26,432	7,424
Value	$563	$4,547	$9,835	$6,872	$2,291
Average Price	.073	.417	.203	.260	.309
LINGCOD (lbs.)	30,341	21,598	30,324	24,176	3,489
Value	$2,711	$1,853	$2,392	$1,894	$283
Average Price	.089	.086	.079	.078	.081
OYSTER, EASTERN (lbs.)+	12,925	12,710	16,166	16,952	16,667
Value	$40,584	$37,681	$47,928	$50,258	$49,001
Average Price	3.14	2.96	2.96	2.96	2.94
OYSTER, PACIFIC (lbs.)+	221,577	185,693	139,178	222,844	219,135
Value	$50,963	$43,174	$32,359	$51,811	$197,222
Average Price	.230	.232	.232	.232	.900++
PERCH (lbs.)	3,590	10,025	13,843	8,563	8,438
Value	$865	$2,704	$3,737	$3,111	$2,859
Average Price	.241	.270	.270	.363	.339
ROCKFISH (lbs.)	82,613	59,024	48,077	64,838	1,133
Value	$5,504	$3,877	$3,616	$4,564	$98
Average Price	.067	.066	.075	.070	.086

* Value based on price paid fishermen.

\+ Packed gallon weight.

++ Price for shucked oysters; equivalent to $.300/pound for unprocessed oysters.

MARIN COUNTY (Cont'd)

Appendix 6 (continued)

SPECIES	1966	1967	1968	1969	Smith (1973) 1970
SABLEFISH (lbs.)	45,200	22,280	8,355	6,540	11,645
Value	$1,842	$831	$336	$345	$619
Average Price	.041	.037	.040	.053	.053
SALMON (lbs.)	902,306	523,958	609,690	538,133	485,062
Value	$523,469	$281,939	$383,588	$352,179	$394,656
Average Price	.580	.538	.629	.654	.814
SANDDAB (lbs.)	25,485	19,285	36,535	21,970	1,303
Value	$2,009	$1,651	$3,041	$2,022	$139
Average Price	.079	.086	.083	.092	.107
SHARK (lbs.)	30,329	11,560	10,717	11,342	800
Value	$1,515	$576	$559	$778	$25
Average Price	.050	.050	.052	.068	.031
SHRIMP, BAY (lbs.)	4,045	17,495	8,475	8,025	[illegible]
Value	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SPECIES	1966	1967	1968	1969	1970
TUNA, ALBACORE (lbs.)	652,565	597,151	336,753	312,828	1,639,037
Value	$115,309	$110,412	$63,137	$62,685	$423,269
Average Price	.177	.185	.187	.200	.258
TURBOT (lbs.)	4,905	4,070	5,240	1,686	...
Value	$243	$208	$258	$83	...
Average Price	.050	.051	.049	.049	...
ALL OTHER (lbs.)	4,105	4,296	4,542	2,122	151
Value	$255	$513	$1,959	$161	$15
Average Price	.062	.119	.431	.076	.100

APPENDIX 7.

Smith (1973)

SAN FRANCISCO BAY AREA COUNTIES
COMMERCIAL FISH LANDINGS AND SHIPMENTS
POUNDS AND VALUE* FOR YEARS 1966-1970

SPECIES	1966	1967	1968	1969	1970
ANCHOVY (lbs.)	18,005	2,695	...	...	217,720
Value	$804	$391	...	...	21,772
Average Price	.045	.145	...	...	.100
CRAB, MARKET (lbs.)	164,778	486,016	382,502	616,077	427,867
Value	$60,845	$138,804	$129,450	$241,123	$148,123
Average Price	.369	.286	.338	.391	.346
FLOUNDER (lbs.)	145,613	325,975	163,010	114,805	92,284
Value	$10,077	$22,431	$10,963	$7,518	$6,449
Average Price	.069	.069	.067	.066	.070
HAKE, PACIFIC (lbs.)+	29,775	200	525	22,205	5,400
Value	$596	$2	$10	$444	$108
Average Price	.020	.010	.019	.020	.020
HALIBUT, CALIF. (lbs.)	152,058	147,680	101,047	48,530	71,217
Value	$38,444	$36,722	$23,908	$12,369	$19,335
Average Price	.253	.249	.237	.255	.271
HERRING, PACIFIC (lbs.)	22,271	10,065	4,580	900	21,915
Value	$1,616	$4,198	$929	$234	$6,759
Average Price	.072	.417	.203	.260	.308
LINGCOD (lbs.)	179,106	138,103	108,264	79,724	226,058
Value	$16,005	$11,846	$8,541	$6,248	$18,333
Average Price	.089	.086	.079	.078	.081
PERCH (lbs.)	9,250	13,796	7,767	19,134	30,964
Value	$2,291	$3,941	$2,184	$7,031	$10,510
Average Price	.248	.286	.281	.367	.339
ROCKFISH (lbs.)	1,401,939	674,476	380,734	375,235	623,087
Value	$89,729	$47,048	$30,905	$27,695	$45,077
Average Price	.064	.070	.081	.074	.072
SABLEFISH (lbs.)	877,200	417,333	119,884	172,313	290,760
Value	$35,754	$15,566	$4,828	$9,083	$15,467
Average Price	.041	.037	.040	.053	.053

* Value based on price paid fishermen.

\+ Due to different reporting methods miscellaneous animal food appears as a sizable item beginning in 1961. Major species are arrowtooth flounder, hake, rockfish, sablefish and sole.

SAN FRANCISCO BAY AREA COUNTIES (cont'd)

Appendix 7 (continued)

Smith (1973)

SPECIES	1966	1967	1968	1969	1970
SALMON (lbs.)	295,179	281,061	373,692	356,529	341,566
Value	$168,339	$157,519	$234,930	$231,072	$278,621
Average Price	.570	.560	.629	.648	.816
SANDDAB (lbs.)	224,937	195,149	193,174	120,726	135,987
Value	$17,732	$16,711	$16,079	$11,112	$14,119
Average Price	.079	.086	.083	.092	.104
SEABASS, WHITE (lbs.)	...	145	167	...	...
Value	...	$41	$47	...	...
Average Price	...	.283	.281	...	...
SHARK (lbs.)	57,260	44,667	32,875	20,700	42,440
Value	$2,332	$1,731	$1,275	$951	$1,922
Average Price	.041	.039	.039	.046	.045
SKATE (lbs.)	46,150	72,900	47,500	18,150	16,024
Value	$604	$893	$595	$224	$214
Average Price	.013	.012	.012	.012	.013
SMELT (lbs.)	17,227	10,572	...	...	...
Value	$1,544	$1,277	...	...	...
Average Price	.090	.121	...	...	...
SMELT, WHITEBAIT (lbs.)	...	1,200	2,215	1,330	700
Value	...	$171	$345	$187	$94
Average Price	...	.142	.156	.141	.134
SOLE, DOVER (lbs.)	2,100,895	1,071,778	136,874	404,583	886,454
Value	$118,825	$61,791	$8,040	$26,734	$64,356
Average Price	.056	.058	.059	.066	.072
SOLE, ENGLISH (lbs.)	1,175,151	1,130,549	1,039,930	527,015	396,336
Value	$105,359	$102,060	$86,765	$44,750	$39,673
Average Price	.090	.090	.083	.085	.100
SOLE, PETRALE (lbs.)	867,217	554,372	326,190	341,934	737,575
Value	$118,759	$74,450	$45,675	$50,095	$111,389
Average Price	.137	.134	.140	.146	.151
SOLE, REX (lbs.)	219,356	173,899	117,795	91,560	129,755
Value	$17,254	$14,718	$10,087	$8,737	$14,289
Average Price	.079	.085	.086	.095	.110
SOLE, SAND (lbs.)	140,670	194,969	161,066	119,680	112,863
Value	$17,002	$22,932	$19,216	$13,905	$13,972
Average Price	.121	.118	.119	.116	.124
TUNA, ALBACORE (lbs.)	736,556	615,038	215,891	212,045	2,251,744
Value	$130,151	$113,719	$40,477	$42,490	$581,496
Average Price	.177	.185	.187	.200	.258

SAN FRANCISCO BAY AREA COUNTIES (cont'd)

Appendix 7 (continued)
Smith (1973)

SPECIES	1966	1967	1968	1969	1970
TUNA, YELLOWFIN (lbs.)	699,448	...	...	...	...
Value	$118,458	...	...	...	...
Average Price	.169	...	...	...	...
TURBOT (lbs.)	59,150	57,362	44,515	18,525	8,700
Value	$2,934	$2,927	$2,193	$910	$442
Average Price	.050	.051	.049	.049	.051
ALL OTHER (lbs.)	169,268	30,215	31,153	23,030	37,579
Value	$25,319	$4,294	$3,762	$3,989	$6,216
Average Price	.150	.142	.121	.173	.165

SHIPMENTS

TUNA, ALBACORE (lbs.)	...	...	...	...	...
Value	...	...	...	...	...
Average Price	...	...	...	...	...
TUNA, BIGEYE (lbs.)	...	...	...	...	...
Value	...	...	...	...	...
Average Price	...	...	...	...	...

Anadromous Fisheries - Salmon and Steelhead

Smith
(1973)

ESTIMATES OF MARIN COUNTY COMMERCIAL
SPORTFISHING EFFORT AND ECONOMIC VALUES*

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

* See explanation of county figures.