California Marine Waters
Areas of Special Biological Significance
Reconnaissance Survey Report

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

April 1979

WATER QUALITY MONITORING REPORT NO. 79-7

Cover Photograph:
Aerial View of Anacapa Island
Area of Special Biological
Significance.

Anacapa Island Area of Special Biological Significance

STATE WATER RESOURCES CONTROL BOARD

AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

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

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

CALIFORNIA'S MARINE WATERS
AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE
RECONNAISSANCE SURVEY REPORT

ANACAPA ISLAND
VENTURA COUNTY

STATE WATER RESOURCES CONTROL BOARD
DIVISION OF PLANNING AND RESEARCH
SURVEILLANCE AND MONITORING SECTION

APRIL, 1979
WATER QUALITY MONITORING REPORT NO. 79-7

ACKNOWLEDGEMENT

This State Water Resources Control Board Report is based on a reconnaissance survey report submitted by Dr. Bruce H. Robison, University of California, Santa Barbara. 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

Anacapa Island is bounded on the westernmost point of West Island by longitude 119° 26' 37" W; to the east by Arch Rock at 119° 21' 24" W; to the north, on West Island, by latitude 34° 00' 58" N; and on the southern coast of Middle Island by 34° 00' 09" N.

The islands are part of Ventura County and lie offshore. The westernmost point of West Island and Arch Rock at the eastern end of East Island are 32.3 and 30.2 statute miles (51.9 and 48.5 km) respectively from the city of Santa Barbara's breakwater. The Anacapa Island ASBS extends one nautical mile offshore of the Island or to the 300 foot isobath, whichever is the greater distance, comprising 21.87 square miles or 13,997 acres.

Anacapa Island's coastline consists largely of bluffs, cliffs, and steep rocky slopes. This type of topography severely limits the types of vegetation which occur there. A small area of coastal strand vegetation occupies a high sandy area, while coastal bluff communities grow in soil pockets along the island cliffs and at their upper margins. Much of the island's flora has been introduced and native forms like tickseed, Coreopsis, have been displaced by the exotics, such as ice plant, Mesembryanthemum.

Water circulation in the Southern California borderland and continental shelf region is dominated by a large, counterclockwise coastal gyre. The effect of this eddy is to recycle water originally derived from the California Current. This recirculated water is subject to coastal warming during its circuit encompassing the area off lower California. Prevailing northwest winds dominate the southern California region. The east-west orientation of the shore and the mountainous channel islands create a corridor which channels the wind patterns into a more easterly direction, resulting in a divergence over the center of the channel. This creates a wind drift of warmer surface waters towards the northern edge of the channel islands.

Surface seawater temperatures around the islands generally range from 55° F (13° C) in winter to 65° F (18° C) in summer. Warmer temperatures occur on the southern, leeward coasts. Water quality around the Island is generally good because of its isolated location. However, oil and tar deposition from natural seeps and ship traffic is chronic, particularly along the north coast.

Anacapa's intertidal substrate consists principally of boulders, rocky out-crops, rock shelves, tidepools and rubble piles. Because of the steepness of the Island's cliffs, the intertidal zone is generally narrow. The northern coast has the richest intertidal biota, such as: acorn barnacles, periwinkles, limpets, chitons, starfish, shore crabs, red algae, and sea lettuce, the California mussel and the black abalone.

The subtidal regions of Anacapa are very rich, with high diversity and great abundance. The rocky substrate supports rich forests of giant kelp, Marcrocystis, the foundation species of a characteristically complex community. Finfish included in the subtidal zones are: rubberlip seaperch, kelp perch, white seaperch, rainbow seaperch, opaleye, blacksmith, halfmoon, sheephead, painted greenling, bluespot goby, and olive rockfish.

West Anacapa is the only known western U.S. nesting area for the brown pelican, Pelecanus occidentalis californicus, which is an endangered species. Anacapa is inhabited by sea lions, elephant seals, and harbor seals on its beaches, and whales, sharks, porpoises and rays directly offshore.

Anacapa and Santa Barbara Islands were established as a National Monument in 1938 to preserve fossils of Pleistocene elephants and trees, examples of ancient vulcanism, deposition, sea erosion, and other geological features. Anacapa contains considerable numbers of archeological and historical artifacts.

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FINDINGS AND CONCLUSIONS

Under the stewardship of the National Park Service, Anacapa Island appears to be receiving adequate protection in terms of water quality. The greatest present destructive threat is oil pollution from offshore drilling platforms and vessel traffic. Unfortunately, there is little predictive capability to estimate the effects of such pollution because of the scarcity of information regarding the general hydrographic characteristics of the surrounding offshore areas. Information on current patterns is particularly lacking, especially along the southern coastlines of the northern channel islands. Baseline and monitoring surveys of the subtidal areas should be conducted in order to assure thorough protection.

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 Boards' Administrative Procedures, September 24, 1970, Section XI. Miscellaneous--Revision 7, September 1, 1972).

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

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

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

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

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

In order for the State Water Resources Control Board to evaluate the status of protection of Anacapa Island ASBS, a reconnaissance survey integrating existing information and additional field study was performed by Dr. Bruce Robison of the University of California, Santa Barbara. 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.

Anacapa Island was designated an ASBS as a result of the unique biological assemblages found there. It is the only nesting ground of the California brown pelican north of the Mexican border. The marine communities in its nearshore waters comprise an outstandingly rich and diverse community. Anacapa is part of the Channel Islands National Monument which was established to protect these features as well as the biological, geological, and archaeological features of its terrestrial regime.

ORGANIZATION OF SURVEY

Anacapa Island is a steep, rugged and restricted area that is best surveyed by small boat. Access to the largest of the three islets, West Anacapa, is prohibited by the National Park Service which manages Anacapa. On the south side, sea conditions can be hazardous, and boats from the University of California, Santa Barbara are generally prohibited from operations there. In the present study, the islands were surveyed by circumnavigation in a 24-foot commercial workboat and by aerial survey using both infrared and color photography. Much information was gathered in discussion with UCSB scientists who conduct research projects at Anacapa.

PHYSICAL AND CHEMICAL DESCRIPTION

Location and Size

Anacapa Island Area of Special Biological Significance (ASBS) is located within the approximate coordinates 119° 21' 24" to 119° 26' 37" W. Longitude, 34° 00' 09" to 34° 00' 58" N. Latitude. Anacapa Island actually consists of a chain of islets oriented, west to east: West Island, Middle Island, East Island, and Arch Rock. Table 1 presents additional information on the size of the land areas as well as the approximately 14,000 acres (5,650 ha) of water area comprising the ASBS.

The islands are part of Ventura County and lie offshore. The westernmost point of West Island and Arch Rock at the eastern end of East Island are 32.3 and 30.2 miles (51.9 and 48.5 km) respectively from the City of Santa Barbara's breakwater; Arch Rock lies 17.9 miles (28.8 km) southwest of the City of Ventura; Arch Rock is 12.2 miles (19.6 km) west of the mouth of Port Hueneme Harbor, the nearest municipality (Figure 1).

The official boundary description for Anacapa Island ASBS is as follows: "Waters surrounding Anacapa Islands to a distance of one nautical mile offshore or to the 300-foot isobath, whichever is the greater distance." (See Figure 2).

Nearshore Waters

Currents: The California Current is the eastern boundary current of the North Pacific Gyre, it bears cold subarctic water southeasterly along the California coast, departing seaward at Point Conception because of the indentation of the Southern California coastline. Circulation in the Southern California borderland and continental shelf region is dominated by a large, counterclockwise coastal eddy. The effect of this large eddy is to recycle water originally derived from the California Current. This recirculated water is subject to coastal warming during its circuit encompassing the area off lower California. The eddy is driven by the entrainment of surface waters by the California Current as it deflects offshore. Northward flow within the Southern California Bight is seasonally enhanced by the Davidson Current in winter. At depths below about 630 ft. (192 m) equatorial water is also carried north by the California Undercurrent or Countercurrent.

Table 1. Physical description, Anacapa Island; shoreline and areal extent (flat projection) of land and nearshore regions.

Island	Shore-line(mi)	Regional Area(mi^2)	Land area Mi^2	Acres	Hectares	Km^2	%	Nearshore Mi^2	Acres	Hectares	Km^2	%	Ratio N/L
West	5.8	10.09	0.37	236	95	0.96	3.7	9.72	6221	2513	25.18	96.3	26.3
Middle	5.3	5.82	0.26	166	67	0.67	4.5	5.56	3558	1437	14.40	95.5	21.4
East	3.4	6.76	0.17	108	43	0.44	2.5	6.59	4218	1704	17.07	97.5	38.8
TOTALS	14.5	22.67	0.80	510	205	2.07		21.87	13997	5654	56.65		28.8

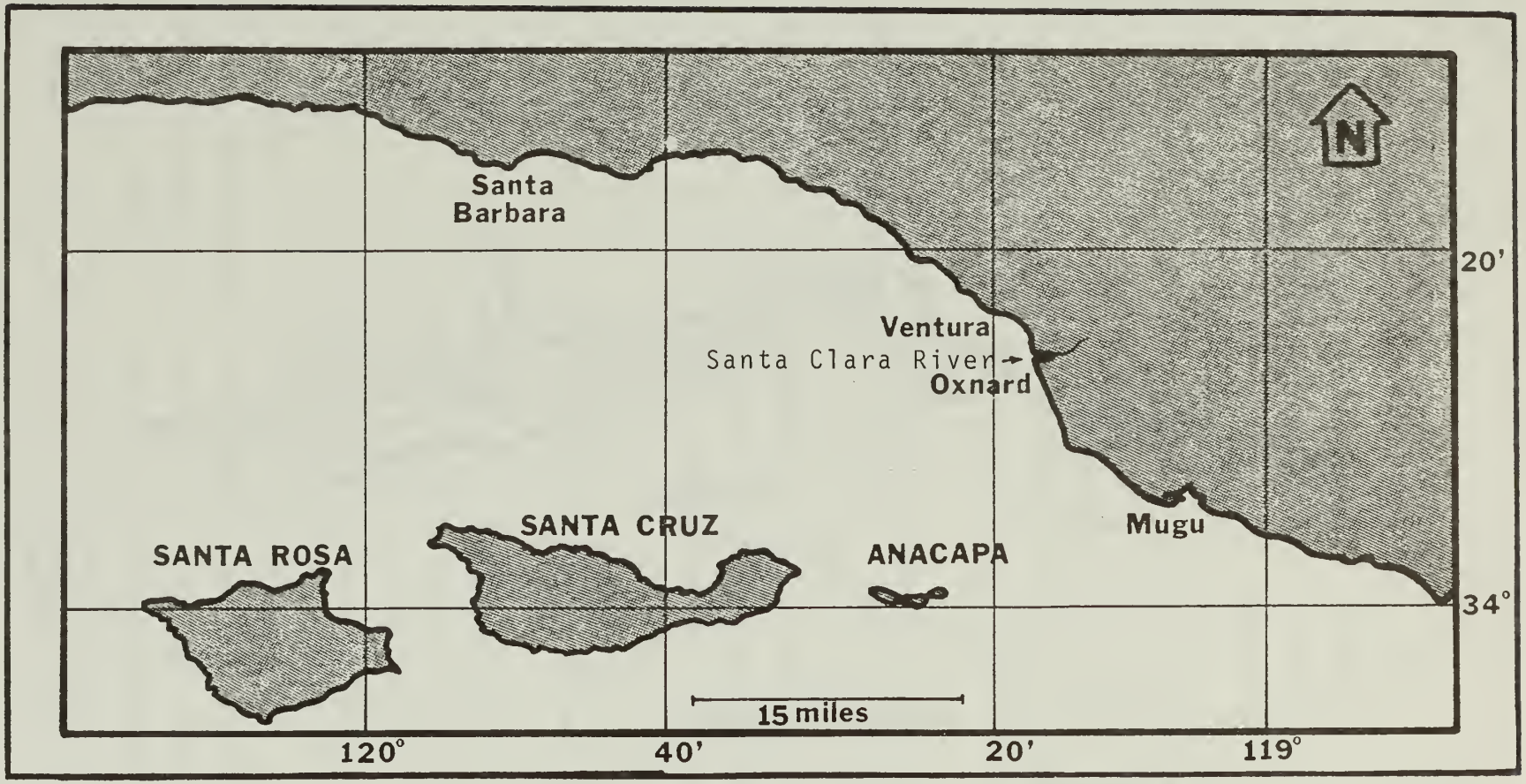


Figure 1. Location map of Anacapa Island.

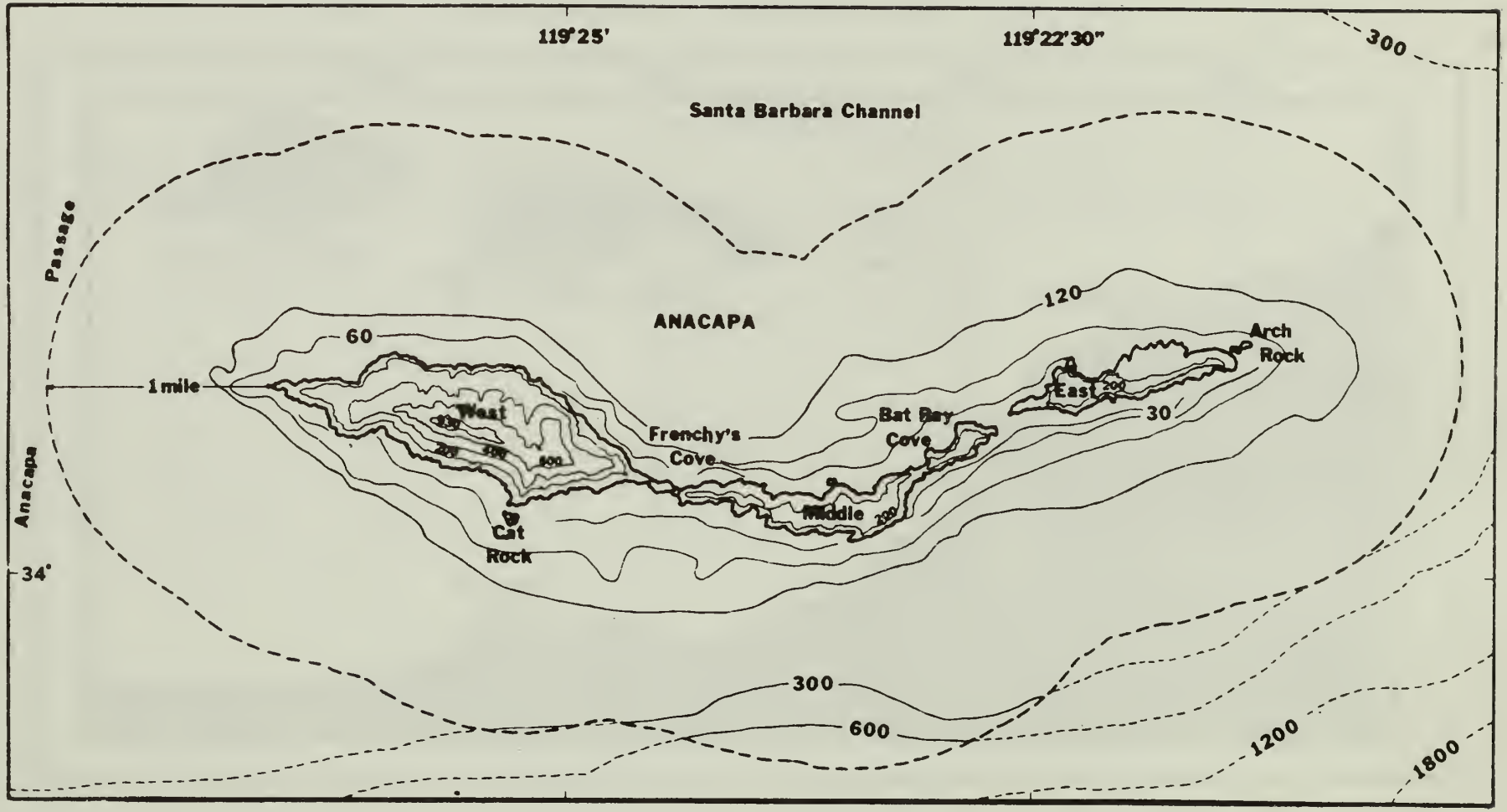


Figure 2. Anacapa Island, depths and heights in feet.

No comprehensive survey of the oceanographic climate of the nearshore waters of Anacapa Island is available, but a general picture can be gained from a synthesis of information from a variety of sources (Figure 3). Within the Santa Barbara Channel, there are consistent indications of counterclockwise circulation, although the general pattern of surface circulation is variable, depending on wind direction and velocity. A weak, non-tidal flow sets east in the spring and summer, and west in autumn and winter. California Current water apparently enters from the west and flows easterly along the northern edge of Santa Cruz Island towards Anacapa Island. Circulation is somewhat more complex in the vicinty of Anacapa, which is under the influence of California Current water carried in from the west and waters derived from coastal gyres to the south. Water passes through the gap between Anacapa and the mainland in either direction, and this circulation is apparently strongly influenced by the set of tidal currents which average about one knot.

Little information is available for circulation of the nearshore waters of the southern fringe of Anacapa and Santa Cruz. There is clearly no direct influence of California Current water in that region, and there is some indication that Santa Barbara Channel water may pass southward through the Anacapa straits and then westward along the southern island fringe. Northerly flow is also suggested through the passage between Anacapa and Santa Cruz, although tidal influences are likely to predominate, causing periodic current reversals despite the net flow patterns. A strong inshore (mainland) set prevails on rising tides over the Hueneme Canyon, which may affect the lower reaches of the Anacapa shelf.

An interesting and significant feature of the oceanographic climate in the vicinity of Santa Cruz and Anacapa Islands is related to the wind patterns. Prevailing northwest winds dominate the Southern California region. The east-west orientation of the shore and the mountainous channel islands create a corridor which channels the wind patterns into a more easterly direction, resulting in a divergence over the center of the channel. This creates a wind drift of warmer surface waters towards the mainland coast and also towards the northern edge of the channel islands, especially Santa Cruz and West Anacapa. The divergence under these circumstances may negatively affect temperature distributions on the southern leeside of Santa Cruz; however, all three Anacapa islands seem to be surrounded by waters of higher temperature.

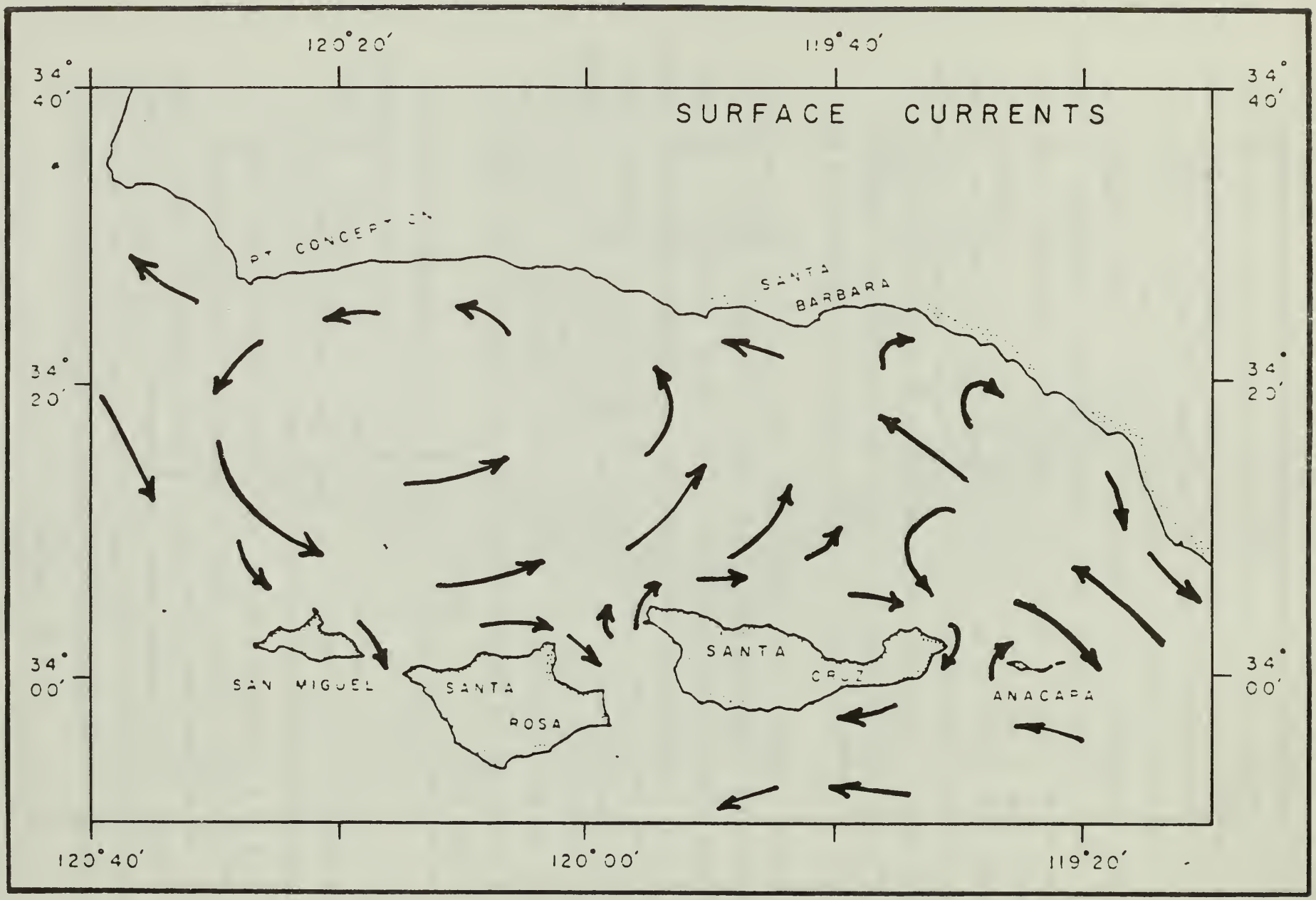


Figure 3. Surface currents around Anacapa Island.

Nearshore upwelling is a consistent feature along the south-facing mainland coast between Ventura and Point Conception. The upwelling is caused by the strong northwesterly winds which drive surface water offshore and bring cooler subsurface waters to the surface. Upwelling due to the same wind patterns may occur along the southern coast of Anacapa Island where the extent of the shelf and water column temperature are similar to that of the mainland coast. The occurrence of upwelling is supported by qualitative observations of lesser water clarity and sporadic cooler water conditions on the island's southern fringe. Unfortunately, no systematic quantitative observations of sufficient frequency are available to document upwelling events there.

There are three apparent hydrographic seasons: January through April brings a wind-generated period of surface mixing; May through July is the cooler, upwelling period; and August through December is a period of stratification.

Water Column: The most extensive series of oceanographic observations which are relevant to interpretation of nearshore conditions in the ASBS were made between 1956 and 1960 by scientists of the University of Southern California's Allan Hancock Foundation, under sponsorship of the (then) California State Water Quality Control Board. These observations, published in 1965, extended from the mainland coast out to the 300 foot (91 m) depth contour. While this zone does not encompass the nearshore waters of Santa Cruz and Anacapa Islands, the information can be extrapolated in general terms to create an overall picture of oceanographic conditions in those waters, especially when they are considered in the context of the broader data base of the California Cooperative Oceanic Fisheries Investigations (CalCOFI). CalCOFI studies which extend considerably beyond the islands into the California Current.

The areas covered by the Southern California Mainland Shelf survey (SWQCB, 1965) which have particular relevance to nearshore waters of the ASBS study sites are:

Area I. The Point Conception Shelf, Point Conception to Santa Barbara Point

Area IIa. Las Pitas Point to Santa Barbara Point

Area IIb. Las Pitas Point to Hueneme Submarine Canyon.

The major axes of hydrographic variability are the windard:leeward break along the main island ridges and east:west gradient of exposure to offshore

conditions. Surface seawater temperatures around the islands generally range from 55° F (13° C) in winter to 65° F (18° C) in summer. Warmer temperatures occur on the southern, leeward coasts and toward the mainland eastward. In waters over the Santa Barbara Basin, surface warming and thermal stratification within the upper 250 ft. (76 m) occur between June and November; mixing removes the thermocline and reduces the temperature of the water in this upper layer between January and March. South of the islands over the Santa Cruz Basin, the thermocline persists longer and the mixing period is restricted to February-March.

Salinity variations follow a similar pattern. Surface layers south of the islands have a generally higher salinity range (34 to 37%) than is found on the windward side (34 to 36%). Dissolved oxygen concentration is a function of mixing in the surface layers; in the Santa Cruz Basin 60% air saturation is the lowest level usually found within the upper 250 ft. (76 m); in the Santa Barbara Basin this layer may contain levels as low as 50% air-saturation, and in deep water 2,000 ft. (609 m) near the bottom, anoxic conditions occur. Turbidity is a wind and current related factor that is generally higher on the north or windward side of the islands and higher downcurrent to the east. Localized turbidity is determined by wind, rain, waves, and shore-type, and thus is greatest off areas like Cristi Beach, Prisoners Harbor, Chinese Harbor, and Frenchy's Cove where the substrate and dynamic factors are most suited for particle suspensions. Interisland regions of the shelf are also areas of high turbidity. Larger scale turbidity patterns form downstream and thus are generally more common along the northern coasts of Santa Cruz and Anacapa. Turbidity along the southern coasts may flow westward when south winds or west gyral currents prevail.

Water quality around the islands is generally good because of their isolated location. However, oil and tar pollution from natural seeps and ship traffic is chronic, particularly along the north coast. Primary productivity in the Santa Barbara Channel shows a peak bloom in the spring and a minor bloom in the summer. Overall, primary productivity is highest in the northeastern portion of the Channel. Upwelling along the islands may lead to periods of locally high productivity.

Topography and Geomorphology

Submarine Topography: The northern tier of Southern California's Channel Islands, San Miguel, Santa Rosa, Santa Cruz, and Anacapa, comprise a subsection of the mainland shelf that is surrounded by seafloor depths of at least 700 ft. (214 m). West of the Islands' shelf, off San Miguel and Santa Rosa, is the outer slope of the Southern California Bight, which grades into deep water offshore. The northern edge of the island platform drops rather steeply into the Santa Barbara Basin (maximum depth about 2,000 ft. or 610 m), an elongate depression running north and west off the mainland coast between Ventura and Point Conception. The southern margin of Santa Cruz Island is bounded by the Santa Cruz Basin (maximum depth 6,200 ft. or 1,891 m) while Anacapa's southern shelf drops into the Santa Monica Basin (maximum depth 3,100 ft. or 946 m). Northeast of Anacapa, the sill ridge between the two inshore basins is cut by the Hueneme Canyon, which provides a connecting deep water link with the Santa Monica Basin.

Anacapa occupies the narrow, easternmost end of the northern Channel Islands platform. The shelf along the northern edge of the island is wider than that on the southern side and both sides taper toward the east. On the north, the shelf descends in two stages to the shallow eastern end of the Santa Barbara Basin; within an average of 0.3 mi (0.5 km) from shore, the bottom depth reaches 165 ft. (50 m), then flattens into a gradually descending 2.5 mi (4 km) wide ledge; it drops another 500 ft. (152 m) to the basin floor within an average of 4 mi (6.4 km) of the shoreline. The shelf on the southern side of the island drops less gradually into the deep Santa Monica Basin on the southeast; the 165 ft. (50 m) isobath is about 1 mi (1.6 km) from shore; 640 ft. (195 m) in depth is 1.5 mi (2.4 km) out, at the upper edge of a steep drop to 1,650 ft. (502 m) within about 1.8 mi (2.9 km) from shore, and to 2,300 ft. (700 m) within 4.5 mi (7 km) from shore.

Landside Geomorphology: The four Northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz and Anacapa), appear to be the tops of submerged mountains, most likely an extension of the coastal Santa Monica Range. The geomorphology of the region shows that it has had a history of vulcanism, uplift, and subsidence. It is near the leading edge of the continental plate, and the area around Santa Cruz and Anacapa Islands has a low to moderate average level of seismic activity. The major fault in the area of Santa Cruz and

Anacapa runs along the central valley of the large island and to the southeast of Anacapa Island. North of the fault are primarily volcanic Cenozoic rocks, while areas south of the fault are chiefly Cenozoic sediments. Fault locations and seismic activity patterns are shown in Figure 4.

Both Santa Cruz and Anacapa have coastlines that consist largely of bluffs, cliffs, and steep rocky slopes. Wave action has formed the cliffs and has created a multitude of caves and clefts in them. Terraces have been formed in places by uplift. Sedimentation is generally most extensive on the northern and southern reaches of the shelf and is thickest to the north. Tidal flow and reversing currents flush the shallow interisland shelf areas, and sediments are generally more sparse, with larger particle sizes.

West Island has a lateral ridge, 930 ft. (283 m) at its summit, that divides the island into north sloping and south sloping sides. From the summit, the elevation drops quickly to the western end and more gradually toward the east. Runoff is primarily to the north and a few intermittent streams occur on this slope. Middle and East Islands are much lower (325 and 250 ft. or 99 and 76 m) in elevation and have flattened tops.

The sides of all three islands rise steeply from sea level, and more than a hundred wave-etched caves exist along these cliffs. Pinnacles and isolated rocks are common. Land slippage and slides occur along both coasts of Anacapa, most frequently on the south. Rocky gaps separate the three islands.

Subtidal Geomorphology: Anacapa Island is surrounded by a subtidal area of interspersed rock, reef and sand. These areas are delineated in Figure 5. About 85% of the sediments in the Santa Barbara Basin, and thus the deep northern margin of Santa Cruz and Anacapa Islands, originate as runoff from the Santa Clara River south of Point Conception. To the south, the deep sediments are mostly a mixture of material of varied southern origin. Shallow shelf sediments are more directly influenced by the islands themselves. Currents and tidal flux in the Anacapa Passage and east of the island keep shelf sedimentation low in those areas, while the island's north and south flanks are more thickly sedimented. Shelf sediments on the east and west end of Anacapa are calcareous and medium to coarse grained. The narrow and relatively steep southern shelf slope has mostly medium and fine grain detrital sand, as does the wider and more gradually sloping northern shelf. Particle size generally decreases with distance offshore.

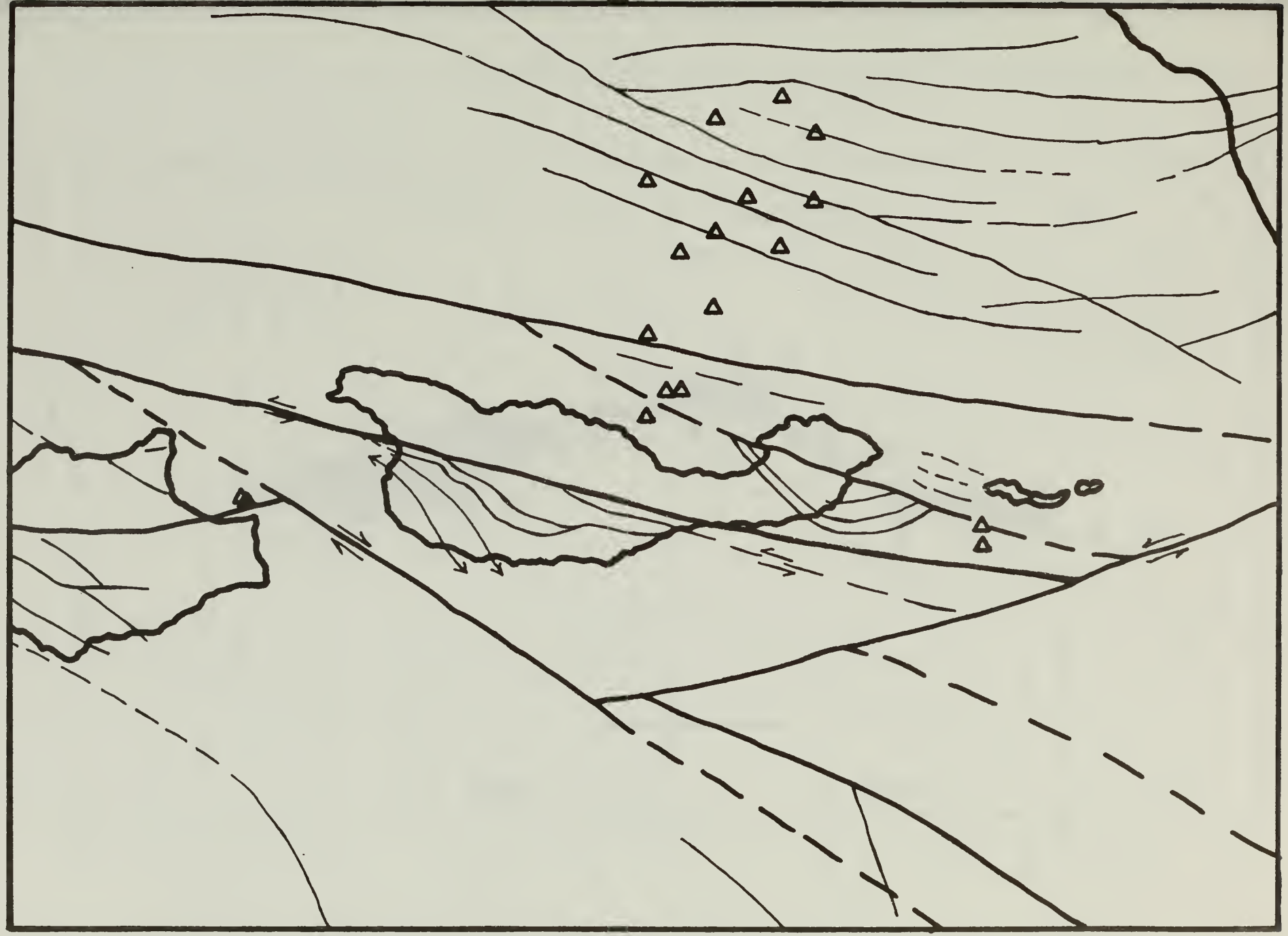


Figure 4. Fault lines and seismic activity (triangles), after Weaver, 1969.

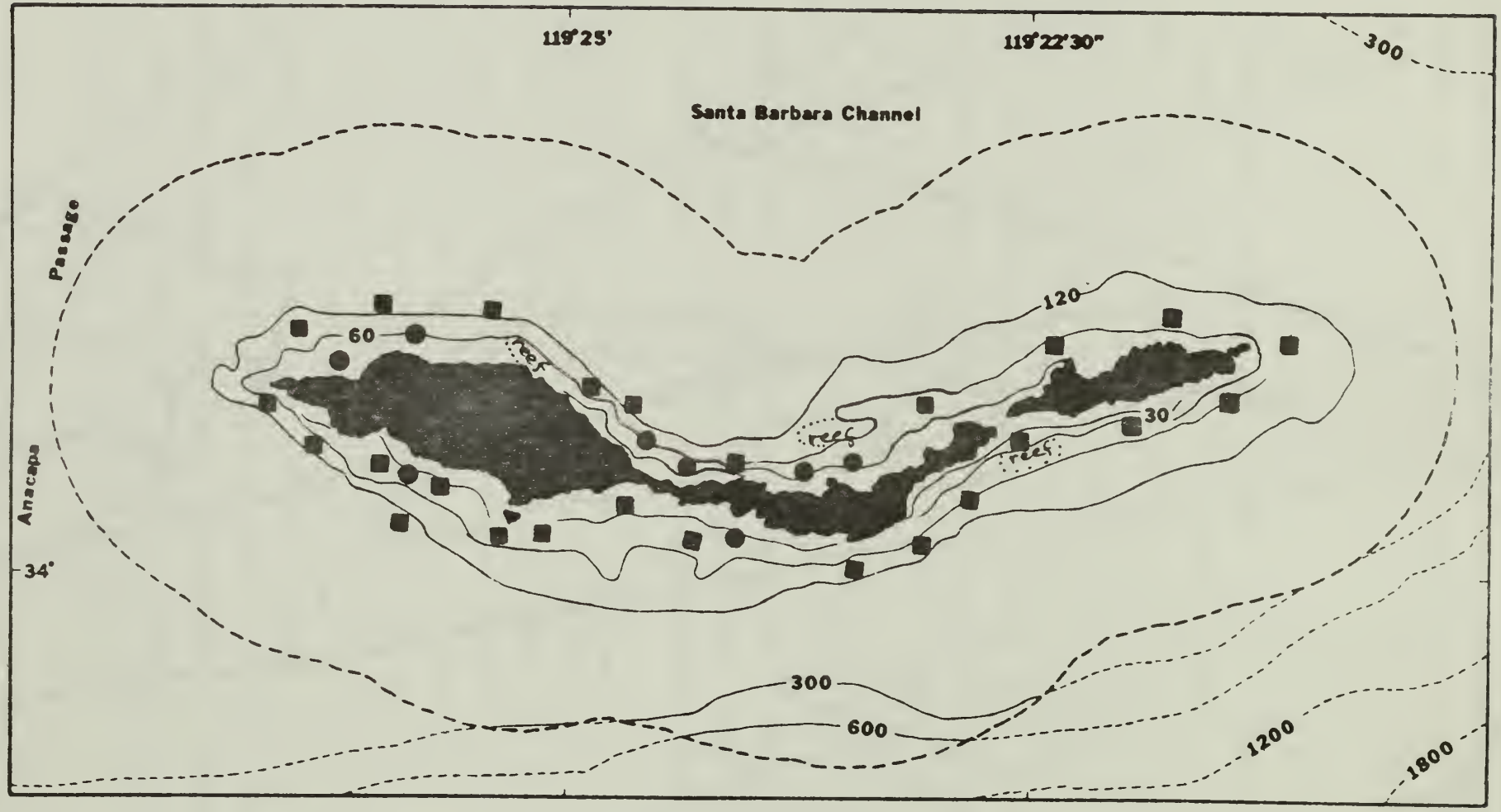


Figure 5. Rock (squares) and sand (circles) substrate localities; depths in feet.

Anacapa is surrounded by faults (Figure 4), but the closest are minor faults lying off the western side of the west island. Seismic activity over the last 30 years has been located primarily to the south of West Island.

Intertidal Geomorphology: The steep and rugged character of Anacapa's shoreline make its intertidal region relatively narrow. The intertidal consists principally of boulders, rocky outcrops, rock shelves, tidepools, and rubble piles. The most extensive tidepool area is located on the southern coast of West Island's narrow eastern neck, opposite Frenchy's Cove. Cobble beaches occur along the southern coast, on the eastern end of Middle Island and on the western end of East Island. Along the northern shore, two small pockets of intertidal cobble are found in protected areas behind arched rock walls on the eastern ends of Middle and East Islands. Intertidal beaches of mixed cobble and black volcanic sand occur in Frenchy's Cove, Bat Ray Cove, and the southern fringes of the interisland gaps. At high tide these beaches are usually submerged.

Climate

The characteristic weather patterns of Santa Cruz and Anacapa Islands are dominated by the East Pacific High Pressure Area, as is the general weather pattern of Southern California. The high pressure area blocks the southerly flow of cold, wet air masses into Southern California and deflects them to the east. In summer, the pressure maximizes, yielding a seasonal climate that is relatively dry and warm. During winter, the pressure in the high is decreased, and it is located further to the south. This allows cold fronts to penetrate further south, bringing rain and cooler temperatures in a southeasterly direction. The effects of these factors are modified by dynamic balancing of the land and sea temperatures.

In summer, cool marine air flows toward a warm, low pressure area that develops inland. A marine layer is established over the coast, which shifts onshore at night and offshore during the day, due to diel thermal balancing between land and sea. A sea breeze blows during the day and flows in a general southeasterly direction. Clouds and fog associated with the marine layer increase the humidity and lower the temperature. Because of their location offshore, Santa Cruz and Anacapa Islands generally have somewhat lower temperatures than the mainland and are more often enveloped by fog. Hot, dry Santa Ana winds occur during winter months when a high pressure area develops

inland and blows warm air seaward, but their effect is diluted over the islands.

The prevailing regional wind flow pattern is from the northwest, but in the Santa Barbara Channel, the islands and coastal mountain range act to funnel a major divergence eastward. In the lee of the northwest winds, the mainland coast of the channel and the southern coasts of Anacapa and Santa Cruz Islands receive occasional winds from the west and southwest (Figure 6). In the channel, west winds blow nearly every afternoon, then diminish at sundown. In the winter, southeast storms occur which impact the islands' southern coasts; Anacapa and Santa Cruz are also subject to occasional northeasters. In strong northwest weather outside the channel, the northern shores of the islands experience a buildup of wind, waves, and swell.

Rainfall on Santa Cruz and Anacapa Islands is sparse, usually coming in the winter along with dense fog that is more persistent than on the mainland coast. Santa Cruz and West Anacapa are within the semi-humid maritime zone which receives more than 13 inches (33 cm) of rain a year, while Middle Anacapa Island and East Anacapa Island are in the arid maritime zone which receives less than 13 inches (33 cm) a year. Santa Cruz and West Anacapa create a rain shadow that reduces the rainfall on lower lying Middle and East Anacapa. The driest time of year is in the spring due to the reduced fog although the least rainfall occurs during summer. Average annual rainfall, measured over 70 years at the Stanton Ranch in Santa Cruz Island's central valley, is about 20 inches (50 cm) with yearly totals ranging from 6.5 inches (16.5 cm) to 56.2 inches (143 cm). On East Anacapa Island the average annual figure is reduced to about 7 inches (17 cm) per year. (Table 2).

Air temperature at the islands is closely related to the range of the surrounding sea temperatures. Coastal temperatures on Santa Cruz are strongly influenced by fog and wind. Coastal temperatures usually range between a low of 35° F (2° C) and an average high of 85° F (30° C). The central valley experiences frost and has an annual temperature range between 30° F (-1° C) and 90° F (32° C). No comparable air temperature data are available for Anacapa although warmer temperatures can be expected toward the east.

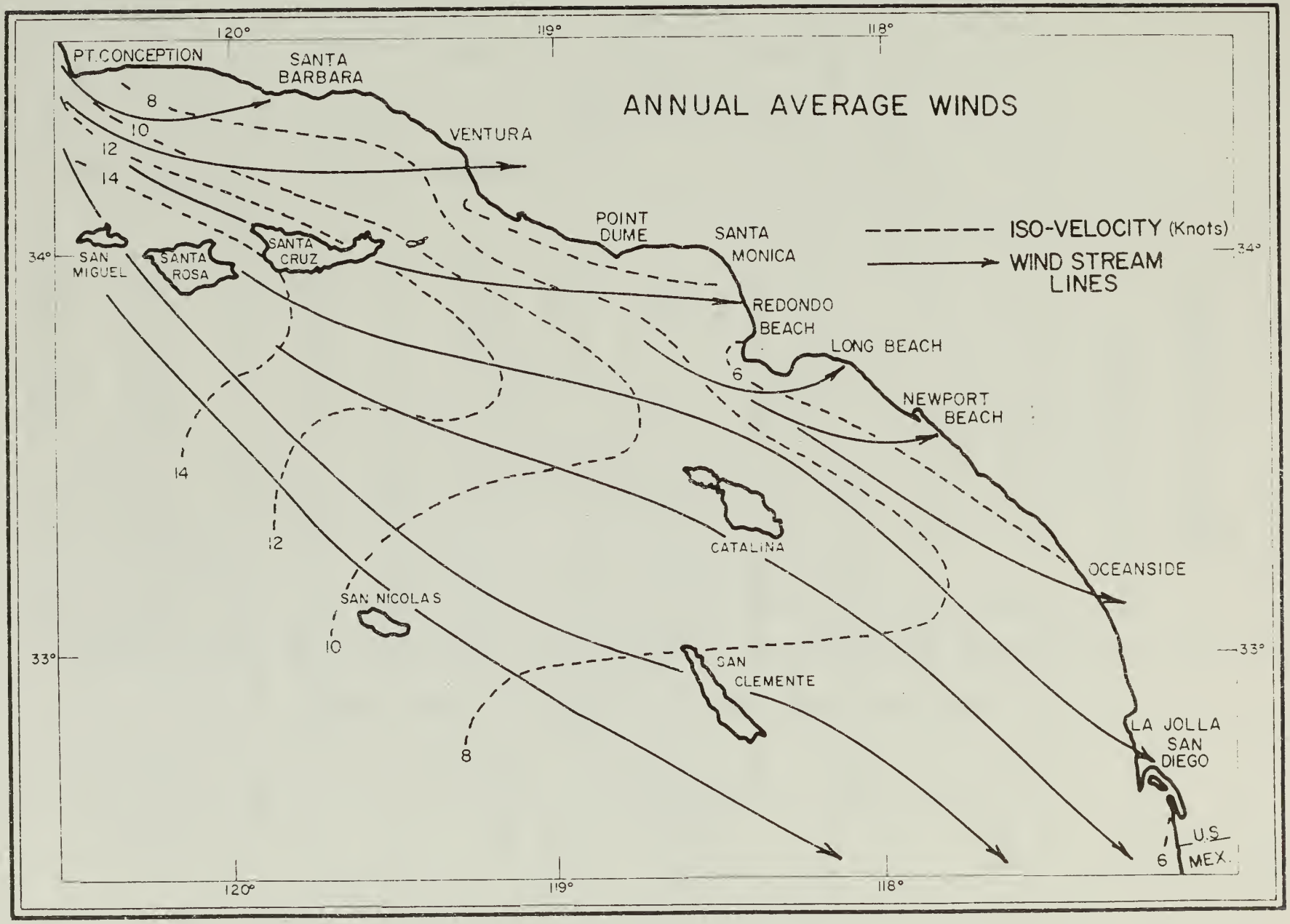


Figure 6. Generalized Wind Patterns of the Channel Islands; Hancock Foundation, 1969.

TABLE 2 Rainfall in inches for Anacapa Island - East Island

	Total	J	F	M	A	M	J	J	A	S	O	N	D
1946	incomplete											.59	.87
1947	.81	.02	.02	.09			.03		.04	.01	.18		.42
1948	incomplete		.04		.21	.02	.01	.01		.01	.01		
1949	incomplete	.72		.38		.08						.19	1.52
1950	incomplete	2.16			.01					.24	.48	.80	.53
1951	7.84	2.35	1.18	.52					.03		.15	.46	3.15
1952	14.27	.52	3.90	.33	4.89	1.28						1.33	1.50
1960	7.45	2.05	2.28	.07	.79							1.96	.30
1961	2.91	.89		.52			.02			.02	.01	1.07	.38
1962	7.26	.46	5.72	1.04			.04						
1963	3.19	.02	1.01	.53	.24					.24	.10	1.05	
1964	2.48	.80		.54	.36						.52	.12	.14
1965	14.53	.19	.43	1.00	4.11					.03		6.00	2.77
1966	5.32	1.66	.69	.05		.05				.02		1.12	1.69
1967	6.43	1.63	.16	.60	3.30	.05				.04		.34	.31
1968	incomplete	.93	.46	2.69	.28						.89	.52	

Blank indicates no rainfall or missing data.

Source: 1947-1952 Robert De Violini, Climatologist
Pacific Missile Range

1960-1968 U. S. Weather Bureau, San Francisco

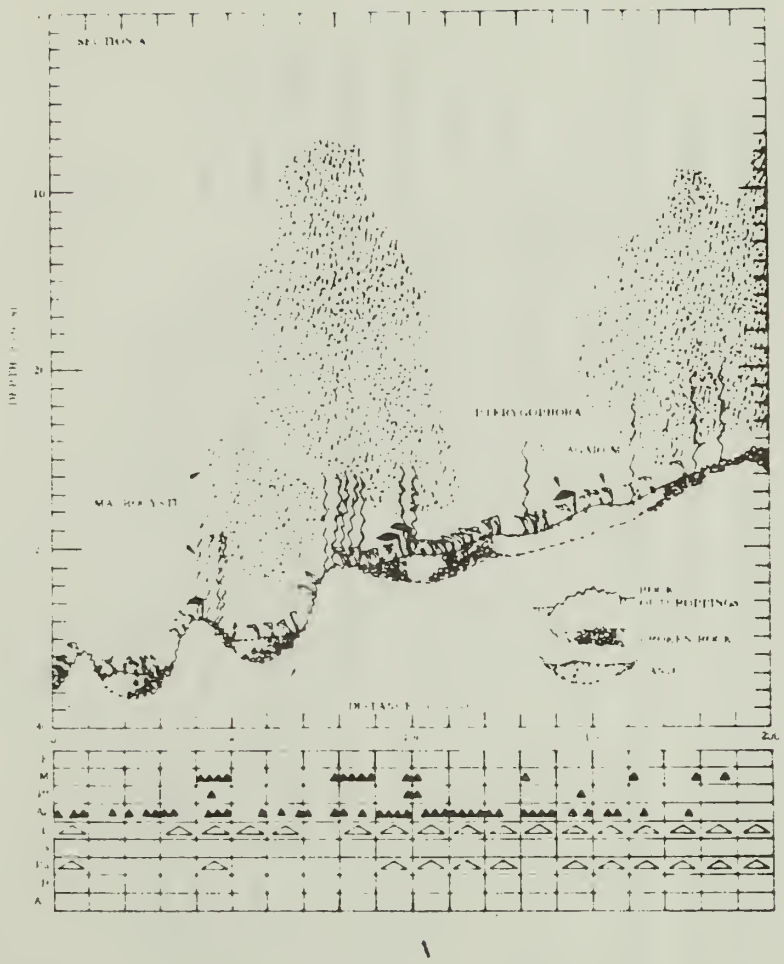
BIOLOGICAL DESCRIPTION

Subtidal Biota

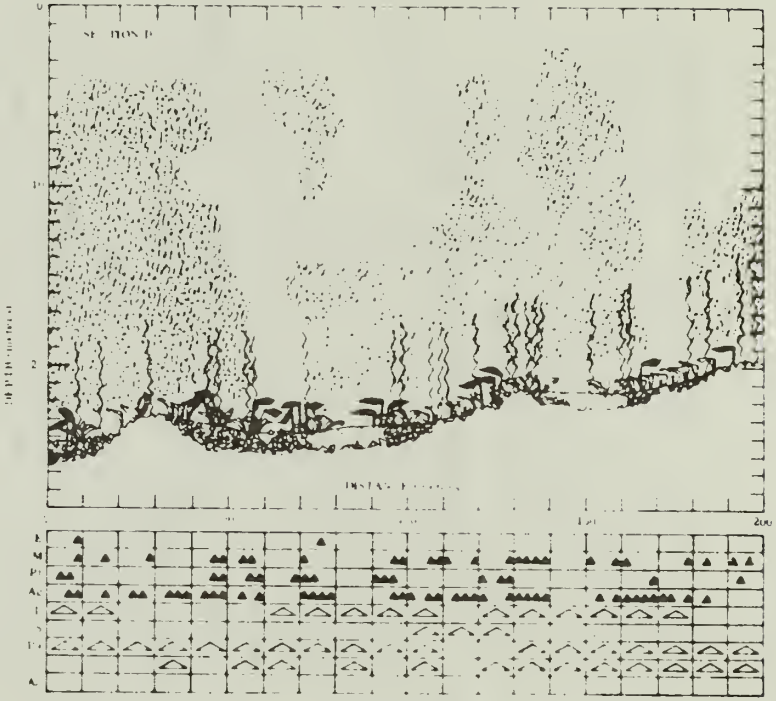
The subtidal biota of Anacapa Island has been characterized in surveys by Neushul, Clarke, and Brown (in Philbrick, R.N., ed., 1967). Three recognizable algal zones occur: (1) from the intertidal to about 26 ft. (8 m), dominated by Eisenia arborea, brown algae, Laminaria farlowii, and surf grass, Phyllospadix torreyi; (2) from 26 ft. (8 m) to about 112 ft (34 m), containing principally giant bladder kelp, Macrocystis pyrifera, Agarum fimbriatum, and Pterygophora californica; (3) below 112 ft. (34 m), typified by small red algae and scattered Agarum fimbriatum (see Figure 7).

The shallow zone invertebrate fauna is represented by four species, listed here in order of decreasing dominance: the purple urchin, Strongylocentrotus purpuratus, giant red urchin, S. franciscanus, anemone, Anthopleura xanthogrammica, and the sea bat, Patiria miniata. This zone also contains abundant populations of the anemone, Anthopleura elegantissima, California mussel, Mytilus californianus, common starfish, Pisaster ochraceous, and the red and white barnacle, Balanus tintinnabulum. The invertebrates of the middle zone are characterized by the appearance of the sea urchin, Lytechinus anamesus and Botruanthus benedini, in addition to the giant red urchin, purple urchin, and the sea bat. Also present are the small red anemone, Corynactis californica, giant starfish, Pisaster giganteus, and the sea hare, Aplysia californica. The deep zone has sea urchin, sea bat, California cucumber, Stichopus californicus, and the bryozoan Tethya aurantia.

Characteristic fishes of the three subtidal zones are: (1) rubberlip seaperch, Rhacochilus toxotes, kelp perch, Brachyistius frenatus, white seaperch, Phanerodon furcatus, señorita, Oxyjulis californica, and rainbow seaperch, Hypsurus caryi; (2) opaleye, Girella nigricans, blacksmith, Chromis punctipinnis, halfmoon, Medialuna californiensis, and garibaldi, Hypsispops rubicundus; (3) California sheephead, Pimelometepon pulchrum, painted greenling, Oxylebius pictus, bluespot goby, Coryphopterus nicholsii, and olive rockfish, Sebastes serranoides.



A



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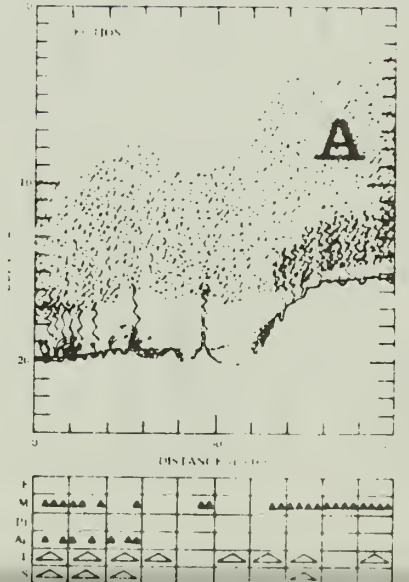

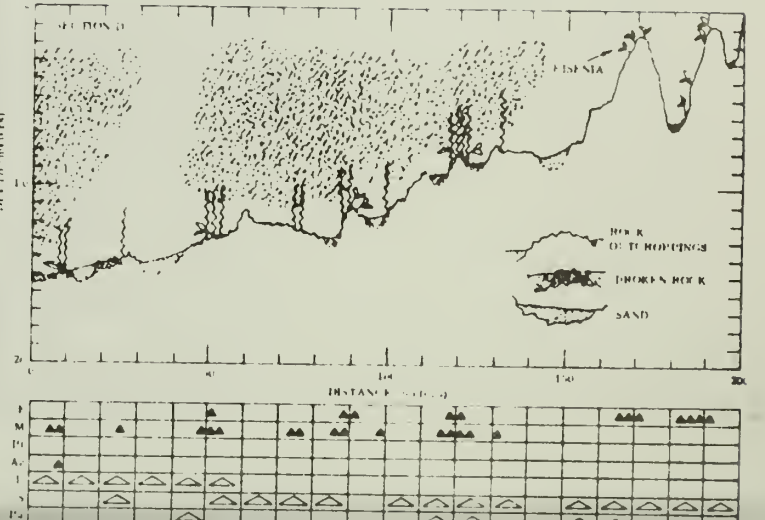

Figure 7. Subtidal transects of Anacapa; from Neushul, et al, 1967.

A – D

Transect off Anacapa Island, California, showing the types of bottom and indicating the distributions of the major plants. The occurrences of the different plants are indicated by symbols which are identified in the figure. The shaded areas above the bottom represent *Macrocystis* plants that lean over the survey line because of a current flowing from west to east. The table at the bottom of the figure indicates the occurrences per two and one-half meter section of four plants: L, *Eisenia arborea;* M, *Macrocystis pyrifera;* Pt, *Pterygophora californica;* Ag, *Agarum fimbriatum;* and the presence or absence per ten meter section of six animals: L, *Lytechinus anamesus;* S, *Strongylocentrotus franciscanus* and S. *purpuratus;* Pa, *Patiria miniata;* B, *Botrynanthus benedini;* An, *Intho-*

Overall, the subtidal regions of Anacapa are very rich, with high diversity and great abundance. The rocky substrate supports rich forests of giant bladder kelp, the foundation species of a characteristically complex community. Figure 8 shows the approximate distribution of major kelp beds around Anacapa. Most of the kelp beds of Southern California have been well exploited by divers, but because of its relative isolation and recent protection, Anacapa has remained relatively unexploited. On the lee (south) side of the island the kelp beds are much more extensive than in other subtidal areas of the Island.

Intertidal Biota

The intertidal biota on Anacapa Islands are diverse and very abundant. The steep cliffs of the Island result in a generally narrow intertidal habitat; however, accumulation of rock rubble at the base of these steep areas has increased the intertidal zone in some areas. Cliffs on the lee (south) side of the Island have experienced less crumbling from wave action and weathering; thus, its intertidal area is less extensive. Variations in the coastline provide differing degrees of exposure to wave action and weather on both coasts, but in general the northern coast has the richest intertidal biota (and the greatest incidence of tar patches). The exposure zones and associated biota are as follows:

Upper zone; invertebrates in decreasing order of abundance: pill bug, Ligia occidentalis, acorn barnacles, Balanus glandula, periwinkles, Littorina planaxis, L. scutulata, limpet, Acmaea digitalis, ribbed limpet, A. scabra; red algae in decreasing amount of coverage: Enteromorpha tubulosa, Endocladia muricata, Polysiphonia simplex.

High intertidal; invertebrates: acorn barnacles, Balanus glandula, barnacle, Chthamalus fissus, mussel-bed snail, Acanthina spirata, periwinkle, Littorina scutulata, tube worm, Phragmatopoma californica, ribbed limpet, Acmaea scabra; algae: rockweed, Pelvetia fastigiata, red algae, Corallina chilensis, and C. vancouverensis, sea lettuce, Ulva californica, Entermorpha tubulosa.

Middle intertidal; invertebrates: California mussel, Mytilus californianus, gooseneck barnacle, Pollicipes polymerous, anemone, Anthopleura elegantissima, red and white barnacle, Balanus tintinnabulum, Nucella lamellosa, chiton, Nuttalina fluxa, common starfish, Pisaster ochraceus,

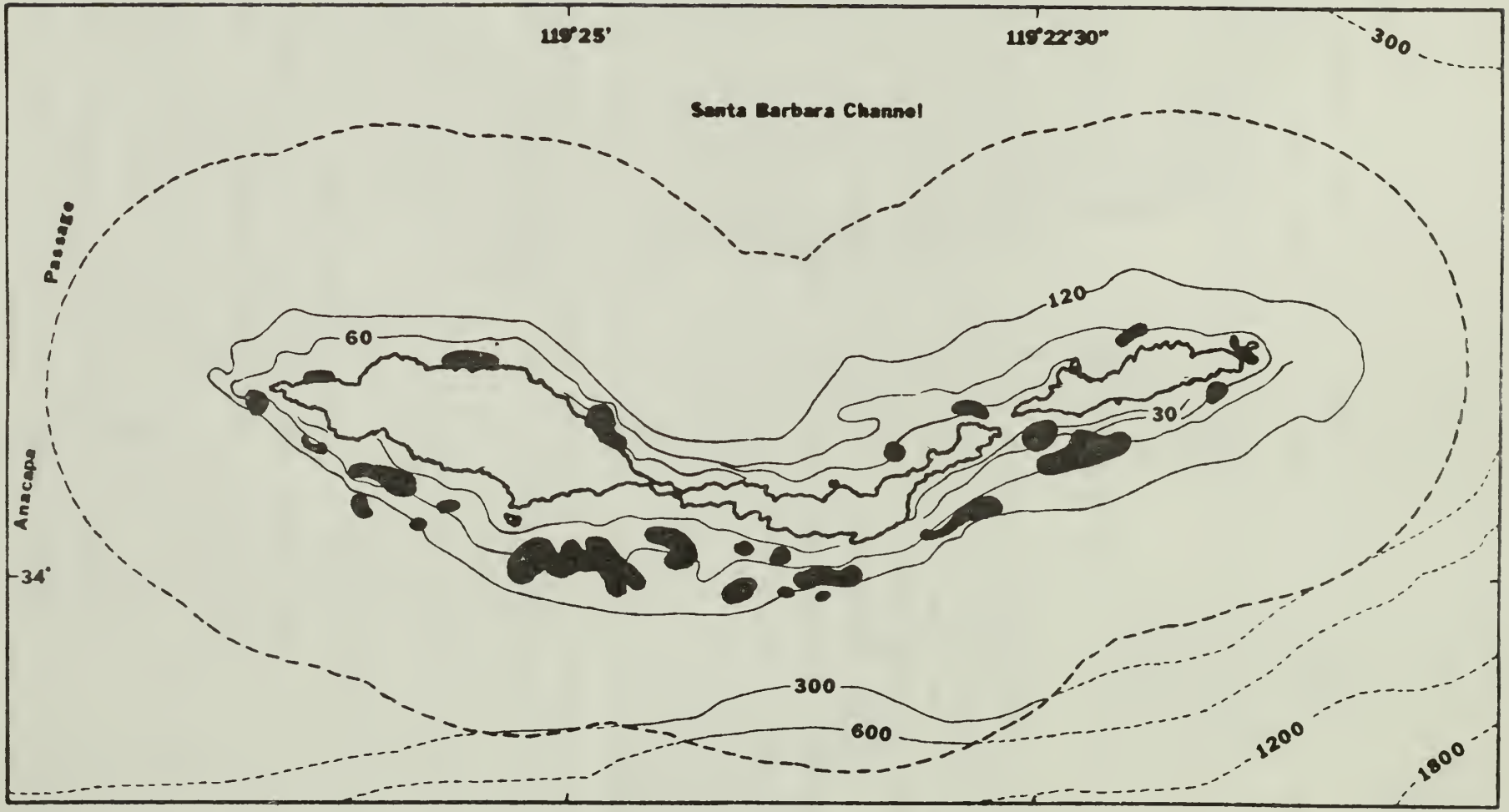

Figure 8. Location of Giant Kelp, Macrocystis, Around Anacapa Island.

lined shore crab, Pachygrapsus crassipes, ribbed limpet, Acmaea scabra; aglae: red algae, Corallina chilensis, C. vancouverensis, rockweed, Pelvetia fastigiata, and Fucus furcatus, Codium fragile, Bossiella sp. Lower intertidal; invertebrates: purple urchin, Strongylocentrotus purpuratus, anemone, California mussel, black abalone, Haliotus cracherodii, common starfish, crab, Pugettia richii, algae: Halidrys dioica, Gigartina spinosa, red algae, Corallina chilensis, brown algae, Laminaria farlowii, Eisenia arborea, surf grass, Phyllospadix torreyi. Tide pools; invertebrates: periwinkles, Littorina planaxis, limpet, Acmaea digitalis, anemone, Anthopleura elegantissima, black turban snails, Tegula funebralis, giant keyhole limpet, Megathura crenulata, hairy hermit, Pagurus hirsutiuculus, chiton, Nuttalina fluxa, copepod, Tigriopus californicus; algae: Enteromorpha tubulosa, sea lettuce, Ulva californica, red algae, Corallina chilensis, and rockweed, Pelvetia fastigiata.

Landside Vegetation

The topography of Anacapa severely limits the types of vegetation which occur there. A small area of coastal strand vegetation occupies the high sandy area behind Frenchy's Cove. Coastal bluff communities grow in soil pockets along the island cliffs and at their upper margins; these consist primarily of wild buckwheat, Eriogonum spp., live-forever, Dudleya candelabrum, D. greenei, ice plant, Mesembryanthemum spp., and tickseed, Coreopsis gigantea. A variety of lichens are also found along the island cliffs. On the upper island surfaces is a coastal sage-scrub community containing lemonadeberry, Rhus integrifolia, Baccharis pilularis, sage, Salvia brandegei, and cholla, Opuntia littoralis.

Vegetation is most dense on the northern slope of the island, but while spring blooms are extensive, the overall vegetation is sparse. Much of the island's flora has been introduced, and native forms like tickseed have been displaced by the exotics (e.g., ice plant). This displacement has been enhanced by the introduction of rabbits, which damage the tickseed.

Unique Components

West Anacapa Island is particularly important as the only known Western U.S. nesting area for the brown pelican, Pelecanus occidentalis californicus, which is an endangered species. (Figure 9). While particular aspects of the Island's natural resources are of individual significance, it is the overall nature of the region that provides its greatest significance. Anacapa offers sea lions, elephant seals, and harbor seals (Figure 10) on its beaches; whales, sharks, porpoises, and rays directly offshore. Rich tidepools, intertidal zones, and subtidal areas bearing dense kelp beds with their diverse communities surround the Island.

Anacapa and Santa Barbara Islands were established as a National Monument in 1938 to preserve fossils of Pliestocene elephants and trees, examples of ancient vulcanism, deposition, sea erosion, and other geological features. The area was expanded to include the marine resources of the nearshore area in 1949. In addition, Anacapa contains considerable numbers of archaeological and historical artifacts.

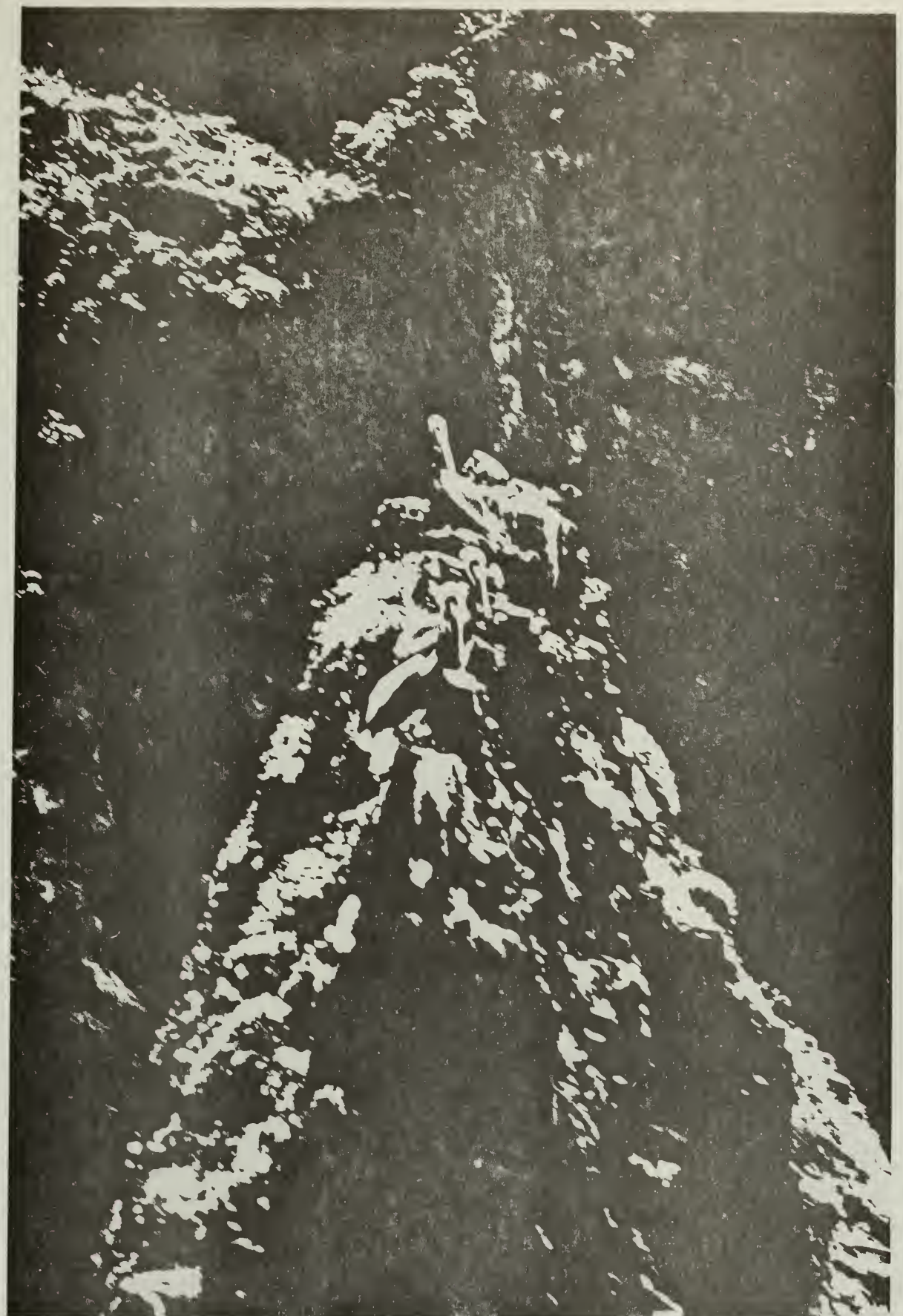

Figure 9. The Brown Pelican, Pelicanus occidentalis californicus, Resting on Anacapa Island.

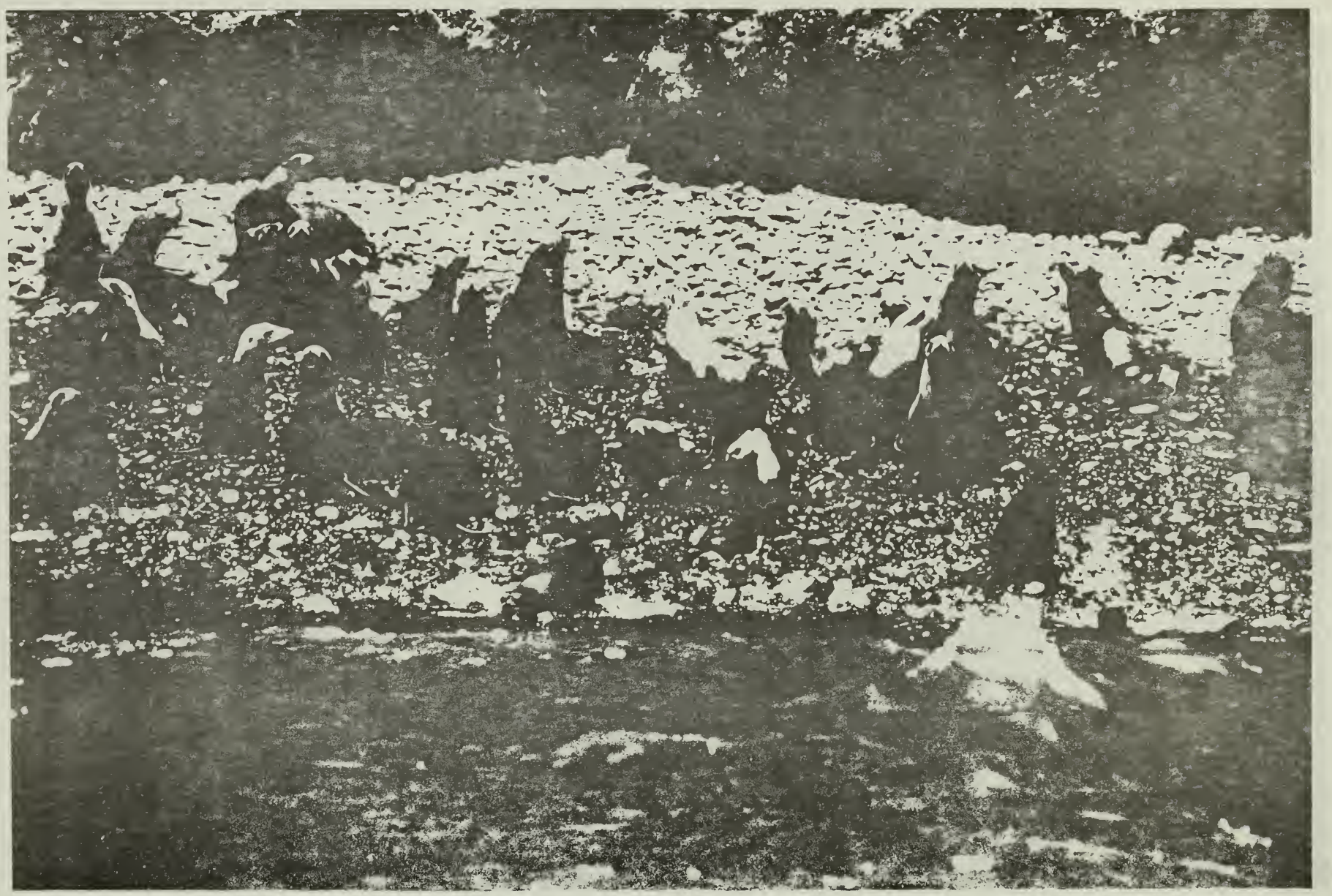

Figure 10. Harbor Seals on Anacapa Island.

Marine Resource Harvesting

The primary commercial fishing activities within the Santa Cruz and Anacapa Islands ASBS are the collection of abalone, urchins, and lobsters. Four species comprise the bulk of the abalone catch: Haliotus cracherodii, H. rufescens, H. corrugata, and H. fulgens. The commercial catch is harvested by divers working in the middle and deep subtidal zones. With the decline of abalone stocks north of Point Conception, pressure on the channel island populations has increased and these stocks appear also to be in decline. Through regulation, the abalone harvest along Anacapa's south coast is being reduced.

Sea urchin fisheries, conducted out of Santa Barbara, Ventura, and Port Hueneme, are locally important within the ASBS. The purple urchin and the giant red urchin are harvested subtidally off Santa Cruz and Anacapa for export. This is a small export fishery, and to date there have been no apparent detrimental effects within the islands' ASBS boundaries.

The lobster fishery for Panularis interruptus places a heavy pressure on the ASBS populations, and, like the abalone, this resource is in a steady decline. Regulation by licensing, season, and size limits has slowed the drop in population size, and the recent development of aquaculture techniques for the eastern lobster, Homarus americanus, offers some promise for relief.

No oil exploration or production takes place within the ASBS boundaries; however, nearby oil platforms do influence the area. The effects of this activity are discussed below in the section entitled Point Sources.

Commerical kelp harvesting takes place in four leased beds around Santa Cruz and Anacapa Islands and within the ASBS boundaries. Bed #79 lies along the southern coast of Anacapa; #82 is off the northern shore of Santa Cruz; Beds #81 and #80 occur west and east, respectively, of Bowen Point along the southern edge of Santa Cruz. Beds #81 and #82 are rather thin and scattered while #79 and #80 are relatively dense. Harvesting significantly decreases the kelp canopy and substantially reduces the character and quality of the kelp forest habitat communities.

Sport fishing and SCUBA diving activities are extensive within the Santa Cruz and Anacapa ASBS; abalone and the olive rockfish appear to be the most heavily exploited species. These activities probably pose no substantial current threat to the ASBS biota.

Governmental Designated Open Space

Anacapa and Santa Barbara Islands comprise the Channel Islands National Monument and are administered by the National Park Service. Four natural zones have been designated:

Natural Environmental Subzone - East Anacapa Island and the waters surrounding all three Anacapa Islands for one nautical mile (1.84 km) seaward. This is a protected area with activities managed by the National Park Service for environmental compatibility.

Environmental Protection Subzone - West Anacapa Island is an area of particular value as wildlife (e.g., brown pelican) habitat and research. It is managed to perpetuate its unique ecological characteristics and is a Research Natural Area.

Outstanding Natural Features Subzone - Middle Anacapa Island and the Arch Rock group possess unique or intrinsically valuable features and are managed to retain their quality while allowing for public access.

Developmental Subzone - Five acres on East Anacapa Island are developed for management purposes. Nineteen small Historic Zones have been designated on Anacapa for preservation of their historic or archaeological value.

Recreational Uses

Anacapa is a popular boating, fishing, and diving area for daytrippers from Santa Barbara, Ventura, and Port Hueneme. Camping is allowed on East Anacapa and hiking on Middle Anacapa. Party boats of fishermen and SCUBA divers frequent the region. All activities are managed according to zones described above. Underwater nature trails have been proposed for several areas around Anacapa.

Scientific Study Uses

A representative listing of the scientific investigations conducted at Anacapa is found in Appendix 1.

Transportation Corridors

Figure 11 shows the Santa Barbara Channel shipping lane. No records of traffic are kept by any agency but it probably rarely exceeds six or seven large vessels per day.

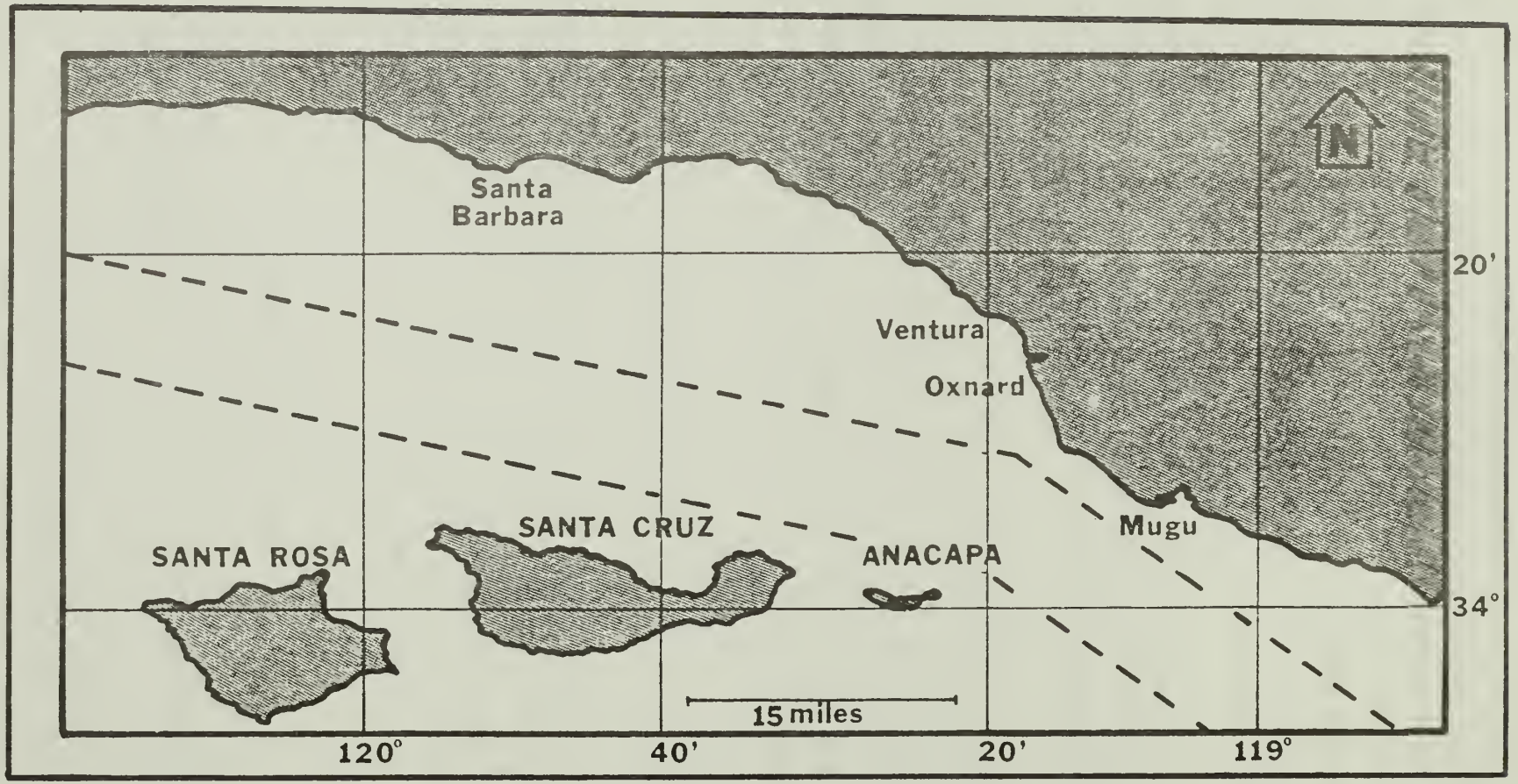

Figure 11. Santa Barbara Channel shipping lane.

ACTUAL OR POTENTIAL POLLUTION THREATS

Point Sources

Radioactive Wastes: There are no radioactive wastes within the Anacapa Island ASBS. However, about 25 miles (40.2 km) to the south (at 33° 35' N, 119° 30' W in the Santa Cruz Basin) there is a radioactive waste dumpsite that was used by the Atomic Energy Commission in the early 1950's. Approximately 2,900 55-gallon drums containing uranium and thorium wastes were dumped. Such dumping is now prohibited. This was low level material (about 60 curies of activity), and it is felt that these wastes pose no threat to the Anacapa ASBS.

Offshore Oil Development: No oil development takes place within the Anacapa Island ASBS boundaries. However, nearby operations in the Santa Barbara Channel and off the mainland coast undoubtedly lead to oil and tar deposition on the Island's coast. Oil slicks extending downstream from the drilling platforms are common occurrences, and the prevailing weather and current patterns dictate that a portion of this petroleum will impact the Island's northern coastline. Many of the nearby offshore oil development leases were granted before the institution of strong environmental considerations, and thus are not constrained by the more recently adopted controls. The proposed sale of future lease sites may include areas in the vicinity of the Northern Channel Islands. Development of these areas will increase the level of oil reaching the Islands. The effects of this increase cannot be predicted because as yet there have been little data available concerning the effects of the current level. It should be noted, however, that observations at Christi Beach on Santa Cruz Island showed a striking difference between the intertidal biota at oil impacted areas and non-impacted areas at the north point, as well as a general difference between the north point and the less polluted south point.

Vessel Discharges: Shipping traffic through the Santa Barbara Channel, and also south of the Islands, undoubtedly leads to some shoreline impact. It is common practice for large vessels to flush their bilges, sewage tanks, and oil storage tanks, prior to and/or after leaving port. The Coast Guard polices this problem, but they can be effective only during the day. Expand-

ing vessel traffic due to the increasing transportation of Alaskan oil and liquified natural gas will add to this pollution problem.

Non-point Sources

Oil Spills and Seeps: The Santa Barbara Channel is a preferred route for north and southbound vessel traffic in periods of bad weather. Traffic is increasing and thus the possibility of oil spills from shipping accidents is also increasing. Oil spills from the offshore drilling rigs also pose a very real threat. Natural oil seeps are common features in the marine environment around the Northern Channel Islands. Several seeps are known to directly affect the islands. Two are located between Santa Rosa Island and Santa Cruz Island, off West Point; two more occur on the shelf along the latter's northern coast; one is known just north of the interisland gap between Santa Cruz and Anacapa Islands, another is located north of East Anacapa. These seeps are periodic, with irregular output volumes.

SPECIAL WATER QUALITY REQUIREMENTS

A special consideration with regard to the biota of the Northern Channel Islands concerns its tolerance to oil pollution. The Santa Barbara Channel has been an area of natural oil seepage through a relatively long period of geological time. The resident biota of this region have evolved under these conditions.

However, there is uncertainty regarding the impact of increasing levels of oil that probably will accompany greater transport and production of petroleum. Therefore, precautions must be taken to avoid oil spillage, and biota must be closely monitored to assure their continued protection.

ANNOTATED BIBLIOGRAPHY

Bremner, C. St. J. 1932. Geology of Santa Cruz Island, Santa Barbara County, California. Santa Barbara Mus. Nat. Hist. Occas. Pap. No. 1.

Comments: Dated but useful for general background of island geology.

Coast Pilot-7, Pacific Coast; thirteenth edition - June, 1977. Dept. of Commerce, Nat. Oceanic and Atmos. Admin., 384 pp.

Comments: A good specific reference for navigational parameters, weather, and currents.

Dunkle, M. B. 1950. Plant ecology of the Channel Islands of California. Allan Hancock Pacific Expeditions 13:247-386.

Comments: Contains a nearly complete vegetation list and climate data.

Emory, K. O. 1958. Shallow submerged marine terraces of southern California. Geol. Soc. Amer. Bull., 69:39-60.

Comments: Contains detailed bottom profiles of the shelf around Anacapa Island.

Emory, K. O. 1969. The Sea off Southern California. Wiley & Sons, New York, 366 pp.

Comments: An excellent background reference with a few specifics to the ASBS.

Hancock Foundation. 1965. An Oceanographic and Biological Survey of the Southern California Mainland Shelf. Calif. State Water Quality Control Bd.; Calif. State Resources Agency, Pub. 27, 232 pp.

Comments: Discussed in text.

National Park Service, Channel Islands National Monument, W. H. Ehorn, Superintendent. March 1977. Statement for Management for San Miguel and Prince Islands (Recommendations).

Comments: Discussion of natural resources and their management, including park policies, park visitation and research.

Philbrick, R. N., ed. 1967. Proceedings of the symposium on the biology of the California Islands. Santa Barbara Botanic Garden.

Comments: Articles on geology, archaeology, terrestrial and marine flora and fauna. (Includes Bartholomew, 1967. Seal and Sea Lion populations of the Calif. Islands.)

Scholl, D. W. 1960. Relationship of the insular shelf sediments to the sedimentary environments and geology of Anacapa Island, California. Jour.

Sed. Petrol., 30 (1):123-139.

Comments: A nearly complete general description of the island's submarine topography, geological characteristics, and sediment patterns.

Southern California Coastal Water Research Project. Annual Reports, 1969-.

Comments: Useful for information from ongoing studies of the Southern California bight; but these programs seldom include Santa Cruz or Anacapa Islands.

Weaver, D. W., et al. 1969. Geology of the northern Channel Islands, Southern California borderland. Am. Assoc. of Petroleum Geologists and the Soc. of Econ. Paleontologists and Mineralogists (Pacific Sections) Misc. Pub., 200 p., 34 plates, 16 fig.

Comments: A classification and characterization of island geography with fault maps.

Weissman, D. B. and D. C. Rentz. 1977. Rainfall data for the California Channel Islands and adjacent mainland. Calif. Acad. Sci. offprint.

Comments: This paper is appended to the report, Appendix I.

APPENDIX 1

STUDIES AT ANACAPA ISLAND

Study Topic	Investigator(s)
Natural Resource Plan Research Basic Data	C. Rozaire, L.A. County Museum
Behavioral Ecology of Nesting *Larus occidentalis*	G. Hunt, Univ. of California, Irvine
Evolution and Origin of the Channel Islands Foxes	D. Odell, J. Waggoner, Univ. of CA, L.A. V. Seal, V.A. Hospital, Minneapolis
Rodent Survey of Anacapa and Santa Barbara Islands	R. Main, Oregon State University
Ecological Impact of Commercial Sea Urchin Farming	A. Lissner, Univ. of Southern Calif.
Evaluation of Rodent Control on Anacapa Island	R. Heimstra, Ventura Calif. County Department of Environmental Health
Energy Flow in Ecosystems	D. Guthrie, Claremont Men's College, California
Environment, Sex Roles and Social Structures, Western Gull	R. Pierotti, California State University, Sacramento
Ecological Survey of the Channel Islands Kelp Bed Commun.	T. Tutschulte, Marine Ecosystems, Inc., California
Insect Collection from Channel Islands	G. James, Orange Coast College, California
Terrestrial Vegetation in the Channel Islands NM	P. Eilers, California State University, Fullerton
Brown Pelican Population Studies	Dr. Anderson, U.S. Fish & Wildlife Serv. H. Leach. Calif. Dept. Fish & Game
Comparative Genetic Study of Deer Mice of the Channel Islands	A. Gill, University of California Los Angeles
Flora of the Channel Islands	R. Philbrick, Santa Barbara Botanic Garden, California
Ecological Status of Terrestrial *Pulmonata* on Santa Barbara Is.	S. Newswanger, Santa Barbara City College, California
Grasshoppers of the Channel Islands	D. Weisman, Stanford University, CA

Study Topic	Investigator(s)
Population Biology of Pinnipeds of San Miguel Island	R. DeLong, B. Antonelis, National Marine Fisheries Service, Seattle
Southern California Intertidal Study and Analysis	M. Littler, Univ. of Calif., Irvine D. Straughan & R. Kanter, USC
Spiders of the Channel Islands	K. Thompson, Los Angeles County Dept. of Recreation
Survey of Land Birds of the Channel Islands	L. Jones, Bureau of Land Management Los Angeles, California
Water Pollution Effects on Marine Biota	D. Young, Southern California Coastal Research Project
Baseline Studies of Seabirds in the Southern California Bight	G. L. Hunt, Jr., University of California, Irvine

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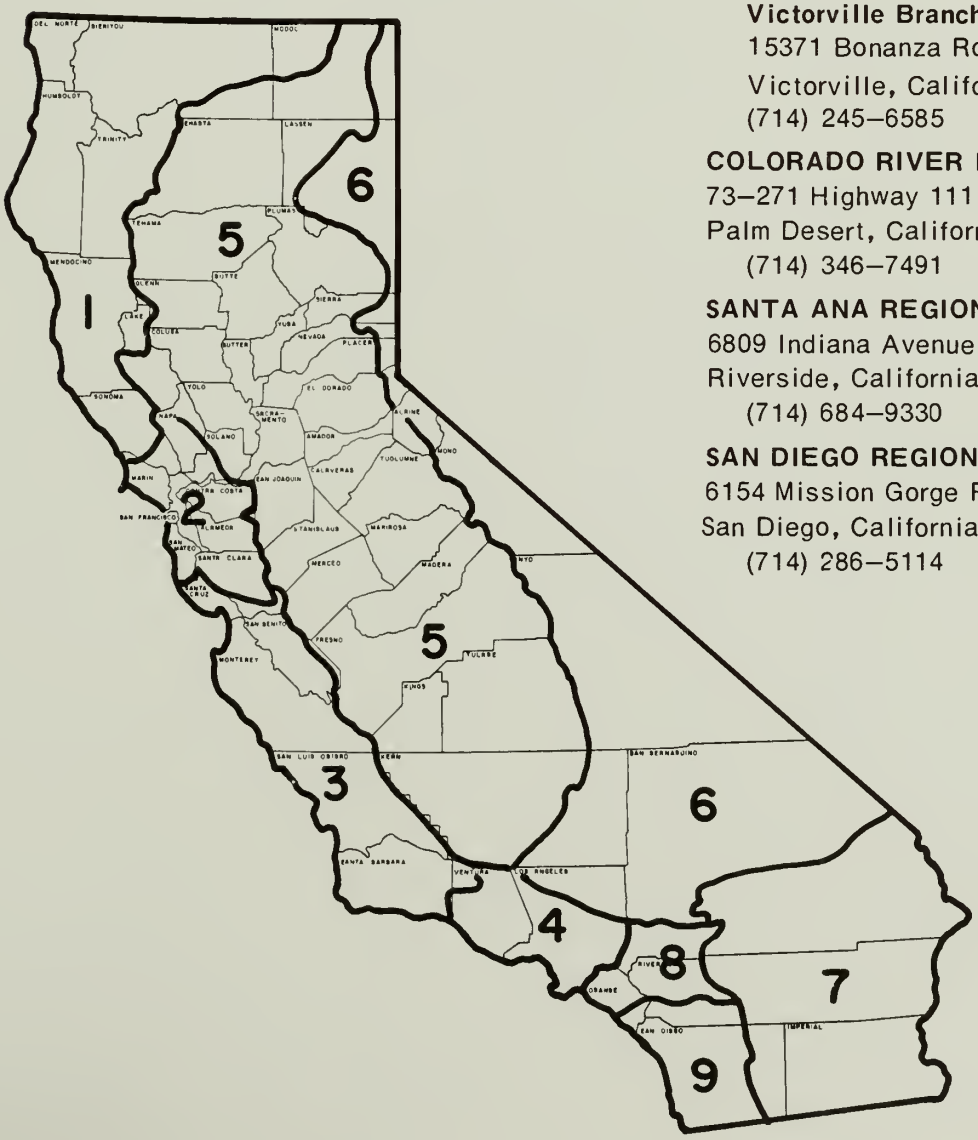

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