CALIFORNIA MARINE WATERS
AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

RECONNAISSANCE SURVEY REPORT

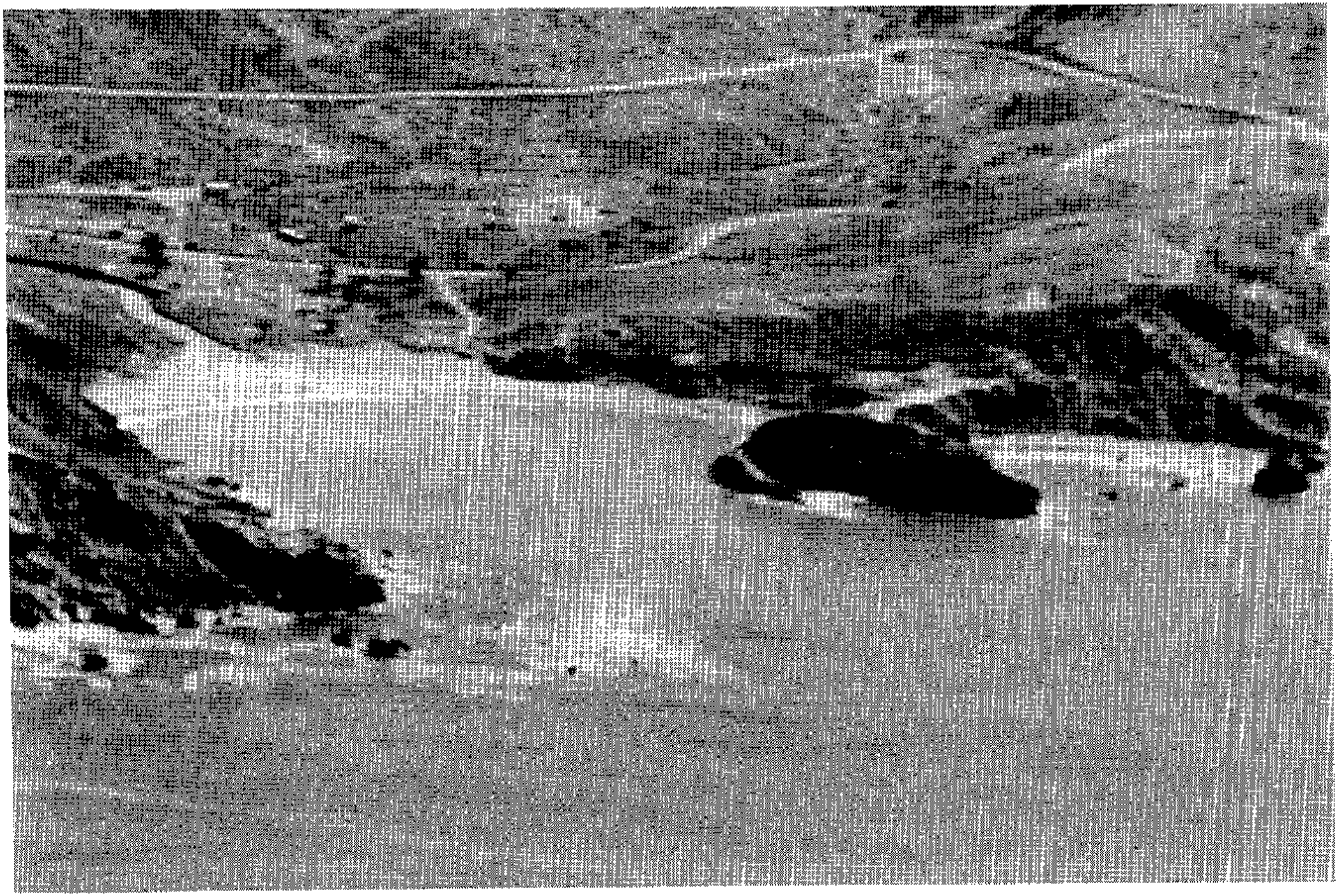
Santa Catalina Island--Subareas II and IV
Los Angeles County

STATE WATER RESOURCES CONTROL BOARD

DIVISION OF TECHNICAL SERVICES

Surveillance and Monitoring Section

October 1981
WATER QUALITY MONITORING REPORT



SANTA CATALINA ISLAND SUBAREAS II AND IV AREAS 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*

ACKNOWLEDGMENT

This State Water Resources Control Board Report is based on a reconnaissance survey report submitted by Drs. James A. Coyer and John M. Engle of the Los Angeles County Museum of Natural History. 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 Areas of Special Biological Significance Survey Reports for the Board under an Interagency Agreement.

ABSTRACT

ASBS Subarea II

Santa Catalina Island ASBS Subarea II encompasses the area between the northern aspect of Little Harbor and Ben Weston Point along the southwestern side of Santa Catalina Island (33°23'N, 118°21'N, 33°21'N, 118°29'W). The seaward boundary extends from the intertidal zone to a depth of 300 ft or to a distance of 1 mi offshore, whichever is greater, and includes approximately 2196 acres of water surface. [The landward boundary extends 0.5 mi inward or to the nearest ridge, encompassing approximately 793 acres of land.] Included within the ASBS are 3.3 mi of coastline.

The land mass adjacent to Subarea II is characterized by a relatively low-lying terrain intersected by five wide streams, which collectively discharge approximately 60% of all surface drainage on Catalina. The highest peaks range from 300-700 ft. Steep seacliffs are present in most areas but are less than 250 ft in height. The area consists primarily of metamorphic rock from the Mesozoic age, and the dominant formation is the Catalina Blue Schist Unit. Intertidal and subtidal geomorphology ranges from fine sand to variable concentrations of boulders and occasional bedrock outcrops or pinnacles. Sandy sediments and rocky substrates account for approximately 20 and 80% of the intertidal zone, and 55 and 45% of the subtidal zone, respectively.

The climate is classified as semi-arid Mediterranean, characterized by mild, wet winters and warm, dry summers. Average winter and summer temperatures are 50 and 80°F, respectively. The annual rainfall is approximately 12 inches,

falling mainly from November through April. Surface water temperatures average 54°F from December through February and 70°F from July through September.

Eight major land vegetation types are found within the ASBS: coastal sage shrub, chaparral, scrub oak/southern woodland, coastal grassland, maritime desert shrub, coastal strand, riparian woodland, and aquatic. The maritime desert is not found elsewhere on Catalina Island, and the ASBS contains the best-developed coastal strand found on the Island.

Marine habitats within Subarea II range from exposed, open-coast sandy beaches (the only examples on Catalina) and rocky headlands to a relatively sheltered beach and cove. The marine communities associated with rocky habitats are dominated by giant kelp, bushy red and brown algae, coralline algae, red urchins, sheephead, and kelp bass. Shallow sandy areas are sparsely populated, but deeper areas are inhabited by worms, snails, sea pens, white urchins, and various fishes.

Subarea II is one of the most popular and accessible recreational areas on Catalina and is used by both island visitors and residents. All of the land [within and] adjacent to the ASBS is common property of the Santa Catalina Island Conservancy and the Los Angeles County Open Space Easement. A County campground was established at Little Harbor in 1975, and up to 150 campers/day can use the facilities. Low to moderate levels of sportfishing and sportdiving occur within the waters of the ASBS, primarily from small, private vessels. Commercial passenger sportfishing and sportdiving vessels occasionally are observed in the area. The main sportfish species are kelp bass, Pacific mackerel, rockfish, and halfmoon; relatively few legal-sized abalone and lobsters are present.

The ocean waters within and adjacent to the ASBS are an important commercial fishing area. Market squid, anchovies, and jack mackerel are the major species harvested.

No major point or non-point sources of pollution are located within or adjacent to the ASBS. Increased recreational usage of the area is a potential threat to water quality, but this possibility is monitored by the Catalina Conservancy and Los Angeles County Department of Parks and Recreation. Surface runoff from winter storms is a temporary and unavoidable source of water quality degradation. Winter flooding is common [within] areas adjacent to the ASBS and can be expected to occur in the future.

ASBS Subarea IV

Santa Catalina Island ASBS Subarea IV encompasses the area between Binnacle Rock and Jewfish Point along the eastern end of Santa Catalina Island (33°18'N, 118°20'W; 33°19'N, 118°18'W). The seaward boundary extends from the intertidal zone to a depth of 300 ft or a distance of 1 nmi offshore, whichever is greatest, and includes approximately 2668 acres of water surface. [The landward boundary extends 0.5 mi inward or to the nearest ridge, encompassing approximately 615 acres of land.] Included within the ASBS are 2.7 mi of coastline.

The land mass adjacent to Subarea IV is extremely rugged and mountainous, intersected by five narrow and steep-sided canyons, which collectively discharge only 3% of all surface drainage on Catalina. The highest peaks are 1563 and 1684 ft. Steep seacliffs are present in most areas, rising precipitously to heights of over 700 ft. The area consists of igneous rock associated with Miocene events, and no metamorphic rocks are present. Intertidal and subtidal geomorphology ranges from fine sand to variable densities of concentrations of boulders and occasional bedrock outcrops or pinnacles. Sandy sediments and rocky substrates account for approximately 40 and 60% of the intertidal zone, and 80 and 20% of the subtidal zone, respectively.

The climate is classified as semi-arid Mediterranean, characterized by mild, wet winters and warm, dry summers. Average winter and summer temperatures are 50 and 80°F, respectively. The annual rainfall is approximately 12 inches, falling mainly from November through April. Surface water temperatures are 54°F from December through February and 70° from July through September.

Four major land vegetation types are found within the ASBS: coastal sage shrub, chaparral, scrub oak/southern woodland, and coastal grassland. Coastal sage is the most common community.

Extensive forests of giant kelp are not present in Subarea IV as most of the subtidal substrate is sand. However, the few beds of giant kelp that do exist are healthy and dominated by bushy red and brown algae, coralline algae, red urchins, sheephead, and kelp bass. Several species present in Subarea IV are absent or found only in deeper areas elsewhere off Catalina.

Shallow sandy areas are sparsely populated, but deeper areas are inhabited by worms, snails, sea pens, white urchins, and various fishes. An unusual "stable sand" habitat is present near Seal Rocks and contains some species that are rare or absent in other areas off Catalina, including a well-established population of the rare orangethroat pikeblenny, *Chaenopsis alepidota*.

The only sea lion colony on Catalina is located within the ASBS. Sea lions have been observed on the beach near Seal Rocks since the late 1800s, and the current population consists of approximately 200-275 individuals.

Moderate to heavy amounts of sportfishing occur within the waters of Subarea IV, with rockfish, kelp bass, and Pacific mackerel comprising most of the catch. Most sportfishing is from small private vessels, but a few commercial passenger vessels utilize the area. Sportdiving activities are low but may gradually increase as more diving activities are initiated from Avalon. Relatively few legal-sized abalones and lobsters are present within the nearshore habitats.

The waters of Subarea IV support a fairly small amount of commercial fishing. The most common commercial species are jack mackerel, market squid, and swordfish.

Most of the Subarea is common property of the Catalina Island Conservancy and the Los Angeles County Open Space Easement. The remaining portion is zoned for industrial use by a privately leased quarry. Access to the Subarea is discouraged by the steep and rugged terrain, lack of protected beaches and coves, and the quarry operations.

Quarry operations are the only possible source of pollution within the ASBS, and current levels of activities apparently do not affect local water quality. The impact of the quarry as a non-point source of pollution (erosion) is not known.

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Findings

ASBS Subarea II

1. All of Santa Catalina Island ASBS Subarea II (Little Harbor to Ben Weston Point) is common property of the Santa Catalina Island Conservancy and the Los Angeles County Open Space Easement.

2. Nearly 60% of all surface drainage on Catalina Island is discharged to the ocean through the five major canyons in Subarea II. The seasonal runoff is heavily sediment-laden due to high erosion rates and high flow velocities; flooding has occurred in the past (most recently in 1980) and can be expected to occur in the future.

3. A tremendous variety of terrestrial and marine habitats are present within Subarea II. Terrestrial communities include the unique Maritime Desert and the best example of Coastal Strand found on the island. The only examples of open-coast, exposed sandy beaches on Catalina are found in Subarea II, and this area also has a semi-protected sandy beach and cove. Over half of the nearshore subtidal substrates within the ASBS are sand. Intertidal and subtidal rocky habitats are composed of talus from eroded seacliffs. Giant kelp forests occur on most of the rocky substrates and appear to be healthy and reproductive. Associated communities of algae, invertebrates, and fishes are well developed.

4. A high proportion of the commercial market squid catch landed in southern California is caught in Catalina waters, including Subarea II. The ASBS is located between two major squid fishing areas.

5. Subarea II is an area of concentrated recreational activity for both island visitors and residents, especially during the summer and on weekends

whenever weather conditions are favorable. A Los Angeles County campground has existed at Little Harbor since 1975 and is utilized by a maximum of 150 campers/day. Ben Weston Beach is a popular retreat for island residents and represents the best surfing beach on Catalina. Shark and Cottonwood Coves are visited by smaller groups of hikers and picnickers.

6. Low to moderate amounts of sportfishing and sportdiving occur within the waters of Subarea II. Most activities originate from private vessels, but commercial passenger vessels occasionally utilize the area.

7. Subtidal sediments adjacent to Subarea II have trace metal concentrations almost as high as for Los Angeles/Long Beach Harbors but very low amounts of petroleum hydrocarbons and pesticides. The major sources of these contaminants presumably are the sewer outfalls on the mainland and airborne particles from the Los Angeles Basin. Other sources of pollution in or near Subarea II are negligible.

ASBS Subarea IV

1. Most of Santa Catalina Island ASBS Subarea IV (Binnacle Rock to Seal Rocks) is common property of the Santa Catalina Island Conservancy and the Los Angeles County Open Space Easement; the remaining portion (Seal Rocks to Jewfish Point) is zoned for existing industrial use by a privately leased rock quarry.

2. The steep terrain within Subarea IV prevents flooding, but storm runoff is heavily sediment-laden due to high erosion rates and high flow velocities.

3. Approximately 80% of the subtidal substrate within Subarea IV is sand, and the "stable sand" habitat located between the East End Light and Seal Rocks is unique to Catalina. A number of species present or common in this area are absent or rare elsewhere around Catalina. The stable sand habitat harbors a well-established population of the rare orangethroat pikeblenny,

Chaenopsis alepidota, a thin, tube-dwelling fish known only from Catalina and the Gulf of California. Kelp beds are not a major habitat in Subarea IV, as they require rocky substrates; nevertheless, the few beds of giant kelp that are present appear to be healthy and reproductive. Associated communities of algae, invertebrates, and fishes are well developed.

4. The only sea lion colony on Catalina Island is located within Subarea IV. As many as 200-275 individuals may be on the beach at one time, with additional individuals in the water immediately offshore. Although sea lions have inhabited this area since the late 1800s, it is unclear as to whether or not the haul-out area also serves as a rookery.

5. A high proportion of the commercial market squid catch landed in southern California is caught in Catalina waters, including Subarea IV. The ASBS is 4 mi east of a major squid fishing area.

6. Moderate to heavy amounts of sportfishing occur from private vessels within the waters of Subarea IV, largely as a result of the close proximity to Avalon. Sportdiving activities within the ASBS are minimal due to the paucity of kelp reefs and generally poor underwater visibility; however, the level of use may increase as more diving activities are initiated from Avalon.

7. Subtidal sediments adjacent to Subarea IV have trace metal concentrations almost as high as for Los Angeles/Long Beach Harbor, but very low amounts of petroleum hydrocarbons and pesticides. The major sources of these contaminants presumably are the sewer outfalls on the mainland and airborne particles from the Los Angeles Basin.

8. The Avalon sewer outfall is located 1.4 mi northwest and upcurrent of the ASBS but does not appear to affect water quality within Subarea IV.

The rock quarry is located between Seal Rocks and Jewfish Point, and its activities necessarily have a major impact on the land mass in this area. Disturbances to the intertidal and subtidal zones to be irregular and minimal, consisting of rocks accidentally dropped during loading activities and occasional slumping of the intertidal quarry rocks. The impacts resulting from other aspects of quarry operations, such as erosion and blasting, are undetermined. Other sources of pollution within Subarea IV are negligible.

Conclusions

ASBS Subarea II

1. The land area within Subarea II is one of the most popular and accessible recreational areas on Santa Catalina Island, especially during the summer. The findings of this survey suggest that populations of terrestrial plants and intertidal organisms within the recreational areas of Subarea II should be surveyed on a regular basis to insure their survival and reproduction in the face of increasing human disturbance.

2. Water quality protection in the ASBS appears adequate. No major sources of pollution are present within Subarea II, but increased recreational usage is a potential source of water quality degradation. Recreational activities should continue to be carefully controlled by the Santa Catalina Island Conservancy and the Los Angeles County Department of Parks and Recreation. Freshwater drawn from aquifers within Subarea II should be monitored and controlled. Heavy freshwater usage may reduce the aquifer, decreasing the amount of water for the surrounding vegetation and possibly causing salt-water intrusion.

3. The abundance of certain subtidal invertebrates such as lobster, abalone, and scallops apparently has been reduced by commercial and sport

harvesting. The adult and juvenile populations of these organisms should be monitored and control measures implemented if the populations continue to decline.

4. Private vessels anchoring in Little Harbor during the summer may adversely affect the benthic biota. This impact should be studied and, if it is significant, may require the establishment of a small number of permanent moorings. It is recommended, however, that no construction of piers and/or floating dinghy-docks be allowed within Subarea II.

ASBS Subarea IV

1. Shoreward access to the ASBS for recreational or other purposes is largely prevented by quarry operations and by the steep, mountainous terrain. Seaward access is discouraged by the lack of protected beaches or coves.

2. Water quality protection within the ASBS appears adequate. Quarry operations are the only possible source of pollution within the ASBS, and current levels of activity apparently do not affect local water quality. The impact of the quarry as a non-point source of pollution (erosion) is not known. Quarry operations cannot expand beyond current boundaries as adjacent lands are owned and controlled by the Catalina Conservancy and the open space easement agreement. However, a monitoring program should be initiated if there is a substantial increase in quarry operations.

3. The presence of habitats and species in the nearshore areas of Subarea IV which are absent or found only in deeper areas elsewhere on Catalina suggests that unusual oceanographic conditions may occur. Further investigations are necessary to document these conditions.

4. The sea lion haul-out near Seal Rocks has existed at least since

the late 1800s. It cannot be approached from land because of steep seacliffs, but as more tour boat, sportdiving, and sportfishing activities are initiated from Avalon, the sea lions may be subjected to increasing harassment. This impact should be assessed and controlled if necessary. It also is recommended that the sea lions be counted on a regular basis, and that studies be initiated to determine whether or not the area serves as a rookery.

General

The findings of this survey suggest that all coastal areas of Santa Catalina Island (with the exception of areas adjacent to Avalon) should be considered as a single ASBS. Each of the other seven Channel Islands is an ASBS in its entirety (except for Wilson Cove on San Clemente Island). Catalina is the only Channel Island that has been divided into ASBS Subareas.

The designation of four separate subareas at Catalina is largely artificial, since the nearshore marine environment is a continuous band of interdependent physical and biological systems, which collectively deserve special status. Also, non-ASBS areas around Catalina Island are known to contain unique habitats (e.g., mudflats at Catalina Harbor, eelgrass meadows at Silver Canyon) and unique species (e.g., fiddler crabs, mud shrimps, and blind gobies in Catalina Harbor).

Approximately 86% of Catalina currently is owned by the Catalina Conservancy and nearly all of this land is available to the public as an open space area for education and recreation. The latter agreement only considers terrestrial components and may terminate after 50 years. Since Catalina is the only Channel Island that is easily accessible from large metropolitan areas in southern California, future recreational and/or developmental demands may arise which could affect water quality. Establishment of Santa Catalina Island as an intact ASBS would ensure wise and prudent consideration of the special nature of Catalina's marine resources, now and in the future.

INTRODUCTION

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

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

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

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

3. Discharge of wastes from nonpoint sources, including but not limited to storm water runoff, silt and urban runoff, will be controlled to the extent

practicable. In control programs for wastes from nonpoint sources, Regional Boards will give high priority to areas tributary to ASBS.

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

In order for the State Water Resources Control Board to evaluate the status of protection of Santa Catalina Island ASBS Subareas II and IV, a reconnaissance survey integrating existing information and additional field study was performed by Drs. James A. Coyer and John M. Engle, Los Angeles County Museum of Natural History. 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.

<u>Reasons for Designating the Areas of Special Biological Significance</u>

The recommendations of the Ocean Advisory Committee to the California Regional Water Quality Control Board, Los Angeles Region, state the rationale for designation of the area between Little Harbor and Ben Weston Point as Santa Catalina Island ASBS Subarea II:

> "Contains excellent examples of exposed and semi-protected sandy pocket beaches in close proximity to combined exposed rocky headlands, a submarine canyon, and lush kelp beds. The faunal situation is entirely different from that elsewhere on the island."

The rationale for designation of the area between Binnacle Rock and Jewfish Point as Santa Catalina Island ASBS Subarea IV:

> "1. Physical and biological conditions are in marked

contrast to the rest of Catalina and the rest of the rest of the Channel Islands.

2. Represents the warmest water region of the Channel Islands."

ORGANIZATION OF THE SURVEY

This project summarizes existing data to describe the physical, chemical, and biological aspects of the intertidal, subtidal, and adjacent land areas within Santa Catalina Island ASBS Subareas II and IV. Subarea II extends from Little Harbor to Ben Weston Point, and Subarea IV from Binnacle Rock to Jewfish Point. Current patterns of land/water use, actual or potential pollution threats, and special water quality requirements also are addressed.

Various agencies and individuals provided information to the investigators (Drs. James A. Coyer and John M. Engle) for some of these aspects. The assistance of the Catalina Marine Science Center, Los Angeles County Museum of Natural History, Los Angeles County Departments of Parks and Recreation and Regional Planning, the Santa Catalina Island Company, the Santa Catalina Island Conservancy, and the Avalon Harbor Department is gratefully acknowledged.

The biological descriptions of intertidal and subtidal regions within both ASBS Subareas are based primarily on the results of extensive field surveys conducted by the investigators in 1979 and 1980. In addition, both investigators have resided at the Catalina Marine Science Center on Catalina Island since 1972 and have studied marine communities all around the island during this period. This background has enabled them to compare the current surveys of Subareas II and IV to previous surveys of these areas, as well as to surveys of other areas surrounding Catalina.

Intertidal areas of Subareas II and IV were examined during low tide on 14 February 1981 and 12 May 1980, respectively. Dr. Carlos Robles assisted with the characterization of the Subarea II intertidal. Information from the Subarea II survey was combined with past investigations of Little Harbor conducted by various investigators and classes from the Catalina Marine Science Center. All of the areas surveyed in each ASBS were documented photographically.

The subtidal descriptions are based primarily on information recorded during extended diving surveys. The subtidal survey within Subarea II occurred from 29 November through 4 December 1979 and consisted of 69 person-dives. The first survey of Subarea IV also was conducted from 29 November through 4 December, and a second survey occurred during 11 and 12 May 1980. These surveys consisted of 62 and 12 person-dives, respectively. On each morning of the winter survey, reconnaissance dives were conducted at ASBS Subarea III (Farnsworth Bank), but these results are discussed in another report.

Assisting with the winter surveys were Lisbeth Hart (algae), Drs. David Hadley and Robert Hart (geology), and several UCLA and USC graduate students from the Catalina Marine Science Center. Dr. James Morin and Anne Harrington participated in the spring survey. Divers and diving activities were based from the R/V Cormorant.

All major habitats within Subareas II and IV were surveyed. Each diver made 3-4 dives/day, with the first dive at 60-70 ft (18-21 m) and subsequent dives from 15-35 ft (4-11 m). Before each dive, the site was mapped and photographed from the research vessel, and the following were recorded: 1) tidal height and direction, 2) sea state, 3) weather, 4) current strength and direction, 5) surface water temperature, and 6) water visibility (see Appendix 1). Underwater, the habitats were described and mapped in detail (some were photographed), bottom temperatures were recorded, and depth of the thermocline was noted. Algae, macroinvertebrates, and fishes were identified (some were photographed), and their abundances were estimated on a relative scale from 1 (rare) to 4 (abundant). Unknown organisms were collected and preserved for later identification and eventual storage at USC's Allan Hancock Foundation (algae) or the Catalina Marine Science Center (invertebrates).

Each evening, all divers were debriefed on the day's activities by the investigators. Information recorded during the day was discussed and transferred to permanent data books. Overall impressions were recorded by each investigator.

The terrestrial portions of Subareas II and IV were surveyed on 21 and 22 April 1980, respectively. The investigators hiked most of each area and were assisted by Michael Haufler, who identified the plants and plant communities. These were mapped and many were photographed. Additional information was gathered from the extensive literature on Catalina flora.

Runoff resulting from a severe rainstorm in March 1980 caused extensive modification of the beaches within ASBS Subarea II. The area was photographed by the investigators from the ground shortly after the storm and from the air in April 1980. Surf generated by a winter storm in January 1981 again caused extensive modification of the beaches within Subarea II. These changes also were documented by the investigators.

Photographs and copies of field notes are archived at the California State Water Resources Control Board. In addition, the National Ocean Survey photographed the Subareas and adjacent land areas during flyovers on 23 and 24 March 1972. Color transparencies (9" x 9") taken during this flyover of Subareas II and IV (1:30,000 scale), and the quarry within Subarea IV (1:15,000 scale), are among the archived photographs.

PHYSICAL AND CHEMICAL DESCRIPTION

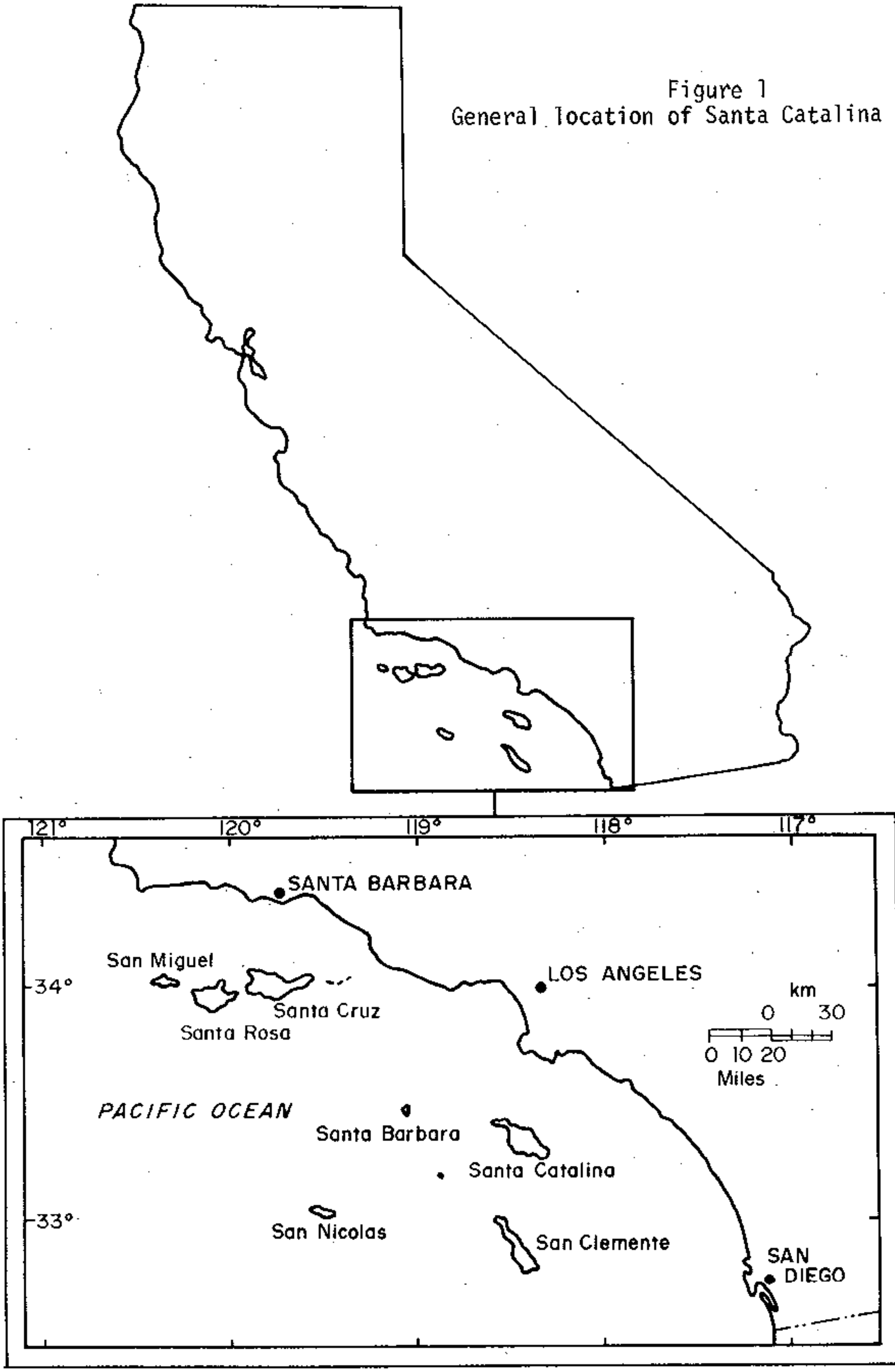
General Description

Santa Catalina Island, the easternmost of the eight Channel Islands, lies about 21 miles southwest of Los Angeles Harbor, but is within the continental borderland (Fig. 1). It is bounded on the east by the San Pedro Basin and on the west by the Santa Catalina Basin. The island is irregularly shaped, 22 mi (35 km) long, 8 mi (13 km) at its greatest width, 0.5 mi (0.8 km) at the narrowest point (Isthmus), and 76 mi^2 (48,438 acres) in area.

Catalina is formed by the emergent portion of an elevated northwest trending fault block, rising a mile above the ocean floor. Consequently, it is oriented in a northwest/southeast direction and is traversed from end to end by a single main ridge which is unbroken except at the Isthmus. This ridge ranges from 1500-2100 ft (457-640 m) and effectively divides the island into a windward (southwest) aspect directly affected by the open Pacific and a leeward side (northeast) which is relatively protected. The leeward side has far more sheltered coves and sandy beaches than the windward side.

The island is rugged and mountainous throughout, intersected by numerous steep-sided canyons and ravines. The shoreline consists largely of precipitous seacliffs 200-1400 ft (61-427 m) high, which are somewhat reduced and less extensive on the leeward side. Underwater, Catalina is surrounded by a narrow shelf extending offshore. The shelf has an average width of 1.2 mi (2 km) on the windward side, but only 0.6 mi (1 km) on the leeward side.

Figure 1
General location of Santa Catalina Island.



The island is part of Los Angeles County. Avalon is the only city, and it is supported primarily by tourism. The population is approximately 1800 during the winter, but can approach 10,000 on major summer weekends. A small community is located at the Isthmus, where approximately 200 permanent residents maintain recreational facilities for a summertime population of 3500.

Location and Size

ASBS Subarea II

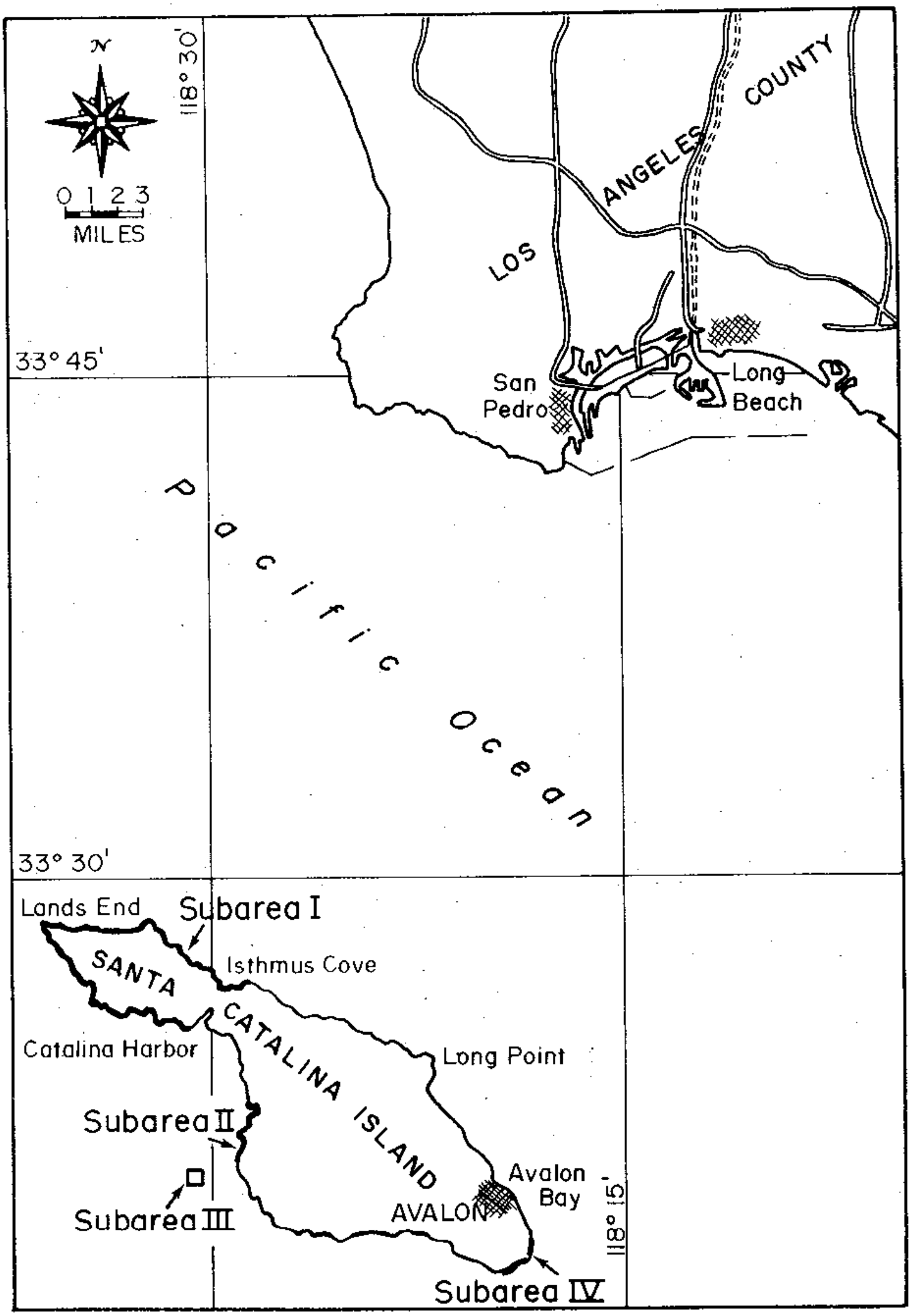
Santa Catalina Island ASBS Subarea II is located on the windward side of the island and lies in a north/south orientation (Fig. 2). The official description for this Subarea is as follows:

> From Point 1 determined by the intersection of the mean high tide line and a line extending due south from USGS Triangulation Station "White Bluff"; thence due west to the 300-ft isobath or to one nautical mile offshore, whichever distance is greater; thence southerly on a meander line following the 300-ft isobath or maintaining a distance of one nautical mile offshore, whichever distance offshore is greater, to a point due west of USGS Triangulation Station "Slip" on Ben Weston Point; thence due east to the intersection of the mean high tide line and a line extending due west from USGS Triangulation Station "Slip"; thence northerly following the mean high tide line to Point 1.

The northern boundary (33°23'12"N, 118°28'42"W) is 6.8 mi (10.9 km) south of Catalina Harbor, and the southern boundary (33°21'24"N, 118°29'18"W) is 10.2 mi (16.4 km) north of the East End light. Included within this ASBS are 3.3 mi (5.3 km) of coastline.

The enclosed water surface is approximately 2196 acres (888 ha). The landward boundary extends 0.5 mi (0.8 km) inward or to the nearest ridge, including approximately 793 acres (321 ha) of land.

Figure 2. Location of Santa Catalina Island ASBS Subareas I, II, III, and IV.



ASBS Subarea IV

Santa Catalina Island ASBS Subarea IV is located at the eastern end of the island (Fig. 2). The official boundary description for this area is as follows:

> From Point 1 determined by the intersection of the mean high tide line and a line extending due north from the highest point of Binnacle Rock; thence due south to a point one nautical mile offshore or to the 300-ft isobath, whichever distance is greater; thence easterly and northerly, maintaining a distance of one nautical mile or to the 300-ft isobath, whichever distance is greater, to a point due east of the easternmost extension of the mean high tide line at Jewfish Point; thence due west to the easternmost extension of the mean high tide line at Jewfish Point; thence southerly and westerly following the mean high tide line to Point 1.

The western boundary (33°18'00"N, 118°20'00"W) is 1 mi (1.6 km) west of the East End light and the northern boundary of (33°19'13"N, 118°18'09"W) is 2 mi (3.3 km) south of Avalon. Included in this ASBS are 2.7 mi (4.3 km) of coastline.

The enclosed water surface is approximately 2668 acres (1080 ha). The landward boundary extends 0.5 mi (0.8 km) inward or to the nearest ridge, including approximately 615 acres (249 ha) of land.

Nearshore Waters

Currents

General. Surface water circulation within the nearshore waters of Catalina Island is complex. It is influenced by interactions between major oceanic or geostrophic currents within the Southern California Bight, and local phenomena such as winds, swells, and tides.

The major geostrophic current influencing surface water flow along the

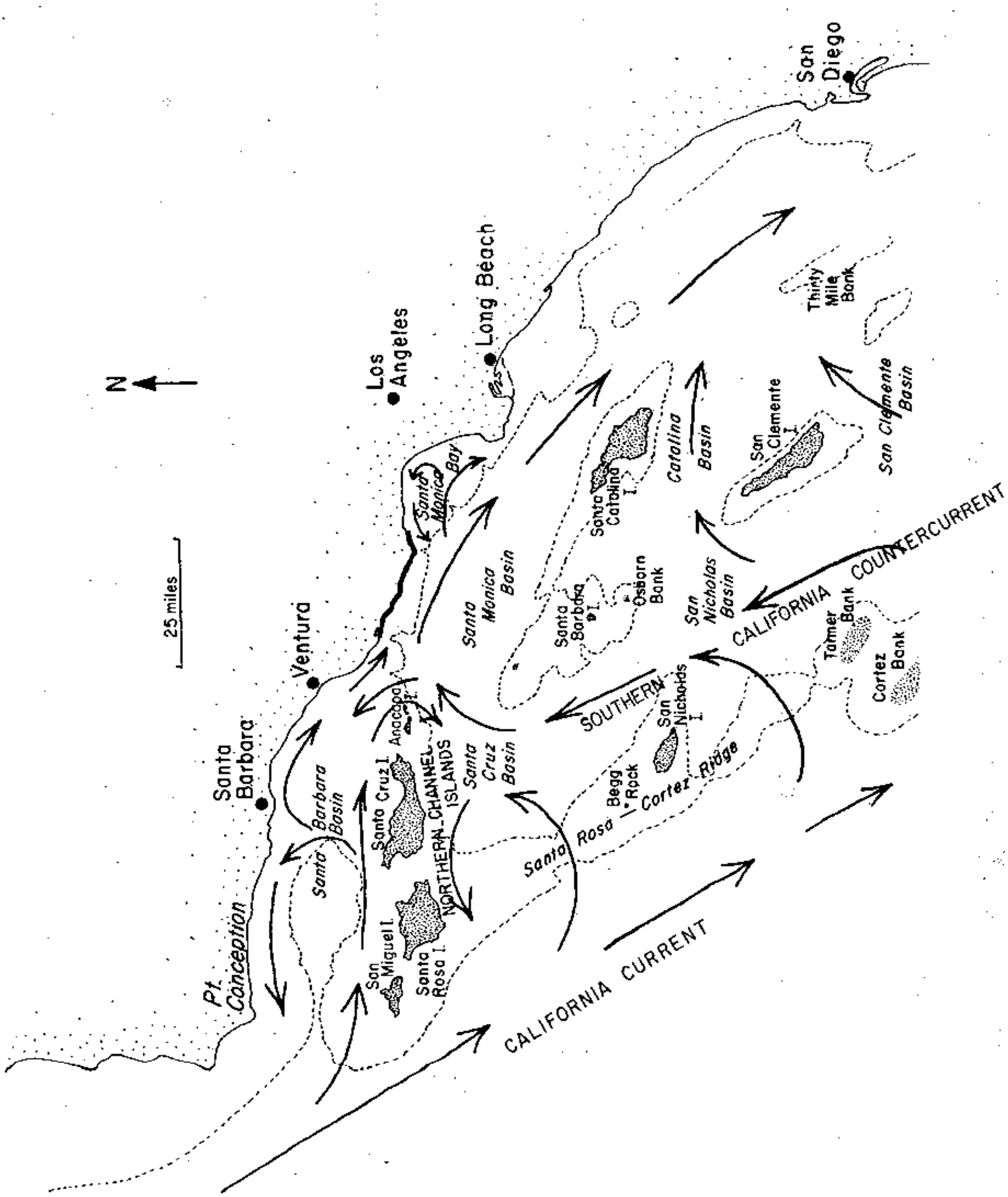
California coast is the California Current. This cold-water current originates near the Canadian border and slowly flows in a southeasterly direction along the western coast of North America (Fig. 3). At Pt. Conception, California, the coastline assumes an east/west configuration, while the edge of the outer continental slope continues in a generally south-southeasterly direction. When the California Current reaches Pt. Conception, it divides into two general flows. A nearshore flow extends eastward at San Miguel Island and part of this water mass continues southeast along the coastline.

The major flow, however, continues south, well off the coast of southern California and beyond the outer Channel Islands. A portion of this flow is deflected eastward, then northward through the southern Channel Islands. This return flow is the Southern California Countercurrent, and it creates a large eddy or counter-clockwise gyre within the Bight.

As the northerly flowing Countercurrent approaches the northern Channel Islands, a portion moves east and joins the nearshore flow of the California Current. This combined water mass moves southeastward along the coast beyond the Mexican border where it eventually rejoins the main portion of the California Current.

When the Countercurrent is well established in summer and fall, surface flow is primarily northwesterly along the windward coast of Catalina, including the Subarea II and the windward portion of Subarea IV (Fig. 3). Superimposed on this general flow, however, are surface currents induced by the prevailing westerly winds and swells. During summer and fall, the gentle morning westerlies increase in intensity by early afternoon, augmented by the normal onshore sea breezes. This generates short-period wave chop in a southeasterly

Figure 3. Major oceanic surface current patterns within the Southern California Bight (from Morin and Harrington 1979).



direction into Subarea II and the western portion of Subarea IV, but the waves rarely are large. The winds and waves are reduced in the evening, and the whole cycle is repeated the next day.

Additionally, tropical storms or "Chubascos" regularly occur during summer and fall off Mexico and Central America, with 1-2 each year generating significant swells in the Bight. These southerly swells strike Subareas II and IV, conflict with local wind and swell-induced currents, and create an unpredictable sea. On rare occasions, the storms have appeared as far north as southern California, subjecting south-facing coastlines and other areas to high winds and waves. During these storms, the entire Subarea IV is exposed to the fury of 10-12 ft waves, and the large swells are refracted into the beaches of Subarea II.

Violent north and northeast winds called Santa Anas occasionally blow across the southern California landmass and out to sea from late fall to spring. These hot and dry winds are very strong, sometimes exceeding 100 mph in the canyons on the mainland and persist for 1-12 days. On Catalina, gusts up to 50 mph and the steady north-northeast winds strongly influence surface circulation all along the northeastern coastline (Figs. 4, 5). Large breakers strike the northeastern portion of Subarea IV and refract around to the southwestern aspect. Santa Anas do not affect Subarea II as the winds are shallow or low-lying and are blocked by the Catalina landmass.

The Countercurrent is reduced in winter and spring and during these periods, surface flow is determined largely by prevailing winds. In the spring, "Pacific" storms with violent northwest winds from 25-50 mph commonly last for days. The entire southwestern coast of Catalina is affected, including all of Subarea II and the western portion of Subarea IV (Figs. 4, 5).

Figure 4. Position of Santa Catalina Island relative to seasonal winds, swells, and sun positions (from Center for Nat. Areas 1976).

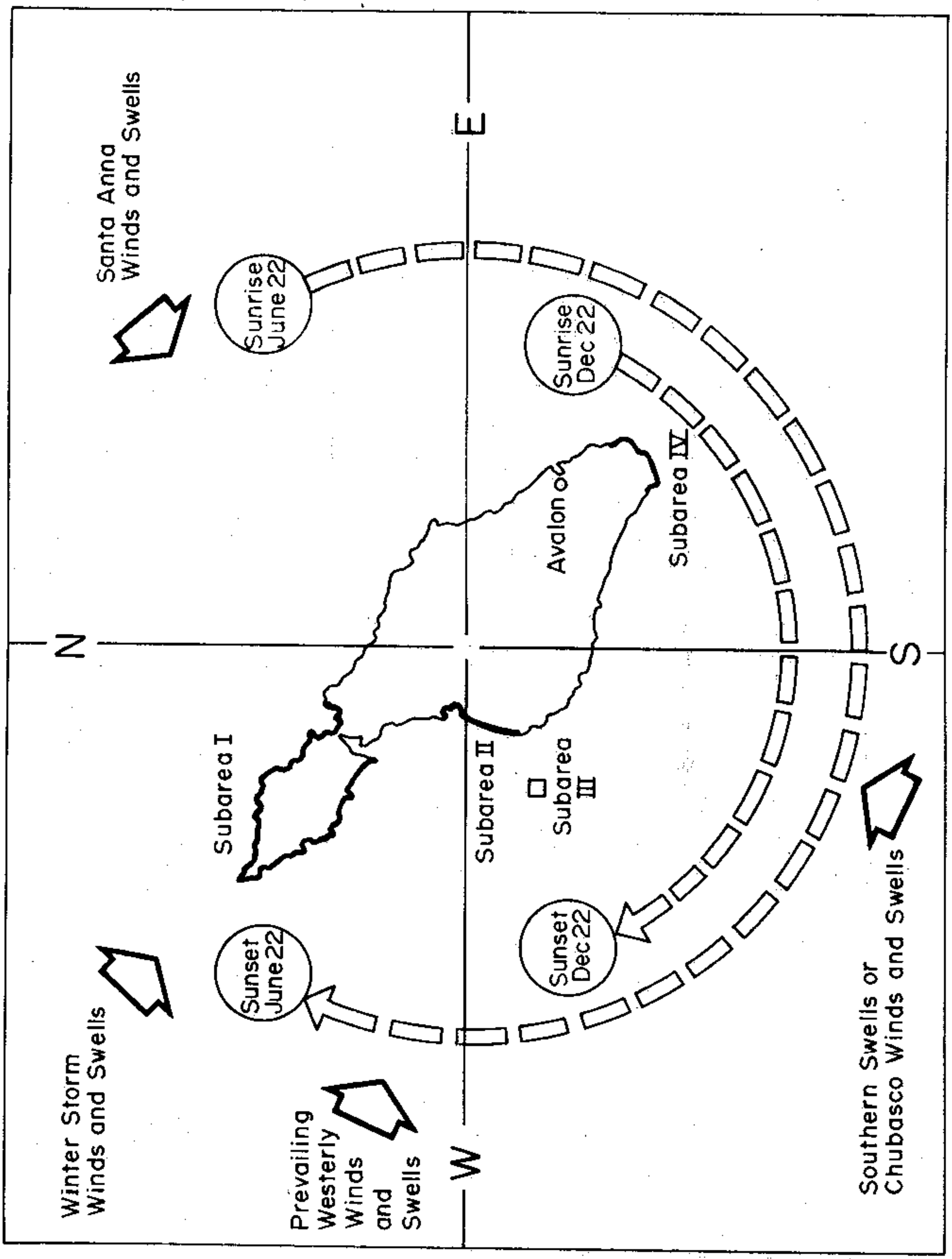
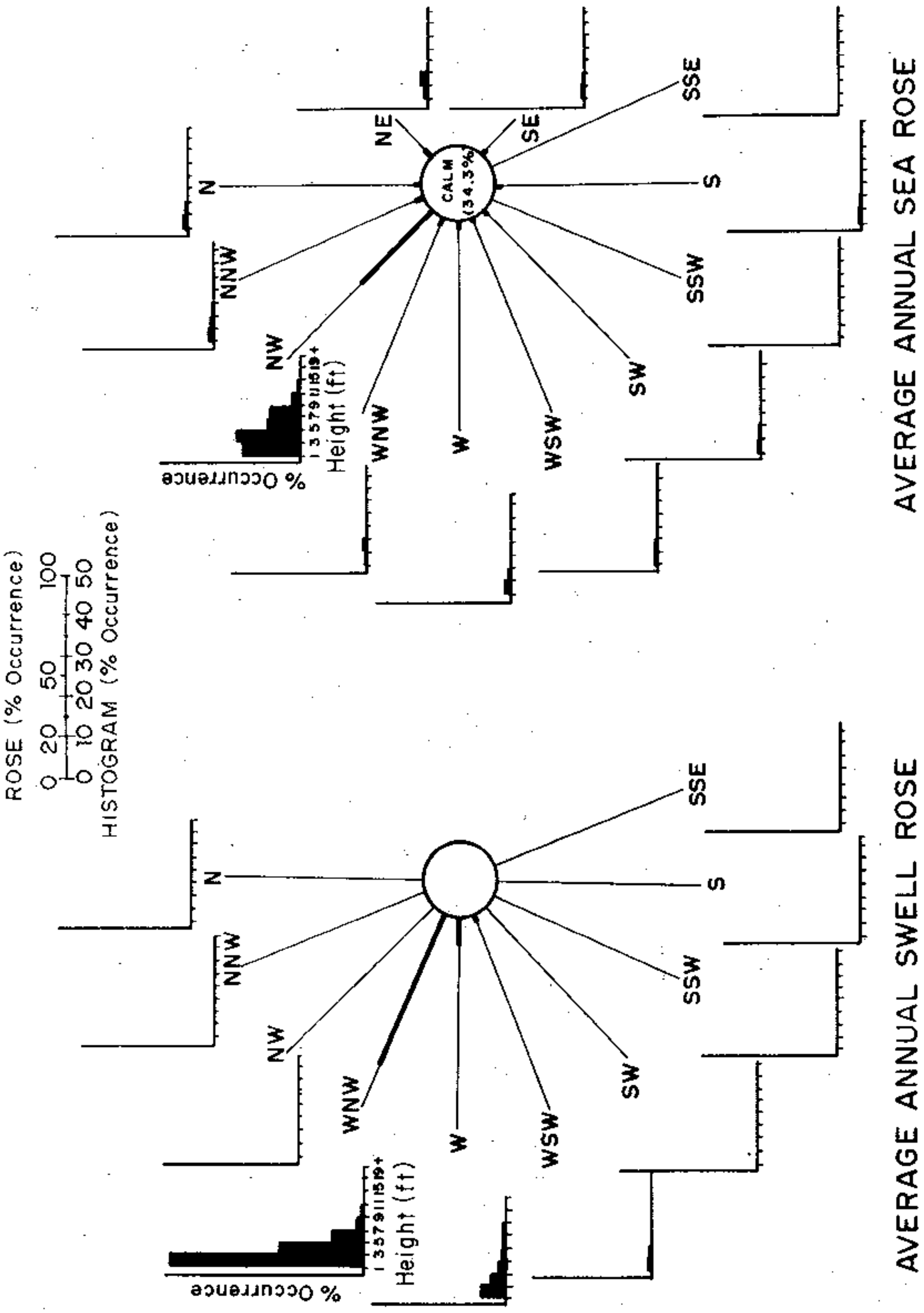


Figure 5. Average annual swell and wind roses for an area 14 nmi west of Santa Catalina Island. Data are from Nat. Mar. Cons. Station 7 (33.5°N, 119.5°W).



The general description of surface flow was synthesized from Emery (1960), Jones (1971), Fay (1972), Water Quality Control Plan Report (1975), and Hendricks (1977).

Tides can have a major effect on surface currents. The most obvious influence is movement of water on and offshore as the tide rises and falls. Maximal movement occurs during spring tides; minimal during neaps. Emery (1960) documented northwest/southeast tidal currents within the Southern California Bight. On ebb tides, water movement is to the southeast and generally stronger than the northwest flow induced by flood tides. During the diving survey in Subareas II and IV, a southeasterly flowing current regularly was formed within the nearshore areas on a falling spring tide. This flow transported large quantities of sediment and formed an obvious zone of high turbidity.

Catalina Island has mixed semidiurnal tides ranging from -1.7 to +7.1 ft MLLW (-0.5 to +2.2 m). The maximum range is 9 ft (3 m), but average fluctuations are from 4-5 ft (1.2-1.5 m).

ASBS Subarea II. Loop (1969) has investigated the physical oceanography of the Little Harbor/Shark Cove complex within Subarea II. This complex is the only protected anchorage within the ASBS and one of two conspicuous bays along the entire windward coast of Catalina. Little Harbor is protected from the northwesterly swells by a small reef extending southward across the harbor's mouth, and numerous aspects of water motion and chemistry are influenced by this protection. Shark Cove is partially protected by the reef, however, both areas receive an appreciable amount of reflected wave energy (Loop, 1969). Surface water flow within the harbor complex is tidally induced. In response to a falling tide, surface water enters the northern portion from the west and continues along the southern wall in a clockwise direction. Temperature and salinity characteristics of the harbors are modified by this flow. Circulation is accelerated by increased wave energies during winter and spring storms.

Sea conditions within Little Harbor generally are calmer than for Shark Cove. Conditions at Shark Cove and the other sandy beach/bay areas within Subarea II usually consist of 2-4 ft westerly swells, although this can vary from flat calm to seas of 10-15 ft on rare occasions.

Ripcurrents are common in nearshore shallow waters, especially off exposed sand beaches. As a result of the pounding surf, massive amounts of water tend to "collect" within the shallow areas. This water flows back to sea via a narrow high-speed current, generally perpendicular to the shoreline.

Ripcurrents occur throughout the year off Ben Weston Beach within Subarea II, particularly when southerly swells develop in the summer. The ripcurrent usually exits from the center of the beach, but it only extends approximately 100 yds (90 m) offshore because of the relatively steep slope. Ripcurrents occur infrequently in Shark Cove and are never present in Little Harbor.

<u>ASBS Subarea IV</u>. No detailed oceanographic studies have been conducted within the boundaries of Subarea IV, but some general comments are possible. In general, the northeastern aspect of the ASBS is calmer than the southwestern portion. Southerly flowing currents are established along both sides of Catalina during a falling tide. These currents meet beyond the southeastern tip of Catalina and sometimes form local tidal rips or discontinuities offshore of Subarea IV. Ripcurrents can be expected along beaches in the southwestern portion, but probably do not extend very far offshore because of the relatively steep slope. The subtidal slope is very steep along the northeastern portion of the ASBS and ripcurrents do not exist.

Upwelling

Upwelling activity along Subarea II probably is minimal throughout most of the year. The configuration of the coastline largely is perpendicular to the prevailing swells and westerly winds, thus surface waters are not displaced and deeper water cannot reach the surface. However, if a strong current flows across the longitudinal axis of Catalina Canyon, a Venturi effect may be created, thereby conveying deeper water into the shallow areas via the Canyon.

The coastline of Subarea IV generally is parallel to the prevailing westerly and northwesterly winds; consequently, surface waters can be displaced during these conditions. Local upwelling occurs when deep water replaces the surface water (upwelling descriptions; Dr. R. E. Pieper, USC, pers. comm.).

Water Column

Water clarity within Subareas II and IV is a function of many factors, including water motion, plankton productivity, distance from shore, and substrate type. Maximum turbidity can be expected throughout the areas in winter and spring because of storms, and from April to July when plankton blooms occur. Winter rains and subsequent runoff also contribute to the poor water clarity during winter. Clarity usually is greatest during fall, but rarely exceeds 70-80 ft (21-24 m). Changing tidal currents often modify water clarity within a very short period of time, and the water column during falling tides usually is more turbid than during rising tides. Within both areas, visibility generally ranges from 10-35 ft (3-10 m) throughout the year.

Water clarity almost always increases to some extent with distance from shore. Over sandy substrates, visibility is usually 1-10 ft (0.3-3 m) at depths to 20 ft (6 m), but steadily increases to maximum values near 30 ft (9 m) and/or below the seasonal thermocline. Clarity is usually slightly greater over adjacent rocky substrates. During the diving survey from 29 November through 4 December 1979, sea conditions were calmer than usual and visibility ranged from 20-60 ft (6-18 m) at depths greater than 20 ft (Appendix 1). Shallower areas, however, were very turbid.

Loop (1969) reported high concentrations of leptopel in the water column and subsequent reduced visibility within the Little Harbor/Shark Cove (Subarea II) complex from late spring through mid-summer. Leptopel is suspended marine detritus resulting from organic decay, often from bacterial conversion of decaying kelp. Within the harbor complex, it is most concentrated in nearshore water overlying the seasonal thermocline. Thus, leptopel production is apparently inshore, with seaward transport. Leptopel can be expected within the nearshore waters of Subarea IV, as well.

Suspended sediment samples collected by Loop (1969) ranged from 0.002-0.006 g/l. An estimated 5.76×10^6 kg of suspended matter was present in the Little Harbor/Shark Cove complex from late spring through mid-summer.

Water Temperatures

ASBS Subarea II. Water temperatures have not been collected on a regular basis for any area within the Subarea II. Satellite imagery studies, however, suggest that the surface temperatures are similar to surface temperatures near the Catalina Marine Science Center (CMSC) on the leeward side of Catalina (Hendricks 1977, p. 76). Using CMSC data collected for the past 10 years as a guide, the following estimates of water temperature dynamics within the ASBS are proposed: 1) surface temperatures normally range between 54-70°F (12-21°C), with minimum values from December to February and maximum values between July and September, and 2) a thermocline of 2-5°F (1-3°C) is present above 66 ft (20 m) from March to October. Loop (1969) reported surface temperatures of 63-65°F (17-18.5°C) in April, with highest values from the enclosed area of Little Harbor.

During the diving survey of the ASBS, temperatures were 61°F (16°C) at the surface and 60-61°F (15.5-16°C) at 60 ft (Appendix 1). No thermocline was noticed.

ASBS Subarea IV. Satellite imagery studies of surface water temperatures suggest that: 1) surface temperatures within Subarea IV are similar to those in Avalon Bay, and 2) waters off the southeastern tip of Catalina Island (including Subarea IV and Avalon Bay) are 2.5-5°F (1.4-2.8°C) cooler than other areas of Catalina (Hendricks 1977, p. 76). Because of the former point, temperature dynamics within the ASBS can be estimated by examining temperatures collected at a NOAA weather station located on the Pleasure Pier in Avalon Bay.

Surface temperatures normally range between 53-72°F (11-22°C) with minimum values from January through March and maximum values in August and September (Fig. 6). During the winter diving survey of the ASBS, temperatures were 61°F (16°C) from the surface to a depth of 35 ft (10 m) (Appendix 1). No thermocline was noted. On the second diving survey in May, temperatures were 62°F (16.5°C) at the surface and 60°F (15.5°C) at 60 ft. No thermocline was noticed.

Water Chemistry

An approximation of water chemistry levels and variability within Subareas II and IV can be obtained by examining data collected by a California Cooperative Oceanic Fisheries Investigation (CalCOFI) station (90.37) off Catalina's East End (Fig. 7). Salinity probably remains relatively constant throughout most of the year. Average monthly salinities at the CalCOFI station ranged

Figure 6. Mean monthly air and water temperatures recorded at the Avalon Pleasure Pier from 1975-1980 (2 mi north of Subarea IV). The solid lines represent mean maximum and minimum air temperatures, the dashed line is mean water temperature.

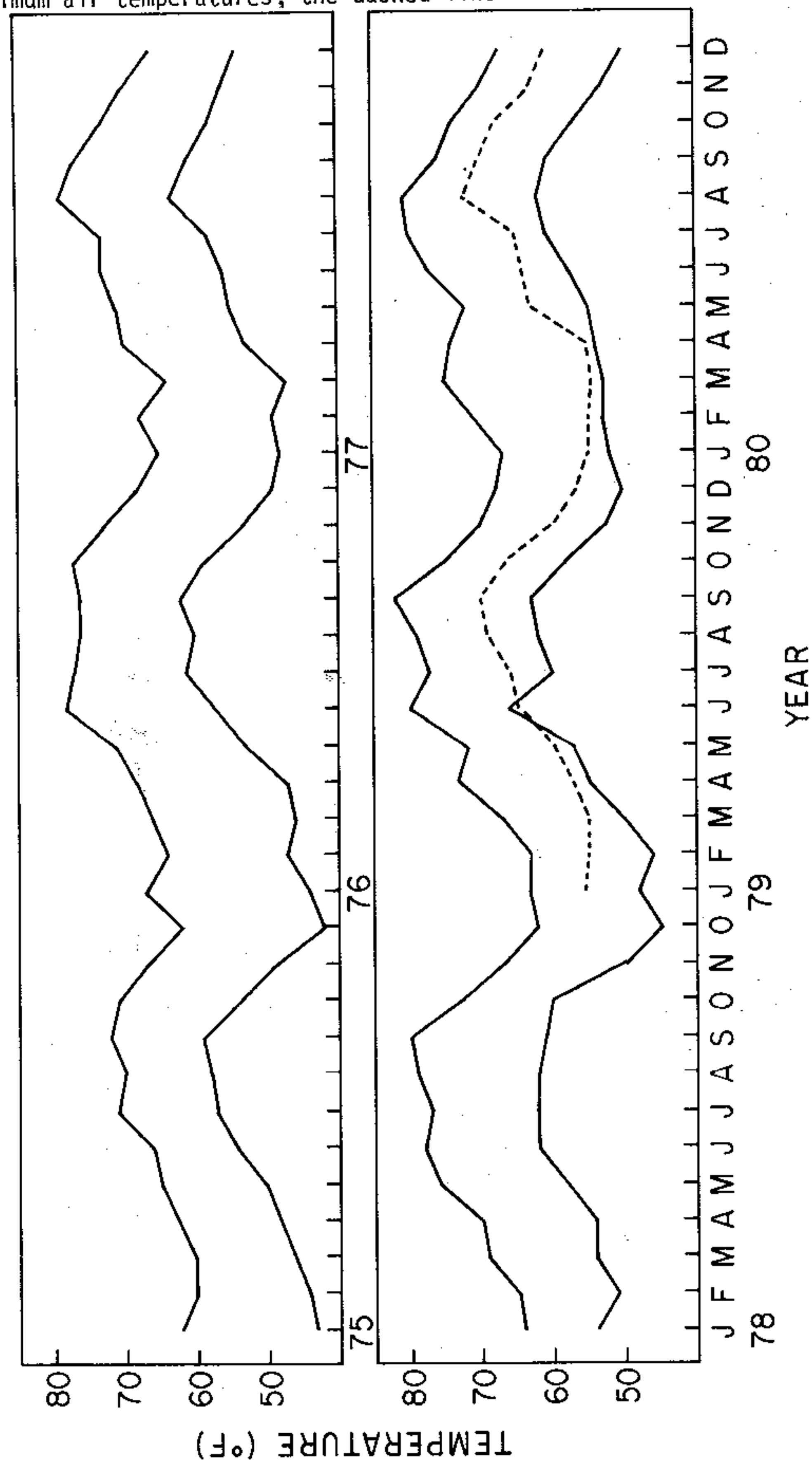
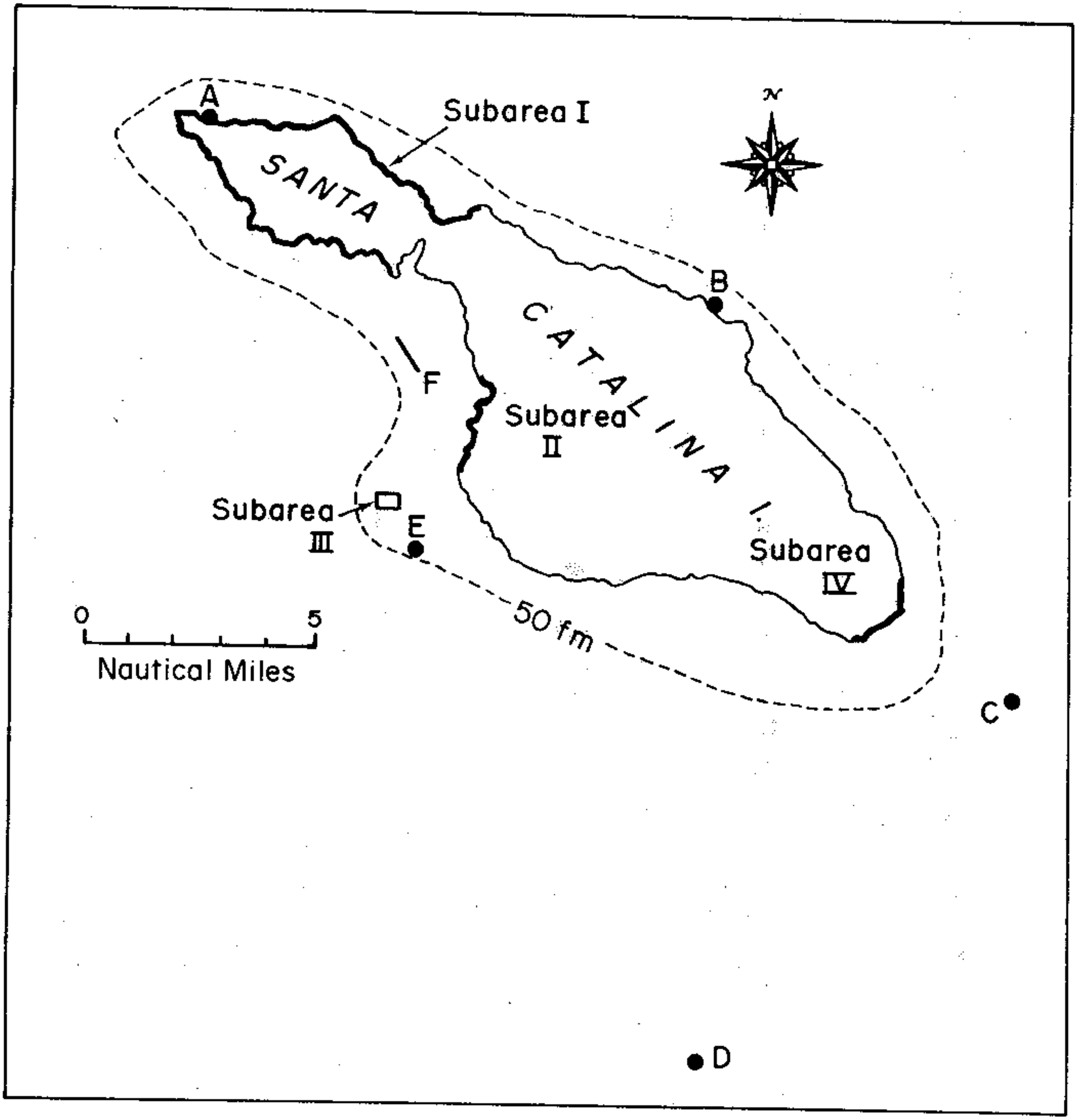


Figure 7. Locations of previous marine studies near Subareas II and IV. Studies include: State Mussel Watch Program Stations, Catalina West (A) and Catalina East (B); Chen and Lu (1974) sediment quality stations (C,4); California Cooperative Oceanic Fisheries Investigation Station #90.37 (D); and Southern California Coastal Water Research Program, otter trawl station (F).



between 33.4-33.8 o/oo within the upper 100 m for the period 1950-1966. These values were highest in summer and lowest in winter. Loop (1969) reported surface salinities of 33.52-33.55 o/oo and bottom salinities of 33.52-33.53 o/oo during late spring in the Little Harbor/Shark Cove complex. Within the protected area of Little Harbor, salinity was slightly higher, suggesting an area of relatively poor circulation and high evaporation. Salinities in the central portion of the harbor complex were lower, possibly due to artesian flow from submerged springs (Loop 1969).

Dissolved oxygen levels within both areas are adequate to support marine life. Average monthly values from the CalCOFI station ranged from 5.5 mg O_2/l at the surface to 3.0 mg O_2/l at 100 m. Surface values are usually higher because of aeration by swells and wind chop.

At the CalCOFI station, phosphate and nitrate-nitrogen values in October and December ranged from 0.34-2.12 and 0.1-23.2 g at/l, respectively, with lowest values at the surface and highest values at 100 m. No nitrate-nitrogen was present except for 0.28 g at/l at 50 m.

During the rainy season, water chemistry within Subareas II and IV undoubtedly is modified by surface runoff. The amount and duration of these changes, however, are not known.

The State Water Quality Control Board has maintained a State Mussel Watch Program in California since 1977, with two stations on the leeward (northeast) side of Catalina (Fig. 7). In this program, samples of mussel tissue are analyzed for trace elements, transuranics, synthetic organics, and petroleum derivatives. Levels of cadmium, lead, and zinc from samples collected at Catalina West were much higher than the proposed interim FDA alert levels for these metals; levels from Catalina East were slightly higher (Table 1).

Table 1. Levels of trace metals (μg/g dry wt) in tissue of mussels (*Mytilus* spp.) from Catalina West (West End) and Catalina East (Long Point). Data were taken from the California Mussel Watch Program (Stephenson et al. 1979 and 1980).

	Aluminum	Cadmium	Chromium	Copper	Iron	Mercury	Manganese	Nickel	Lead	Silver	Zinc
Catalina West											
1977	46.7	8.4	2.4	5.3	181.7	0.1	3.2	1.6	25.3	1.7	195.7
1978	195.0	11.0	3.3	5.5	--	0.3	9.8	--	26.5	1.9	216.7
1979	235.0	8.5	1.9	3.8	--	0.4	5.4	1.4	38.5	1.5	257.0
Catalina East											
1978	272.3	5.6	2.6	4.9	--	0.3	11.5	--	4.2	1.5	150.0
1979	490.0	5.7	2.7	4.6	--	0.4	11.8	1.8	3.6	1.2	193.0
Proposed DFA Interim Alert Levels	--	1.5	--	--	--	--	--	--	2.0	--	30.0

Levels of DDE, PCB, and hydrocarbons were 1-2 orders of magnitude below levels on the mainland (Table 2).

Submarine Topography

ASBS Subarea II. The ASBS extends from the intertidal zone seaward to the 300 ft (100 m) depth contour (Fig. 8). It is part of the gently sloping (1:350) southwesterly facing shelf extending for an average distance of 1.2 mi (2 km) from the windward coast of Catalina Island. The northwestern aspect of the ASBS forms a gradual and broad submarine valley, which funnels into the mouth of the Santa Catalina Canyon at a depth of 270 ft (90 m) approximately 0.6 mi (1 km) west of Shark Cove. To the south, the ASBS boundary approaches the canyon fan complex. The canyon widens and leads into the northern portion of the Catalina Basin.

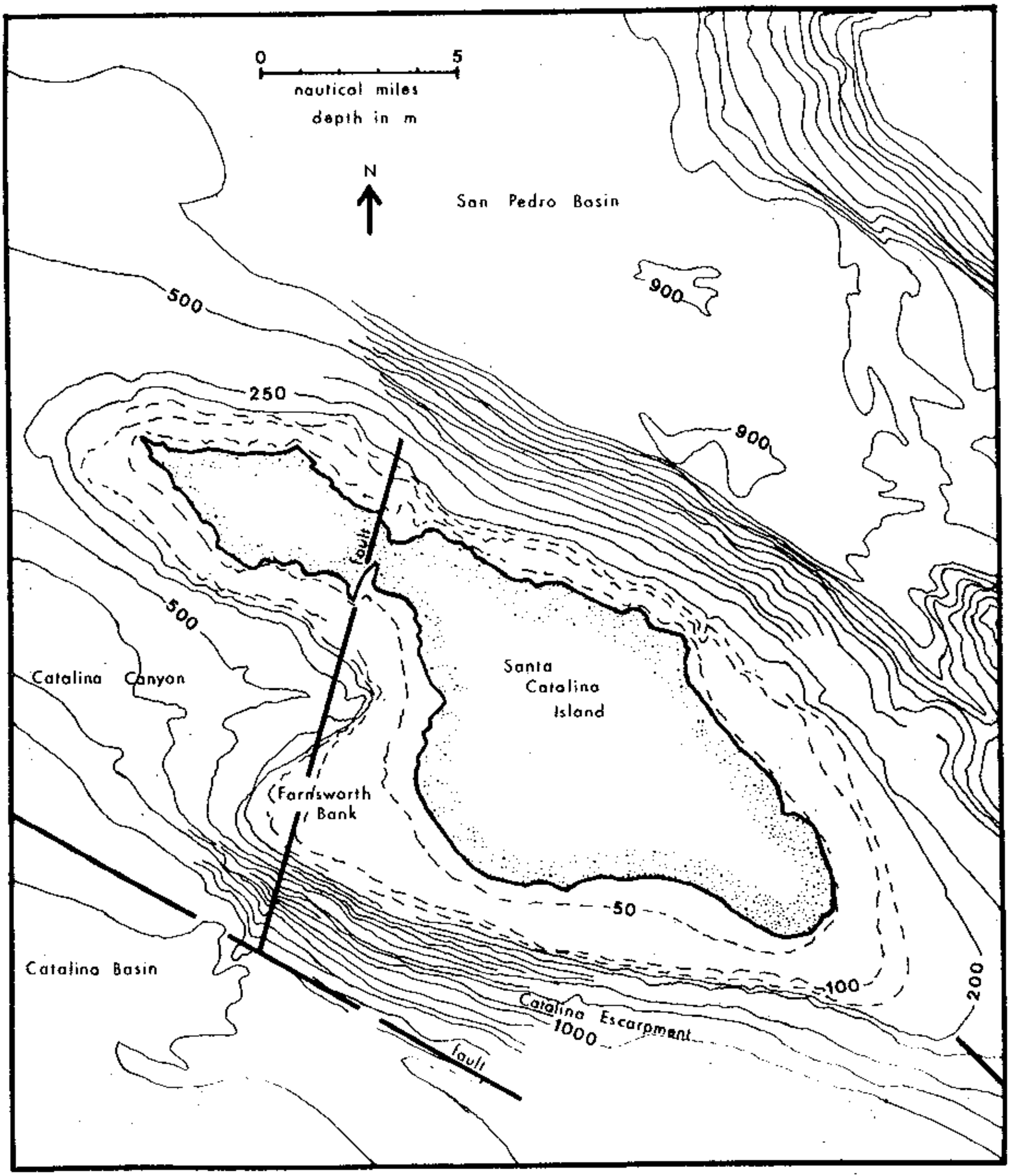
Catalina Canyon is one of the 13 major submarine canyons within the Southern California Bight. According to Loop (1969) and Samaras and Gellura (1979), the terrace forming the southern flat-topped rim of the Little Harbor/ Shark Cove complex was developed in response to a rising sea (glacial and/or tectonic) during the Pleistocene. This terrace was subsequently dissected by two major surface streams and the concomitant westward transport of sediments further developed the Catalina Canyon. Santa Catalina Basin receives over 67% of surface drainage on Catalina, and over 75% of this discharge is channeled through Catalina Canyon.

ASBS Subarea IV. The ASBS extends from the intertidal zone seaward to the 300 ft (100 m) depth contour (Fig. 8). It is part of a gently sloping southeasterly facing shelf extending for an average distance of approximately 5 mi (8 km) from the east end of the island. No submarine canyons are near the ASBS.

Table 2. Levels of organic pollutants (ng/g dry wt) in tissue of California mussels (*Mytilus californianus*) from Catalina West (West End) and Catalina East (Long Point). Data were taken from the California Mussel Watch Program (Risebrough et al. 1980).

	PCB		DDE		Total Unresolved Hydrocarbons		Total Resolved Hydrocarbons	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Catalina West								
1978	41	19	23	9	--	--	--	--
Catalina East								
1977	56	57	49	12	0.004	0.001	0.002	0.001
1978	35	17	9	9	--	--	--	--

Figure 8. Submarine topography surrounding Santa Catalina Island (from Assoc. Eng. Geologists 1967). Dark lines indicate the positions of potentially active earthquake faults.



Geophysical Characteristics

Land Geomorphology

General

Geologic formations on Santa Catalina Island consist of metamorphic rocks of Jurassic-Cretaceous age capped by Tertiary volcanics. The metamorphic rocks or Catalina Schist are the oldest assemblage of basement rocks found offshore of the Southern California Borderland. This assemblage is the equivalent of the Franciscan complex in the borderland and consists of three tectonic units. The Blueschist Unit is overlain by the Greenschist Unit, and both are in turn overlain by the Amphibolite Unit (including Serpentinite). These units were formed about 110 million years ago, when various proportions of sediments and volcanic rocks were deposited on the ocean bottom in a region of active vulcanism. This material subsequently was thrust into the upper mantle via a subduction zone. Metamorphosis of the schists occurred as a result of the high pressures and geothermal gradients associated with the zone of subduction, and a period of gradual uplift began.

The schists were exposed and covered during Miocene time (13-25 million yrs ago), although the timing and mechanisms are poorly understood. At some point in the Miocene, Catalina was submerged which accounts for the presence of marine sediments (diatomaceous shale and limestone) overlying the metamorphic rocks (schists).

Mid-Miocene was a period of extensive volcanic and tectonic activity. Consequently, the schists were folded and faulted with numerous igneous intrusions and extrusions.

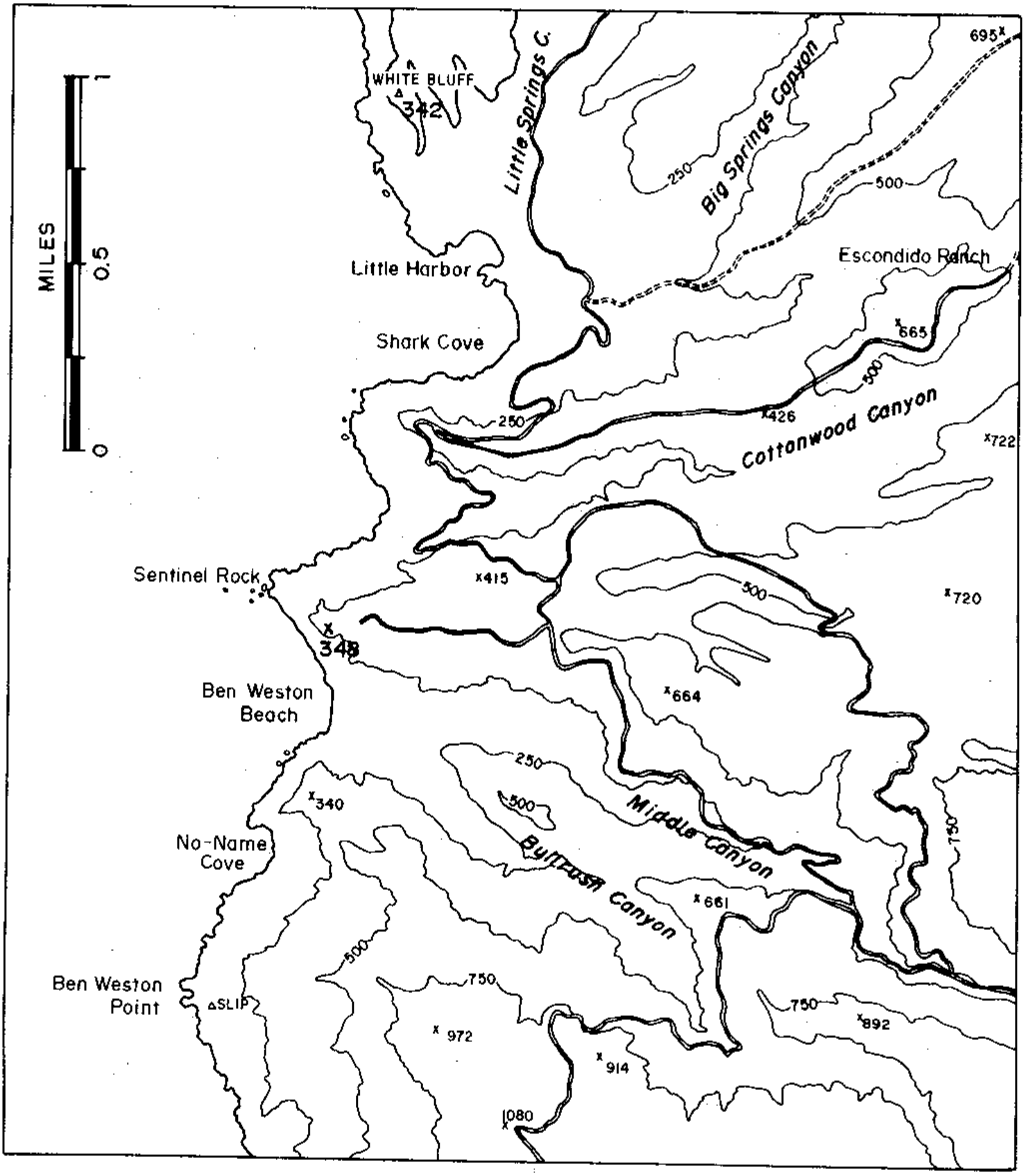
The gradual uplift of metamorphic rock which began in Jurassic-Cretaceous time, was completed by the late Miocene. Cessation of the uplift and the absence of sediments younger than Miocene age suggest that the physiography of Catalina at the end of the Miocene was similar to that of today. Block faulting and regional warping continued into the Pleistocene and local tectonic movements are still common within the Southern California Borderland. These movements cause the active seismicity of the area, of which Catalina is a part.

Pleistocene events on Catalina within the last 1-2 million years have consisted of considerable submergence and emergence in response to changing sea levels associated with glaciation and tectonic activity. During maximum submergence about 500,000 years ago, the island was submerged to the 1500 ft (457 m) level. Subsequent emergence reached maximum levels about 17,000-18,000 years ago. Since this time, the sea level gradually has risen to present levels (Vedder and Howell 1980).

Marine terraces formed by changing sea levels generally are rare and poorly preserved on Catalina, but three examples are found within Subarea II: 1) south side of Cottonwood Canyon, 2) behind Indian Head Rock on the seaward flank of Cottonwood Canyon, and 3) between Cottonwood Canyon to the southeast and Little Harbor on the northwest. The pebbles and cobbles were generated by waves rather than fluvial action, thus establishing their terrace identity (Samaras and Gellura 1979). Marine fossil assemblages are poorly represented in these areas.

ASBS Subarea II. The land mass within Subarea II is characterized by a relatively low-lying terrain intersected by four wide stream valleys (Fig. 9). The highest peaks within the Subarea range from 300-700 ft (91-213 m) in elevation and peaks adjacent to the ASBS are slightly less than 1000 ft

Figure 9. Topographic map of the land mass within and adjacent to Subarea II. Double lines indicate roads.



(300 m). Steep seacliffs are present in some areas, especially between Ben Weston Beach and Ben Weston Point, but they are less than 250 ft (76 m) in height.

Almost all geological formations within the ASBS are metamorphic rocks of Mesozoic age, but their primary structures have been modified by recrystallization and strain. The Catalina Blueschist Unit is by far the dominant formation (Fig. 10). Metavolcanic rocks comprise most of the Blueschist within this area, consisting of glaucophane schist, glaucophane-bearing sandstones, conglomerates of basaltic composition, and greenstones.

The Catalina Greenschist Unit is much less abundant than Blueschist within Subarea II, and is confined primarily to a large outcrop at the Little Harbor/ Shark Cove complex. This Greenschist consists mainly of gray pelitic schist, the most abundant form of metasedimentary rock. Albite, stained dark by included carbonaceous matter, forms most of the pelitic schists. Contacts between Blueschist and Greenschist invariably are abrupt and faulted.

Other geological formations are weakly represented or absent within the ASBS. A small area of exposed Miocene volcanics is present on the south wall of Middle Canyon, near Ben Weston Beach. An extension of Miocene volcanics from a large eastern outcrop approaches the ASBS near Cottonwood. Unfossiliferous limestone representing Miocene sediments is exposed in Cottonwood Canyon, slightly east of the ASBS boundary. Outcroppings of Catalina Amphibolite, the third unit comprising metamorphic rock, are not found within the ASBS.

<u>ASBS Subarea IV</u>. The land mass within Subarea IV is extremely rugged and mountainous, intersected by five narrow and steep-sided canyons leading to the sea (Fig. 11). Mountain peaks with elevations of 1563 and 1684 ft

Figure 10. Generalized geologic map of Santa Catalina Island (from Platt 1976).

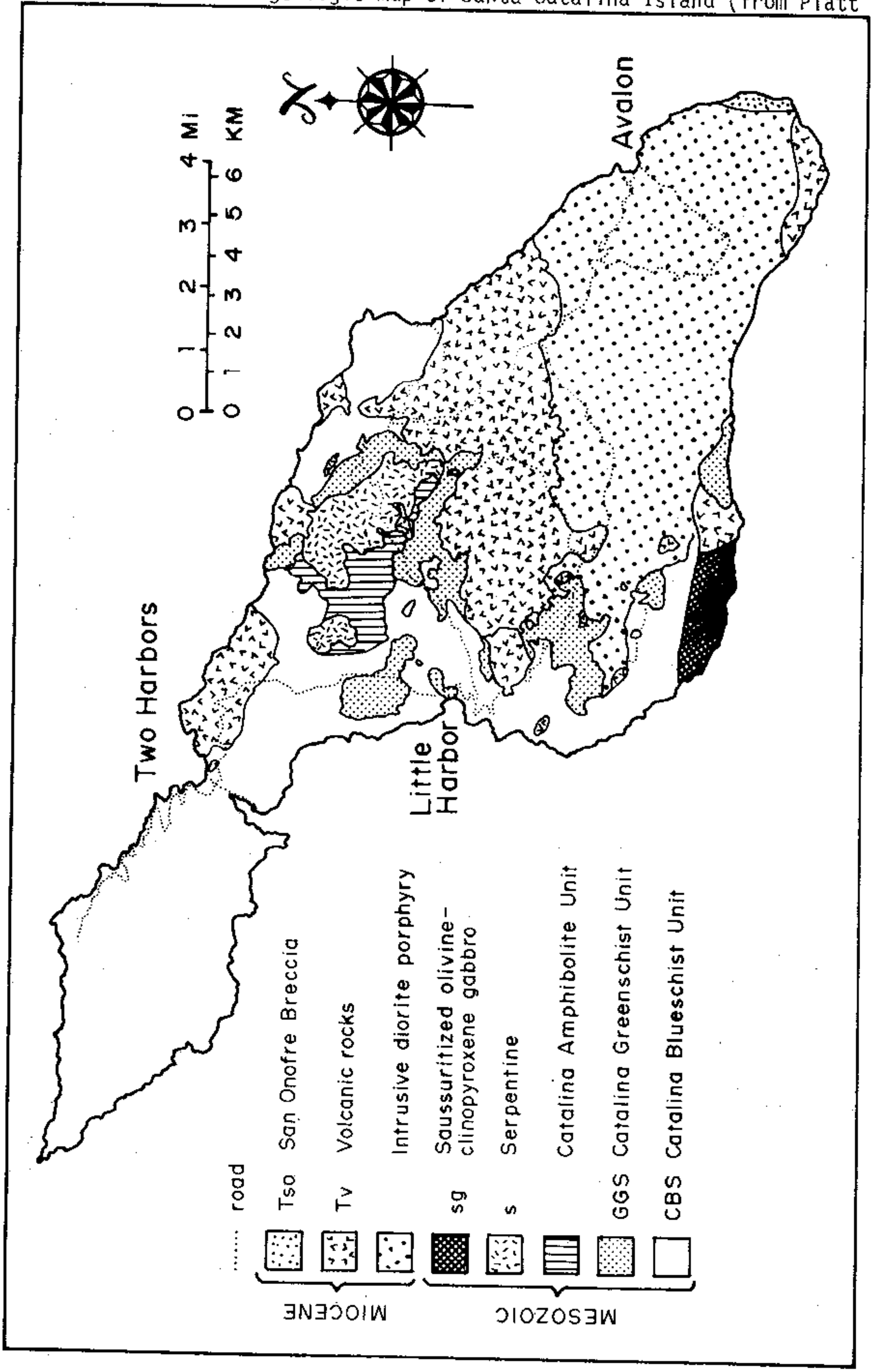
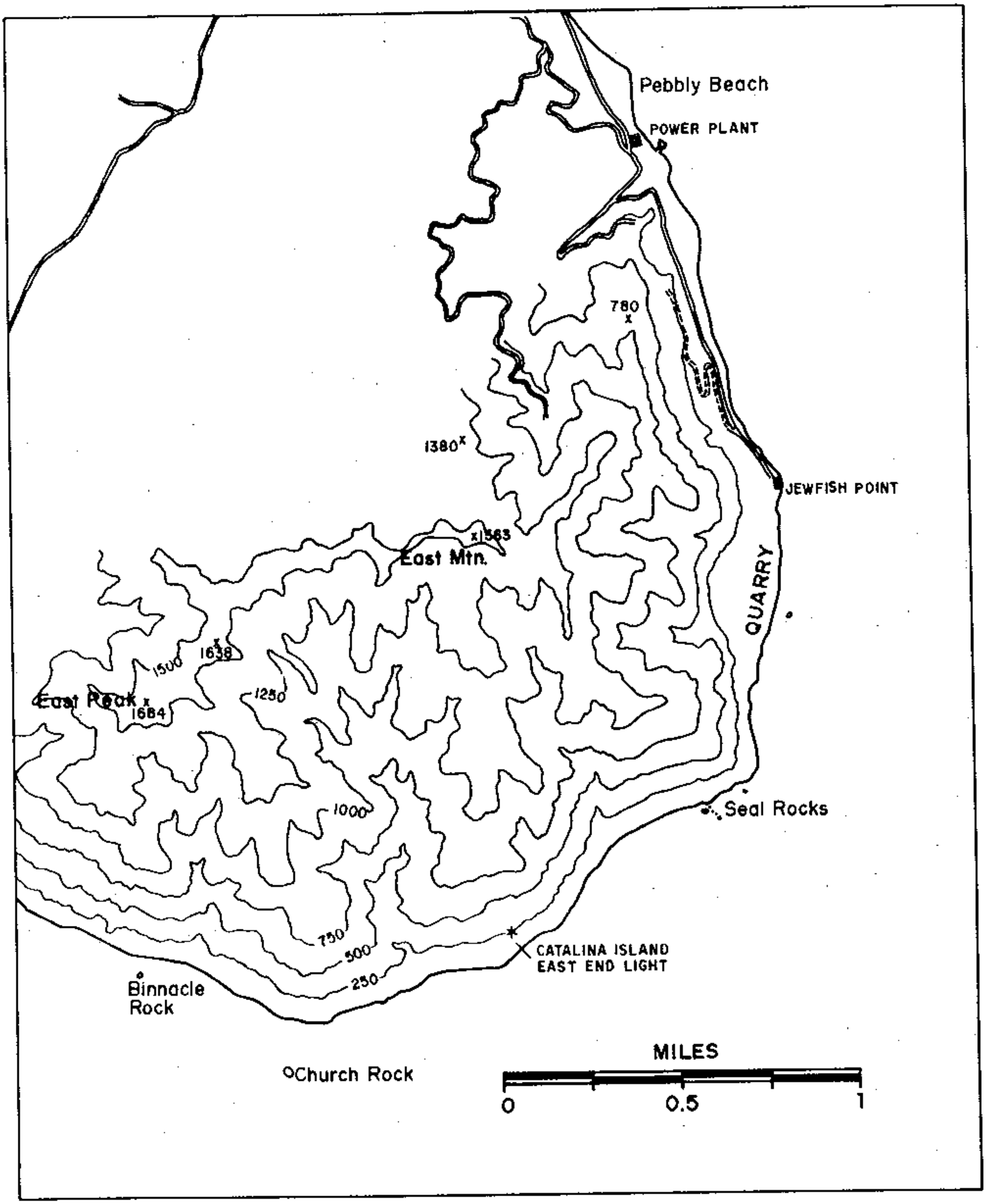


Figure 11. Topographic map of the land mass within and adjacent to Subarea IV. Double lines indicate roads.



(476 and 513 m) lie within 0.5 mi (0.8 km) of the intertidal region. In many areas, seacliffs rise precipitously to heights of over 700 ft (213 m).

Mesozoic basement rocks in the southeastern portion of Catalina Island were denuded and subsequently covered by lava flow, volcanoclastic rocks, and San Onofre Breccia during the Miocene. Consequently, all geological formations within Subarea IV consist of igneous rock materials associated with Miocene events and outcroppings of the three units of metamorphic rock found on Catalina (Blueschist, Greenschist, Amphibolite) are not present (Fig. 10).

The western portion of the ASBS consists entirely of volcanic rocks. The eastern portion, including the quarry, is composed of San Onofre Breccia carrying clasts of Catalina schist and altered mafic and intermediate plutonites. The bulk of rock excavated from the quarry is andesite. Quartz diorite porphyry extends into the middle portion of the ASBS, part of a much larger outcrop covering most of the southeastern portion of the island. The porphyry intrudes the Catalina schist and is assigned an age of 19 million years.

Seismic Activity

Potentially active faults traverse the Catalina Shelf and Basin off the southwestern coast and the southeastern tip of the island (Fig. 8). Subareas II and IV are near these faults. The maximum probable and maximum credible earthquakes along any of the major offshore faults are Richter magnitude 6+ and 7+, respectively. No earthquakes greater than magnitude 5 have been located instrumentally within 25 mi (40 km) of Catalina, but small earthquakes commonly occur within this area. Several have been located offshore of Subareas II and IV. In October 1973, the epicenter of a 4.5 magnitude earthquake was located 1.3 mi (2 km) off Subarea IV. Seismic activity is to be expected along the local or distant faults, and this activity may produce variable degrees of seismic shaking on the Catalina land mass.

Seismic shaking apparently has induced landslides in many areas of Catalina, but coastal landslides also can be initiated by wave action undercutting and removing the bases of seacliffs. Regardless of the mechanism, numerous landslides are evident within Subareas II and IV. Slumps are particularly evident in Subarea II. Slumping is a common event during the periods of heavy rainfall and forms the characteristic hummocky terrain in Subarea II. Landsliding and slumping are important mechanisms by which rock debris is introduced into the intertidal and subtidal areas of both ASBS.

Hydrology

General. Most streams on Catalina contain water only during periods of intense rainfall, becoming dry soon after the rains cease. A few streams exhibit a sustained base flow throughout the year, but this flow is always confined to a small section of the stream. During the dry season, no streams flow continuously from the upper part of the watershed to the sea.

Nearly 90% of Catalina's yearly rainfall evaporates and most of the remaining portion runs off into the stream channels. Very little rainfall percolates into the ground because of the shallow soils. The shallow soils and even the deeper soils in the valleys are totally depleted of their soil moisture during the long dry season (late spring-late autumn).

There is very little information on the ground-water resources of the island. One of the few sizeable ground-water aquifers on the island is located in the lower portion of Cottonwood Canyon, near the eastern boundary of Subarea II. A well has been established in this area and currently is supplying water to the Isthmus area.

Stream flow during the rainy season is heavily sediment-laden due to high erosion rates and high flow velocities resulting from the steep channel gradients. Flooding has occurred in the past (see Subarea II, below) and will occur in the future. Specific data on mean annual discharges and flood flow due to storm events are virtually non-existent for most of the drainage areas on Catalina.

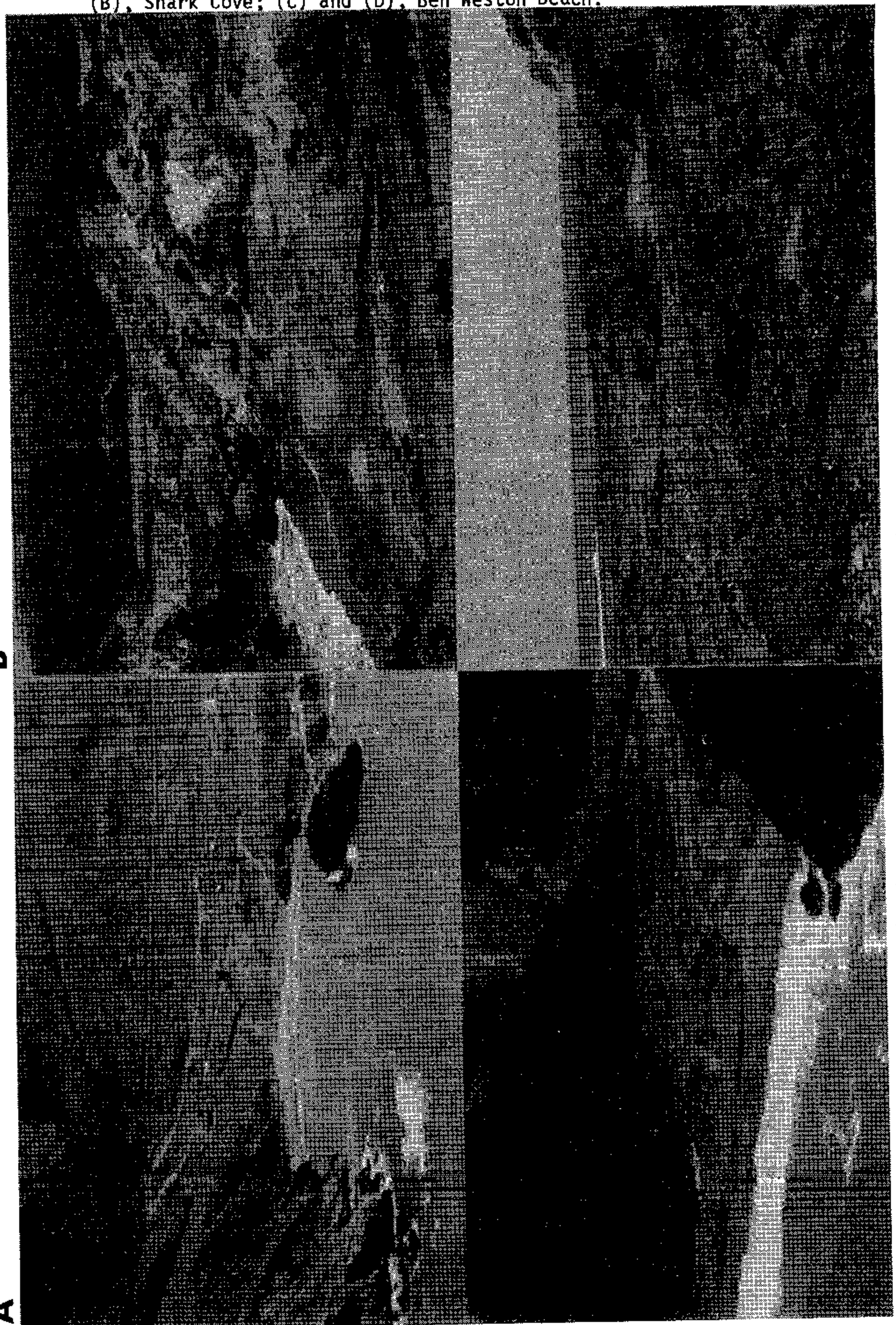
ASBS Subarea II. Approximately 59% of all surface drainage on Catalina is discharged to the ocean through Subarea II. The Little Harbor/Shark Cove complex drains Big Springs and Little Springs Canyon; Cottonwood Beach receives runoff from Fern and Cottonwood Canyons; and Ben Weston Beach drains Sweetwater, Cape, Middle, and Bullrush Canyons. With the exception of Big Springs, all of these streams flow throughout the year along a short reach of some part of the stream. Within the ASBS, only the lower portion of Cottonwood and Middle Canyons have year-round flow.

The terrestrial portion of Subarea II was modified extensively as a result of abnormally high rainfall during the winters of 1978 and 1980, and these events were documented photographically by the investigators (Fig. 12). The patterns of flood water flow in both years were similar, suggesting a certain degree of predictability.

The road passing near the Little Harbor/Shark Cove complex was washed away in numerous places, as the main flow discharged from Little Springs Canyon. At Little Harbor, a large lagoon was formed on the backbeach, shoreward of the beach berm. This lagoon gradually decreased in size as the brackish water evaporated and seeped into the ground table. The lagoon was not present during the drought years preceding 1978.

Drainage into Shark Cove deposited much sediment and debris along the southern portion of the beach. The heavy rains also caused widespread slumping

Figure 12. Subarea II beaches after a severe storm in March 1980. (A), Little Harbor; (B), Shark Cove; (C) and (D), Ben Weston Beach.



along the southern highland slopes.

Runoff from Cottonwood Canyon discharged directly to the sea at Cottonwood Beach. As the flow diminished, the beach berm was re-established by surf activity and effectively blocked subsequent runoff. Consequently, a large lagoon was formed, extending 300 ft (90 m) inland. The lagoon at Little Harbor may have been formed in the same manner.

The road to Ben Weston Beach was destroyed in several areas by runoff from Middle and Bullrush Canyons. Most of the flood waters exited along the southern wall of the beach area, depositing large amounts of debris and sediment. Wave activity deposited large quantities of kelp on the northern part of the beach. Slumping was evident on most of the surrounding slopes.

ASBS Subarea IV. Approximately 3% of Catalina's surface drainage is discharged through Subarea IV. Five unnamed canyons drain this area but none have year-round flow.

Intertidal Geomorphology

Intertidal geomorphology within Subareas II and IV ranges from fine sand beaches to bedrock outcrops covered by variable densities of gravity-transported boulders, often forming a boulder apron (Figs. 13, 14). Sandy sediments and rocky substrates make up approximately 20% and 80%, respectively, of the intertidal zone in Subarea II, and 40% and 60%, respectively, in Subarea IV. The beach material is derived primarily from weathering of the adjacent land mass - Franciscan basement rocks (Catalina Schist) in Subarea II, Miocene volcanics and breccia in Subarea IV. The bedrock represents the erosion-resistant cores of ancient seacliffs, whereas the boulders are fragmented debris from ancient or modern seacliffs.

ASBS Subarea II. Surface beach samples at Shark Cove contain less than

Figure 13. Major types of intertidal and subtidal substrates within Subarea II and locations of stations for the subtidal survey.

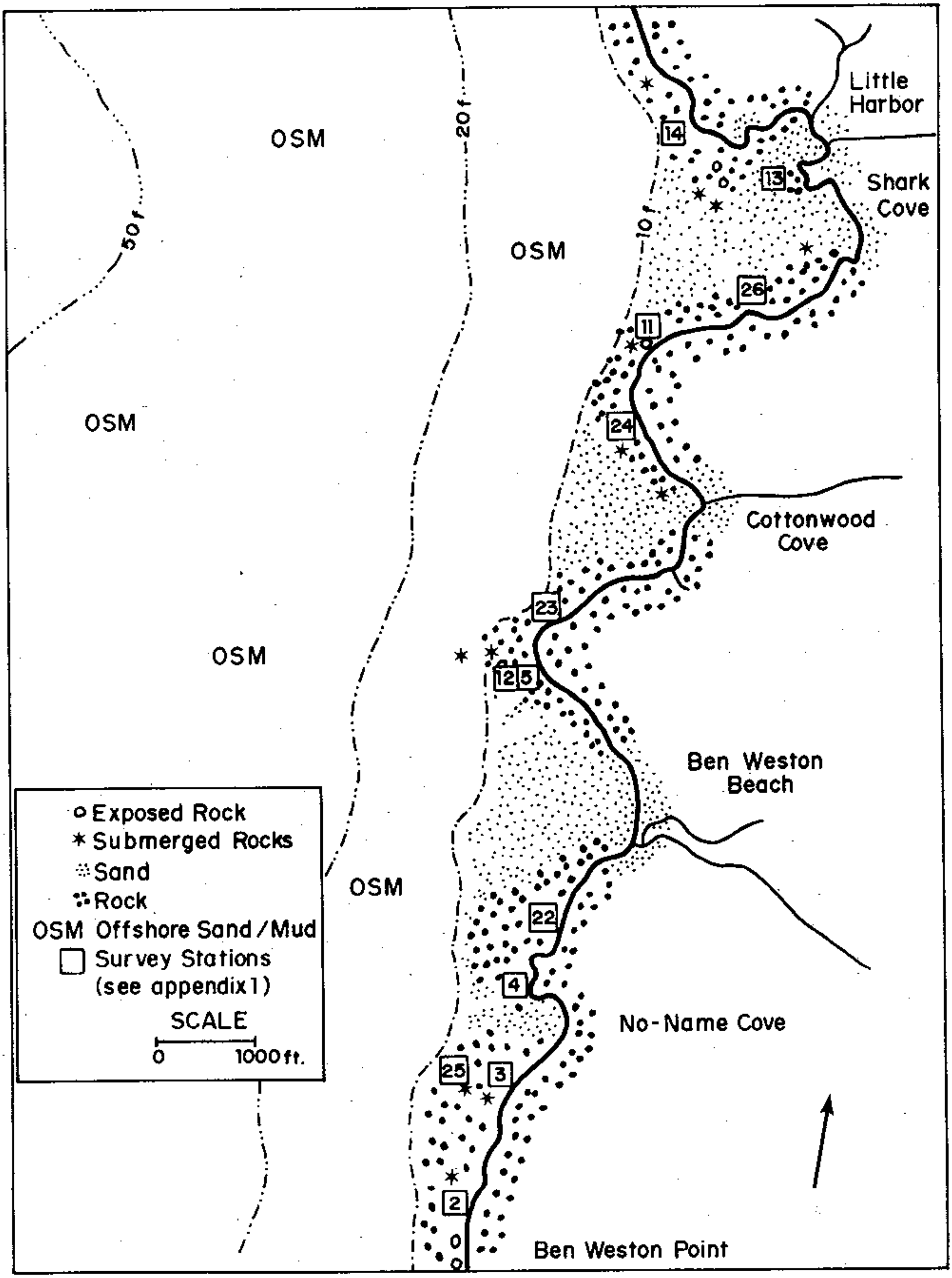
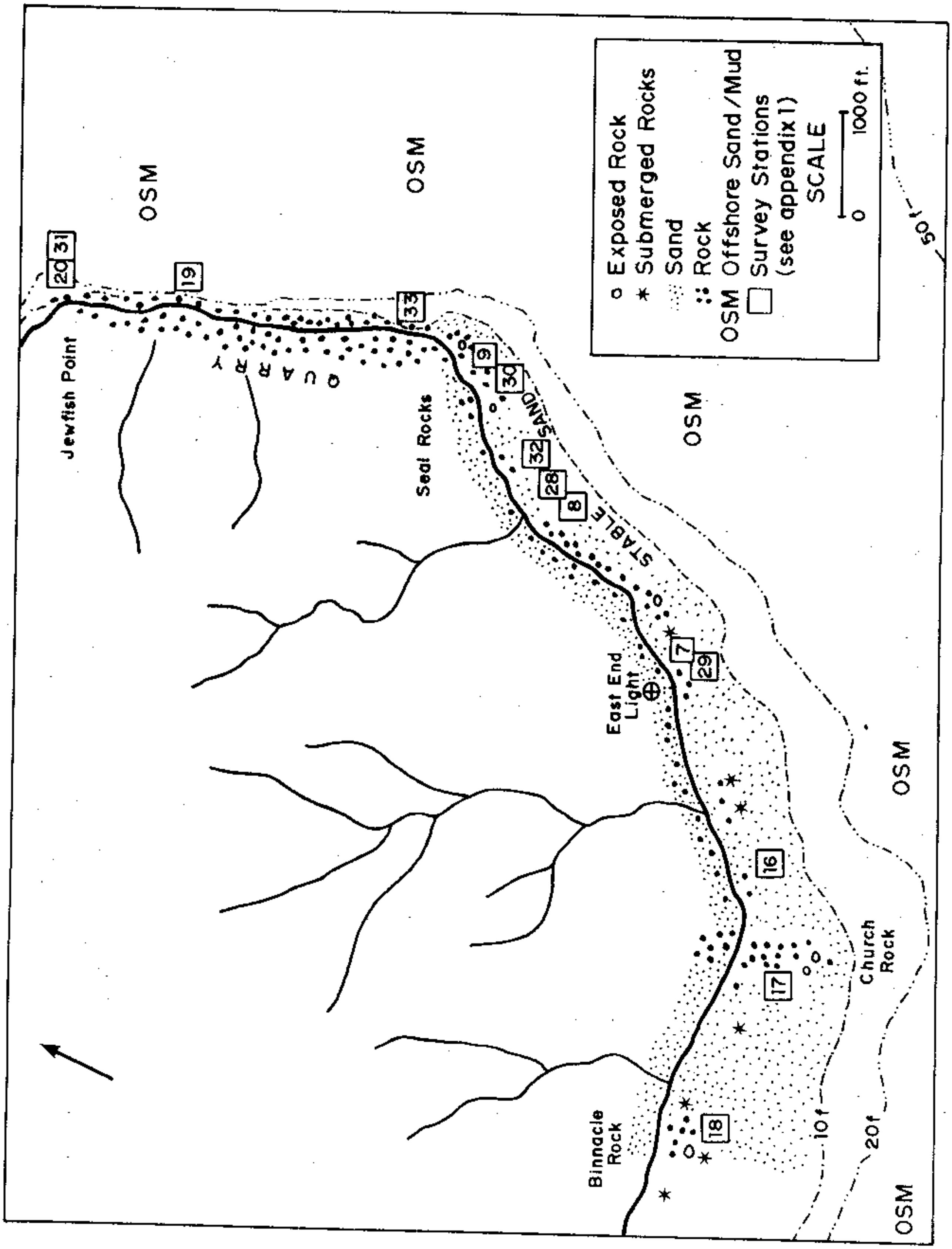


Figure 14. Major types of intertidal and subtidal substrates within Subarea IV and locations of stations for the subtidal surveys.



1.8% calcium carbonate (biogenic sediment derived from shells, urchin tests, calcareous algae) and less than 1.0% organics (Loop 1969). These characteristics indicate a relatively high incoming wave energy. The waves maintain the beach sediment in motion, thereby removing the lighter material. Sediment characteristics of the other exposed beaches within the ASBS (Cottonwood, Ben Weston) probably are similar to Shark Cove as wave energies at the exposed beaches are equal or greater than those of Shark Cove.

Little Harbor is the most protected area in the ASBS, partially illustrated by a slightly higher organic content of the beach sediments. Mean grain size characteristics reflect the pattern of incoming waves. The northern beach is composed of coarser material (1.60 mm) than the southern beach (0.08 mm), suggesting erosion of the northern portion with subsequent southerly transport and deposition on the southern portion.

Straughan (1978) examined winter and summer profiles of the beaches at Little Harbor and Shark Cove. Beach profiles in the winter were lower than in summer, because the winter storms and swells remove large quantities of beach material. Straughan also collected sediment samples along mid-beach transects in both areas (Table 3).

ASBS Subarea IV. No sediment analyses of the beaches within Subarea IV have been conducted. As beaches in the western portion of the ASBS are subjected to prevailing westerly winds and swells, the sediment characteristics probably are similar to those described for exposed beaches within Subarea II.

The intertidal regions of the eastern portion have been modified by quarry operations. Most of the intertidal zone consists of large boulders, although some areas contain small boulders and gravel. Occasionally, large swells generated by Santa Ana conditions will dislodge some of the large boulders and cause

Table 3. Intertidal abiotic parameters measured at Little Harbor and Shark Cove on Santa Catalina Island. Data were taken from Straughan (1978).

	LITTLE HARBOR		SHARK COVE	
	1977 Summer	1978 Winter	1977 Summer	1978 Winter
Intertidal Length (ft)	7.0	120.0	120.0	150.0
Intertidal Slope	0.11	0.09	0.06	0.07
Rock Exposure (ft)				
High Intertidal	35	0	0	0
Low Intertidal	35	0	0	30
*Grain Size (mean phi)	1.60	1.72	2.26	1.68
*Skewness	-0.03	-0.12	-0.44	0.26
*Kurtosis	-0.40	-0.19	0.44	-0.24
*Ohaus Moisture Content (%)	7.1	9.4	12.5	13.7
*Ohaus Organic Content (%)	0.37	0.38	0.77	0.63
Tar (g)	386.7	0	0.2	0
Kelp	+	0	+	0
Debris	0	0	0	0
Temperature (°C)				
Air	23.5	14.0	21.5	14.0
Water	22.0	15.0	21.5	14.0
Substrata	22.0--35.5	15.0-16.0	21.5-39.0	14.0-16.0
Salinity (o/oo)				
Ocean	34	30	34	30
Interstitial	34	30	34	30

* = Average values; + = Present.

them to roll down the subtidal slope. These boulders are replaced by the quarry company, as the company is mandated by the lease agreement to retain the original coastline configuration. Sand beaches are not present within the eastern portion of Subarea IV.

Subtidal Geomorphology

ASBS Subarea II. The nearshore subtidal geomorphology within Subarea II ranges from sandy areas immediately offshore of the sandy beaches to high-relief boulder fields offshore of the rocky headlands. Approximately 55% and 45% of the nearshore subtidal zone in Subarea II is composed of sandy sediments and rocky substrates, respectively (Fig. 13).

The nearshore sediments generally grade from coarse to fine as depth increases. This pattern is most obvious off the four sandy beaches (Little Harbor, Shark Cove, Cottonwood, Ben Weston) within the ASBS, which are the major avenues of surface runoff. In these areas, sediments shallower than 35-40 ft (10-12 m) are coarse (0.6-0.8 mm) and contain a high proportion of biogenic material (34-39%). Ripples are present and typically are aligned perpendicular to vectors of water motion. They are largest in the areas of strongest water motion. Submarine scour sometimes is evident by the exposure of "scoured" bedrock in the areas of heaviest water motion.

Deeper than 35-40 ft, ripples usually are absent and the sediment is composed of fine, clean sand (0.08-0.09 mm). Organic material is absent and the proportion of biogenic material is low (1-11%). With increasing depths along the shelf, however, silt and organics become more abundant in the sediments.

This general pattern of sedimentation is subjected to seasonal modification. Strong water motion associated with winter and spring storms results in a deeper extension of the coarser and biogenic sediment. The calmer conditions of summer, however, permit the encroachment of fine sand into shallow water, forming a thin (1-2 cm) veneer over the coarser sediment.

Several characteristics of the subtidal sediments within Little Harbor further reflect the low-energy environment or protected nature of the harbor. Sediments high in organics are found at depths as shallow as 15 ft (4.5 m) in the center of the harbor and a layer of hydrogen sulfide is present 1 cm below the sediment-water interface. A small discontinous clay deposit surrounded by fine sand also is found near the harbor's center. This may represent a remnant of a more extensive clay sheet deposited by surface runoff during periods of heavy rainfall.

All subtidal rocky headlands within the ASBS are similar to the adjacent intertidal areas. Bedrock outcrops are covered by variable quantities and sizes of gravity-transported boulders. Most of the shallow areas are a mixture of medium- and large-sized boulders from 5-30 ft (1.5-9 m) in diameter, and the overall physical relief is high. The boulders tend to decrease in size with increasing depth. Consequently, areas deeper than 35-40 ft often consist of moderate- to low-relief bedrock with a few 3-6 ft (1-2 m) boulders. Channels or patches of coarse, biogenic sediment are frequently interspersed among boulders of all sizes, especially in areas of relatively reduced water motion. In all areas, the bedrock gives way to fine sand beyond a depth of 60-70 ft (18-21 m), although a few isolated boulders can be found "imbedded" in the sandy substrate.

Exposed offshore rocks are found near Ben Weston Point, along the rocky headlands between Shark Cove and Cottonwood Beach, and between Cottonwood Beach and Ben Weston Beach (Sentinel Rocks). Many of these rocks are large, ranging from depths of 20-25 ft to elevations of 20-30 ft above the water's surface.

Under water, the rocks are characterized by steep or vertical walls and strong surges usually are present.

The nearshore subtidal area off No-Name Cove differs from other areas in Subarea II, as it is composed of gravel. The gravel grades into a sandy substrate at depths of 35-40 ft.

Subtidal sediments gradually grade from relatively coarse sand within the nearshore areas to a sand/mud mixture on the shelf. The sediments become mud off the head of Catalina Canyon and in deeper water beyond the boundary of Subarea II.

No man-made structures such as jetties, piers, or submerged artificial reefs have ever been present within the ASBS.

<u>ASBS Subarea IV</u>. The subtidal region of the western portion of the ASBS is similar to that described for Subarea II, above. Approximately 80% and 20% of the nearshore subtidal zone in Subarea IV, is composed of sandy sediments and rocky substrates, respectively (Fig. 14). Subtidal areas near headlands are characterized by exposed bedrock, either with interspersed pockets of coarse sand or covered by variable quantities and sizes of gravity-transported boulders. Most boulders are medium-sized (2-5 ft, 0.6-1.5 m), resulting in areas of medium physical relief. Exposed bedrock and boulders become less common with increasing depth as the substrate changes to fine sand beyond a depth of 35-40 ft (10-12 m). This changes to a sand/mud mixture on the shelf and finally into mud beyond the Subarea IV boundary.

Sediments in subtidal areas offshore of the beaches grade from coarse to fine as depth increases. Sediments shallower than 35-40 ft are coarse and are characterized by ripples of various heights. The ripples are aligned perpendicular to vectors of water motion, and ripple size is directly proportional to the amount of water motion. Ripples sometimes are large enough to trap detrital algae within the trough.

Deeper than 35-40 ft, ripples usually are absent and the sediment is composed of finer sand with some organics. An unusual "stable sand" habitat is present at depths of 35-70 ft between the East End Light and Seal Rocks. In winter, a dense algal growth is present on the many worm tubes in the area, and a diatom film covers the substrate surface (see section on Subarea IV Subtidal Biology, below).

Throughout much of the eastern aspect of Subarea IV, a shallow and flat shelf extends from the intertidal zone to a depth of 15 ft (4.5 m), beyond the shelf, the substrate slopes sharply (25-35°) to depths of 110-120 ft (33-36 m), then begins a gradual descent into deeper water.

The shelf is composed entirely of clean gravel or cobble; macroalgae and macroinvertebrates are not present. In some areas, the gravel/cobble extends down the slope to the deeper depths The uppermost portions of most slopes, however, are composed of rocky rubble interspersed with sand pockets. The rubble or talus averages 3-4 ft (1-1.5 m) in diameter, although some larger boulders are present. Beginning at depths of 35-40 ft, the slopes change from talus to areas of mostly sand with interspersed rocks, before grading to pure sand at the deeper depths.

Within the quarry region, the subtidal area has been modified by quarry operations. Large intertidal boulders occasionally are dislodged by storm swells, and roll down the subtidal slopes. Similar-sized boulders then are placed in the intertidal zone by the quarry company, so as to preserve the original coastline. A small amount of rocks are introduced into the subtidal inadvertently during barge-loading operations.

No man-made structures such as jetties, piers, or submerged artificial reefs, have ever been present within the western portion of Subarea IV; a small jetty for loading rock is present at the quarry in the eastern part of the ASBS.

The above descriptions of hydrology and geomorphology were synthesized from Bailey (1940), Gaal (1966), Loop (1969), Platt (1976), Assoc. of Engineering Geologists (1977), Center for Natural Studies (1976), Vedder and Howell (1980), and surveys by the investigators.

Sediment Chemistry

According to Chen and Lu (1974), sediments surrounding Catalina Island have trace metal concentrations almost as high as those of the Los Angeles/ Long Beach Harbor complex. One of the many Catalina areas investigated in Chen and Lu's study was slightly south of Subarea II at a depth of 164 ft (50 m) (Fig. 7). At this station, levels of chromium, copper, and nickel were much higher than background levels for the entire San Pedro Channel (Table 4). The high chromium and nickel levels, however, may be due to rock and soil compositions in the drainage areas producing the surface runoff to this area (Chen and Lu 1974).

Concentrations of chlorinated pesticides (DDT) and polychlorinated biphenyls (PCB) are much lower in all Catalina sediments than within sediments off the mainland coast (Table 5). Levels of other organic compounds, however, are similar.

A study by the Los Angeles County Sanitation District in 1971-1972 for the Southern California Coastal Water Research Project (SCCWRP) examined the levels of DDT and PCB in the muscle tissue of Dover sole, a flatfish that lives on the substrate. The fish were trawled from a depth of 330 ft (100 m), near Subarea II (Fig. 7). Levels of DDT and PCB were 0.5 and 0.03 mg/wet kg, respectively,

Table 4. Levels of trace metals (mg/kg) in sediments near Santa Catalina Island ASBS Subareas II and IV (after Chen and Lu 1974). Data are reported for three levels of sediment depth (in).

	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Zinc
Subarea II									
0-2"	2.29	1.67	107.0	23.0	25,690	37.7	0.029	142.7	39.1
2-6"	2.11	1.30	86.9	21.7	27,950	39.1	0.025	133.2	34.8
6-12"	2.03	1.51	117.6	22.5	24,680	33.8	0.031	91.4	27.9
Subarea IV									
0-2"	2.82	2.79	54.0	12.6	16,470	57.3	0.034	46.5	42.9
2-6"	2.40	2.46	40.6	12.7	14,100	55.9	0.028	39.1	37.8
Natural Background	1-1.5	1-1.5	20-30	5-10	12,000-15,000	20-25	0.025-0.050	15-20	30-35

Table 5. Levels of organic pollutants in sediments near Santa Catalina Island ASBS Subareas II and IV (after Chen and Lu 1974). Data are reported for three levels of sediment depth (in).

	Chemical Oxygen Demand ($\times 10^4$ ppm)	Organic Nitrogen (ppm)	Oil and Grease (ppm)	Total Phosphorus (ppm)	Total Organic Carbon (%)	Total Volatile Substances (%)	DDD (ppm)	p,p'DDE (ppm)	Total DDT (ppm)
Subarea II									
0-2"	1.35	103.0	2,350	507	0.549	3.08	0.001	0.004	0.005
2-6"	1.41	87.0	1,630	493	0.354	2.69	--	0.002	0.002
6-12"	1.33	60.4	1,250	418	0.134	2.43	--	--	--
Subarea IV									
0-2"	1.40	180.0	2,110	1,215	0.365	1.81	0.034	0.006	0.007
2-6"	1.53	229.0	2,130	1,153	0.327	2.57	--	0.002	--
Mainland Ranges									
0-2"	1.1-7.4	81-1,406	1,060-4,630	750-1,575	0.205-2.309	1.15-15.70	0.002-0.296	0.031-0.864	0.016-1.332
2-6"	0.6-6.7	36-1,330	1,140-2,920	438-1,568	0.110-1.824	1.26-7.50	0.002-0.228	0.003-1.430	0.003-2.112
6-12"	2.5-4.4	91-1,512	1,150-5,560	1,155-1,645	0.212-1.502	2.69-4.50	0.018-0.150	0.063-0.776	0.101-1.112

much lower than mainland levels which ranged up to 9.3 for DDT and 4.1 mg/wet kg for PCB. This study also examined Dover sole liver tissue and found copper levels of 1.7 mg/dry kg, slightly lower than the highest mainland value (6.8). There was a normal incidence of tumors and fin erosion disease in flatfishes caught off Catalina (SCCWRP 1972).

Another study examined DDT levels in liver tissue from numerous fish species and found Catalina levels to be 1-2 orders of magnitude below mainland levels (Los Angeles Co. Sanit. Dist. 1973).

In summary, studies of sediment and organism tissue from Catalina have revealed high concentrations of trace metals, but relatively low amounts of petroleum hydrocarbons and pesticides. The major sources of these contaminants are the sewer outfalls and the Los Angeles/Long Beach Harbor complex on the mainland, but airborne contaminants from the mainland also may be important (Chen and Lu 1974; Stephenson et al. 1979). Although none of these samples were collected within Subarea II or IV, the islandwide patterns for these contaminants strongly suggest similar values for Subareas II and IV.

Climate

General. The climate of Catalina Island is classified as semi-arid Mediterranean, characterized by mild, wet winters and a warm, dry period from late spring to late autumn. Temperatures in the high 30s and upper 40s (1-4°C) are recorded a few times each winter, but freezing temperatures have never been recorded at sea level. This pattern is controlled by a high-pressure cell, the Eastern Pacific High, which is located off the coast of northern California. During spring and summer, this high-pressure cell prevents storm-producing, low-pressure systems from reaching the southern California area.

Consequently, the summers are warm, dry, and moderated by prevailing westerlies. The westerlies increase in intensity during the afternoon, die-off in the evening, and repeat the cycle the next day.

Skies are mostly clear from late spring through autumn, and each year an average of 267 days are sunny or partly sunny. Heavy cloudiness occurs primarily in the early spring months when stratus clouds drifting in from the sea may cause low ceilings or fog. The clouds are usually 300-400 ft (90-122 m) thick, with bases near 1500 ft (457 m). The relative humidity averages 60-70%, largely influenced by the surrounding Pacific Ocean.

The Eastern Pacific High weakens and moves south in the fall, allowing storm systems to move down the coast. Stormy southeast winds and clearing westerlies are typical of winter, whereas violent storms with strong westerly winds (25-50 mph) lasting for days are common in spring. Fogs develop in late spring and persist into late summer or until the afternoon westerlies develop.

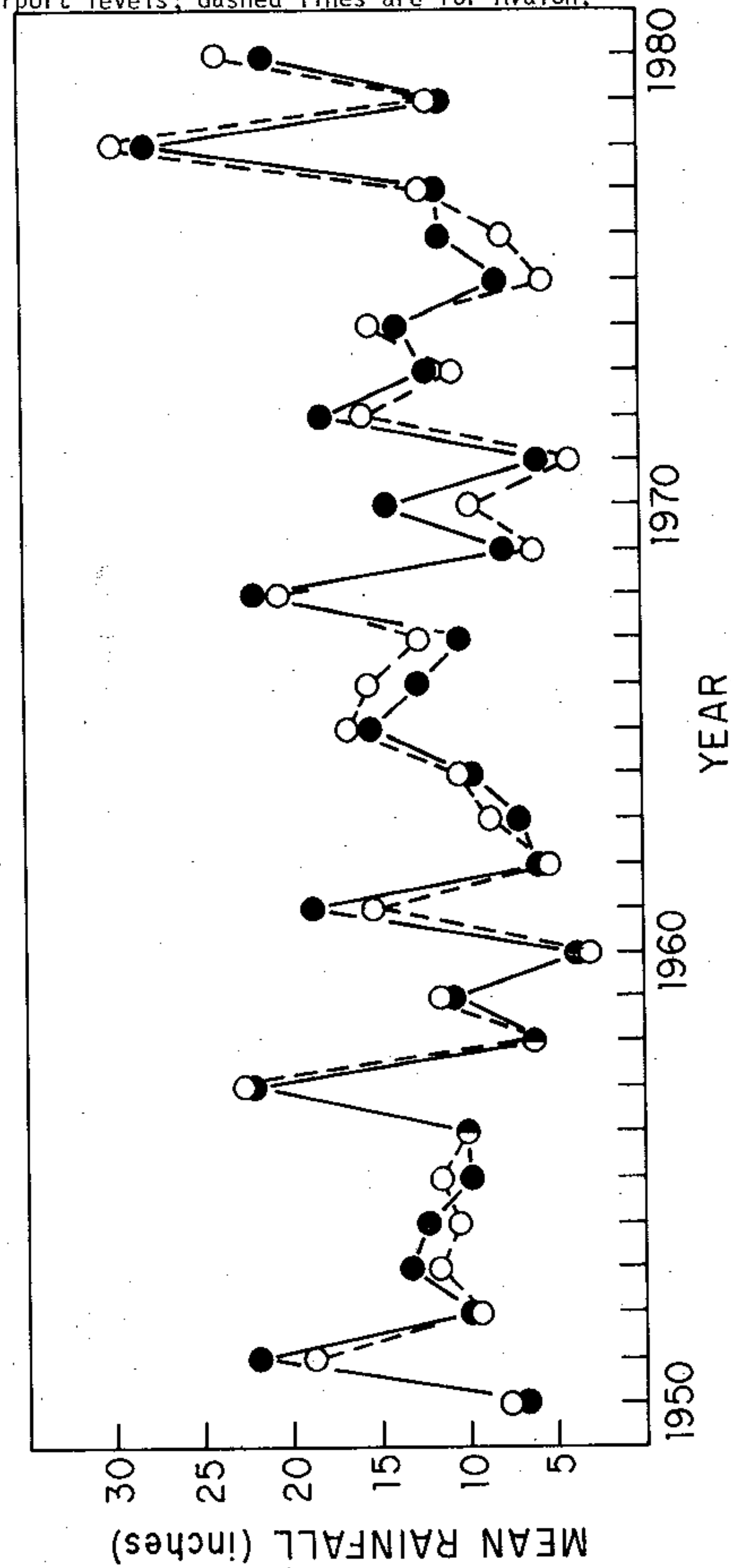
The winter and spring patterns are broken at irregular intervals by the occurrence of Santa Ana winds. A high-pressure system is established over the Great Basin, creating a strong northeast/southwest pressure gradient over southern California. This can last for 1-12 days. The resulting Santa Ana winds blow from the northeast and are typically strong, gusty, hot and very dry. They frequently attain speeds of 100 mph on the mainland, but rarely exceed 50 mph at Catalina. Usual Santa Ana conditions on the island consist of high temperatures, very low humidities, gentle warm breeze, and smog from the Los Angeles Basin.

The average yearly rainfall at Catalina is approximately 12 in (30 cm), falling mainly from November through April, with 62% occurring in December, January, and February (Fig. 15). Precipitation is usually in the form of a steady, gentle rain. Squalls and thundershowers are rare, usually associated with the rare "Chubascos" from the south, or unusually strong Pacific storms from the west. Catalina experienced severe drought conditions in 1975-78, averaging less than 10 in/yr (25 cm/yr). Abnormally high amounts of rain fell during the winters of 1978 and 1980, with annual totals of 29 and 22 in (74, 57 cm), respectively. Snowfall, with slight accumulations of 1-2 in (2.5-5 cm) occurs about once every 20 years is at altitudes above 1500 ft.

ASBS Subarea II. Weather data have never been recorded on a regular basis within Subarea II, but general patterns can be discussed. The ASBS generally experiences cooler winters and warmer summers than areas on the leeward side of Catalina, because it is exposed to winter storms and to the long afternoon sun during the summer. Summer and winter temperatures within the ASBS are usually around 80°F (26.5°C) and 50°F (10°C), respectively. Annual precipitation varies, but is comparable to the amount falling in Subarea IV (Fig. 15). Santa Ana winds never reach the ASBS, as they are blocked by the Catalina land mass, but winds from Pacific storms strike the ASBS with full force.

ASBS Subarea IV. The ASBS consists of leeward or sheltered (southwestern) and windward or open (northeastern) aspects, and each can experience slightly different climates. The southwestern portion of the ASBS can be expected to have a wider range of temperatures than the northeastern aspect, as it is exposed to winter storms from the west and the long, hot afternoon sun during the summer. Climate in the southwestern portion probably is similar to Subarea II. Weather patterns along the northeastern coast can be estimated

Figure 15. Annual rainfall at Airport-in-the-Sky (3 mi northeast of Subarea II) and Avalon (2 mi northeast of Subarea IV) from 1950-1980. Solid lines depict Airport levels; dashed lines are for Avalon.



by examining weather data recorded at Avalon, but slight differences may occur as Avalon is semi-protected in a canyon. The mean annual temperature in Avalon is 60-61°F (15.5-16°C), rarely exceeding 80°F (26.5°C) in the summer or falling below 45°F (7°C) in the winter (Fig. 6). Winds from Pacific storms affect the southwestern coast more than the northeastern coast, but Santa Anas affect the northeastern aspect more than the southwestern portion. Precipitation patterns in both the leeward and windward aspects probably are similar, and both are comparable to amounts of rainfall in Subarea II (Fig. 15).

BIOLOGICAL DESCRIPTON

Subtidal Biota

Subtidal habitats are divided into nearshore sands, offshore sands and mud, and shallow water rocky reefs. The distribution of these general habitats and the location of dive survey stations in each Subarea are depicted in Figs. 13, 14. The plant, invertebrate, and fish species associated with each of these habitats in Subareas II and IV are discussed in this section and listed in Appendix 2.

High-exposure sand/shelly debris habitats consist of shallow (<30 ft, 10 m) areas immediately offshore of the beaches. Water motion is strong in these areas, resulting in high turbidity and sand ripples of varying sizes. Low-exposure sand/shelly debris habitats consist of shallow areas within semi-protected locations (e.g., Little Harbor) and deeper areas offshore of high-exposure habitats. Water motion is considerably reduced below depths of 35-40 ft (11-12 m), as evidenced by smaller or no sand ripples, smaller sediment sizes, and relatively high concentrations of organic material. At depths greater than 70-80 ft (21-24 m), the offshore sands contain increasing amounts of organics and mud.

A mixture of habitats is present on the shallow water rocky reefs; thus, reefs are subdivided into areas of low, moderate, or high physical relief. Rocky substrates composed of low-lying bedrock, gravel, or small rocks (<3 ft) are areas of low physical relief. Small rocks and gravel often are tumbled and relocated by water motion associated with storms or high surf and are areas of relative instability.

Moderate relief areas are composed of larger rocks (3-6 ft) and/or folded or faulted bedrock, forming moderate crevices and projections. The larger rocks increase habitat diversity by presenting rock-tops, rock-sides, and under-rock areas for utilization by attached and mobile species. Juxtaposing rocks create numerous small crevices or "caves" of moderate size.

Areas with very large boulders (>6 ft) and/or highly faulted bedrock, possess a high degree of physical relief. Sheer vertical walls are common in these areas, formed by the faces of large boulders or exposed bedrock "cliffs." Large and deep crevices are present in the faulted bedrock. In some areas, adjacent boulders create deep "caves."

Within Subarea II, moderate relief areas are most abundant and low relief regions are somewhat less common. In contrast, the most abundant rocky habitats in Subarea IV are low relief, with areas of moderate relief less common. Few high relief habitats are present in either area.

ASBS Subarea II

High-exposure Sand

Plants. No attached macroalgae are present in sand, shelly debris, or gravel habitats exposed to the prevailing northwest swells. Fine algal debris from nearby reefs often is suspended in the water column, and larger pieces of algae drift back and forth with the surge along the bottom. In some cases, drifting plant fragments collect in the troughs formed by large sand ripples.

Invertebrates. Few invertebrates are found in unstable and shifting sand habitats. The purple olive snail, *Olivella* sp, is abundant in some areas; sand dollars (*Dendraster* sp) and small sea pens (*Stylatula elongata*) are present in others. Occasionally, swarms of tiny opossum shrimp (Mysidacea) are observed hovering and swimming a few inches above the sandy substrate. Some mobile and burrowing organisms (clams, polychaetes, etc.) may be present in this habitat, but none were observed during the diving survey.

Fishes. Few fishes inhabit sandy/shelly debris areas with high-water motion. Thornback rays (Platyrhinoides triseriata), black perch (Embiotoca jacksoni), rock wrasse (Halichoeres semicinctus), and sheephead (Semicossyphus pulcher) are the only benthic fishes present. Water-column fishes include atherinids, kelp bass (Paralabrax clathratus), and halfmoon (Medialuna californiensis). All benthic and water-column fishes are rare to uncommon in occurrence.

Low-exposure Sand

Plants. Most of the low-exposure habitats contain solid objects such as worm tubes or small rocks which provide firm substrates for algal attachment. No algae are attached directly to the sand. Red (Ceramiales, Gracilaria spp, Polysiphonia mollis) and brown algae (Dictyopteris undulata, Dictyota sp, Pachydictyon coriaceum, Sporochnus pedunculatus, Zonaria farlowii) commonly are found attached to tubes of the gray tube worm, Diopatra ornata, and the parchment worm, Chaetopterus variopedatus. These species also are attached to small rocks in the sand, as are other species of brown algae (Egregia menziesii, Sargassum muticum, Sphacelaria californica, Taonia lennebackeriae) and red algae (Botryocladia pseudodichotoma, Helminthocladia australis, Scinaia johnstoniae). The algal assemblage is dominated on a seasonal basis by "sargassum weed" (S. muticum), an introduced species from Japan. During the winter, it grows rapidly from a small (2 in, 5 cm) perennial thallus to heights of 9-30 ft (3-10 m). After reproduction from March through June, the tall and bushy adult dies back to the inconspicuous thallus.

Though most deepwater (>60 ft, 18 m) sandy substrates are devoid of algae, some low rocks embedded in the sand are covered by the large-bladed kelp, Laminaria farlowii.

Invertebrates. Relatively few invertebrates are present on low-exposure sand plains. Sea pansies (Renilla kollikeri), gray tube worms (D. ornata) and olive snails (Olivella sp) are common in some areas. Other invertebrates occasionally present include tube anemones (Pachycerianthus fimbriatus), tube worms (Chaetopterus variopedatus, Spiochaetopterus costarum), tube amphipods (Ampeliscidae), sand shrimp (Crangon sp), swimming crabs (Portunus xantusii), hermit crabs (Paguristes sp), cone snails (Conus californicus), moon snails (Polinices lewisii), navanax sea slugs (Navanax inermis), sea hares (Aplysia californica, A. vaccaria), phoronid worms (Phoronopsis californica), sand stars (Astropecten armatus), and southern sea cucumbers (Parastichopus parvimensis).

Deeper (>60 ft) stable sand plains occasionally contain sea pens (Stylatula elongata), frog shells (Bursa californica), turrid shells (Megasurcula carpenteriana), and white urchins (Lytechinus anamensus). Market squid (Loligo opalescens) spawn from November through March in the ASBS area, covering the sand substrates at depths down to 100 ft (30 m) or more with their egg capsules.

The assemblage of invertebrates living beneath the soft sediment surface was not sampled in this survey, but probably is diverse. Numerous species of small polychaetes, crustaceans, and bivalve mollusks are present in similar habitats around Catalina Island (see Dykzeul and Given 1979).

Fishes. The diurnal benthic fish assemblages in low-exposure, sandy/shelly debris habitats are characterized by moderate abundances of senoritas (Oxyjulis californica) and sheephead (Semicossyphus pulcher), with somewhat fewer numbers of small kelp bass, black perch, and blackeye gobies (Coryphopterus nicholsii). Angel sharks (Squatina californica) are uncommon and are partially buried and quiescent. No flatfishes were noted during the survey.

Abundances of water-column fishes vary with water clarity. When waters are clear, small schools of blacksmith (Chromis punctipinnis) and halfmoon are common. Only a few individuals of these species are present when the water is turbid.

Fishes associated with sandy/shelly debris areas at night differ substantially from the diurnal assemblages. Many species, such as flatfishes, rays, and angel sharks are partially buried during the day, but actively forage in areas of low- and high-water motion at night. Queenfish (Seriphus politus) migrate from diurnal retreats offshore into shallow, sandy areas at night, feeding primarily in the upper water column. Croakers (sciaenids), atherinids, walleye surfperch (Hyperprosopon argenteum), olive rockfish (Sebastes serranoides), and some kelp bass forage over sandy areas at night.

Small Rocks (low physical relief)

Plants. Unstable cobble and small rock habitats in shallow areas of moderate- to high-water motion either are devoid of macroalgae or support ephemeral populations of fine, filamentous green or brown algae. Red coralline algae are abundant on small rocks which are more stable, often covering 100% of the exposed rock surface. Encrusting corallines (Lithothamnion sp, Lithophyllum sp) predominate. Common erect (articulated) corallines include Lithothrix aspergillum, Corallina officinalis, Haliptylon gracile, and other unidentified species. In some areas, early successional-stage brown algae ("weed species") are present, including Colpomenia sinuosa/Hydroclathrus clathratus, Sargassum muticum, and Scytosiphon lomentaria. Small rocks which are overturned rarely by storm swells are covered by the brown algae (Dictyopteris undulata, Dictyota sp, Pachydictyon coriaceum, and Zonaria farlowii).

Invertebrates. Relatively few macroinvertebrates inhabit unstable, small rock habitats. Mobile herbivorous snails are present or common on rocks covered by ephemeral algae. These include gilded turbans (Tegula aureotincta), banded turbans (T. eiseni), queen turbans (T. regina), and wavy-top turbans (Astraea undosa). Present on more stable rocks are sessile invertebrates such as sponges (e.g., Clathrina sp), various hydroids, calcareous tube worms (Spirobranchus spinosus, Spirorbidae), tube snails (Serpulorbis squamigerus), encrusting bryozoans (e.g., Rhynchozoon rostratum/Parasmittina californica), and white tunicates (Trididemnum opacum). Orange cup corals (Balanophyllia elegans) are present on low-silted rocks at only one location in the ASBS (No-Name Cove). Present under more stable rocks are encrusting sponges (e.g., Hymenamphiastra cyanocrypta), bryozoans, and tunicates, as well as mobile shrimps (e.g., Alpheus sp), crabs (e.g., Paraxanthias taylori), brittle stars (e.g., Ophiothrix spiculata, Ophiopteris papillosa, Ophioderma panamense), and juvenile sea urchins (Strongylocentrotus sp). Red (S. franciscanus) and purple urchins (S. purpuratus) are abundant in crevices between small, relatively stable rocks. Some friable rocks are pitted by burrowing purple urchins.

Fishes. Sheephead (Semicossyphus pulcher) are the most abundant benthic fish in rocky areas (cobble and/or bedrock) with seasonal algal cover and low physical relief. All sizes are present. Other common benthic species are black perch (Embiotoca jacksoni), rock wrasse (Halichoeres semicinctus), senorita (Oxyjulis californica), and garibaldi (Hypsypops rubicundus). Small schools of opaleye (Girella nigricans) are common and sizes are distributed by depth, small individuals in shallow water and larger individuals in deeper areas. Small-to medium-sized kelp bass (Paralabrax clathratus) are present in low numbers, and adult sargo (Anisotremus davidsonii) occasionally can be observed. Island kelpfish (Alloclinus holderi) and spotted kelpfish (Gibbonsia elegans) are uncommon among the benthic rocks and algae, respectively.

Water-column fishes include blacksmith (Chromis punctipinnis), senoritas, and halfmoon (Medialuna californiensis). All are present in moderate numbers. Atherinids can be seen infrequently. Kelp perch (Brachyistius frenatus) are associated with the upper portions and canopy of giant kelp (Macrocystis pyrifera) plants, but in low abundances.

Medium Rocks (moderate physical relief)

Plants. Plant diversity is high in areas of medium-sized boulders exposed to the prevailing northwest swells. The macroalgal assemblage is dominated by forests of giant kelp (Macrocystis pyrifera) which cover most rocky habitats between 20-60 ft (6-18 m) in depth. In areas where giant kelp is dense and the surface canopy extenisve, little light is available to support understory algae. This situation, coupled with high densities of herbivorous red and purple urchins, results in boulders relatively barren of bushy or foliose algae. However, red coralline algae is abundant in these low-light areas, especially encrusting (Lithothamnion sp, Lithophyllum sp) and erect forms (Calliarthron cheilosporioides and/or Bossiella orbigniana).

Inshore from the Macrocystis canopy, or in areas where giant kelp is sparse, a variety of bushy and foliose algae predominate atop the boulders.

Pterocladia capillacea, Gelidium nudifrons, G. robustum, and Plocamium cartilagineum are the most common reds. Dominant brown algae include southern sea palms (Eisenia arborea), bladder kelp (Cystoseira sp), Sargassum muticum, and large-bladed Laminaria farlowii. Also present are smaller species of brown algae: Dictyopteris undulata, Dictyota sp, Pachydictyon coriaceum, and Zonaria farlowii. One species of green algae, Codium cuneatum, is common. Surf grass (Phyllospadix torreyi), a marine flowering plant, is dominant atop medium-sized boulders at depths of 5-15 ft (1.5-4.5 m). Much of the surf grass is covered by the encrusting coralline alga, Melobesia mediacris.

Offshore from the giant kelp beds (>60 ft in depth), most of the substrate is sand. The few deep-water boulder habitats are dominated by the brown algae, L. farlowii and E. arborea.

Invertebrates. Medium-sized boulders provide numerous microhabitats for a wide variety of invertebrates. Most conspicuous are large populations of red urchins (Strongylocentrotus franciscanus) encountered in areas where boulders provide many crevices. These herbivorous animals are capable of causing severe damage to giant kelp plants. Although understory vegetation is sparse in areas dominated by red urchins within the ASBS, the Macrocystis beds appear to be healthy. Also present in crevices are purple urchins (S. purpuratus), spiny lobsters (Panulirus interruptus), green abalone (Haliotis fulgens), pink abalone (H. corrugata), and two-spot octopus (Octopus bimaculatus). Less common are black urchins (Centrostephanus coronatus), chestnut cowries (Cyparea spadicea), and black abalone (H. cracherodii); the latter present only in depths less than 15 ft (4.5 m). Commercial lobster traps containing adult lobsters were observed during survey dives in boulder areas, but most of the lobsters noted in crevices were smaller than legal size (carapace length = 3.25 in). Similarly, adult pink and green abalone can be found in shallow water, but sublegal individuals (total length = 6 in) are much more common.

Boulders at depths from 30-60 ft (9-18 m) have little algal cover; instead they are dominated by the gorgonians, Muricea californica and M. fruticosa. These sea fans are especially common along the ecotone between giant kelp beds and the deeper sand plains. Also common on deeper boulders is a silty turf consisting of various sessile invertebrates. This assemblage includes sponges (e.g., Verongia aurea, Tethya aurantia), hydroids, cup corals (Astrangia lajollensis, Paracyathus stearnsi), calcareous tube worms (Spirobranchus spinosus), tube snails (Serpulorbis squamigerus), bryozoans (e.g., Rhynchozoon rostratum/Parasmittina californica, Bugula sp), and tunicates (e.g., Trididemnum opacum, Euherdmania claviformis). The southern sea cucumber, Parastichopus parvimensis, a detritus feeder, is common. Less common are the carnivorous gastropods, Kelletia kelletii and Pteropurpura trialata, and the blue sea star, Pisaster giganteus. Mobile invertebrates often present on boulders shallower than 30 ft include herbivores such as wavy-top turbans (Astraea undosa) up to 6 in. tall and queen turbans (Tegula regina). Also present are a detritus-feeding sea star (Linckia columbiae) and carnivores such as giant keyhole limpets (Megathura crenulata), hornmouths (Ceratostoma nuttalli), and gem murex (Maxwellia gemma).

Plant populations add more structural diversity to boulder reefs. The canopy, mid-stipe, and holdfast regions of Macrocystis plants provide microhabitats for numerous, mostly small, invertebrates. Within the interstices of giant kelp holdfasts dwell a variety of species from nearly every major invertebrate phylum. Frost bryozoans (Membranipora sp) and spirorbid polychaetes (Spirorbidae) commonly encrust blades of giant kelp and southern sea palms. Herbivorous kelp turbans (Norrisia norrisi) and gilded turbans (Tegula aureotincta) are common among the fronds of both kelp species. Smaller understory algae provide substrata for numerous epiphytic and mobile micro-invertebrates. For example, the orange colonial tunicate, Metandrocarpa dura, covers the lower blades of bladder kelp (Cystoseira sp) in some areas of Subarea II.

The shallow surf grass habitat also provides a heterogeneous environment for many invertebrate species. Sessile sponges, hydroids, and tunicates are attached to blades and roots. Small mobile mollusks and crustaceans inhabit the layer of decaying organic material and sediment which accumulates around the roots. Surf grass also serves as a nursery for juvenile spiny lobsters during their first year after settlement.

Fishes. Fishes are abundant in areas of medium-sized boulders and moderate physical relief. The benthic fish assemblage is dominated by sheephead (Semicossyphus pulcher) of all sizes. Large males were numerous and curious during the survey dives, often approaching or following the divers. Other fishes occurring in moderate to high densities are senoritas (Oxyjulis californica), kelp bass (Paralabrax clathratus), opaleye (Girella nigricans), garibaldi (Hypsypops rubicundus), and black perch (Embiotoca jacksoni). Occurring in lower abundances are rock wrasse (Halichoeres semicinctus), pile perch (Damalichthys vacca), and sargo (Anisotremus davidsonii). Small numbers of kelp perch (Brachyistius frenatus) are associated with the upper portions and canopy of giant kelp. An occasional giant kelpfish (Heterostichus rostratus) can be observed among the kelp fronds, and a few kelp rockfish (Sebastes atrovirens) hover near the kelp column or rest quietly on the bottom.

Among the small and cryptic fishes, blackeye gobies (Coryphopterus nicholsii) and island kelpfish (Alloclinus holderi) are abundant among the rocks, but bluebanded gobies (Lythrypnus dalli) and painted greenlings (Oxylebius pictus) are uncommon. Larger cryptic species such as horn sharks (Heterodontus francisci), swell sharks (Cephaloscyllium ventriosum), grass rockfish (Sebastes rastrelliger), and treefish (S. serriceps) are observed frequently within the rocky interstices. Large bat rays (Myliobatus californica) are rare.

Large schools of senoritas and blacksmith (Chromis punctipinnis) are present in the water column, especially in open areas between stands of giant kelp. Halfmoon (Medialuna californiensis) are common.

Large Rocks (high physical relief)

Plants. Two major plant assemblages are present in areas of high physical relief formed by large boulders and bedrock pinnacles. The rock-top assemblage is similar to that found on medium-sized boulders. In areas below 25 ft (8 m), it is dominated by giant kelp (less commonly, southern sea palms) and encrusting and erect coralline algae (usually Calliarthron cheilosporioides/Bossiella orbigniana). Shallow rock-tops (<25 ft) in moderately exposed areas are covered by lush growths of red algae (Pterocladia capillacea, Gelidium nudifrons, G. robustum), kelps (Eisenia arborea, Cystoseira sp), green algae (Codium cuneatum), and surf grass.

Contrasting with the rich plant cover on the rock-tops is the sparse algal assemblage on surgy and often shaded rock walls. Some Calliarthron cheilosporioides, Gelidium nudifrons, Plocamium cartilagineum, and Codium cuneatum are present. However, the larger bushy algae usually are replaced by various species of small foliose or filamentous reds interspersed with sessile invertebrates, together forming a low turf community. Present are Rhodymenia californica, R. pacifica, Rhodoglossum affine, Carpopeltis bushiae, Sciadophycus stellatus, and other unidentified species.

Invertebrates. Relatively few conspicuous invertebrates (other than epiphytes) can be seen on the tops of giant boulders covered by bushy algae. Invertebrates present are similar to those on medium-sized boulders. In contrast to the medium boulders, however, the sides of tall rocks and pinnacles are dominated by a rich assemblage of sessile, suspension-feeding invertebrates. Key members of this community are large and conspicuous gold (Muricea californica) and brown (M. fruticosa) gorgonians, as well as inconspicuous, but abundant, rock oysters (Chama arcana). Rock oysters cover nearly 100% of the rock surface on some vertical walls. Their highly rugose shells apparently promote settlement of invertebrates which camouflage the oysters from predators such as the blue sea star, Pisaster giganteus (Vance 1978).

Other sessile invertebrates which are present or common on vertical walls include sulphur sponges (Verongia aurea), various hydroids, strawberry anemones (Corynactis californica), cup corals (Astrangia lajollensis, Paracyathus stearnsi), calcareous tube worms (Spirobranchus spinosus), red-and-white barnacles (Megabalanus californicus), tube snails (Serpulorbis squamigerus), rock scallops (Hinnites giganteus), staghorn bryozoans (Diaperoecia californica), salmon sea cucumbers (Cucumaria salma), tunicates (Trididemnum opacum, Euherdmania claviformis, Pyura haustor), and other unidentified encrusting species. Less common are orange puffball sponges (Tethya aurantia), gray moon sponges (Spheciospongia confoederata), orange corals (Coenocyathus bowersi), pink gorgonians (Lophogorgia chilensis), several bryozoans (Bugula sp, Hippodiplosia insculpta, Lichenopora novae-zelandiae, Phidolopora labiata), and tunicates

(Clavelina huntsmani, Metandrocarpa taylori).

In general, mobile predators are less common on vertical walls than on sloping or horizontal surfaces. Those present include giant keyhole limpets (Megathura crenulata), cone snails (Conus californica), hornmouths (Ceratostoma nuttalli), gem murex (Maxwellia gemma), and blue sea stars (Pisaster giganteus). Small comet sea stars (Linckia columbiae) also are present. Black urchins (Centrostephanus coronatus) occasionally can be found in depressions or crevices on rock walls, from which they emerge at night to forage on encrusting invertebrates.

Red urchins (Strongylocentrotus franciscanus) are common to abundant in crevices at the bases of giant boulders. Also present are purple urchins (S. purpuratus), spiny lobsters (Panulirus interruptus), green abalone (Haliotis fulgens), pink abalone (H. corrugata), and two-spot octopus (Octopus bimaculatus).

Fishes. Senoritas (Oxyjulis californica), sheephead (Semicossyphus pulcher), and the cryptic island kelpfish, Alloclinus holderi, are the most common fishes associated with habitats of high physical relief. Large opaleye (Girella nigricans) frequently can be observed foraging along the bottom, as well as within the upper portions and canopy of giant kelp. Other fishes present, but in lower numbers, are black perch (Embiotoca jacksoni), kelp bass (Paralabrax clathratus), rock wrasse (Halichoeres semicinctus), and garibaldi (Hypsypops rubicundus). A few rubbberlip perch (Rhacochilus toxotes) and kelp rockfish (Sebastes atrovirens) hover in the water column near columns of giant kelp. The giant kelpfish (Heterostichus rostratus) can be found infrequently among the kelp fronds.

The blackeye goby is the only commonly observed cryptic species; others such as horn sharks (Heterodontus francisci), moray eels (Gymnothorax mordax), and bluebanded gobies (Lythrypnus dalli) rarely are seen. Two black croakers (Cheilotrema saturnum) were noted during the survey in deep and dark caves formed by large boulders, and a single spotfin croaker (Roncador stearnsii) was observed in more open areas. A small school of juvenile sargo (Anisotremus davidsonii) with the typical juvenile, striped pattern was present under a rocky ledge in shallow water.

Halfmoon (Medialuna californiensis) and blacksmith (Chromis punctipinnis) are moderately abundant in the water column along the edges of the kelp forest; a few individuals are in open areas within the forest. Kelp perch (Brachyistius frenatus) and small senoritas are abundant in the kelp canopy.

Another important nearshore habitat for fishes is surf grass (Phyllospadix torreyii), usually located on rocky surfaces between the nearshore margins of giant kelp forests and the intertidal zone. Surf grass beds offer areas of high physical relief for fishes residing within the habitat, but areas of low relief for fishes swimming overhead.

Surf grass beds within the ASBS are relatively common, but small in size. Strong surge and water motion make these areas difficult to sample, but they can be expected to shelter small benthic fishes such as the spotted kelpfish (Gibbonsia elegans), reef finspot (Paraclinus integripinnis), blennies (Hypsoblennius spp), pipefish (Syngnathus spp), and cottids (Artedius spp, Clinocottus spp). Along the edges of the bed, opaleye, kelp bass, sheephead, and senoritas are present. Blacksmith and atherinids occasionally can be found in the water column above the bed.

At night, the distribution of fishes in rocky areas with all types of physical relief changes dramatically. Sheephead, garibaldi, blacksmith, and opaleye seek shelter among the rocks and within rocky crevices. Rock wrasse and many kelp bass nestle in the benthic algae and rocks, while senoritas bury in the sand and shelly debris of adjacent areas. Other diurnally active fishes do not change locations at night but are inactive.

Kelp rockfish are one of the few nocturnally active fishes, foraging in the open areas of kelp forests, as well as in the upper and canopy portions of giant kelp. Swell sharks, horn sharks, and moray eels also are more active at night. Other fishes such as queenfish (*Seriphus politus*) and walleye surf-perch (*Hyperprosopon argenteum*) may move into the kelp forests from adjacent sandy areas.

ASBS Subarea IV

High-exposure Sand

Plants. Shallow, shifting sand habitats within the ASBS are relatively barren. Typically, small amounts of algal debris drift over areas with small sand ripples. A few isolated eelgrass plants (*Zostera marina*) are present. Worm tubes can be found in some areas, each covered with species of ephemeral brown and red algae. Stable rocks on the sand are covered by bladder kelp (*Cystoseira* sp), southern sea palms (*Eisenia arborea*), surf grass (*Phyllospadix torreyi*), and the red alga, *Pterocladia capillacea*. Sargassum weed (*Sargassum muticum*) is attached to some less stable rocks.

Invertebrates. Relatively few invertebrate species are present on shallow, unstable sand habitats. Burrowing heart urchins (*Lovenia cordiformis*), purple olive snails (*Olivella* sp), and tube-dwelling amphipods (Ampeliscidae) are common in some areas. The amphipods can be found clinging onto drift debris in the troughs of sand ripples. Less common are sea pens (*Stylatula elongata*), parchment worms (Chaetopterus variopedatus), gray tube worms (Diopatra ornata), sand stars (Astropecten armatus), and sand dollars (Dendraster sp). Several "ghost" lobster traps lost by commercial fishermen were encountered during survey dives. Most were empty, but one trap contained nine legal-sized lobsters. Single specimens of three northern (cold-water) echinoderms were encountered near the rock quarry. These species, unusual for shallow water at Catalina Island, are the northern sea cucumber, Parastichopus californica, the pink sea star, Pisaster brevispinis, and the red sea star, Mediaster aequalis.

Fishes. Only two fish species typically are present in high-exposure sand habitats: the thornback ray, Platyrhinoides triseriata, and small sand dabs (Citharichthys sp). No fishes are present in the water column. More fishes may move into this area at night, as discussed previously (see High-exposure Sand description for Subarea II).

Low-exposure Sand

Plants. An unusual algal assemblage was discovered during the diving survey at depths of 40-60 ft (12-18 m) in the center of the ASBS (Fig. 14). Here, the fine-sand habitat is relatively free of disturbance by swells and surge, and infaunal invertebrates (especially tube-building polychaetes) are abundant. The stability of the sediment allows attachment and growth of filamentous red algae (primarily Polysiphonia mollis) directly on the substrate. In some areas, this fragile algal turf forms scattered low mounds or clods. The extent of the turf may vary seasonally, as it was well developed in December 1979, but sparse in May 1980.

Invertebrates. The unique stable sand habitat, located at depths of 40-60 ft in the center of the ASBS, is a rich area for soft-bottom invertebrates.

Tube worms (Spirochaetopterus costarum, Chaetopterus variopedatus, Diopatra ornata, Myxicola infundibulum) and orange phoronid worms (Phoronopsis californica) are abundant. Small sea pens (Stylatula elongata), sand shrimp (Crangon sp), southern sea cucumbers (Parastichopus parvimensis), sand stars (Astropecten armatus), sea hares (Aplysia californica), and siphons from geoducks (Panopea generosa) and jackknife clams (Tagelus sp) are common. Less common are sand hydroids (Corymorpha palma), tube anemones (Pachycerianthus fimbriatus), swarms of mysid shrimp (Mysidacea), crabs (Cancer gracilis, Portunus xanthusii, Randallia ornata), anomuran crabs (Blepharipoda occidentalis, Paguristes sp), opistobranch mollusks (Bulla gouldiana, Navanax inermis, Hermissenda crassicornis, Rictaxis punctocelatus), snails (Bursa californica, Conus californicus, Fusinus luteopictus, Megasurcula carpenteriana, Pollinices lewisii), and brittle stars (Amphiodia sp, Ophiopsila californica). Numerous other inverebrates probably live beneath the surface of this stable, organic-rich sand. Many internal shells (pens) of market squid (Loligo opalescens) were lying on the sand in December 1979, suggesting that squid recently had spawned, died, and decomposed within the ASBS. A few squid egg capsules were attached to the substrate.

The invertebrate assemblage below 60 ft (18 m) on the stable sand is dominated by white sea urchins (Lytechinus anamesus). Deep-water sea pens (Acanthoptilum gracile, Virgularia sp) and mantis shrimp (Stomatopoda) burrows are present, in addition to some of the invertebrates listed above for 40-60 ft depths.

Fishes. The benthic fish assemblage associated with low exposure, sand/shelly debris habitats within Subarea IV is dominated by the orangethroat pikeblenny, Chaenopsis alepidota. This small species lives in unoccupied worm tubes (usually Chaetopterus). It is uncommon north of the Gulf of California, and relatively few individuals have been reported from Catalina Island, none from Subareas I, II, or III. The population within Subarea IV is one of the largest observed in southern California and consists of individuals ranging in size from 3-5 in (80-120 mm) total length. Thus, the population appears to be well established.

During the first diving survey from 29 November through 4 December 1979, most blennies were observed darting among the algae-encrusted worm tubes and resting under the algal cover. Few individuals were noted within the tubes. During the second survey (11 May 1980), most blennies were found in the tubes, possibly because the algae had disappeared and the area was devoid of protective cover. When present, the algae also provided a habitat for pipefish (Sygnathus sp); however, this species rarely was observed. No other fishes were noted within the algal habitat.

Numerous fishes are present in non-algal portions of the low exposure, sand/shelly debris habitat. Blackeye gobies (Coryphopterus nicholsii), small kelp bass (Paralabrax clathratus), quiescent juvenile and adult angel sharks (Squatina californica), sargo (Anisotremus davidsonii), small bat rays (Myliobatis californica), sand dabs (Citharichthys spp), and C-O turbots (Pleuronichthys coenosus) are moderately abundant. Thornbacks (Platyrhinoides triseriata) and large horn sharks (Heterodontus francisci) are uncommon. Blacksmith (Chromis punctipinnis) are the only fish present in the water column, often forming very large schools at levels within visual contact of the benthos.

Nocturnal fish assemblages associated with low-exposure sandy habitats undoubtedly are different from diurnal assemblages. These differences have been discussed in the description of low-exposure sandy habitats for

Subarea II, above.

Small Rocks (low physical relief)

Plants. Unstable cobble and small rock habitats in shallow areas with moderate surge either are devoid of macroalgae or support ephemeral populations of fine, filamentous green or brown algae. Opportunistic "weed species" of brown algae (*Colpomenia sinuosa*/*Hydroclathrus clathratus*, *Scytosiphon lomentaria*, *Sargassum muticum*, *Desmarestia* sp) are abundant on cobble in protected areas (i.e., the rock quarry). Common on small, silted rocks in low-exposure habitats are green (*Codium cuneatum*, *C. fragile*), brown (*Dictyopteris undulata*, *Dictyota* sp, *Pachydictyon coriaceum*, *Sargassum muticum*, *S. palmeri*, *Zonaria farlowii*), and red algae (*Laurencia* sp). The fuzzy epiphyte, *Acinetospora nicholsoniae*, often covers individual *S. muticum*. Some rocks are dominated by various species of encrusting and erect corallines (e.g., *Lithothamnion*/*Lithophyllum*, *Lithothrix aspergillum*). Young giant kelp plants (*Macrocystis pyrifera*) are common on small rocks near the rock quarry in December.

Invertebrates. Relatively few macroinvertebrates inhabit unstable, small rock habitats. Grazing snails (small *Astraea undosa*, *Tegula aureotincta*, *T. eiseni*), barnacles, and southern sea cucumbers (*Parastichopus parvimensis*) are present or common in shallow areas of the ASBS. In protected locations where small rocks rarely are disturbed, aggregations of calcareous tube snails (*Serpulorbis squamigerus*) are abundant on the sides of rocks, and black urchins (*Centrostephanus coronatus*) are common in crevices between rocks. Red and purple urchins are rare or absent. Sea stars rarely are present, but one group of bat stars (*Patiria miniata*) was noted during survey dives. Rock-tops are dominated by algae, however, some bryozoans (e.g., *Rhynchozoon rostratum*/*Parasmittina californica*, *Bugula* sp) and small carnivorous snails (e.g., Conus californicus, Ceratostoma nuttalli) are present as well. Under-rock fauna includes a variety of encrusting sponges, bryozoans, and tunicates, as well as mobile worms, shrimps, crabs, mollusks, and brittle stars.

Fishes. Some areas of low physical relief with small- to medium-sized boulders are dominated by the small, bluebanded goby, Lythrypnus dalli. In other areas, the bluebanded goby is joined by blackeye gobies (Coryphopterus nicholsii), garibaldi (Hypsypops rubicundus), opaleye (Girella nigricans), kelp bass (Paralabrax clathratus), and island kelpfish (Alloclinus holderi) as the most common fishes. Somewhat less numerous are sheephead (Semicossyphus pulcher) and rock wrasse (Halichoeres semicinctus). Pile perch (Damalichthys vacca), California morays (Gymnothorax mordax), and senoritas (Oxyjulis californica) are present in lower numbers. Infrequently observed are horn sharks (Heterodontus francisci), giant kelpfish (Heterostichus rostratus), grass rockfish (Sebastes rastrelliger), treefish (S. serriceps), and spotted kelpfish (Gibbonsia elegans). A single black croacker, Cheilotrema saturnum, was observed during survey dives deep within a small cavity formed by fallen boulders.

Blacksmith (Chromis punctipinnis) are common throughout the water column, frequently forming mixed aggregations with the less numerous atherinids and halfmoon (Medialuna californiensis). Kelp perch (Brachyistius frenatus) are moderately abundant around kelp canopies and columns, but are less frequent in other areas.

Medium Rocks (moderate physical relief)

Plants. The narrow zone of silty, medium relief rocks inshore of extensive sand plains is dominated by a variety of conspicuous species of algae. Giant kelp (Macrocystis pyrifera) forests are common in some areas, although most are small in size. Inshore from the kelp canopy, or in areas where giant kelp is sparse, the following brown algae predominate: southern sea palms (Eisenia arborea), bladder kelp (Cystoseira sp), Halidrys dioica, and Sargassum muticum. Also present are numerous species of red algae (Gelidium robustum, G. nudifrons, G. purpurascens, Pterocladia capillacea, Plocamium cartilagineum), erect corallines (Calliarthron cheilosporioides/Bossiella orbigiana, Corallina officinalis, C. vancouveriensis, Haliptylon gracile, Lithothrix aspergillum, and others), and surf grass (Phyllospadix torreyi). Epiphytes such as Acrosorium uncinatum (on Gelidium spp) are common. Less common are Codium cuneatum, C. fragile, feather-boa kelp (Egregia menziesii), small browns (Dictyopteris undulata, Dictyota sp, Pachydictyon coriaceum, Zonaria farlowii), and reds (Rhodoglossum affine, Rhodymenia californica, R. pacifica). The lower sides of rocks along the sand/rock ecotone are free of attached algae as shifting sand periodically covers and uncovers these areas. The large-bladed kelp, Laminaria farlowii, is present on some rocks in deeper water.

Invertebrates. Many different invertebrates are associated with silted or sandy boulder habitats, yet few species are dominant. Abundances vary considerably throughout the ASBS, and may be a result of local differences in the degree of water motion, siltation, and sanding. For example, red urchins (Strongylocentrotus franciscanus) are common near moderately exposed Church Rock, but rare near the more protected rock quarry. Abundances of black urchins (Centrostephanus coronatus) show the opposite trend: common near the quarry and uncommon near Church Rock. Other locally common crevice-dwellers are spiny lobsters (Panulirus interruptus) and two-spot octopus (Octopus bimaculatus). Less common are purple urchins (S. purpuratus), pink abalone (Haliotis corrugata), green abalone (H. fulgens), and red rock shrimp (Lysmata californica). Gorgonians (Muricea californica, M. fruticosa), southern sea cucumbers (Parastichopus parvimensis), and giant keyhole limpets (Megathura crenulata) are conspicuous on some boulders. Small zoanthid anemones (Epizoanthus sp) and tube snails (Serpulorbis squamigerus) also are common. Sessile invertebrates present on rock surfaces include sponges (e.g., Verongia aurea), hydroids (e.g., Lytocarpus nuttingi), anemones (e.g., Corynactis californica), cup corals (Astrangia lajollensis, Paracyathus stearnsi), calcareous tube worms (Spirobranchus spinosus), bryozoans (e.g., Bugula sp), and tunicates (e.g., Euherdmania claviformis, Metandrocarpa taylori, Trididemnum opacum). Mobile gastropods (Aplysia californica, A. vaccaria, Astraea undosa, Conus californicus, Norrisia norrisi, Tegula regina) generally are uncommon. Sea stars are rare except for some blue stars (Pisaster giganteus) near the rock quarry.

Various small invertebrates are associated with the abundant plant cover in Subarea IV. Kelp holdfasts, surf grass rhizome systems, and other plant surfaces provide complex microhabitats for faunal assemblages. Most species are inconspicuous, but a few are obvious. For example, arms from countless brittle stars (Ophiothrix spiculata) can be seen projecting from the interstices of Macrocystis holdfasts. Also conspicuous are bryozoans (Membranipora sp) encrusting the surfaces of large algae, such as southern sea palms and giant kelp.

Fishes. Rock wrasse (Halichoeres semicinctus), sheephead (Semicossyphus pulcher), senorita (Oxyjulis californica), garibaldi (Hypsypops rubicundus), kelp bass (Paralabrax clathratus), black perch (Embiotoca jacksoni), and horn sharks (Heterodontus francisci) are the most abundant fishes associated with areas of medium physical relief. Commonly observed, but in somewhat fewer numbers, are smaller species: island and spotted kelpfish (Alloclinus holderi, Gibbonsia elegans) and bluebanded and blackeye gobies (Lythrypnus dalli, Coryphopterus nicholsii). Treefish (Sebastes serriceps) are common. A single aggregation of 15 black croakers (Cheilotrema saturnum) was noted during survey dives deep within a small cave. Sargo (Anisotremus davidsonii), opaleye (Girella nigricans), and pile perch (Damalichthys vacca) are present in low numbers. Giant kelpfish (Heterostichus rostratus), California morays (Gymnothorax mordax), and grass rockfish (Sebastes rastrelliger) are observed infrequently, as are the surfperches: white (Phanerodon furcatus), walleye (Hyperprosopon argenteum), rubberlip (Rhacochilus toxotes), and rainbow (Hypsurus caryi). The observation of a rainbow surfperch during the survey was highly unusual, as this species is extremely rare at Catalina; it is fairly common on the northern Channel Islands. An adult zebraperch (Hermosilla azurea) also was noted. Juveniles are present elsewhere at Catalina, but adults rarely are observed.

Large schools of blacksmith (Chromis punctipinnis) are abundant throughout the water column. Atherinids and halfmoon (Medialuna californiensis) are present in fewer numbers. Kelp perch (Brachyistius frenatus) are numerous in giant kelp vegetation.

Large Rocks (high physical relief)

Plants. The tops of large rocks or pinnacles in depths from 20-60 ft (6-18 m) are dominated by stands of giant kelp, Macrocystis pyrifera. In the few areas where giant kelp is dense, bushy understory algae are sparse.

Various species of erect coralline algae, however, are common on rock surfaces between the Macrocystis holdfasts. Rock-tops in depths less than 20 ft (or deeper if Macrocystis is uncommon) support various species of foliose and bushy algae, including southern sea palms (Eisenia arborea), bladder kelp (Cystoseira sp), reds (Gelidium robustum, G. nudifrons, G. purpurascens, Pterocladia capillacea, Plocamium cartilagineum), and surf grass (Phyllospadix torreyi). Plant cover is less developed on steep rock walls, especially in shaded areas. Some vertical walls in shallow depths are covered by the reds, P. capillacea or P. cartilagineum. Usually, the larger bushy algae are replaced by various species of small, foliose or filamentous red algae, interspersed with sessile invertebrates, forming a low-turf community. Algal species in the turf include Rhodymenia californica, R. pacifica, Rhodoglossum affine, Carpopeltis bushiae, and other unidentified species.

Invertebrates. Relatively few macroinvertebrates are encountered on giant boulder tops dominated by bushy algae. Herbivorous kelp turbans (Norrisia norrisi) are common on southern sea palms. Most of the sea palms are heavily encrusted with frost bryozoans (Membranipora sp). The sides of large rocks and pinnacles are dominated by a rich assemblage of sessile, suspension-feeding invertebrates. Large gorgonians (Muricea californica, M. fruticosa) are common, especially near the bases of boulders in deeper water. Some of the gorgonians have been overgrown and killed by the colonial zoanthid anemone, Parazoanthus lucificum. Much of the vertical wall surface is covered with rock oysters (Chama arcana). Attached to the rugose outer shells of the oysters or to any other available space on the wall are orange puffball sponges (Tethya aurantia), gray moon sponges (Speciospongia confoederata), hydroids, pink gorgonians (Lophogorgia chilensis), strawberry anemones (Corynactis californica), cup corals (Astrangia lajollensis, Paracyathus stearnsi), calcareous tube worms (Spirobranchus spinosus), red-and-white barnacles (Megabalanus californicus), tube snails (Serpulorbis squamigerus), rock scallops (Hinnites giganteus), bryozoans (Bugula sp, Diaperoecia californica, Hippodiplosia insculpta, Lichenopora novae-zelandiae, Phidolopora labiata), salmon sea cucumbers (Cucumaria salma), white tunicates (Trididemnum opacum), and other unidentified encrusting species. Mobile carnivores present on rock walls include giant keyhole limpets (Megathura crenulata), iodine sea slugs (Flabellinopsis iodinea), blue sea stars (Pisaster giganteus), and black urchins (Centrostephanus coronatus). The black urchins are present only in depressions or crevices which provide shelter from wave surge and protection from predatory fish (e.g., sheephead, Semicossyphus pulcher).

Fishes. Sheephead and rock wrasse (Halichoeres semicinctus) are the dominant fishes associated with areas of high physical relief in Subarea IV. Also common in these areas are black perch (Embiotoca jacksoni), senorita (Oxyjulis californica), garibaldi (Hypsypops rubicundus), and kelp bass (Paralabrax clathratus). Island kelpfish (Alloclinus holderi), spotted kelpfish (Gibbonsia elegans), and blackeye gobies are present in low numbers, but giant kelpfish (Heterostichus rostratus) and bluebanded gobies (Lythrypnus dalli) are uncommon. Sargo (Anisotremus davidsonii), opaleye (Girella nigricans), and horn sharks (Heterodontus francisci) also are present in low numbers.

Blacksmith (Chromis punctipinnis) are moderately abundant throughout the water column. Atherinids and halfmoon (Medialuna californiensis) are less abundant but can be commonly observed in the water column.

Nocturnal fish assemblages associated with rocky substrates are different than the diurnal assemblages. These differences have been discussed in the description of the large boulder habitat for Subarea II, above.

Intertidal Biota

ASBS Subarea II

The intertidal zone of ASBS Subarea II consists primarily of unprotected, open-coast habitats according to the scheme presented by Ricketts et al. (1968). The ASBS is fully exposed to the effects of westerly winds and swells because of its north/south orientation. Furthermore, as the shoreline drops quickly into the deep water, the nearshore shelf and kelp beds are too narrow to provide more than minimal protection from prevailing swells. Variations in the degree of exposure within the ASBS are related to the irregular coastal topography (Fig. 9). Northwest-facing sides of headlands are more exposed than southwest-facing aspects. West-facing beaches at Shark, Cottonwood, and Ben Weston Coves are subjected to considerably greater surf than the small, south-facing beach at Little Harbor. Little Harbor is protected further by a partially submerged reef extending from the northwestern rocky headland.

Most of the intertidal shoreline of Subarea II consists of a narrow band of rock fragments at the bases of steep cliffs. These talus shores are composed of large boulders mixed with small rocks and cobble. On some headlands, short bedrock platforms extend out from the cliff bases. Tidepools are infrequent and small. Sand beaches are located at Little Harbor, Shark Cove, Cottonwood Cove, and Ben Weston Beach. Gravel patches are present on these beaches, especially in winter. A small cobble beach is located at No-Name Cove.

The organisms associated with sandy and rocky intertidal habitats within Subarea II are listed in Appendix 3 and are discussed below.

Sandy Intertidal Biota

Plants. Attached plants are not present on exposed and semi-protected soft substrate beaches within ASBS Subarea II. Drift algae, primarily giant kelp (*Macrocystis pyrifera*) and southern sea palms (*Eisenia arborea*), often are present along the high tide line, especially after storms. Semi-terrestrial coastal strand plants are found on stabilized sand dunes rarely inundated by the sea (see Land Vegetation, below).

Invertebrates. Relatively few macroinvertebrates are found on sandy beaches within Subarea II. Extensive movement of sand precludes most organisms from living in these areas. Beaches at Little Harbor and Shark Cove were surveyed by Straughan (1978) in Summer 1977 and Winter 1978. Crustaceans and insects were the only animals collected in line transect samples (Appendix 3). These surveys and those by the investigators found that beach hoppers (*Orchestoidea* spp), sand isopods (*Tylos punctatus*), various beetles, and kelp flies (*Coelopa vanduzeei*) are present wherever drift kelp accumulates on the beach. Patches of small sand crabs (*Emerita analoga*) have been found in the surf line on all four sandy beaches.

Fishes. The intertidal regions of all sandy beaches within Subarea II are used as spawning areas by the California grunion (*Leuresthes tenuis*). Every two weeks from late February to August, grunion swim onto sandy beaches to deposit fertilized eggs in the cool, moist sand. The timing is fairly precise: 2-5 nights after each new or full moon and 30-60 minutes after the night high tide. Females burrow vertically into the sand to deposit the eggs. Males wrap around the burrowed females, releasing sperm which flows down the body of the female and fertilizes the buried eggs. A typical grunion run lasts 1-3 hours and can involve many thousands of fishes. Although grunion may run on most sandy beaches at Catalina, the Little Harbor and Shark Cove runs are by far the largest. The investigators recall past runs in which a solid band of fish 10-12 ft wide extended across most of the beach at Little Harbor and a third of the beach at Shark Cove.

Rocky Intertidal Biota

In general, all of the rocky areas have a similar flora and fauna and are treated together (Table 6). Differences due to variations in degree of exposure are mentioned. Intertidal life extends further up the shore in areas fully exposed to prevailing winds and waves than in partially protected areas. Zonation is most distinct on large rocks or bedrock platforms. The discussion of rocky intertidal shores follows the general zonation scheme of Ricketts et al. (1968) (Table 6).

Plants. The uppermost horizon (Zone 1 or Splash Zone) is relatively barren. A few semi-terrestrial lichens and a film of microscopic blue-green algae are the only species present. In the high intertidal (Zone 2), scattered tufts of low red algae (e.g., Endocladia muricata, Gelidium pusillum, Gloiopeltis furcata) are common. Patches of tar-spot brown algae (Ralfsia sp, Pseudolithoderma nigra), spongy brown algae (Cylindrocarpus rugosus), and encrusting coralline algae (Lithothamnion/Lithophyllum) are present, especially on shaded rock walls. Tiny growths of ephemeral algae, including Porphyra perforata, Enteromorpha sp, and Ulva sp are present on rocks along the edges of sandy beaches. Sand abrasion apparently eliminates herbivores which would normally graze these algae. The high intertidal rockweeds, Pelvetia fastigiata and Hesperophycus harveyanus, are present only in partially sheltered areas, such as the north sides of Shark Cove and Little Harbor.

The middle intertidal (Zone 3) is dominated by a low turf consisting

Table 6. Dominant organisms within the various rocky intertidal zones of Santa Catalina Island ASBS Subarea II (following Ricketts et al. 1968).

Zone 1 (Uppermost Horizon) [+5.0 to 7.0 ft above MLLW]:

Littorina planaxis (eroded periwinkle)

Microalgae film (mostly microscopic blue-green algae)

Chthamalus fissus (acorn barnacle)

Ligia occidentalis (rock slater)

Collisella digitalis (fingered limpet)

Balanus glandula (acorn barnacle)

Zone 2 (High Intertidal) [+2.5 to 5.0 ft above MLLW]:

Collisella scabra (rough limpet)

Lottia gigantea (owl limpet)

Tetraclita rubescens (thatched barnacle)

Endocladia muricata (small red alga forming clumps)

Gelidium pusillum (small red alga forming clumps)

Littorina scutulata (checkered periwinkle)

Pachygrapsus crassipes (lined shore crab)

Tegula funebralis (black turban snail)

Ralfsia sp (tar-spot brown algae)

Cylindrocarpus rugosus (spongy brown algae)

Zone 3 (Middle Intertidal) [+0.0 to 2.5 ft above MLLW]:

Mytilus californianus (California mussel)

Pollicipes polymerus (gooseneck barnacle)

Corallina spp (erect coralline algae)

Lithothamnion/Lithophyllum (encrusting coralline algae)

Gigartina canaliculata (red algae)

Gelidium/Pterocladia (red algae)

Laurencia pacifica (red alga)

Rhodoglossum affine (red alga)

Gigartina leptorhynchus (red alga)

Rhodymenia spp (red algae)

Sargassum agardianum (brown alga)

Table 6 (continued)

Zone 3 (continued)

Pseudochama exogyra (reversed rock oyster)
Collisella limatula (smooth limpet)
Pagurus samuelis (hermit crab)

Zone 4 (Low Intertidal) [-1.6 to 0.0 ft below MLLW]:

Eisenia arborea (southern sea palm)
Phyllospadix torreyi (surf grass)
Halidrys dioica (bladder kelp)
Sargassum muticum (sargassum weed)
Egregia menziesii (feather-boa kelp)
Haliotis cracherodii (black abalone)
Strongylocentrotus purpuratus (purple urchin)
Strongylocentrotus franciscanus (red urchin)
Serpulorbis squamigerus (tube snail)
Tegula eiseni (banded turban)
Norrisia norrisi (kelp turban)
Ceratostoma nuttalli (Nuttall's hornmouth)
Zonaria farlowi (brown alga)
Codium fragile (green alga)
Gelidium/Pterocladia (red algae)
Encrusting and erect coralline algae

of erect corallines (e.g., Corallina officinalis, C. vancouverensis, Lithothrix aspergillum, Jania spp), encrusting corallines (Lithothamnion/ Lithophyllum), bushy reds (e.g., Gigartina canaliculata, G. leptorhynchus, Gelidium/Pterocladia, Laurencia pacifica, Sargassum agardhianum), and foliose reds (e.g., Rhodoglossum affine, Rhodymenia californica, Rhodymenia pacifica). Less common are Gastroclonium coulteri, Endarachne binghamiae, and Gigartina spinosa. The bulbous brown algae, Colpomenia/Hydroclathrus and Leathesia difformis may be common seasonally. On semi-protected boulders in Little Harbor, the erect corallines, Corallina vancouverensis and Lithothrix aspergillum, form dense algal mats up to 2 in thick. These mats become impregnated with sand and debris.

The flora of the low intertidal (Zone 4) are practically indistinguishable from that on the shallow subtidal reefs discussed above. Dominating this rich algal assemblage are dense patches of southern sea palms (Eisenia arborea) and sea grass (Phyllospadix torreyi). Sea palms with long, thick stipes are especially abundant along rocky headlands exposed to surf and swell. Surf grass completely covers many low intertidal boulder tops in exposed and semi-exposed areas. Numerous epiphytes are attached to the surf grass blades, including the encrusting red alga, Melobesia mediacris, and the iridescent red alga, Chondria californica. The kelp, Halidrys dioica, is abundant at the zero tide level in summer and fall but dies back to a low vegetative thallus in winter and spring. Other conspicuous algae include Sargassum muticum, S. palmeri, Egregia laevigata, Cystoseira sp, Zonaria farlowii, Dictyota/Pachydictyon, Gelidium/Pterocladia, Plocamium cartilagineum, and various erect corallines. Areas grazed by black abalone (Haliotis cracherodii) are covered by encrusting corallines (Lithothamnion/Lithophyllum). Silted rocks in low-exposure areas within Little Harbor have low algal diversity. Mats of erect corallines (Corallina/Lithothrix), tufts of foliose brown (Zonaria farlowii), and clumps of finger-like green algae (Codium fragile) are common.

Invertebrates. In the uppermost portions of the intertidal (Zone 1), herbivorous periwinkles (Littorina planaxis) are found within small pits or crevices. Acorn barnacles (Chthamalus fissus) become abundant in the lower parts of this zone. These small white barnacles may cover up to 100% of the rock surface. Less common are slightly larger acorn barnacles (Balanus glandula) and scattered finger limpets (Collisella digitalis). The omnivorous isopod, Ligia occidentalis, is abundant in large boulder areas. All of these splash zone organisms are well adapted to withstand dessication and extreme temperatures.

Splash zone organisms also are found in the high intertidal (Zone 2), but are less common. An important herbivore in high-exposure areas is the large territorial owl limpet, Lottia gigantea. Owl limpets can be found tucked against irregularities on the rock surface in the region between areas dominated by barnacles and beds of mussels (Mytilus californianus). Lottia territories are conspicuous as patches of bare rock surface up to two square feet in area. These grazing spaces are maintained by actively eliminating newly settled barnacles, limpets, or mussels, and by driving out all invading herbivores. Another common high intertidal limpet, Collisella scabra, typically is found outside of Lottia territories. Large adults, however, apparently can resist aggression by Lottia.

Ridges and peaks in the high intertidal are populated by the large thatched barnacle, Tetraclita rubescens. Checkered periwinkles (Littorina scutulata) and small mussels (Brachidontes adamsianus) are present in narrow cracks.

Black turban snails (Tegula funebralis) and lined shore crabs (Pachygrapsus crassipes) are common in crevices between boulders. In semi-protected areas, porcelain crabs (Petrolisthes cabrilloi) are abundant under small rocks.

The middle intertidal (Zone 3) often is dominated by beds of California mussels (Mytilus californianus), especially on fully exposed bedrock platforms. Mussels attach to the underlying substrate and other mussels by secreting strong byssal threads. Sediment and detritus are trapped within the three-dimensional structure of the mussel bed, thus providing a heterogeneous environment for a wide variety of small invertebrates, including anemones, worms, mollusks, crustaceans, brittle stars, and bryozoans. Over 100 species of invertebrates have been identified from a mussel bed at Bird Rock on the lee side of Catalina Island (Kanter, 1978). Other organisms, such as thatched barnacles (T. rubescens) and various species of algae, grow on the mussel shells. Clumps of gooseneck barnacles (Pollicipes polymerus) also are associated with mussels.

Few invertebrates are present on sand-scoured rocks along the edge of exposed beaches, such as Shark and Ben Weston Coves. In some areas, the aggregating green anemone, Anthopleura elegantissima, is present on the lower sides and leeward faces of sand-scoured rocks. These middle intertidal anemones commonly cover themselves with bits of shell or coarse sand and are barely recognizable when fully contracted.

Algae dominate smaller boulders in the middle intertidal zone of semi-protected areas and harbor many small invertebrates. Reversed rock oysters (Pseudochama exogyra), volcano limpets (Fissurella volcano), mossy chitons (Mopalia muscosa), and other mollusks attach to rock surfaces under the plants. Smooth limpets (Collisella limatula) are common under algae and on rock sides in boulder areas. Hermit crabs (Pagurus samuelis), living in turban snail shells, forage along the bottom of small tide pools between rocks. Under rocks in the semi-protected areas of Little Harbor can be found aggregations of tube snails (Serpulorbis squamigerus), chitons (e.g., Cyanoplax hartwegii, Stenoplax conspicua), ribbed hoof shells (Hipponix tumens), crabs (e.g., Lophopanopeus frontalis, Petrolisthes cabrilloi), shrimps (e.g., Betaeus sp, Heptacarpus sp), and brittle stars (e.g., Ophioderma panamense).

Organisms of the low intertidal zone (Zone 4) are similar to those found on shallow subtidal rocks and reefs discussed above. Herbivorous black abalone (Haliotis cracherodii) are particularly prevalent in crevices and under ledges or boulders in all exposed and partially protected areas within the ASBS. Often ten or more are aggregated on the lower, leeward-facing sides of boulders receiving the full force of incoming swells. Other conspicuous low intertidal invertebrates include purple urchins (Stronglyocentrotus purpuratus), red urchins (S. franciscanus), tube snails (Serpulorbis squamigerus), kelp turbans (Norrisia norrisi), banded turbans (Tegula eiseni), hornmouths (Ceratostoma nuttalli), cone snails (Conus californicus), and wavy-top turbans (Astraea undosa). Most of the sessile, suspension-feeding invertebrates found in the low intertidal zone reach their maximum abundance further down in the shallow subtidal zone.

Fishes. Intertidal fishes are restricted to the relatively few tidepools present on bedrock platforms or between rocky boulders. Small woolly sculpins (Clinocottus analis) are common in pools between rocks in low-exposure areas of Little Harbor. Less common are juvenile opaleye (Girella nigricans). California clingfish (Gobiesox rhessodon) can be found attached to the undersides of rocks in the low intertidal zone at Little Harbor.

ASBS Subarea IV

The intertidal zone within ASBS Subarea IV consists of semi-protected open coast habitats. This region is partially protected from the prevailing northwest swells, yet it is subject to considerable surge, currents, and winds refracting around the east end of the island. Intertidal habitats at the southwestern end of the Subarea (Binnacle Rock to Church Rock) are more exposed than habitats at the northeastern end (Seal Rocks to Jewfish Point). Most of the intertidal shoreline consists of a mixture of rock fragments, sand, and gravel, forming a narrow, relatively flat band below precipitous cliffs. Small sand beaches are scattered throughout the area. Bedrock shelves are rare, confined to small areas at Church Rock and Seal Rocks. The intertidal region along the rock quarry has been modified by quarry operations. It consists of a short, steeply sloping band of piled boulders, with gravel and sand lodged in crevices between the rocks.

Sandy Intertidal Biota

Continual surge-induced movement of sand on the small beaches within Subarea IV precludes most organisms from living in these areas. Beaches are barren of plants except for small amounts of drift giant kelp (*Macrocystis pyrifera*). The only invertebrates observed are a few beach hoppers (*Orchestoidea* spp). and kelp flies (*Coelopa vanduzeei*). Spawning runs of California grunion (*Leuresthes tenuis*) have not been reported from these small beaches.

Rocky Intertidal Biota

In general, all of the rocky areas within ASBS Subarea IV have a similar flora and fauna and will be treated together (see Appendix 3). Dominant organisms within the four intertidal height zones are similar to those in Subarea

II (Table 6), but the abundance and diversity of species is much lower in Subarea IV, where much of the rock surface is barren. Depauperate intertidal assemblages in Subarea IV are the result of two factors: 1) small rocks often are overturned by the surge, burying and/or crushing attached organisms, and 2) large rocks are surrounded by sand and gravel, which scour the rock surfaces during strong surge. Some organisms survive on the leeward faces of rocks, which receive less sand abrasion.

Plants. The uppermost horizon (Zone 1) is barren, except for a film of microscopic blue-green algae. The high intertidal (Zone 2) is dominated by a thin veneer of ephemeral green algae in areas where sand abrasion has eliminated herbivores. Patches of tar spot brown algae (*Ralfsia* sp, *Pseudolithoderma nigra*) and encrusting coralline algae (*Lithothamnion*/*Lithophyllum*) are present. The middle intertidal (Zone 3) is sparsely populated by encrusting and erect coralline algae, brown algae (*Endarachne binghamiae*, *Sargassum agardhianum*), and red turf algae (e.g., *Gigartina canaliculata*, *Gelidium*/*Pterocladia*). Unstable, low intertidal (Zone 4) rocks are covered with early successional stage brown algae (*Scytosiphon lomentaria*, *Colpomenia*/*Hydroclathrus*). The tops of larger, stable rocks are dominated by patches of stubby bladder kelp (*Halidrys dioica*), surf grass (*Phyllospadix torreyi*), southern sea palms (*Eisenia arborea*), feather-boa kelp (*Egregia menziesii*), and sargassum weed (*Sargassum muticum*). Tufts of low, foliose brown algae (*Zonaria farlowii*) and clumps of finger-like green algae (*Codium fragile*, *C. cuneatum*) are common.

Invertebrates. Herbivorous periwinkles (*Littorina planaxis*) are common at the highest reaches (Zone 1) of rocks scarred with small pits and crevices. Further down in this zone, acorn barnacles (*Chthamalus fissus*) may be present to common on large rocks. Finger limpets (*Collisella digitalis*) are locally present on the leeward sides of boulders. Rapidly moving rock slaters (Ligia occidentalis) are common in boulder areas, especially along the rock quarry.

Limpets (Collisella scabra, Lottia gigantea) are present in the high intertidal (Zone 2) on large rocks. Thatched barnacles (Tetraclita rubescens) are common in patches along the sides of boulders. Checkered periwinkles (Littorina scutulata) and small mussels (Brachidontes adamsianus) are present in narrow cracks. Boulder piles provide good microhabitats for striped shore crabs (Pachygrapsus crassipes) and black turban snails (Tegula funebralis).

Patches of California mussels (Mytilus californianus) occasionally are present in middle intertidal (Zone 3) areas. Clumps of gooseneck barnacles (Pollicipes polymerus) are common in small crevices on rocks. The lower sides and leeward faces of some rocks near sand are covered with carpets of aggregating green anemones (Anthopleura elegantissima). Smooth limpets (Collisella limatula) are common on rock sides in boulder pile habitats, such as along the rock quarry.

Much of the low intertidal (Zone 4) in Subarea IV is sandy substrate. A few black abalone (Haliotis cracherodii) and purple urchins (Strongylocentrotus purpuratus) are present in boulder areas. Aggregating tube snails (Serpulorbis squamigerus) and calcareous tube worms (Spirobranchus spinosus) are common on the sides of small rocks along the rock quarry. Other invertebrates occasionally encountered in the low intertidal zone are more typical of shallow subtidal habitats discussed above.

Fishes. Tidepool microhabitats are lacking in Subarea IV, hence intertidal fishes are not present.

Marine Birds

Approximately 20 sea birds have been observed on Catalina Island, but less than five are common and only the western gull (Larus occidentalis) presently nests on the island (Appendix 4). Abundances of the common species generally are small, although the populations become somewhat larger and more concentrated in the nearshore areas during the winter spawning runs of squid. During the diving survey of Subareas II and IV (29 November-4 December 1979), the seabird populations probably were larger than normal because of the large squid run occurring off the southwest coast of Catalina.

ASBS Subarea II. Western gulls are the most common sea bird within Subarea II, but the population is fairly small. Double-crested cormorants (Phalacrocorax auritus) were observed infrequently during the survey. Offshore rocks are one of the major habitats used by sea birds, and the low number of offshore rocks within Subarea II may be one reason why sea birds are not very abundant.

ASBS Subarea IV. Western gulls and brown pelicans (Pelecanus occidentalis) are the most common sea birds within Subarea IV. Both species are abundant on offshore rocks, especially Church Rock. Double-crested cormorants were present in moderate numbers and a few immature terns were observed on Binnacle Rock during the survey.

Marine Mammals

Seals and Sea Lions

According to Scammon, large numbers of seals and sea lions were found off Catalina in 1874, especially from February to June. In 1899, however, the State Fish and Game Commission decided that the seals and sea lions were causing too much damage to California's fishing industry and recommended killing the mammals all along the coast, including the offshore islands. By 1909, the number of seals was so reduced that legislative action was necessary to protect them. Today, sea lions (Zalophus californianus) are common at Catalina, but the population is small. Harbor seals (Phoca vitulina) also are observed, but less frequently, because they are not as abundant as the sea lions.

ASBS Subarea II. A harbor seal haul-out was discovered within Subarea II during the diving survey. Twelve seals were hauled-out on several flat rocks at the base of a precipitous cliff west of Ben Weston Point, and several more were swimming offshore. Two pups were observed among the adults on the rocks. Seals were sighted in this area on each day of the diving survey but were not common in other areas of the ASBS.

A few solitary sea lions were noted within the nearshore waters of the ASBS and an occasional individual was hauled out. However, groups of sea lions were not observed, either in the water or on the shore. Sea lions prefer sandy or gravel beaches with no shoreward access for their haul-out areas and rookeries. As all such beaches within the ASBS are easily accessible from land and are utilized extensively by humans, no major sea lion haul-outs or rookeries can be expected within Subarea II.

ASBS Subarea IV. The only sea lion colony on Santa Catalina Island is located within Subarea IV, on the sand/gravel beach immediately southwest of Seal Rocks. This long and narrow beach lies at the foot of a sheer, 750 ft (229 m) cliff and can be approached only from the sea. The beach is primarily a haul-out area, although some reports suggest it may serve as a rookery as well.

Since the turn of the century, visitors to Avalon have traveled to Seal Rocks by boat to view the sea lions from the water. This activity continues today, either by private vessels or on regularly scheduled tour boats operating during the summer.

Photographs taken by the investigators on two different days during the first diving survey in Subarea IV (30 Nov, 4 Dec) revealed approximately 40 and 85 sea lions, respectively, lying in a large mass near the center of the beach. At least 30 and 10, respectively, were swimming immediately offshore. Several large groups or rafts of sea lions were swimming near Silver Canyon, an area northwest of the ASBS and the site of a large spawning aggregation of squid. The rafts contained up to 25 individuals. In addition, small groups or isolated individuals were present on most of the offshore rocks and reefs.

Greater numbers of sea lions were observed on the haul-out beach during the second diving survey. Photographs taken 11-12 May 1980 documented 200-275 individuals on the beach, and a few were observed on offshore rocks or in the water. Sea lions breed during the spring, and the larger beach numbers may represent a reproductive aggregation or rookery. However, as no squid were present during the second survey, it also is possible that sea lions are simply more dispersed during a squid aggregation.

Several small groups of 2-4 harbor seals were observed on flat-topped rocks southwest of the sea lion haul-out during the diving survey. A few sea lions and harbor seals were noted on rocks near the quarry on the northeast side of the ASBS. Quarry operations make this an unsuitable area for utilization by large numbers of sea lions or seals.

Whales and Porpoise

Gray whales (*Eschrichtius robustus*) frequently are observed offshore of Subareas II and IV during their annual migrations along the California coast from December to March. Occasionally, they will venture into the ASBS regions. On 26 January 1981, a young gray whale was sighted just beyond the surf zone (300 ft, 91 m offshore) at Ben Weston Beach.

Pilot whales (Globicephala macrorhyncus) are common year-round residents throughout the southern California Borderland. They feed primarily on squid and will follow the squid when they aggregate in the nearshore waters off Catalina to spawn. Squid were spawning during the diving surveys of Subareas II and IV, and several pods of pilot whales were observed within both areas. At night, the whales moved into shallow water, often adjacent to the kelp beds. Employees at the rock quarry report that pods of pilot whales commonly pass close inshore (within 150 ft, 46 m) during the winter months.

Porpoise are very abundant throughout the southern California Borderland, but rarely venture close to land. Consequently, they rarely are observed in Subareas II and IV.

Sea Otters

Historically, sea otters (Enhydra lutris) were numerous within the coastal regions of California and were hunted at Catalina until at least 1830. Extensive hunting all along the coast nearly drove the otters to extinction, but a very small population persisted off central California. This population slowly is expanding, and otters occasionally are observed in southern California. A pair of young otters was reported (unconfirmed) east of Avalon in 1954 and another pair was observed (confirmed) off the west end of Catalina in 1972 (Leatherwood et al. 1978). None have been reported since.

Land Vegetation

Plant Community Description

The annual rainfall on Catalina Island is about 12 in (30 cm), which, combined with the nature of the soil and the abundant rock outcrops, creates a semi-arid environment supporting relatively sparse, desert-like plant communities. These communities are for the most part similar in both ASBS Subareas. The vegetation of Catalina Island has been described by Millspaugh and Nuttall (1923), Thorne (1967, 1969), and Minnich (1980). Community designations for the following discussion have been taken from Munz (1968) and Thorne (1967).

Plant communities within Subareas II and IV are not complete representations of the same communities on the California mainland. This is due to the relative paucity of plant species on Catalina Island, the result of poor dispersibility of many plants over water. There are four major plant communities in Subareas II and IV; coastal sage scrub, chaparral, scrub oak/southern woodland, and coastal grassland. Coastal sage scrub and coastal grassland communities are more common in Subarea II than in Subarea IV; the latter has more chaparral and composite scrub oak/southern woodland communities. Less well-developed vegetation types, present only in Subarea II, are maritime desert shrub, coastal strand, riparian woodland, and aquatic communities. Each community has several dominants, some of them different from their mainland counterparts and often in fewer numbers.

Typical species comprising the eight plant communities encountered within 0.5 mi of the shore of Subareas II and IV are listed in Appendix 5. Each of the plant communities is described briefly, followed by an account of its distribution within the ASBS.

Coastal sage scrub is the best represented plant community on Catalina Island. It is found on slopes, ridges and flats, and on dry, clay or rocky soil. Many of the steeper slopes are covered by 70% prickly pear cactus

(Opuntia littoralis). The community is rather open, with the tallest shrubs and cacti 1-3 ft (0.3-0.9 m) high. Precipitous rocky cliffs have only cactus, sagebrush (Artemisia californica), and spike moss (Selaginella bigelovii) present. Coastal sage scrub often intergrades with grasslands.

Catalina chaparral, a thin representative of mainland chaparral, is found on steep slopes of protected southern or eastern exposure. Shrubs and trees are 3-7 ft (0.9-2.1 m) tall. The community is somewhat open and not impenetrable as is mainland chaparral. This is due to reduced species diversity and to the arborescent nature of vegetation pruned by feral goats.

Scrub oak/southern woodland communities are mixed on moderate to steep south- and east-facing slopes, especially in Subarea IV, where better soil has been formed from leaf litter. Shrubs and trees are typically 2-20 ft (0.6-6.1 m) tall and dominated by black sage (Salvia mellifera), with clusters of taller trees in protected ravines.

Coastal grassland is found on the shallow soils of slopes, ridges, and valleys, mostly in Subarea II. Before the introduction of goats, several perennial grasses (Stipa spp) were probable dominants. Grasses are 0.5-2.5 ft (0.2-0.8 m) tall, persisting dry through the winter months.

The maritime desert shrub assemblage is unique to a few south- and west-facing slopes between Little Harbor and Ben Weston Beach. These areas are strongly influenced by prevailing westerly winds and salt spray. Several cacti (Opuntia littoralis, O. prolifera, Bergerocactus emoryii) and low shrubs (0.5-3 ft, 0.2-0.9 m tall) dominate on thin rocky soil or bluffs.

Coastal strand plants are limited to sand dunes in Subarea II, particularly at Little Harbor and Ben Weston Beach. Patches of low-growing succulents and semi-halophytes are present, though restricted by heavy foot traffic in these recreational areas.

Along the few permanent streams, especially in Cottonwood and lower Middle Ranch Canyons, is a riparian woodland consisting of cottonwood (Populus fremontii), willow (Salix lasiolepis), and elderberry (Sambucus mexicana) trees. In addition, shrubs and vines often form tangled thickets along the streams. The aquatic community is composed of submersed plants such as pondweed (Potamogeton pectinatus) and ditch grass (Ruppia maritima), free-floating water ferns (Azolla filiculoides), and emersed palustrine plants including scouring rush (Equisetum laevigatum), horsetails (Equisetum telmateia braunii), mints (Mentha spp), and dock (Rumex spp). Riparian woodland and aquatic plant assemblages represent fragile resources increasingly threatened as more water supplies are sought for human consumption.

Plant Community Distribution

Jewfish Point, the northern boundary of Subarea IV, lies at the bottom of a steep drainage covered by scrub oak/southern woodland vegetation. Larger trees are located deep within the ravine. The tops of the surrounding ridge consist of bare dirt and grasses. The adjacent watershed to the south is similar in size and topography, with less-protected slopes above 700 ft (213 m) in elevation. Coastal sage scrub covers lower, south-facing slopes, and a thinner scrub oak/southern woodland grows in the upper regions. East Mountain lies at the top of the next adjacent canyon. Above 900 ft (274 m) the south-facing slopes are dominated by black sage (Salvia mellifera). On the protected, northeast-facing slopes is a dense scrub oak/southern woodland. Below 900 ft, the slopes are steeper, more exposed, and covered by coastal sage scrub. The last 100 ft (30 m) above the shore is bare cliffs. The watershed southwest of this is the largest one in Subarea IV. It lies between East Mountain and East Peak and contains several ravines that converge and terminate just west of the East End Light. The upper slopes are covered by chaparral, and the lower slopes support a well-developed coastal sage scrub. Woodland vegetation grows at the bottoms of the numerous ravines. The most southerly drainage in Subarea IV lies above Binnacle Rock. The lower 800 ft (244 m) are 50° to 60° slopes somewhat open to the weather and covered by a thin coastal sage scrub. Above this, more gradual slopes support low-growing chaparral and coastal sage scrub plants.

The most southerly drainage in Subarea II extends from Ben Weston Point to No-Name Cove. It supports a characteristic coastal sage scrub community on gentle to moderate slopes. A coastal grassland grows on flatter slopes just above the shore. The watershed north of this empties at Ben Weston Beach. The best coastal strand community on Catalina Island covers the beach dunes, with coastal sage scrub on the surrounding steeper slopes, and coastal grassland on more gradual slopes near the shore. The upper reaches of Cottonwood Canyon support characteristic coastal sage scrub with flatter areas covered by coastal grassland. Riparian woodland and aquatic communities are associated with the permanent stream in Cottonwood Canyon. The maritime desert shrub community grows on the south-facing slope below 300 ft (91 m). A final watershed drains Big Springs and Little Springs Canyons and two small ravines. The shoreline is primarily bare, with rocky and clay bluffs on either side of Shark Cove and Little Harbor. Coastal strand vegetation covers some sand dunes, especially at Little Harbor. Very gradual slopes behind the beaches support an extensive coastal grassland community, with sparse riparian growth in the canyon bottoms, and coastal sage scrub on the higher slopes.

Unique Components

ASBS Subarea II

Santa Catalina Island ASBS Subarea II contains a few biological species which might be classified as unique; however, the multiplicity of distinct habitats and organisms present in a relatively healthy state collectively make the Subarea unique. Two physical factors combine to account for Subarea II's unique species assemblage: a high degree of wave exposure and the presence of sandy beaches. The Subarea contains organisms typical of the exposed, seaward side of Catalina Island which are encountered rarely (or less commonly) on the leeward side. They include certain intertidal red algae (*Endocladia muricata*, *Gastroclonium coulteri*, *Gloiopeltis furcata*, *Porphyra perforata*), subtidal red algae (*Botryocladia pseudodichotoma*, wide-bladed *Gigartina spinosa*, *Helminthocladia australis*, *Prionitis* spp, *Scinaia johnstoniae*), large gray moon sponges (*Speciospongia confoederata*), orange cup corals (*Balanophyllia elegans*), queen turbans (*Tegula regina*), orange colonial tunicates (*Metandrocarpa dura*), and convict fish (*Oxylebius pictus*). One type of erect coralline alga (*Calliarthron cheilosporioides*), red urchins (*Stronglylocentrotus franciscanus*), golden gorgonians (*Muricea californica*), and brown gorgonians (*M. fruticosa*) dominate subtidal rock habitats within Subarea II; generally, all are much less common on Catalina's leeward side. In contrast, certain high intertidal algae (*Hesperophycus harveyanus* and *Pelvetia fastigiata*), black urchins (*Centrostephanus coronatus*), and rock wrasse (*Halichoeres semicinctus*) are less common in Subarea II than on the leeward side of the island.

Subarea II also contains organisms typical of sand or sand/rock habitats that are encountered rarely in the predominant rock habitats around Catalina

Island. They include several subtidal brown algae (Taonia lennebackeriae, Tinocladia crassa, Sphacelaria californica), red algae (Gracillaria spp, Neo-agardhiella baileyi, Rosenvingea floridana), sea pansies (Renilla kollikeri), honeycomb sand worms (Phragmatopoma californica), sand crabs (Emerita analoga), purple olive snails (Olivella spp), sand dollars (Dendraster sp), and California grunion (Leuresthes tenuis).

A species of rare fish was collected once within Subarea II. On 23 March 1971, biologists from the Los Angeles County Museum of Natural History collected 3 specimens of the kelp goby, Lethops connectens, from a poison station set in 60 ft (18 m) of water near the southwestern point of Shark Cove. This secretive fish, also called the halfblind goby, apparently lives under rock rubble or in burrows within sand/rock substrates. Although Lethops connectens ranges from Carmel south to Cape Colnett, Baja California, less than 20 individuals have been collected (Dr. R. Lavenberg, LACM, pers. comm.). It is not known whether this species is truly rare in nature, or whether few specimens are encountered simply because of its cryptic habits.

Two terrestrial plant communities are unique to Subarea II: maritime desert shrub and coastal strand. These communities are discussed above (see Land Vegetation) and by Thorne (1967). The coastal strand vegetation on stabilized sand dunes at Little Harbor, Shark Cove, and Ben Weston Beach particularly is vulnerable to trampling by the increasing number of visitors utilizing these beaches for recreational activities.

ASBS Subarea IV

Santa Catalina Island ASBS Subarea IV contains a unique stable sand habitat harboring a population of rare orangethroat pikeblennies (Chaenopsis alepidota)

(Fig. 14). These pikeblennies also have been found in some sandy coves along the leeward side of Catalina Island, but not in densities as high as in Subarea IV. Other than a photographic record from Anacapa Island, *Chaenopsis alepidota* is known only from Catalina Island and the Gulf of California. Bohlke (1957) recognized the California population as a subspecies (*C. alepidota californiensis*) separate from the Gulf of California form (*C. alepidota alepidota*).

Orangethroat pikeblennies are characterized by thin, elongate bodies and pikelike mouths. On the stable sand habitat, these small fish were observed nestled amidst fine, filamentous red algae (*Polysiphona mollis*) or inside parchment worm tubes (usually *Chaetopterus variopedatus*). In the Gulf of California they are known to feed on free-swimming crustaceans. Males are territorial and defend their tubes vigorously. Eggs are guarded by the males until the larvae are released. Recently (1979-1980), pelagic larvae of *Chaenopsis alepidota* have been identified from plankton samples taken off the Palos Verdes Peninsula near Los Angeles; however, adult specimens are not known from the California mainland (Dr. R. Lavenberg, LACM, pers. comm.).

Reconnaissance surveys of the stable sand habitat in Subarea IV were conducted in November/December 1979 and in May 1980. Pikeblenny densities were difficult to estimate due to their cryptic habits and patchy distribution. During the first survey, individuals ranging in size from 3-5 in (80-120 mm) were observed in densities as high as $1/m^2$ at depths between 40-60 ft (12-18 m). Thus the population appears to be well established. Fewer pikeblennies were observed during the second survey, and those encountered were within worm tubes, possibly because the protective carpet of red algae largely had disappeared.

Surveys in May 1980 using underwater propulsion vehicles determined that the stable sand habitat is present as a discrete zone between 40-60 ft, extending at least from the East End Light northeast to Seal Rocks. The inshore edge of this habitat is delimited by the disturbing effects of swells and surge. Below 60 ft, light apparently limits the growth of the algal turf, thus changing the character of the community.

The stable sand habitat in Subarea IV also contains a variety of organisms rarely (or less commonly) found in sand habitats at similar depths around Catalina Island. These include the seasonally abundant turf of red algae (*Polysiphona mollis*), sand hydroids (*Corymorpha palma*), sea pens (*Stylatula elongata*), sand shrimp (*Crangon* sp), sand crabs (*Cancer gracilis*, *Portunus xanthusii*, *Randallia ornata*), geoducks (*Panopea generosa*) and other clams, sand stars (*Astropecten armatus*), and heart urchins (*Lovenia cordiformis*).

Several unusual single-specimen observations were noted in Subarea IV during the surveys. A rainbow perch (*Hypsurus careyi*) observed near Church Rock and a pink sea star (*Pisaster brevispinis*) collected off the rock quarry represent the first records of these species at Catalina Island. A red sea star (*Mediaster aequalis*) and a northern sea cucumber (*Parastichopus californicus*) found near the quarry at 40 ft (12 m), represent unusual shallow-water records for these northern (cold-water) species at Catalina Island. Two fishes observed near the East End Light, an adult zebraperch (*Hermosilla azurea*) and a barred sand bass (*Paralabrax nebulifer*), are encountered rarely elsewhere around Catalina Island. A small red alga (*Gloiopeltis tenax*), epiphytic on *Gelidium purpurascens* at Church Rock, was known previously only from Japan.

The significance of the single-specimen sightings within Subarea IV is not known. As local oceanographic conditions are complex (see Nearshore Waters above), the presence of the unique stable sand assemblage and the occurrence of other unusual species in Subarea IV may be related to current patterns and/or upwelling occurring around the east end of Catalina Island.

The colony of California sea lions (Zalophus californianus) located immediately southwest of Seal Rocks is unique to Catalina Island (see Marine Mammals section, above, for a full description). Sea lions hauling out on this beach are vulnerable to disturbance from human activities, especially crowded tour boats approaching close inshore and nearby quarrying operations (e.g., blasting); however, the sea lions have been exposed to these activities for many years, with no documented ill effects.

LAND AND WATER USE DESCRIPTIONS

Marine Resource Harvesting

ASBS Subarea II

Commercial Fishing. The California State Department of Fish and Game has divided oceanic waters along the California coast into a series of units called "Catch Blocks." These units enable the Department to organize, record, and monitor all commercial and sportfishing activities and catches along the coast. Subarea II lies entirely within Catch Block 761, which includes both northeast (leeward) and southwest (windward) portions of the Catalina coast (Fig. 16). Commercial fishing activities are allowed only along the southwest coast of Catalina. As Subarea II comprises over 50% of the southwest coast within Catch Block 761, data from this unit accurately describe commercial-fishing activities within the ASBS.

Market squid (Loligo opalescens) form the most important fishery within Catch Block 761. During most years from 1965-1975, the squid fishery within Block 761 comprised 40-50% of the total squid catch landed in southern California (Fig. 17) and 12-35% of the total catch landed in the State. Indeed, up to 90% of the southern California squid catch is taken from Catalina waters.

Squid are fished in nearshore waters where they aggregate to spawn from November to March, and in deeper waters during June. Commercial fishermen use lights to attract large numbers of squid to the fishing vessels at night. The squid concentrate at the surface and are scooped from the water with large nets or brails.

Figure 16. Location of Santa Catalina ASBS Subareas I, II, III, and IV in relation to California Department of Fish and Game Catch Blocks.

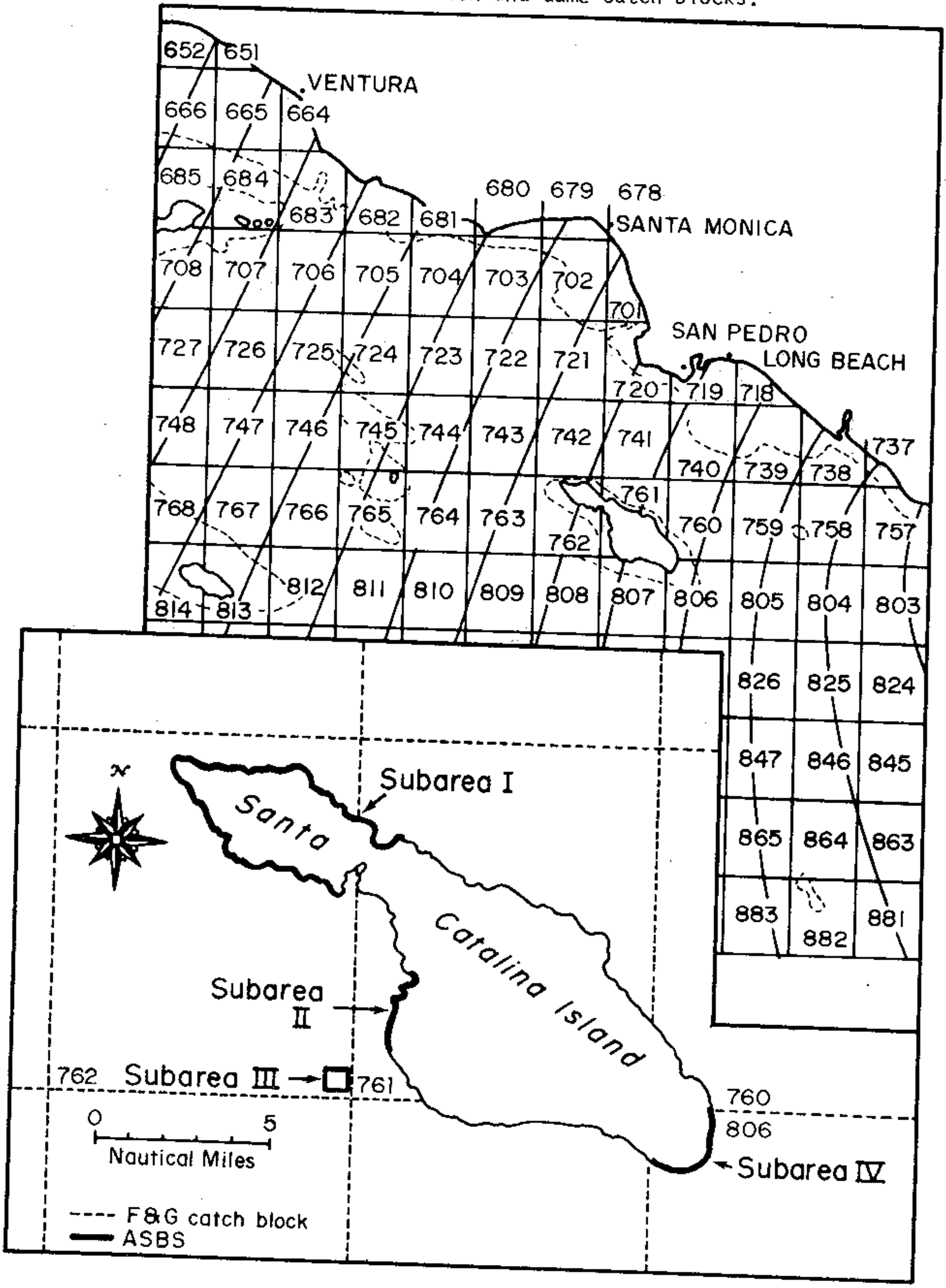
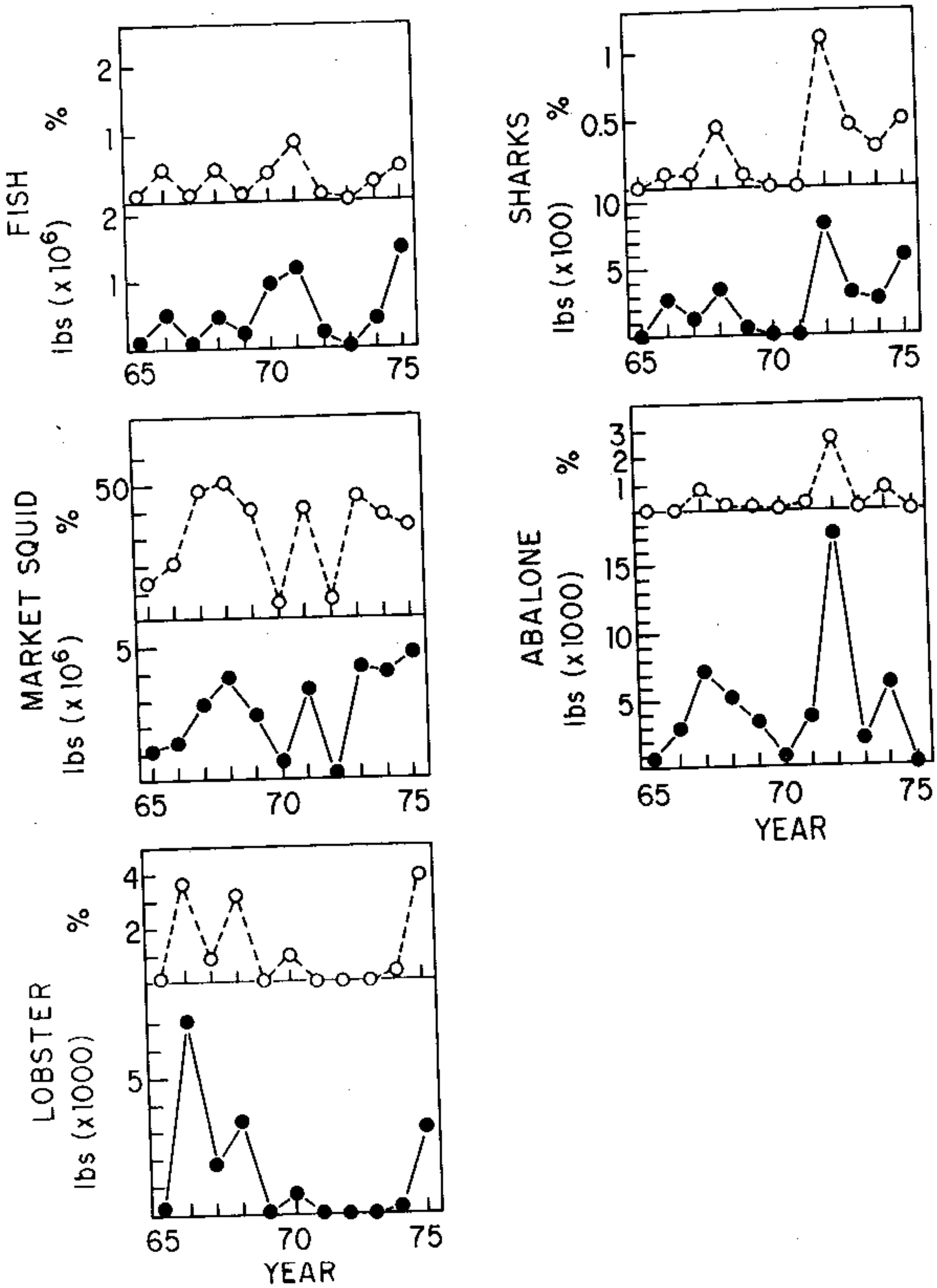


Figure 17. Annual commercial landings of fish, shark, market squid, abalone, and lobster within Catch Block 761 from 1965-1975. The proportion of each group landed in Los Angeles Area ports from Catch Block 761 is displayed in the upper figures. Data are from Calif. Dept. Fish and Game Fish Bulletins.



A major squid aggregation occurred during the Subarea II diving survey conducted by the investigators from 29 November through 4 December 1979. At night, many commercial squid vessels were observed fishing the nearshore areas immediately north and south of the ASBS. Numerous blue sharks (Prionace glauca) and pilot whales (Globicephala macrorhyncus), both known to follow and feed on the squid aggregations, were observed in waters just offshore of the ASBS during the day.

As a group, the finfish fishery from Catch Block 761 is relatively minor, never comprising more than 1% of the total catch landed in Los Angeles (Fig. 17). Certain species are important, however, as the flying fish, sculpin, and swordfish catch in 1977 formed 28, 11, and 6% of the Los Angeles area catch, respectively (Table 7). Northern anchovy were second to squid in total pounds landed within Catch Block 761, but anchovies formed less than 0.5% of all anchovies landed in Los Angeles during 1977.

Lobsters were an important fishery in Catch Block 761 during the mid-1960s (Fig. 17). The lobster fishery has declined drastically since this time, although 1975 marked a slight increase. During the ASBS diving survey, at least three lobster-fishermen and 36 lobster-trap buoys were observed. Most of the traps were located within the kelp beds between Ben Weston Point and No-Name Cove.

Abalone were never an important fishery within Catch Block 761, and the catch has never provided more than 3% of the total annual catch landed in Los Angeles (Fig. 17). Abalone cannot be harvested by commercial divers in depths less than 20 ft along the southwest coast of Catalina. During the ASBS survey, few legal-sized abalone were noted in shallow water; probably they were removed by sport divers. No abalone were observed in deeper areas.

Table 7. Commercial fisheries activity from Catch Block 761 during 1975.

Fish	Total Pounds	% Landed in Los Angeles Area	% Landed in California
Northern anchovy (Engraulis mordax)	1,140,500	0.5	0.3
Jack mackerel (Trachurus symmetricus)	350,400	1.0	1.0
Swordfish (Xiphias gladius)	31,428	5.9	3.6
Bluefin tuna (Thunnus thynnus)	30,235	0.8	0.7
Flyingfish (Cypselurus spp)	26,149	28.7	28.7
Rockfish (Sebastes spp)	2,820	0.4	<0.1
Shark	596	0.5	0.1
Bocaccio (Sebastes paucispinis)	552	--	--
Sculpin (Scorpaena guttata)	408	11.3	0.4
White sea bass (Cynoscion nobilis)	347	0.6	0.2
Albacore (Thunnus alalunga)	246	<0.1	<0.1
Perch (embiotocids)	30	0.2	<0.1
Yellowtail (Seriola dorsalis)	20	0.2	<0.1
Invertebrates			
Market squid (Loligo opalescens)	4,727,490	35.0	20.0
Sea urchin (Strongylocentrotus franciscanus)	57,060	25.9	0.8
Lobster (Panulirus interruptus)	3,107	3.9	1.5
Green abalone (Haliotis fulgens)	94	<0.1	<0.1

Sharks formed a small fishery within Catch Block 761, never contributing more than 1-2% of the total Los Angeles catch (Fig. 17). Most sharks are caught beyond the ASBS seaward boundary.

Sportfishing. Unlike commercial fishing, sportfishing activities are allowed along the entire Catalina coastline. Thus, sportfishing data for Catch Block 761 include the northeast or leeward coast (Fig. 16). Despite the increased area, the fishery data from Catch Block 761 can describe general sportfishing patterns within Subarea II.

Sportfishing activities from commercial passenger sportfishing vessels occur during all months of the year but are heaviest from May through September (Table 8). During 1978, approximately 1.1 fish were caught per angler hour and each angler caught 6.8 fish. Kelp bass were by far the most important sportfish species, followed by Pacific mackerel, rockfish, halfmoon, and sheephead (Table 9). Since 1971, however, sportfishing efforts and catch have declined steadily within Catch Block 761 (Fig. 18).

The amount of sportfishing from small, private vessels is small, with most activity occurring during the summer or calm water periods. Some of the small boats arrive directly from the mainland, but most are launched from larger boats anchored in Little, Shark, or Catalina Harbors. Island residents occasionally fish within the ASBS boundary.

Sportdiving. Sportdiving activities are allowed all along the coast of Catalina, and data from Catch Block 761 can describe general patterns of sportdiving within Subarea II. Activities were high from 1971-1975, but declined by nearly 50% during 1975 through 1977 (Fig. 19). This decline was probably a reaction to the increased regulation of sportdiving and commercial sportdiving vessels by Los Angeles County beginning in 1975.

Table 8. Sportfishing effort on commercial passenger sportfishing vessels in Catch Block 761 during 1978. The southern California area includes all ports between Huntington Beach-Balboa and Santa Barbara-Port Hueneme.

Month	Number of Fish	Number of Anglers	Number of Angler-Hours	Number of Boat-Days
January	384	32	195	5
February	724	70	376	4
March	1,289	184	1,049	12
April	3,102	452	3,031	20
May	5,613	926	6,142	34
June	8,637	1,194	6,909	37
July	10,763	1,734	10,684	57
August	4,577	708	3,914	29
September	5,021	693	5,358	23
October	1,739	289	2,151	13
November	481	46	306	3
December	2,390	248	1,263	6
TOTAL	44,720	6,576	41,377	243
% in southern California	3.7	4.5	--	--
% in California	0.8	0.9	--	--

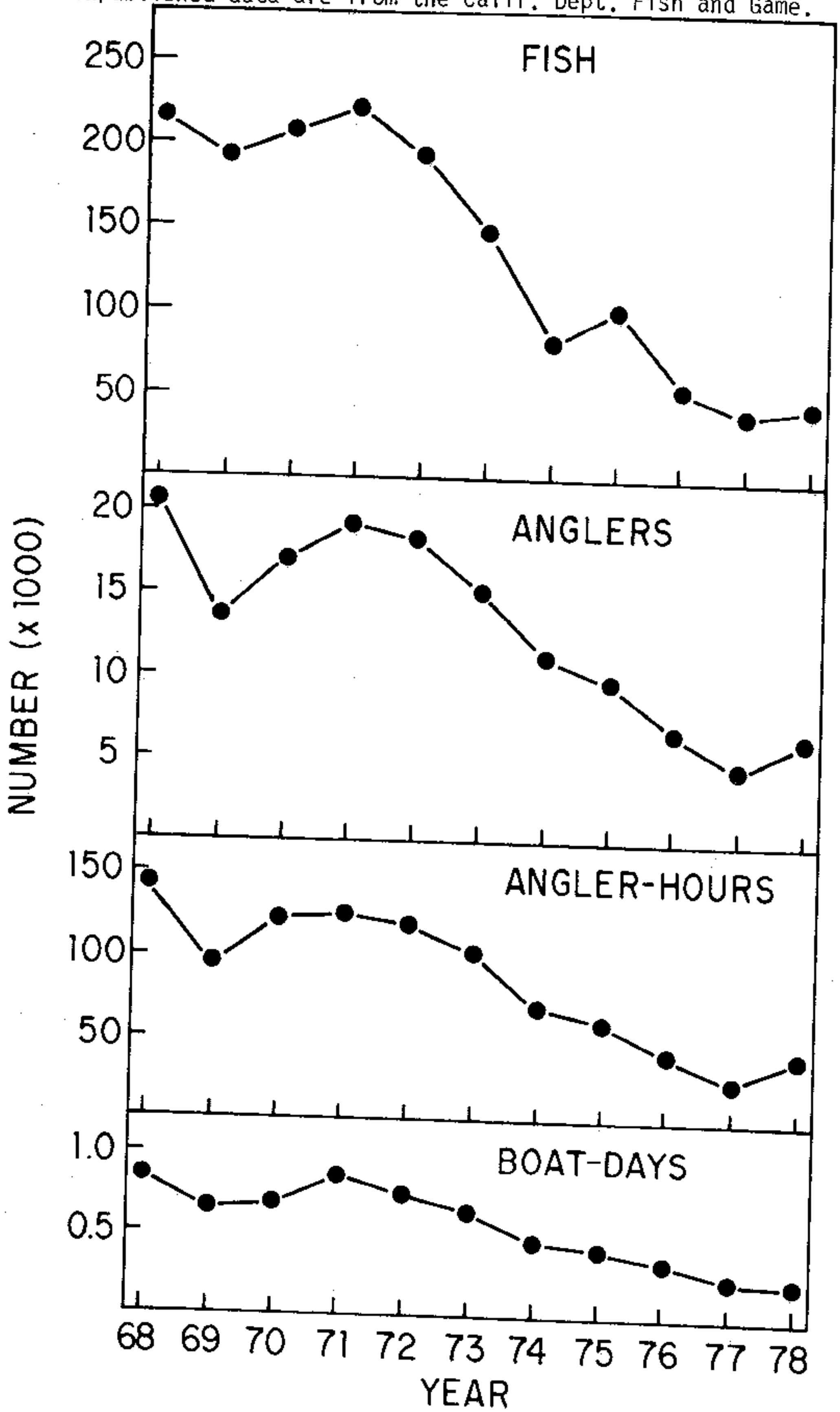
Table 9. Catch from commercial passenger sportfishing vessels in Catch Block 761 during 1978. Skin and scuba-diving catches are not included. The southern California area includes all ports between Huntington Beach-Balboa and Santa Barbara-Port Hueneme.

Fish	Number	% Landed in Southern California	% Landed in California
Kelp bass (*Paralabrax clathratus*)	17,079	14.7	4.7
Pacific mackerel (*Scomber japonicus*)	8,271	3.0	0.9
Rockfish (*Sebastes* spp)	5,644	0.9	0.2
Halfmoon (*Medialuna californiensis*)	5,566	25.9	12.4
Sheephead (*Semicossyphus pulcher*)	1,158	9.1	3.4
Sculpin (*Scorpaena guttata*)	410	2.2	0.9
California barracuda (*Sphyraena argentea*)	209	1.3	0.3
Yellowtail (*Seriola dorsalis*)	173	11.7	0.4
Sand bass (*Paralabrax nebulifer*)	141	0.7	0.1
Flounder	117	--	--
Jack mackerel (*Trachurus symmetricus*)	108	24.0	2.1
Opaleye (*Girella nigricans*)	91	--	14.1
Cowcod (*Sebastes levis*)	68	6.1	1.1
Yellowfin croaker (*Umbrina roncador*)	66	--	17.1
Rock bass (*Paralabrax* spp)	55	1.2	0.9
Sanddab (*Citharichthys* spp)	54	--	10.2
California halibut (*Paralichthys californicus*)	46	1.9	0.8
Smelt	28	--	--

Table 9 (continued)

Fish	Number	% Landed in Southern California	% Landed in California
Lingcod (*Ophiodon elongatus*)	14	0.6	<0.1
Cabezon (*Scorpaenichthys marmoratus*)	5	0.8	<0.1
Topsmelt (*Atherinops affinis*)	4	--	--
Jacksmelt (*Atherinopsis californiensis*)	2	--	0.9
White sea bass (*Cynoscion nobilis*)	1	0.9	<0.1
Giant sea bass (*Stereolepis gigas*)	1	--	0.7
Blue shark (*Prionace glauca*)	1	--	<0.1

Figure 18. Commercial Passenger Sportfishing efforts in Catch Block 761 from 1968-1978. Unpublished data are from the Calif. Dept. Fish and Game.



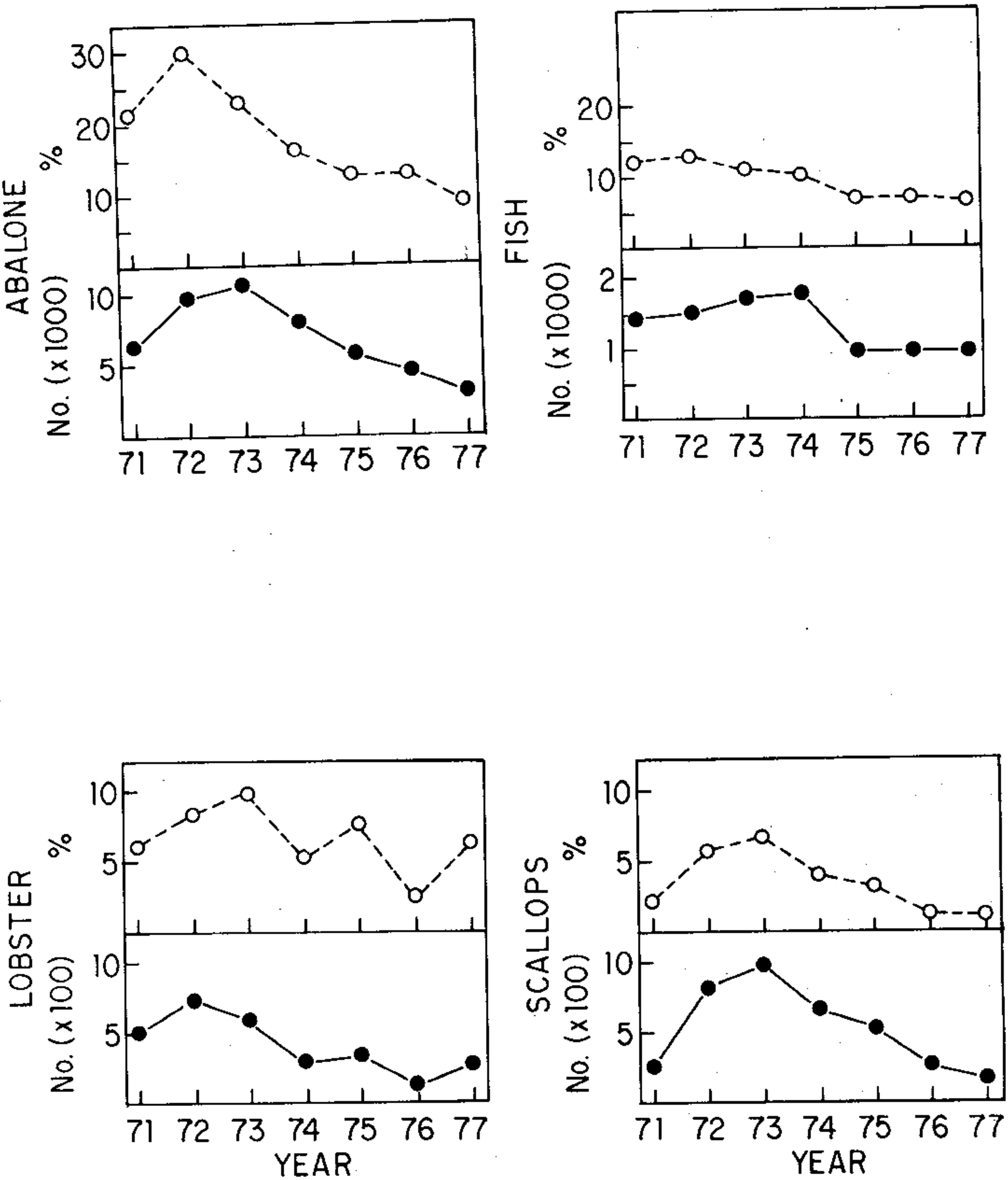


Figure 19. Sportfishing catch by sportdivers from Commercial Passenger Sportdiving Vessels in Catch Block 761 from 1971-1977. The annual catch is expressed in total numbers and as a proportion of the total sportdiving catch landed in southern California (Channel Islands and Pt. Loma). Unpublished data are from California Department Fish and Game.

Most sportdiving occurs along the protected northeast coast of Catalina; the unprotected southwest coast (including the ASBS) is not a popular diving location. A survey of five sportdiving-vessel skippers conducted by the investigators in 1980 describes recent diving activities within the ASBS. Heaviest diving activities occurred during summer with most vessels making 6-10 trips/mo from June through August. No vessels were active from February through April and 1-5 trips were made during all other months. The number of divers/vessel day ranged from 6-30. The Subarea II was judged average for sportfish and abalone; poor to average for lobster, scallops, and photography; and poor for diver certification check-out dives.

An analysis of sportdiving data from Catch Block 761 can give an indication of the sportdiving catch within the ASBS. Each sportdiver caught 0.8 fish; each diver-hour produced 0.1 fish (Table 10). Sheephead were the most common species caught, followed by kelp bass and opaleye (Table 11). The total fish catch by sportdivers within Catch Block 761 ranged from 7-13% of the total sportdiver catch landed in southern California (Fig. 19). The annual catches of abalone, lobsters, and scallops have declined steadily since the early 1970s.

The Little Harbor/Shark Cove complex is a popular anchorage for recreational boaters, especially during the summer, when up to 50 boats may be present. Some of these people sportdive, either from the anchored boats or from small dinghys. Most diving occurs along the rocky headlands adjacent to the harbors.

According to Rangers from the Parks and Recreation Department, little sportdiving and snorkeling originates from shore within the County campground at Little Harbor. The nearest facility for air-fills or gear rental is at the Isthmus, 8 mi (12.8 km) north of the campground. Few campers, whether they arrive at the campground by foot or truck, are willing to transport diving

Table 10. Sportdiving effort from commercial passenger diving vessels in Catch Block 761 during 1977.

Month	Number of Fish	Number of Dives	Number of Diver-Hours	Number of Boat-Days
January	113	150	829	6
February	88	225	1,204	8
March	46	157	769	5
April	582	516	2,506	18
May	681	538	3,127	19
June	601	405	2,141	16
July	539	538	2,730	20
August	683	916	4,346	38
September	443	539	2,532	18
October	332	425	2,292	18
November	254	650	3,095	24
December	85	259	1,253	9
TOTAL	4,447	5,318	26,826	199

Table 11. Catch from commercial passenger diving vessels in Catch Block 761 during 1977.

Fish		Number
Sheephead (*Semicossyphus pulcher*)		412
Kelp bass (*Paralabrax clathratus*)		267
Opaleye (*Girella nigricans*)		101
Sand bass (*Paralabrax nebulifer*)		40
Rockfish (*Sebastes* spp)		35
Halfmoon (*Medialuna californiensis*)		30
California halibut (*Paralichthys californicus*)		24
Sculpin (*Scorpaena guttata*)		23
Jacksmelt (*Atherinopsis californiensis*)		13
Smelt		10
Lingcod (*Ophiodon elongatus*)		4
Pacific bonito (*Sarda chiliensis*)		3
Yellowtail (*Seriola dorsalis*)		1
Invertebrates		
Abalone		3,005
Green (*Haliotis fulgens*)	1,694	
Pink (*H. corrugata*)	943	
Black (*H. cracherodii*)	290	
White (*H. sorenseni*)	38	
Unidentified	26	
Red (*H. rufescens*)	14	
Lobster (*Panulirus interruptus*)		279
Rock scallop (*Hinnites giganteus*)		189
Spider crab		1

equipment in addition to their camping gear.

ASBS Subarea IV

Commercial Fishing. Subarea IV comprises nearly all of the Catalina coastline within Catch Block 806. Commercial fishing is allowed in half of the ASBS area (in depths greater than 20 ft of the western aspect) and in essentially all of the open water beyond the ASBS seaward boundary. Consequently, data from Block 806 directly reflects the importance of commercial and sportfishing activities within the ASBS.

Very little commercial fishing occurs within Block 806 and Subarea IV. Few species are harvested and for the past 10 years they have formed a very small proportion of their respective catches landed in the Los Angeles area (Fig. 20).

In 1977, jack mackerel and market squid were by far the most important commercial species harvested in Block 806, but they formed only 1.6 and 0.8%, respectively, of the total catch landed in Los Angeles (Table 12). The largest squid catch since 1965 contributed only 7% of the Los Angeles catch. No commercial vessels were observed fishing within the ASBS during the dive survey (29 November through 4 December 1979), although a major squid fishing area was located near Silver Canyon, on the southwest side of the Catalina and a few miles west of the ASBS. Numerous commercial vessels were fishing for squid in this area at night, and large numbers of blue sharks (*Prionace glauca*) and pilot whales (*Globicephala macrorhyncus*) were observed near the area during the day.

Lobsters and abalone rarely are harvested by commercial fishermen within the ASBS. Only two lobster traps were observed in the area during the diving survey.

Figure 20. Annual commercial landings of fish, shark, market squid, abalone, and lobster within Catch Block 806 from 1965-1975. The proportion of each group landed in Los Angeles Area ports from Catch Block 806 is displayed in the upper figures. Data are from Calif. Dept. Fish and Game Fish Bulletins.

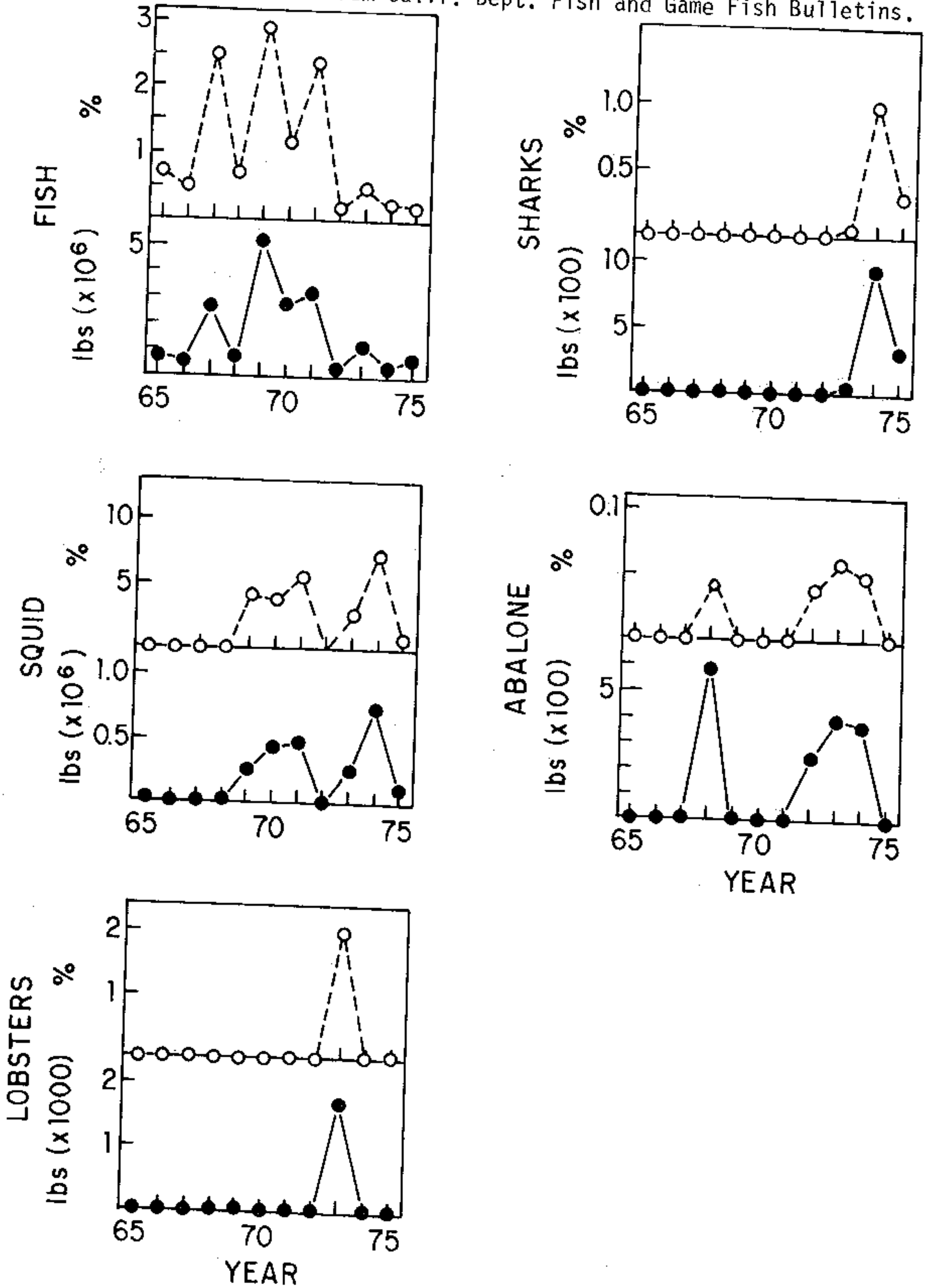


Table 12. Commercial fisheries activity from Catch Block 806 during 1975.

Fish	Total Pounds	% Landed in Los Angeles Area	% Landed in California
Jack mackerel (*Trachurus symmetricus*)	580,500	1.6	1.6
Swordfish (*Xiphias gladius*)	20,299	3.8	2.3
Rockfish (*Sebastes* spp)	8,755	1.1	<0.1
Bluefin tuna (*Thunnus thynnus*)	2,295	<0.1	<0.01
Bocaccio (*Sebastes paucispinis*)	1,075	--	--
Shark	329	0.3	<0.1
Perch (embiotocids)	302	2.0	0.3
California halibut (*Paralichthys californicus*)	251	0.2	<0.1
Sheephead (*Semicossyphus pulcher*)	38	1.2	0.6
White sea bass (*Cynoscion nobilis*)	20	<0.1	<0.01
Sole	9	<0.1	<0.01
Invertebrates			
Market squid (*Loligo opalescens*)	110,050	0.8	0.5
Rock crab (*Cancer* spp)	36	<0.01	--

Sportfishing. The East End of Catalina, including all of Subarea IV, has been an important sportfishing area for the past several decades. Several books have described the fishermen and fishing within this period (see Doran 1963 for references). A world-famous fishing club, the Tuna Club, is located in nearby Avalon, and members have fished the East End for years.

Sportfishing from small private boats continues to be very popular off the East End in general and within the ASBS. Each year, Avalon attracts thousands of yachtsmen from the mainland, and many of these people, as well as Avalon residents, fish within the ASBS.

As Subarea IV forms essentially all of the nearshore portion of Catch Block 806, sportfishing data from this Block can provide additional information on sportfishing activities within the ASBS. Commercial passenger sportfishing vessels fish the area during nearly all months of the year, but mainly from February through April and in June and August (Table 13). During 1978, approximately 1.1 fish were caught per angler-hour and each angler caught 8.4 fish (Table 13). Rockfish were the most important sportfish species, followed by kelp bass and Pacific mackerel (Table 14). Since 1969, however, sportfishing efforts and catch have declined steadily within Catch Block 806, although 1974 and 1975 marked slight increases (Fig. 21).

Sportdiving. In general, Subarea IV is not a popular location for sportdiving. Gamefish and shellfish catches always have been low and have declined since 1974 (Fig. 22). According to a survey of dive-vessel skippers conducted in 1980 by the investigators, dive vessels from the mainland made 1-5 trips during May, June, November, and December, but no dives during the other months. The ASBS was judged average for sportfish and lobster, poor to average for abalone, and poor for scallops, photography, and diver certification check-out

Table 13. Sportfishing effort on commercial passenger sportfishing vessels in Catch Block 806 during 1978. The southern California area includes all ports between Huntington Beach-Balboa and Santa Barbara-Port Hueneme.

Month	Number of Fish	Number of Anglers	Number of Angler-Hours	Number of Boat-Days
January	0	0	0	0
February	1,178	109	557	3
March	1,271	197	1,070	5
April	1,994	181	880	6
May	16	25	93	2
June	2,905	395	3,661	10
July	0	0	0	0
August	1,623	163	1,531	4
September	258	63	603	2
October	172	18	158	2
November	319	26	130	1
December	215	14	70	1
TOTAL	9,951	1,191	8,755	36
% in southern California	0.8	0.8	--	--
% in California	0.2	0.2	--	--

Table 14. Catch from commercial passenger sportfishing vessels in Catch Block 806 during 1978. Skin and scuba-diving catches are not included. The southern California area includes all ports between Huntington Beach-Balboa and Santa Barbara-Port Hueneme.

	Number	% Landed in Southern California	% Landed in California
Rockfish (*Sebastes* spp)	4,732	0.8	0.2
Kelp bass (*Paralabrax clathratus*)	2,223	1.9	0.6
Pacific mackerel (*Scomber japonicus*)	1,312	0.5	0.1
Bonito (*Sarda chiliensis*)	826	1.1	0.3
Cowcod (*Sebastes levis*)	344	30.9	5.8
Halfmoon (*Medialuna californiensis*)	148	0.7	0.3
Sheephead (*Semicossyphus pulcher*)	137	1.1	0.4
Ocean whitefish (*Caulolatilus princeps*)	112	0.8	0.3
Yellowtail (*Seriola dorsalis*)	40	2.7	0.1
Lingcod (*Ophiodon elongatus*)	22	1.0	<0.1
California halibut (*Paralichthys californicus*)	21	0.8	0.4
Jacksmelt (*Atherinopsis californiensis*)	16	--	7.1
California barracuda (*Sphyraena argentea*)	14	<0.1	<0.1
Yellowfin croaker (*Umbrina roncador*)	4	--	1.4
Sargo (*Anisotremus davidsonii*)	2	--	0.8
Sculpin (*Scorpaena guttata*)	1	<0.1	<0.1

Figure 21. Commercial Passenger Sportfishing Vessel efforts in Catch Block 806 from 1968-1978. Unpublished data are from Calif. Dept. Fish and Game.

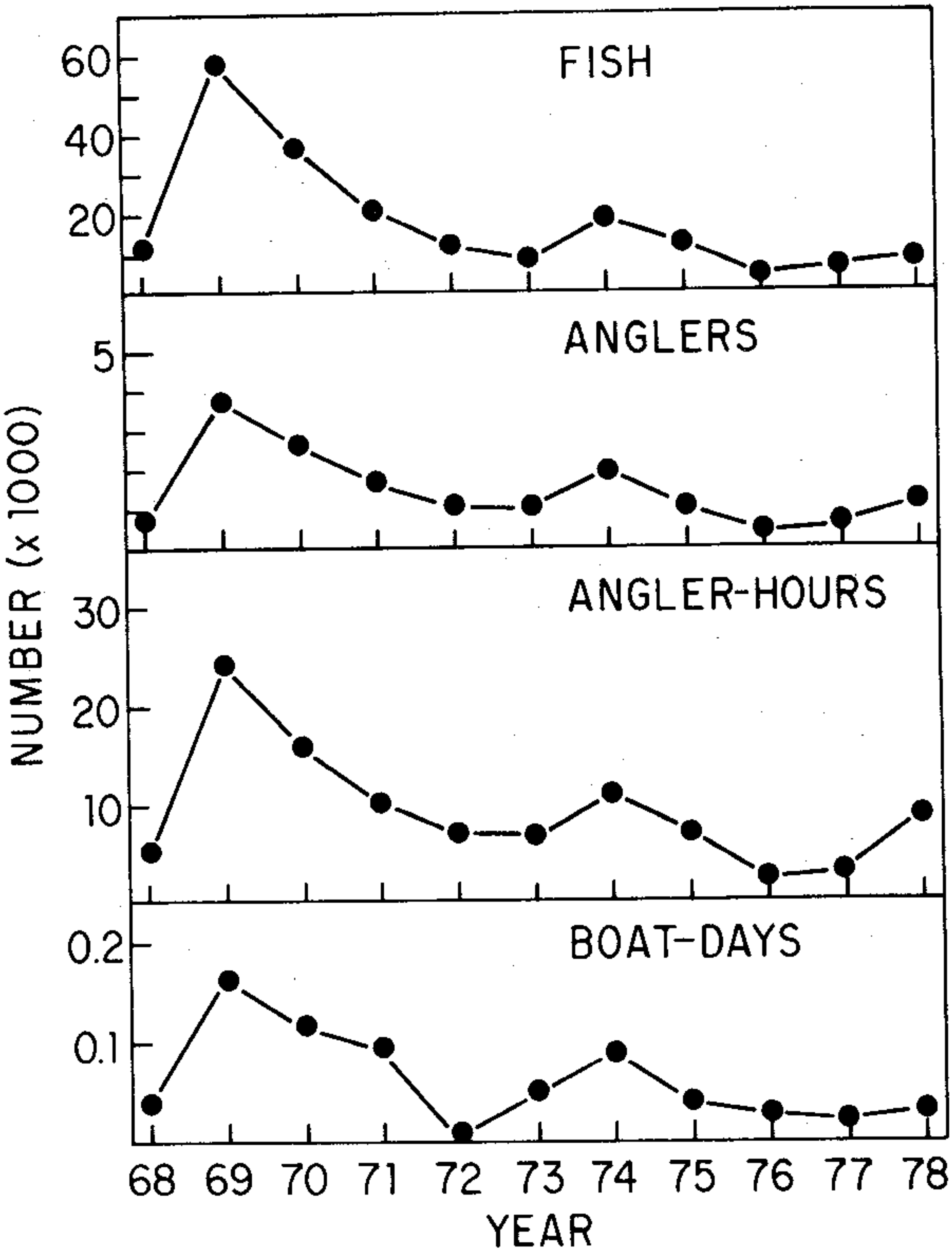
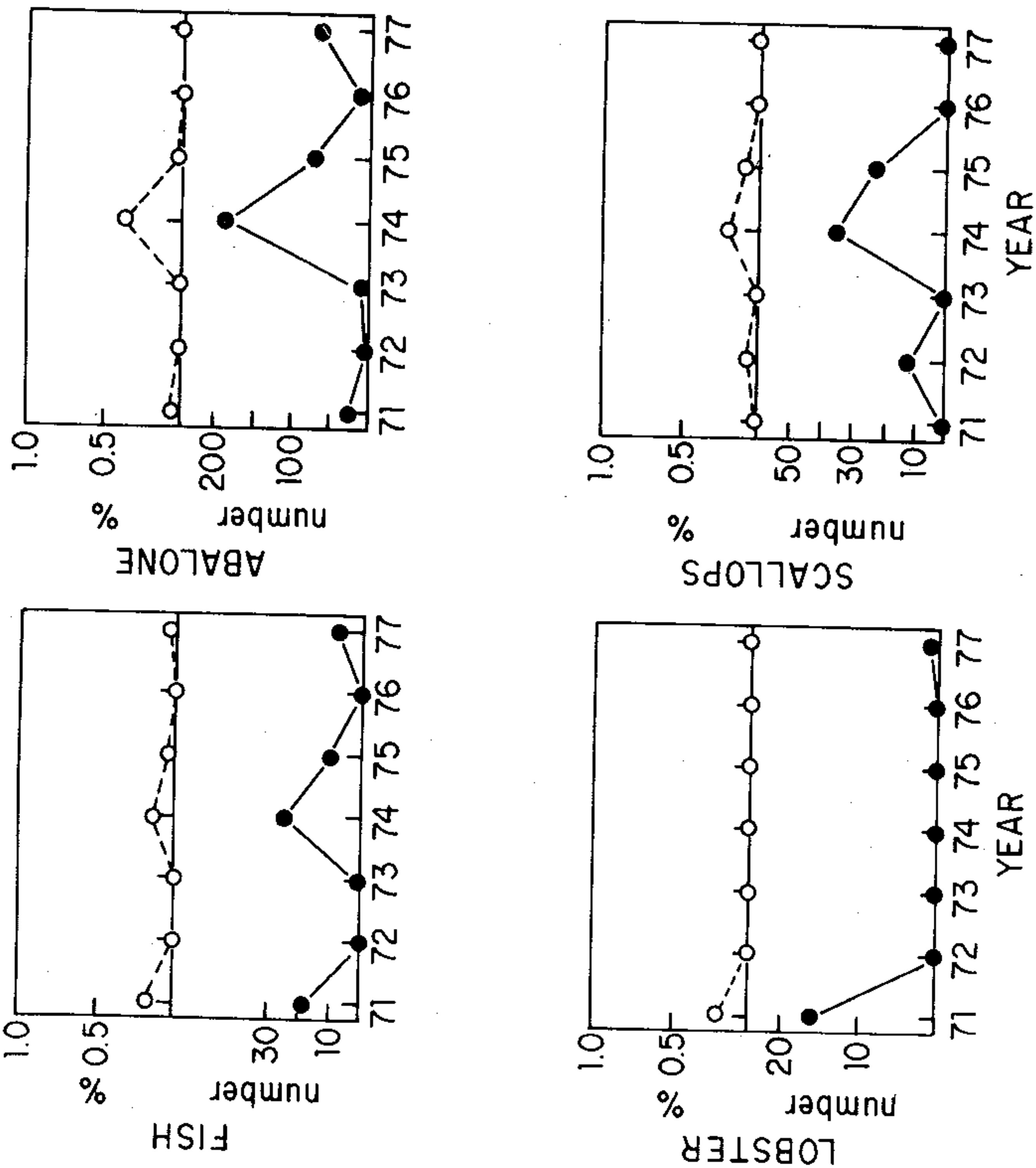


Figure 22. Sportfishing catch by sportdivers from Commercial Passenger Sportdiving Vessels in Catch Block 806 from 1971-1977. The annual catch is expressed in total numbers and as a proportion of the total sportdiving catch landed in southern California (Channel Islands and Pt. Loma). Unpublished data are from Calif. Dept. Fish and Game.



dives. In 1977, sheephead and kelp bass were the only finfishes reported caught by divers in the ASBS (Table 15). The annual catch indicated 0.2 fish/diver-hour (fish = finfish + shell fish) and 0.8 fish/diver (Table 16).

Despite the unpopularity of the ASBS for mainland-based dive vessels, the area was utilized extensively by a dive vessel from Avalon in 1979. More than 10 trips/mo were made from July through October, 6-10 trips/mo during May and June, and 1-5 trips/mo during all other months. Avalon-based diving vessels may become more popular in the future, and the use of Subarea IV as a sportdiving location for these vessels may increase.

Sportdiving from small private vessels is common, but mostly confined to the summer months. Most of these vessels come from Avalon. Diving from shore is not possible as the steep cliffs prohibit access.

Kelp Harvesting

The California State Department of Fish and Game has numbered all major kelp beds (*Macrocystis pyrifera*) along the coast of California to facilitate identification and management regarding kelp harvesting operations by private companies. Kelp beds are either leased by the State to the companies for exclusive harvesting rights, or are unleased and declared open for harvest by anyone. The kelp beds off Catalina, including those within Subareas II and IV, collectively are designated Bed 105 (#42 in the original 1911 State Kelp Survey) and are unleased. Harvesting returns from Bed 105 would be marginal because of the small size (0.47 mi^2); consequently, no kelp off Catalina has been harvested within the last 10 years (E. Smith, CF & G, pers. comm.).

Municipal and Industrial Activities

There are no municipalities in or within one mile of Santa Catalina Island

Table 15. Catch from commercial passenger diving vessels in Catch Block 806 during 1977.

Fish		Number
Sheephead (*Semicossyphus pulcher*)		6
Kelp bass (*Paralabrax clathratus*)		2
Invertebrates		
Abalone		64
Green (*Haliotis fulgens*)	33	
Pink (*H. corrugata*)	24	
Black (*H. cracherodii*)	5	
White (*H. sorenseni*)	2	
Lobster (*Panulirus interruptus*)		1

Table 16. Sportdiving effort from commercial passenger diving vessels in Catch Block 806 during 1977.

Month	Number of Fish	Number of Dives	Number of Diver-Hours	Number of Boat-Days
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0
May	12	21	126	1
June	50	38	114	1
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	11	28	224	1
November	0	0	0	0
December	0	0	0	0
TOTAL	73	87	464	3

ASBS Subareas II and IV. The southeastern boundary of the City of Avalon, with a resident population of approximately 1800 persons, is located 1.9 mi (3.1 km) northwest of Jewfish Point, the northern boundary of Subarea IV.

No industrial activities are located in or within one mile of ASBS Subarea II. A rock quarry, leased from the Santa Catalina Island Company by Connolly-Pacific Company (a subsidiary of L. G. Everist Corporation) is located along the northeastern quarter of Subarea IV (Fig. 11). This quarry has been active off and on since the late 1800's, when rock was mined for construction of the San Pedro breakwater. Dense riprap for breakwaters, jetties, and other shoreline structures is still the primary product of the quarrying operation. Periodically, rocks are blasted loose from the steep hillsides with explosives. Landslides also provide fresh material. Some rocks are reduced by a crushing machine capable of producing various sizes of small rocks and bedding gravel. Unusable fine rock and soil material are redeposited on an inactive slope. Bulldozers and dumptrucks transport rocks to the loading area near Jewfish Point where a crane loads the rock onto 1200-1400 ton (1089-1270 metric ton) barges. Empty and loaded barges are maneuvered by a tugboat between several offshore moorings and a nearshore mooring where loading occurs. Loaded barges are towed two at a time to various destinations, usually in the Los Angeles area.

Quarry activity depends on the demand for riprap. The quarry was active sporadically in the early and mid 1970s; however, during the past few years, it has been operating nearly full time. Currently, 21 people are employed at the site. Annual production figures were not available; however, company representatives estimate that 300 to 400 barge loads, or approximately 400,000 to 500,000 tons (362,874-453,592 metric tons) of rock are shipped each year.

In the first 63 days of 1981, 90 barge loads were shipped to the mainland for construction of a marina near Long Beach.

The 0.8 mi (1.3 km) of shoreline bordering the quarry is composed of large boulders deposited by the quarrying operations. Part of the lease agreement with the Santa Catalina Island Company stipulates that Connolly-Pacific Company must maintain the natural shoreline contours, thus some rocks are added periodically to areas where storms have caused slippage. Other terms of the lease agreement require Connolly-Pacific Company to reconstruct a "natural" hillside topography should the quarry be closed down, however, the large supply of quarry rock and predicted needs for riprap indicate that the quarry will continue to operate into the foreseeable future.

A landfill/dump for the City of Avalon is located 0.8 mi (1.3 km) northwest of Jewfish Point, on a plateau 200 ft (61 m) above sea level and 0.1 mi (0.2 km) inland. Solid waste is processed by a combination of periodic burning and landfill. Typically, a trench is cut, filled with solid waste, burned, and covered over. It is estimated that this site has the capacity for operating five to seven more years.

Pebbly Beach, the industrial maintenance area for the City of Avalon, is located 1.0 to 1.4 mi (1.6 to 2.2 km) northwest of Jewfish Point. Along the beach nearest the ASBS boundary (1.0 mi) is a power plant and a wastewater treatment facility. The Southern California Edison Company Power Plant provides electrical service for all of Santa Catalina Island. Five diesel-powered generators provide 6200 kw of energy through two 12 kv circuits and two 2.4 kv circuits from Pebbly Beach. Diesel fuel is barged from the mainland and offloaded at a fuel pier at the plant. In 1983 an existing generator will be rebuilt with a larger capacity to handle new development. In 1984 another generator will be rebuilt.

The Avalon Wastewater Treatment Facility is located 0.2 mi (0.3 km) inland from the power plant. Since 1976, domestic sewage has been treated by secondary aeration, rotifer digestion, and chlorination. The facility has a 500,000 gallons-per-day capacity which has the capability to be expanded to 1,500,000 gallons per day. Processed wastewater is discharged through a pipe offshore from the northwest end of Pebbly Beach, 1.4 mi (2.2 km) from Jewfish Point (see Point Source Pollution Threats below).

The following industrial activities are located northwest of the power plant along Pebbly Beach, 1.1-1.4 mi from Jewfish Point: an old freight shed and yard, a beverage warehouse (Catalina Beverage Company), a boatyard (George's Marine Service), a fuel storage area (Chevon Oil Company), an old lumberyard and warehouse, an amphibious plane ramp and heliport area (Catalina Airlines), an Airport Cantina, a stained-glass shop (Shorrock Studio), and a barge-landing and freight-storage area (Catalina Freight Lines).

Agribusiness and Silviculture

No farming or logging operations are located within or adjacent to Subareas II or IV. The only agricultural productions on Catalina consist of two small ranches. One is located in Middle Canyon (Middle Ranch) and has 35 cattle and 20 horses; the other is in Cottonwood Canyon (Rancho Escondido) and has 20 horses. Neither is able to expand current levels of operation. Middle Ranch and Rancho Escondido are approximately 5 and 3 mi (8, 5 km) east of Subarea II, 8 and 10 mi (13, 16 km) northwest of Subarea IV, respectively.

Introduced feral herbivores account for essentially all grazing activities on Catalina Island. Overgrazing by feral goats (*Capra hirca*) has caused major erosional problems on Catalina, and these problems are evident in both Subareas II and IV. The goat problem in Subarea II has been somewhat relieved in recent years by a successful program of trapping and removal, however, goats remain abundant and destructive within the relatively remote Subarea IV. Herds of bison or "buffalo" (Bison bison) commonly occur within Subarea II, but their grazing causes minimal damage; bison are not found in Subarea IV.

Rooting by feral pigs (Sus scrofa) also is very destructive to the vegetation of Catalina. Studies on the island have demonstrated that over 85% of all land under the canopy of trees has been rooted by the pigs. In recent years, the pig problem has become more and more severe within Subarea II, especially near the Little Harbor area. Increased numbers of pigs have been attracted to the refuse associated with expanded camping activities and facilities at the popular Little Harbor campground. Pigs also are present within Subarea IV, but their effect is difficult to determine.

Governmental Designated Open Space

From 1919 to 1972, Catalina Island was privately owned by members of the Wrigley family, as they held a majority interest in the Santa Catalina Island Company. Conservation of the natural resources of Catalina Island was a primary objective of the Wrigley family, and most of the island (with the exception of the City of Avalon, the Isthmus, two ranches, and a series of coves on the lee side) remained undeveloped. After World War II, Los Angeles County taxes for Catalina increased steadily to over one million dollars/yr in 1972, but did not provide significant County services for some 900,000 recreational visitor-days/yr outside of Avalon. In 1972, a non-profit foundation, the Santa Catalina Island Conservancy, was organized to preserve Catalina

Island in its natural state. The Conservancy was to operate without funding from Los Angeles County or any other governmental body but would depend upon revenues from its limited operations and on contributions from the public through memberships. Operated first by a president and three founding directors, Conservancy directors would then be elected yearly by "benefactor" members (i.e., those who donate $100,000).

In 1974, the Santa Catalina Island Company entered into a 50-year open space easement with Los Angeles County, thus restricting private development on 41,000 of the 42,135 acres which the Conservancy would eventually own. With this agreement to restrict development, county taxes were reduced, and Los Angeles County acquired specific access rights to most of Catalina Island (subject to reasonable restrictions concerning the needs of the land). Whereas the tax assessment had been based previously on "highest and best" commercial use, tax rates now were based on the land's use as an open space area for public education and recreation. The 41,000 acre easement roughly doubled the entire amount of existing City- and County-owned and leased parks. In approving this open space easement, the Los Angeles County Board of Supervisors defined two goals:

1) To provide a variety of recreation and outdoor education experiences for a major segment of Los Angeles County's seven million residents, with particular emphasis on the young and disadvantaged, and

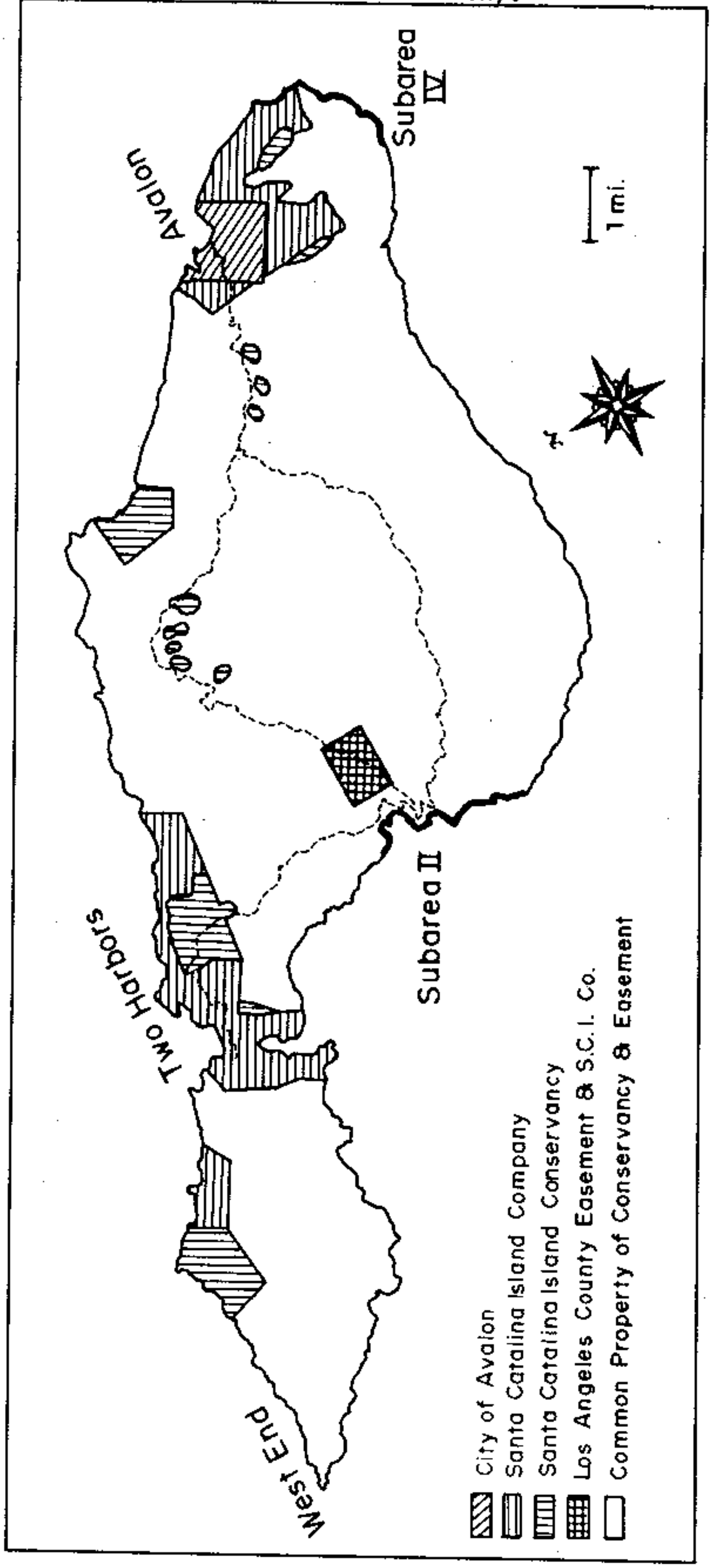
2) To accomplish this recreational objective without destroying, minimizing, or in any way compromising the essential natural integiry of the easement area.

The Department of Parks and Recreation became the administrative unit acting for Los Angeles County and working with the Conservancy in the development of land use programs. They would control hiking, camping, and other recreational activities within the easement and facilitate other public use of the land consistent with Conservancy objectives.

In 1975, the Catalina Conservancy received from the Wrigley family through the Santa Catalina Island Company a $16-million gift of 42,135 acres or approximately 86% of Catalina Island. This land (66 mi^2) included 55 mi of roads and 54 mi of coastline. The Conservancy established a policy that "all property owned and operated by the Catalina Conservancy will be open to the general public, subject to reasonable restrictions concerning the needs of the land, with the primary interest of the foundation being in preserving the natural areas." Figure 23 delineates lands owned by the Conservancy and the Santa Catalina Island Company, as well as those forming the open space easement. All of ASBS Subarea II and most of ASBS Subarea IV are common property of both the Catalina Conservancy and the Los Angeles County open space easement. The Santa Catalina Island Company owns the section of ASBS Subarea IV from Seal Rocks to Jewfish Point. This area is zoned for existing industrial use (i.e., the rock quarry).

The Catalina Conservancy and the Department of Parks and Recreation currently are involved in developing a long-range Conservation and Recreation Plan for Catalina Island. Accordingly, the Department of Parks and Recreation contracted with a consulting firm (Center for Natural Areas) to provide information on legal issues, socioeconomic considerations, existing support services, and the archeology, hydrology, lithology, and ecology of the island. The consulting firm also conducted a general population survey to determine the

Figure 23. Boundary map of Santa Catalina Island (from Los Angeles County Dept. of Parks and Recreation).



preferences and attitudes of County residents for use of the open space easement area. In addition, the California Coastal Commission directed the firm to develop a comprehensive Natural Resource Management Plan, addressing the flora and fauna, water, geology, and various management techniques.

The Conservation and Recreation Plan and the Natural Resource Management Plan are being formed in conjunction with the Local Coastal Program, which is being prepared by the Los Angeles County Department of Regional Planning (as required by the California Coastal Act of 1976). The Local Coastal Program covers all of Catalina Island. It consists of a Land Use Phase detailing permitted land and water uses and an Implementation Phase utilizing zoning and/or other devices to enforce the provisions of the land use plan.

Draft documents of the Conservation and Recreation Plan, the Natural Resources Management Plan, and the Local Coastal Program were available in late 1980; however, modifications of these draft plans are expected as input is received from citizens and technical advisory groups. The final documents should be available in 1981 and will contain a variety of information pertinent to ASBS Subareas II and IV. These documents will set the policies and principles guiding future use, management, and development within the ASBS, as well as addressing the associated environmental impacts.

Recreational Uses

Since the late 1800s, Santa Catalina Island has been famous as a vacation resort for tourists, anglers, and boating enthusiasts. In recent years, hunting, hiking, camping, and scuba diving have also become popular (Table 17). Organized gun and bow hunting for pigs, goats, and deer occur in seasons throughtout the fall and winter months. Controlled numbers of hunters are permitted to

Table 17. Hunting, hiking, and camping activities at Santa Catalina Island, 1976-1980. Data were provided by the Santa Catalina Island Conservancy, the Los Angeles County Department of Parks and Recreation, and the Catalina Cove and Camp Agency.

	1976	1977	1978	1979	1980
Gun Hunter Days	724	438	1,619	865	--
Bow Hunters	633	419		969	--
Day Hikers (under permit)	2,112	2,545	3,337	2,095*	--
Campers (under permit)					
Little Fisherman Cove	--	--	5,041	6,111	5,744
Little Harbor	9,408**	6,102	5,902	5,015	6,634
Black Jack	1,608	1,010	1,098	3,721	∿720***

Campers at Little Harbor during 1980 (under permit):

Jan	Feb	Mar	Apr	May	Jun
24	15	184	736	597	751

Jul	Aug	Sep	Oct	Nov	Dec
1,162	1,976	816	200	134	39

*Decrease due to hikers not obtaining permits.

**Reflects outdoor education program sponsored by Los Angeles County Department of Parks and Recreation.

***Decrease due to suspension of program providing transportation for large groups of campers.

hunt in certain areas of the island. Occasional hunting for pigs and goats may take place within ASBS Subarea II. Hunting rarely occurs in Subarea IV.

Day hiking and backpacking on Catalina Island are regulated by free permits and are limited to roads and established trails. Hiking is the primary means of visitor access to the ASBS Subareas since use of private vehicles in the interior is limited to residents and others with special passes. Most hikers pass through Subarea II because it is centrally located along the main road between campgrounds. Subarea IV rarely is visited by hikers due to the lack of roads and the steep terrain.

No campgrounds or other recreational facilities are located within ASBS Subarea IV. Various recreational activities in Subarea II are centered around the four sandy beach coves. One of Catalina's three major public campgrounds is located at Little Harbor. Though used sporadically for camping prior to 1975, it was at this time that the Los Angeles County Department of Parks and Recreation developed Little Harbor into an organized overnight campground capable of accommodating up to 150 persons at one time. Facilities include thatched roof sunshades, picnic tables, fire pits, fresh-water spigots and showers, trash containers, and a row of ten chemical toilets. Hitching posts have been installed in perimeter areas for occasional use by equestrian campers. Camping activities at Little Harbor are seasonal, with peak campground occupancy during midsummer months (Table 17).

Primitive camping (no fresh-water) and picnicking is permitted at Shark Cove and Ben Weston Beach. Vehicle parking areas, picnic tables, fire pits, and trash containers are maintained at both areas. One chemical toilet is located at Ben Weston Beach. No facilities are present at Cottonwood Cove. Overnight use of primitive campgrounds currently is low. Approximately 200 persons, primarily island residents, camped at Ben Weston Beach in 1980 (B. Weeks, DPR, pers. comm.). Limited expansion of the various campground facilities by the Department of Parks and Recreation is planned in the future.

Accessible beach areas within Subarea II are used for sunbathing, beachcombing, tidepooling, swimming, surfing, snorkelling, and scuba diving. Visitor use is heaviest near the campground at Little Harbor. Lifeguards are stationed at Little Harbor and Ben Weston Beach during the summer months. Surfing is a popular recreational activity for island residents at Ben Weston Beach and Shark Cove. Shore-based scuba diving activity is minimal (approximately 100 divers per year at Little Harbor) because of the surf and the lack of convenient tank-filling facilities. Swimming and diving activities at Little Harbor may increase in the future if the Department of Parks and Recreation proposal to establish an underwater park or recreation area becomes a reality.

Party boats and private pleasure boats frequently venture to Catalina Island and its environs for fishing, diving or sightseeing. Sportfishing and scuba diving activities within ASBS Subareas II and IV are discussed above (see Marine Resource Harvesting). Most recreational boating around Catalina Island is pursued with light sailboats and small power boats, during daylight hours, and almost exclusively on the leeward side of the island. The seaward side, including ASBS Subareas II and IV, is several miles more distant, features few coves suitable for anchoring, and is subject to dangerous waves and swells. No moorings are present in coves within Subarea II, and safe anchorage is available only at Little Harbor. This semi-protected cove has room for 10 to 15 boats, yet as many as 25-50 boats may be anchored in the area on summer holiday weekends.

Recreational boats pass through Subarea IV when rounding the East End of Catalina Island; however, no coves are suitable for overnight anchoring. Party boats and private vessels from Avalon bring sightseers to visit and photograph the sea lion colony on the East End.

Scientific Study Uses

ASBS Subarea II

Several scientific studies have been conducted within or adjacent to Subarea II. As the area is easily accessible by road, terrestrial and near-shore marine investigations can be expected to continue in the future.

Biological Studies

Marine. Little Harbor and Shark Cove are used throughout the year for biological field trips by graduate and undergraduate classes at the Catalina Marine Science Center. These areas provide excellent examples of habitats and organisms characteristic of an unprotected coast in southern California, and many organisms present here are not found on the northeast or leeward side of the island. The intertidal region at Little Harbor is visited at least once by nearly all classes taught at the Center. During the spring, several trips are made to observe the grunion runs and to obtain fertilized eggs for culture and further study at the laboratory. At irregular periods, ichthyology classes use small seine nets to sample day and night fish populations within Little Harbor. Subtidal studies are less common, as all diving gear must be transported from the Center. Nevertheless, some classes encourage or require subtidal surveys and projects.

Several formal surveys and collections have been conducted within the intertidal and nearshore waters of Subarea II. The first subtidal survey using scuba was performed by Given and Lees, who made a number of dives throughout the Little Harbor/Shark Cove area in September 1966 and in June, August, and October 1967. They also conducted one of the first surveys of the intertidal area at Little Harbor in November 1966 and January 1967. Species lists generated by these surveys are presented in Appendices 2 and 3.

Biologists from the Los Angeles County Museum of Natural History used scuba to investigate the subtidal areas of Little Harbor in March 1971. Working from the R/V Searcher, they made 17 person dives at depths ranging from 30-135 ft (10-41 m). During this same period, the museum biologists investigated an intertidal site at Hidden Harbor.

Intertidal organisms from the beaches at Little Harbor and Shark Cove were collected and identified by Straughan in 1977-78, as part of a Bureau of Land Management baseline investigation. This study also examined moisture and organic content, organic and inorganic carbon, tar, and grain size of the sediments.

A long-term study of the Little Harbor intertidal zone was started in 1980 by Dr. Carlos Robles from California State University--Los Angeles. This study will investigate species interactions and community dynamics using experimental manipulations and will compare the Little Harbor intertidal zone to other intertidal areas on Catalina.

The Southern California Coastal Water Research Project (SCCWRP) has conducted several studies in areas just offshore of the ASBS. Benthic organisms and sediment samples have been collected; these data are summarized in the Physical-Chemical section of this report.

Terrestrial. Plant communities within Subarea II have been investigated by Millspaugh and Nuttall (1923), Thorne (1967, 1969), and Minnich (1980) as part of their general surveys of land plants and their distributions on Santa Catalina Island. A maritime desert is present within the ASBS and represents the only example of this habitat on the island. In addition, coastal strand vegetation is best developed on the sand dunes of Ben Weston Beach (see section on Land Vegetation). Most terrestrial ecology classes taught at the Catalina Marine Science Center schedule field trips to these unique areas.

Geological Studies

Bailey (1940) and Platt (1976) examined geological aspects of Subarea II as part of their overall investigations of Catalina Island. Loop (1969) used scuba techniques to study physical oceanography of the Little Harbor/Shark Cove complex. The best examples of Pleistocene marine terraces on Catalina are found within the ASBS and have been examined in detail by Samaras and Gellura (1979). Results of all studies have been summarized and presented in the Physical-Chemical Description of this report.

Archeological Studies

Catalina Island had been inhabited by Chumash Indians for at least 3500 years before Spanish explorers arrived in the early 1500s. Approximately 2000 archeological sites are estimated to be on the island, but only 920 have been mapped and described. One of the most well-known sites is located within Subarea II, on the headland between Shark Cove and Cottonwood Canyon. This site was excavated by Meighan and his UCLA students from 1953-1955 and is actually one of seven sites surrounding Little Harbor. Two were destroyed by early vandals; four are too small or badly eroded for further study.

The Little Harbor site is a shell midden, 200 x 400 ft (61 x 122 m) with a maximum depth of 4 ft (1.2 m). Radiocarbon dating of charcoal collected at the site indicated an age of nearly 4000 years (1924 ± 250 BC). Only a small amount of the midden was excavated by Meighan (1959), but it yielded 356 stone-and-bone artifacts, innumerable shells, and over 6200 bones and bone fragments. One midden sample was 56% shells by weight, one of the highest proportions recorded in California. Many fish bones were present and most of the mammal bones were identified as cetaceans (81%) or pinnipeds (16%).

According to Meighan (1959), the Little Harbor midden resulted from an intensive exploitation of the marine environment, much more than what has been described for other middens in California. The aboriginal inhabitants lived on a "high protein" meat diet with about half being shellfish and the other half marine mammals and fish. As no harpoons were found in the midden, it appears that the Indians hunted cetaceans with spears, requiring great skill as boatsmen and marksmen. The lower levels of the midden were dominated by abalone (*Haliotis* spp) shells, whereas the upper layers consisted primarily of mussel (*Mytilus* spp) shells. Meighan suggests that the inhabitants over-exploited the favored abalone, then consumed more and more of the less desirable mussels. When mussels formed nearly all of their shellfish food, the Indians abandoned the site and it was never reoccupied.

Since Meighan's work in the 1950s, a few additional archeological excavations have occurred within Subarea II. Further excavations of the Little Harbor sites were conducted in 1960 by Eberhart from the California State University--Los Angeles; Martz and Gilmore investigated a Cottonwood Creek site in 1973. Currently, the University of California--Riverside is developing a research program to investigate the aboriginal use and trade of soapstone.

ASBS Subarea IV

Very few scientific studies have been conducted within Subarea IV. Prior to the diving survey in early winter 1979, the only subtidal and intertidal investigations consisted of occasional and informal surveys conducted by biologists from the Catalina Marine Science Center. Scientists from SCCWRP have collected water samples, benthic organisms, and sediment samples from offshore areas adjacent to the ASBS (Fig. 7).

In 1950, various universities and state agencies formed the California Cooperative Oceanic Fisheries Investigation (CalCOFI) in an attempt to determine the total pelagic and bathypelagic fisheries resources available in the California current system. Since this time, CalCOFI has continued to sample water chemistry, water quality, midwater organisms, and benthic organisms at a number of permanent stations established along the coast. One of these stations (90.37) is located approximately 16 mi (26 km) offshore of Subarea IV (Fig. 7), and some of the water chemistry data collected at this station have been summarized in the Physical-Chemical Description, above.

Terrestrial studies include plant descriptions by Millspaugh and Nuttall (1923), Thorne (1967, 1969), and Minnich (1980), and general geological characteristics by Bailey (1940) and Platt (1976). No archeological sites have been discovered.

Transportation Corridors

ASBS Subarea II

The only road within Subarea II is part of the road connecting the Isthmus and Avalon (Fig. 9). It enters the ASBS at Little Harbor and bifurcates at the Scenic Vista located on the headland between Shark Harbor and Cottonwood

Canyon. One fork continues southeast within the ASBS until it exits into Middle Canyon, the other fork extends east and out of the ASBS toward Airport-in-the-Sky and the northeast side of the island. The road is dirt from Little Harbor to the bifurcation and either dirt or paved with oil slurry from the bifurcation to Avalon.

Although all vehicular traffic between Avalon and the Isthmus must utilize this road, flow rates are low because road permits are required. The investigators estimate traffic flow to be 100-200 vehicles/day during summer months, but less than 15 vehicles/day during the winter. Four-wheel drive vehicles are necessary to traverse the dirt roads after winter rains; sometimes the roads become impassable.

The largest vehicles utilizing the roads are Inland Tour busses from Avalon, but they never go past the bifurcation into Little Harbor. During the summer, 1-2 busses/day travel through the ASBS; the number declines to less than 3/weekend during the winter.

No shipping lanes for ocean vessels are near the ASBS. The main shipping lanes into Los Angeles-Long Beach Harbors occur well beyond the east end of the island and between Catalina and the mainland.

ASBS Subarea IV

The only roads within Subarea IV are a small road reserved for quarry operations and another private road for fire-break maintenance. As public travel is forbidden or severely restricted, vehicular traffic is extremely low.

The Coast Guard-established Gulf of Catalina shipping lane into Los Angeles-Long Beach Harbor is 5 mi (8 km) east of the ASBS. The freighter/tanker traffic into the harbors during 1976 was 51,792 arrivals/departures. Average daily traffic was 142 ships/day. As these figures include the ships entering the harbors via all shipping lanes, the number entering via the Gulf of Catalina lane was somewhat less.

ACTUAL OR POTENTIAL POLLUTION THREATS

Point Sources of Pollution

Municipal and Industrial Wastes

No municipal or industrial wastes are discharged into ocean waters in or within one mile of Santa Catalina Island ASBS Subareas II and IV. Domestic sewage from the rock quarry in Subarea IV is piped into a septic tank. Municipal sewage from Avalon is discharged at Pebbly Beach, 1.4 mi (2.2 km) northwest of the northern boundary of Subarea IV. As prevailing ocean currents flow to the southeast, it is possible for the effluent to enter the ASBS. Since 1976, domestic sewage has been treated by secondary aeration, rotifer digestion, and chlorination. No industrial wastes are discharged. Wastewater is a mixture of 60% seawater and 40% freshwater and is discharged through a 12 in (30 cm) pipe extending 400 ft (122 m) offshore to a depth of 130 ft (40 m). Average flow rates in 1981 are 200-250 gal/day (757-946 l/day). Summer rates are double this amount but can reach 1.3 million gal/day (419 million l/day) on major summer weekends.

Although benthic fauna within 100 ft (30 m) of the discharge are affected by the effluent, no adverse impacts can be discerned outside the 100 ft radius or at a control station 1 mi from the northern boundary of Subarea IV (Given 1975). Permanent abiotic or sludge areas are not present, even during periods of highest volume.

Cooling Water Effluents and Intakes

No cooling water effluents or intakes are located in or within one mile of ASBS Subareas II and IV.

Dredging and Spoil Disposal

No known dredging or spoil disposal occurs in or within one mile of ASBS Subareas II and IV, except for minor dredging activities at the rock quarry barge loading site near Jewfish Point in Subarea IV. Rocks occasionally are spilled during barge loading operations; they are dredged with a clam shell so that the nearshore water remains deep enough for barge maneuvers.

Radioactive Wastes

No known dumping of radioactive wastes occurs in or within one mile of ASBS Subareas II and IV.

Ocean Dumping

No known ocean dumping occurs in or within one mile of ASBS Subareas II and IV.

Offshore Oil Development

At the present time, there is no offshore oil development near the ASBS Subareas. Transportation of petroleum products to and from the Los Angeles area offers some general risk of oil spillage and pollution. Future development of oil lease areas near Catalina Island might impact the ASBS Subareas.

Vessel Discharges

Coast Guard regulations prohibit the discharge of untreated sewage from vessels within three miles of shore. However, some vessels ignore these regulations. Minor discharges of sewage from recreational vessels anchored in

Little Harbor or passing through ASBS Subareas II and IV may occur. Observations by R. Given (CMSC) in the more heavily used boat anchoring and mooring areas at Catalina Island seem to indicate no lasting effects of marine vessel discharges on the marine environment.

Offshore Mining

No known offshore mining occurs in or within one mile of ASBS Subareas II and IV.

Non-Point Sources of Pollution

Agricultural Wastes

ASBS Subarea II. The small ranches in Middle and Cottonwood Canyons are the only agricultural activities on Catalina, and neither is able to expand current levels of operation. Both Canyons drain into Subarea II, but only the lower portions of the Canyons have year-round flow. The amounts of bacteria, nutrients, and chemical residues resulting from the agricultural activities are very small and enter into the ASBS only during periods of heavy rainfall. Consequently, the small amounts of agricultural pollutants are greatly diluted and the overall effect in Subarea II probably is negligible.

Overgrazing by feral herbivores has caused severe erosional problems in Subarea II. During periods of heavy rainfall, surface runoff has a high sediment load which may affect terrestrial, intertidal, and subtidal communities. The effects of excessive surface runoff have been discussed in the Hydrology section of this report.

ASBS Subarea IV. No agricultural activities occur within or near Subarea IV, thus no agricultural pollutants are present. Herbicides are sprayed on the many fire-breaks within the ASBS to keep them clear of flammable vegetation. Presumably, some chemical residues are washed through the ASBS during heavy rainfall, but their identity, amounts, and effects are unknown.

Oil Seeps and Spills

ASBS Subarea II. There are no oil or tar seeps within or near Subarea II. The closest known seeps are near the west end of Catalina (Emery 1960), 12 mi (19 km) from the ASBS. However, these seeps actually may emanate from shipwrecks (Straughan, cited in Dykzeul and Given 1979).

No major oil spills have been reported within Subarea II. Straughan (1978) reported tar within intertidal sediments at Little Harbor in summer 1977, but none in winter 1978. The source was unknown, but may have originated from natural seeps throughout the southern California Bight. Straughan (1978) states that the small amounts of oil from natural seeps typically have a short residence time on open coast beaches (such as within Subarea II), as the sediments constantly are re-distributed by the tides and storms. Small amounts of fresh tar were found on Subarea II beaches during the intertidal surveys conducted by the investigators.

Bureau of Land Management (BLM) studies have calculated the probability of Catalina being contacted by one or more 1000-barrel oil spills from tankers or pipes between 1979 and 2000 (Table 18). These calculations have considered time from spill and whether spills are from proposed or existing leases.

There is a 33% chance that Catalina will be contacted within 60 days of a spill from existing leases. This probability increases to 48% if the spill is from both existing and proposed leases. The sources most likely to affect Subarea II are the existing leases along the Santa Rosa-Cortes Ridge

Table 18. Probability of Catalina Island being contacted by one or more 1000-barrel oil spills between the years 1979 and 2000 (source: U.S. Dept. Interior, BLM, 1979).

	Days from Spill			
Source	3	10	30	60
Proposed leases	0.02	0.13	0.20	0.22
Existing leases	0.03	0.21	0.32	0.33
Both	0.06	0.32	0.45	0.48

and near Santa Barbara Island. Prevailing winds and swells would push a spill from these areas into the southwest coast of Catalina, including the ASBS (Fig. 4). To date, however, there are no production platforms within these areas. Sites yet to be proposed within OCS Lease Call #68 also may be important sources.

ASBS Subarea IV. No oil or tar seeps are located within or near Subarea IV, and no major oil spills have been reported. The probability of Catalina being contacted by an oil spill from tankers or pipes is discussed in a previous section and Table 18. Potential sources of oil spills affecting Subarea IV are the existing leases along the Santa Rosa-Cortes Ridge, near Santa Barbara Island, and in the San Pedro Basin. The only production platforms, however, are in the San Pedro Basin. Sites yet to be proposed within OCS Lease Call #68 also may be important sources.

Land Development

ASBS Subarea II. The Los Angeles Department of Parks and Recreation currently is preparing a Master Plan of Recreation for Catalina's Open Space Easement (see section on Governmental Designated Open Space, above). Further development of campground facilities at Little Harbor, Shark Cove, and Ben Weston Beach may necessitate some land development within Subarea II. Proposed projects include administration and maintenance buildings for Park Rangers, interpretive centers for visitors and campers, all-weather hostels for year-round camping, and additional camping sites. Final locations for these facilities have not been determined; consequently, they may or may not be located within the ASBS.

Portions of the road within the ASBS are paved 1-2 times each year with an oil slurry. Surface runoff from the road base during heavy rainfall, therefore, can be expected to transport some oil and other hydrocarbons through the ASBS. This potential impact has not been measured.

Air- and water-borne pollutants from the Los Angeles metropolitan area probably have an impact on the biota of Subarea II (see Water Chemistry, above). Tissue studies of mussels collected from intertidal areas along the northwest coast of Catalina revealed high levels of lead, cadmium, and zinc (Stephenson et al. 1979). Aerial fallout into the sea of automobile emissions originating from the Los Angeles Basin are thought to be the main source of lead in the mussel tissues. Sediment samples collected from Catalina contain high concentrations of some trace metals and may be due to aerial fallout and sewage discharges from the mainland (Chen and Lu 1974). During the Santa Ana conditions, smog from the Los Angeles Basin is transported to Catalina, and air quality becomes very poor. In addition, smoke and ash from mainland fires fanned by Santa Ana conditions often reach Catalina.

ASBS Subarea IV. No land development is projected for the ASBS except for continued mining at the quarry. The effect of this industrial activity on erosional patterns has not been determined. Air- and water-borne pollutants from the Los Angeles Basin can be expected to affect biota with Subarea IV as has been described for Subarea II, above. Smog and associated poor air quality are common during Santa Anas. Smoke from burning refuse at the Avalon land disposal site occasionally enters the ASBS but has no measurable effects.

Harbor Development

ASBS Subarea II. There are no developed harbors within the ASBS. Although Little Harbor and to a lesser extent, Shark Cove, are popular anchorages for yachtsmen in the summer, the County has no plans to develop harbor facilities to accommodate this traffic.

ASBS Subarea IV. There are no harbor facilities within the ASBS, and none are feasible because of the exposed location and lack of access from shore. A small jetty at the quarry is used to load rock onto barges.

Solid Waste Disposal

Solid wastes in Subarea II are transported to a land disposal site. There is no solid waste disposal within Subarea IV, but the land disposal site for Avalon is located 0.8 mi (1.4 km) north of the ASBS (see Municipal and Industrial Activities, above).

SPECIAL WATER QUALITY REQUIREMENTS

Feral herbivores have removed much of the stabilizing vegetation on Catalina Island and, in so doing, have created a severe problem of erosion. Consequently, surface runoff from major rainstorms in the winter temporarily reduces water quality within Subareas II and IV. Long-term degradation of water quality has not been observed, however, as no major industrial or agricultural activities are present within the Subareas or on the island. Nevertheless, Catalina presumably receives air- and water-borne pollutants from sources on the mainland, as tissue samples collected from intertidal organisms and sediment samples collected from offshore areas both indicate high concentrations of trace metals. As input from the mainland can be expected to continue, a program monitoring the levels of pollutants in tissues, water, and sediments should be established.

Within Subarea II, camping activities at Little Harbor may affect water quality within the immediate area. Any activities which would release soap or cleaning detergents into the harbor should not be allowed, and the use of chemical toilets should be continued. Current levels of water quality should be maintained by camper education and/or regulation.

Quarry operations within Subarea IV are the only activities that might cause local reduction of water quality. Surface runoff from the quarry during the rainy season causes a temporary degradation of water quality, but the level probably is similar to that caused by natural runoff at Catalina. Very little rock or debris falls into the nearshore waters during loading operations, and current regulations require maintenance of the shoreline and intertidal zone in the original configuration. Monitoring of local water quality may be required, however, if current levels of quarry operations are increased substantially.

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A complete discussion and description of the marine terraces found within Santa Catalina ASBS Subarea II (Cottonwood).

Southern California Coastal Water Research Project (SCCWRP). 1972. Annual report for the year ended 30 June 1972. W. Bascom, Project Director.

Contains a series of reports documenting the sources and distribution of pollutants in the marine environment off southern California and assesses the impact of these pollutants on the biota.

Stephenson, M. D., M. Martin, S. E. Lange, A. R. Flegal, and J. H. Martin. 1979. California mussel watch 1977-1978. Vol. II. Trace metal concentrations in the California mussel *Mytilus californianus*. Water Qual. Mon. Rep. No. 79-22. 110 pp.

A detailed analysis and discussion of trace metals found in tissues of the California mussel collected all along the California coast. Two stations are located on Catalina Island.

Straughan, D. 1978. Sandy beach and slough community analysis. Southern California baseline study. Intertidal, year three. Vol. II, Rep. 8.0; Vol. III, Rep. 3.0; Vol. IV, Rep. 3.0. Bureau of Land Management, U.S. Dept. Interior, Washington, D.C. 152 + 39 + 123 pp.

This baseline report contains limited information from two line transect surveys (Summer 1977, Winter 1978) conducted at Little Harbor and Shark Cove.

Thorne, R. F. 1967. A flora of Santa Catalina Island, California. Aliso 6: 1-67.

An account of the distribution of land plants on Catalina Island with some comparisons to other Channel Islands and to Mediterranean islands. Brief descriptions of the island and its history are included. An important reference.

Thorne, R. F. 1969. A supplement to the floras of Santa Catalina and San Clemente Islands, Los Angeles County, California. Aliso 7:73-83.

This publication updates the earlier study by including descriptions of plants found after 1967.

U.S. Department of the Interior. Bureau of Land Management. 1979. Final environmental statement for proposed outer continental shelf oil and gas lease sale of southern California. OCS Sale No. 48. Los Angeles, Calif.

A series of four volumes describing in great detail the physical, geological, meterological, and biological characteristics of the Southern California Bight. These volumes form the environmental impact report for proposed oil and gas exploration and production within the Bight. Much information is applicable to Catalina in general.

Vance, R. R. 1978. A mutualistic interaction between a sessile marine clam and its epibionts. Ecology 59:679-685.

This study demonstrates that the high rugosity of the Chama shell tends to encourage other suspension-feeding organisms to settle on them. Anemones are one example of these organisms and apparently deter predatory sea stars from preying on the Chama.

Vedder, J. G. and D. G. Howell. 1980. Topographic evolution of the southern California borderland during late Cenozoic time. Pages 7-34 in: D. M. Power (ed). The California Islands: proceedings of a multidisciplinary symposium. Santa Barbara Mus. Nat. Hist. 787 pp.

An excellent summarization of geoloigcal and paleontological information for the period beginning in late Miocene (5-6 million years ago) to the Recent. The authors describe in general terms the key events that created the present seafloor topography of the Southern California Borderland.

Water Quality Control Plan Report. 1975. Los Angeles River Basin (4B). Vol. I, Part II. Calif. State Water Res. Control Bd., March 1975.

Appendix 1. Subtidal Survey Station Data for Santa Catalina Island ASBS Subareas II and IV. Survey stations are listed in geographic order, from north to south in Subarea II, and from southwest to northeast in Subarea IV. Specific locations for the dive survey stations are shown in Figures 13 and 14.

LOCATION KEY

BP = Ben Weston Point

BR = Binnacle Rock

BW = Ben Weston Beach

CC = Cottonwood Cove

CR = Church Rock

EE = East End Light

JP = Jewfish Point

LH = Little Harbor

NE = Northeast

NN = No-Name Cove

NW = Northwest

RQ = Rock Quarry

SC = Shark Cove

SR = Seal Rocks

SW = Southwest

SEA STATE KEY

Calm = 0-2 ft swells

Slight = 2-4 ft swells

Mod = 4-8 ft swells

CURRENT KEY

None = 0-0.25 knots

Low = 0.25-0.75 knots

Med = 0.75-1.5 knots

High = 1.5-3.0 knots

Survey Station	Date	Location	Sea State	Current	Water Temp (°C) Surface	Bottom	Depth (ft)	Visibility (ft)
II-14	12-1-79	NW LH	Mod	None	16.0	16.0	40	20
II-13	12-1-79	LH-SC	Mod	None	16.0	16.0	30	5
II-26	12-3-79	SW SC	Calm	None	16.0	16.0	40	35
II-11	12-1-79	SW SC	Mod	None	16.0	15.5	60	10
II-24	12-3-79	NW CC	Calm	None	16.0	16.0	35	20
II-23	12-3-79	SW CC	Calm	None	16.0	16.0	45	45
II-5	11-29-79	NW BW	Slight	Low	16.0	15.5	25	40
II-12	12-1-79	NW BW	Mod	None	16.0	16.0	55	15
II-22	12-3-79	SW BW	Calm	None	16.0	15.5	50	25
II-4	11-29-79	NW NN	Slight	Low	16.0	15.0	40	20
II-3	11-29-79	SW NN	Slight	None	16.0	15.5	40	30
II-25	12-3-79	SW NN	Calm	None	16.0	15.0	60	40
II-2	11-29-79	BP	Slight	None	16.0	15.0	55	60
IV-18	12-2-79	BR	Calm	None	16.0	16.0	35	3
IV-17	12-2-79	CR	Calm	None	16.0	16.0	40	15
IV-16	12-2-79	NE CR	Calm	Low	16.0	16.0	45	15
IV-7	11-30-79	NE EE	Slight	Low	16.0	16.0	25	10
IV-29	12-4-79	EE	Calm	Med	16.0	15.5	40	40
IV-8	11-30-79	EE-SR	Slight	None	16.0	15.5	40	50
IV-28	12-4-79	EE-SR	Calm	Low	16.0	15.5	60	30
IV-32	5-11-80	EE-SR	Slight	Low	16.5	15.5	60	20
IV-30	12-4-79	SR	Calm	Med	16.0	16.0	35	20
IV-9	11-30-79	SR	Slight	None	16.0	16.0	35	10
IV-33	5-11-80	SR-RQ	Calm	High	16.5	16.0	45	25
IV-19	12-2-79	RQ	Calm	Med	16.0	16.0	35	20
IV-20	12-2-79	JP	Calm	High	16.0	16.0	35	20
IV-31	12-4-79	JP	Calm	Med	16.0	15.5	50	45

APPENDIX 2. Subtidal Organisms Found within Santa Catalina Island ASBS Subareas II and IV during the ASBS Survey and by Previous Investigators.

LOCATION KEY

Subarea II:
NW LH = North West Little Harbor (ASBS Station 14)
CM LH = County Museum, Little Harbor (Scuba survey conducted by divers from the Los Angeles County Museum of Natural History during March 22-23, 1971)
GL LH = Given and Lees, Little Harbor (4 scuba survey dives conducted by R. Given and D. Lees during 1966 and 1967 for the Catalina Marine Science Center: includes SCIBS 57:66, 35:67, 43:67, and 49:67)
LH SC = Little Harbor-Shark Cove (ASBS Station 13)
SW SC = Southwest Shark Cove (ASBS Stations 11 and 26)
NW CC = Northwest Cottonwood Cove (ASBS Station 24)
UT CC = Underwater Techniques Class, Cottonwood Cove (survey dive conducted by 13 students on August 24, 1977, as part of a class in advanced underwater techniques at the Catalina Marine Science Center)
SR = Sentinel Rock area (ASBS Stations 5, 12, and 23)
SW BW = Southwest Ben Weston Beach (ASBS Stations 4 and 22)
SW NN = Southwest No-Name Beach (ASBS Stations 2, 3, and 25)

Subarea IV:
CR = Church Rock area (ASBS Stations 16, 17, and 18)
EE = East End area (ASBS Stations 7, 8, 9, 28, 30, and 32)
RQ = Rock Quarry area (ASBS Stations 19, 20, 31, and 33)

DATA KEY

R = Rock habitat
S = Sand habitat
1 = Rare
2 = Present
3 = Common
4 = Abundant
X = Abundance not determined
* = Laboratory identification (voucher specimens preserved)

		NW	CM	GL	LH	SW	NW	UT		SW	SW	Subarea IV		
	R/S	LH	LH	LH	SC	SC	CC	CC	SR	BW	NN	CR	EE	RQ
PHYLUM CHLOROPHYTA (green algae)														
Chaetomorpha spiralis	R			X*										
Chaetomorpha sp.	R													2
Cladophora graminea	R			X*									2*	
Codium cuneatum	R	3		X	3	3	3	X	3	3	2	3	2	2
Codium fragile	R		X	X*		2	1		1		2	2	2*	3
Codium setchelli/hubbsii	R				2	1					1	1		2
Derbesia marina ("Halocystis" stage)	R												2	
PHYLUM PHAEOPHYTA (brown algae, kelp)														
Acinetospora nicholsoniae	R,S													2
Collodesme californica	R			X				2						1
Colpomenia sinuosa	R,S			X*										
Colpomenia sinuosa/Hydroclathrus clathratus	R,S	1		X	3	2	2	2	2			2	2	3
Cutleria cylindrica	R,S			X*									2*	
Cystoseira neglecta (bladder kelp)	R			X*	3*			X						
Cystoseira neglecta/osmundacea	R	3	X	X	3	3	3	X	3	3	3	2	3	2
Desmarestia sp.	R,S													3
Dictyopteris undulata	R,S	2	X	X*	2*	3	2	X	2			2*	2	3

	R/S	NW LH	CM LH	GL LH	LH SC	SW SC	NW CC	UT CC	SR	SW BW	SW NN	Subarea IV CR	EE	RQ
PHYLUM PHAEOPHYTA (continued)														
Dictyota binghamiae	*R,S*				2								2	
Dictyota flabellata	*R,S*				2							2	2	
Dictyota sp.	*R,S*	2	X		2	2	2		2	2	2	3		3
Ectocarpus parvus	*R*			X*										
Egregia menziesii (feather-boa kelp)	*R,S*			X*	1	2	2	2	2	2	2		2	2
Eisenia arborea (southern sea palm)	*R*	2	X	X*	2	2	3	X	3	3	3	3	3	2
Feldmania globifer	*R*		X*											
Giffordia granulosa	*R*			X*										
Halidrys dioica	*R*				3		2	X				2	2	2
Hydroclathrus clathratus	*R,S*			X*										
Laminaria farlowii	*R*	2	X	X*		2	2	X	2	3	3	2*		2
Leathesia difformis	*R*											3		
Macrocystis pyrifera (giant kelp)	*R*	3	4	X*	2	3	3	3	3	4	4	3	2	2
Myrionema sp.	*R*			X*										
Pachydictyon coriaceum	*R*			X*	3		2	2	2		2	2	2	2
Rosenvingea floridana	*S*			X*										
Sargassum agardhianum	*R*			X	1									
Sargassum muticum	*R,S*	2		X*	3*	3	2	2	3	2	2	2	2	3
Sargassum palmeri	*R*			X*	2	2						2		2
Scytosiphon lomentaria	*R,S*			X*				2						3
Sphacelaria californica	*R,S*			X*	3*							2	2*	
Sporochnus pedunculatus	*R,S*			X*										
Taonia lennebackeriae	*R,S*			X*	3*							2		
Tinocladia crassa	*R,S*			X*				1						
Zonaria farlowii	*R,S*	2		X*	2	2	2	2	2			2	2	3
PHYLUM RHODOPHYTA (red algae)														
Acrosorium uncinatum	*R,S*	3		X*	3*			X	1	1		3	3*	3
Amphiroa zonata	*R*			X*										
Antithamnion defectum	*R*												3*	
Antithamnionella breviramosa	*R*											2*	3*	
Antithamnionella glandulifera	*S*												2*	
Binghamia sp.	*R*				2*								2*	
Bossiella orbigniana	*R*			X*										
Bossiella sp.	*R*		X											
Botryocladia pseudodichotoma	*R,S*	2*						X	1		1			
Branchioglossum undulatum	*R*											3*	2*	
Calliarthron cheilosporioides	*R*												2*	
Calliarthron/Bossiella (erect corallines)	*R*	3			3	3	3		3	3	4	2	2	
Callithamnion acutum	*R*												2*	
Callithamnion biseriatum	*R*												2*	
Callophyllis flabellulata	*R*											3*	2*	
Carpopeltis bushiae	*R*				2			X				2	2*	
Ceramiales	*R,S*				3							2	3	2
Ceramium caudatum	*R*												2*	
Ceramium equisetoides	*R*												2*	
Ceramium procumbens	*R*												2*	
Ceramium zacae	*R*												2*	
Chondria californica	*R*				2*									
Corallina officinalis chilensis	*R*	3		X	3*							3	2*	
Corallina vancouveriensis	*R*											2	3	
Corallina sp.	*R*		X					X						
Corallines-enrusting	*R*	4			3	4	4	3	4	4	4	3	3	3
Corallines-erect	*R*	4			3	4	4	3	4	4	4	3	3	3
Cryptopleura corallinara	*R*			X*	3*							3*	3*	
Cryptopleura crispa	*R*			X*									X*	
Delesseriaceae	*R,S*											3	2	
Fauchea lacinata	*R*												2*	
Fauchea sp.	*R*												2*	
Gelidium nudifrons	*R*	2		X*	2	2	2	X	3	3	3	3	2*	2
Gelidium purpurascens	*R*				2							3*	3*	1

	R/S	NW LH	CM LH	GL LH	LH SC	SW SC	NW CC	UT CC	SR	SW BW	SW NN	Subarea IV CR	EE	RQ
PHYLUM RHODOPHYTA (continued)														
Gelidium robustum	R			X*		1		2	2	2	2	2*		
Gelidium sp.	R			X				X					3	3
Gigartina spinosa	R			X*		2		X	1	2			1*	
Gloiopeltis tenax	R											2*		
Gracilaria andersonii	R,S			X*										
Gracilaria verrucosa	R,S				3*									
Gracilaria sp.	R,S				2*									
Griffithsia pacifica	R												2*	
Gymnogongrus platyphyllus	R			X*				2						
Haliptylon gracile	R				3*							2	2	2
Helminthocladia australis	R			X*										
Herposiphonia plumula	R				2*									
Heterosiphonia erecta	R			X*									2*	
Hypnea valentiae	R												3*	
Jania sp.	R			X										
Laurencia pacifica	R			X*	2								2*	
Laurencia subopposita	R			X*										
Lithothamnion/Lithophyllum	R	4	X	X	3	4	4	X	4	4	4	3	3	3
Lithothrix aspergillum	R			X	3*				3		3	2		3
Neoagardhiella baileyi	R,S			X*										
Nienburgia andersoniana	R												2*	
Pleonosporium vancouverianum	R											2*	2*	
Plocamium cartilagineum	R	2		X*	2	2	2	X	2	2	3	2	2*	2
Polysiphonia mollis	S				3*								4*	
Polysiphonia sp.	R			X*										
Prionitis australis	R				2*							2*	2*	
Prionitis lanceolata	R			X*					2				2	
Prionitis sp.	R				X				X				X	
Pterocladia capillacea	R	2		X*		2	2	X	3	3	2	2	2	3
Pterosiphonia sp.	R			X*										
Rhodoglossum affine	R			X*	2								2	
Rhodymenia californica	R			X*	3							3	3*	
Rhodymenia pacifica	R			X*				X				2	2	
Rhodymenia rhizoides	R												2*	
Rhodymenia sp.	R			X				2						
Sciadophycus stellatus	R										2			
Scinaia johnstoniae	R,S			X*										
Sorella pinnata	R											2*		
Tiffaniella snyderiae	R			X*								2*		
PHYLUM TRACHEOPHYTA (vascular plants)														
Phyllospadix torreyi (surf grass)	R,S		X	X	3	3	2	X	3	2	2	3	3	2
Zostera marina (eelgrass)	S											1	1	
PHYLUM PORIFERA (sponges)														
CLASS DEMOSPONGIAE (common sponges)														
Astylinifer arndti	R			X*										
Axinella mexicana	R			X*										
Haliclona sp.	R			X*										
Hymenamphiastra cyanocrypta (cobalt blue sponge)	R			X		2			2	2	1		1	
Lissodendoryx firma	R			X*										
Microciona parthena	R			X*										
Penares cortius	R			X*							1	1		
Spheciospongia confoederata (gray moon sponge)	R	2	X	X							1	2		
Tethya aurantia (orange puffball sponge)	R	1	X	X		1			1	1	1	2		
Verongia aurea (sulphur sponge)	R	2		X		2			2	2	2	2	1	2
CLASS CALCAREA (calcareous sponges)														
Clathrina blanca/coriacea	R	2				1				3	2	1		1
Leucandra heathi	R			X*										
Leucetta losangelensis	R			X										
Leucilla nuttingi	R											1		
Sycon sp.	R			X										

		NW	CM	GL	LH	SW	NW	UT		SW	SW	Subarea IV		
	R/S	LH	LH	LH	SC	SC	CC	CC	SR	BW	NN	CR	EE	RQ
PHYLUM CNIDARIA														
CLASS ANTHOZOA (anemones, corals, etc.)														
ORDER ZOANTHINIARIA (zoanthid anemones)														
Epizoanthus induratum/leptoderma	R			3		2				3		2	3	
Parazoanthus lucificum	R		X	X						1		2	1	
ORDER CORALLIMORPHARIA														
Corynactis californica (strawberry anemone)	R	1	X	X		2	2		1	2	2	3	2	2
ORDER ACTINIARIA (anemones)														
Anthopleura artemisia (sand anemone)	S										2			
Anthopleura elegantissima (green anemone)	R										2			1
Epiactis prolifera (proliferating anemone)	R												1	
Tealia coriacea	R			X					1					
ORDER SCLERACTINIA (corals)														
Astrangia lajollensis (aggregate coral)	R	2		X		3	2		2	2	3	2	2	2
Balanophyllia elegans (orange coral)	R										2			
Coenocyathus bowersi (colonial coral)	R			X							2	1		
Paracyathus stearnsi (goblet coral)	R	1	X	X		2	2		2	2	2	2	1	1
ORDER CERIANTHARIA														
Pachycerianthus fimbriatus (tube anemone)	S		X	X	2	2					1		2	2
ORDER STOLONIFERA (octocorals)														
Clavularia sp.	R											2		
ORDER GORGONACEA (gorgonians)														
Lophogorgia chilensis (pink gorgonian)	R		X						2	1	1	2	1	
Muricea californica (golden gorgonian)	R	2	X	X		3	3	X	3	3	3	3	2	2
Muricea fruticosa (brown gorgonian)	R	2	X	X		3	3	X	3	3	3	3	1	1
ORDER PENNATULACEA (sea pens)														
Acanthoptilum gracile	S												1	
Renilla kollikeri (sea pansy)	S			X										
Stylatula elongata	S		X		2								3	
Virgularia sp.	S												2	
CLASS HYDROZOA (hydroids)														
Agalaophenia octocarpa	R			X*										
Bougainvillea sp.	S												1	
Corymorpha palma	S												2	
Diplocheilus allmani	R			X*										
Halecium delicatulum	R			X*										
Halecium sp.	R													2
Hydractinia sp.	R													2
Lytocarpus nuttingi (stinging hydroid)	R					2						2	2	
Plumularia floridana	R			X*										
Sertularella turgida	R			X*										
Sertularia desmoides	R			X*										
PHYLUM PLATYHELMINTHES (flatworms)														
Enchiridium punctatum	R													1
Eurylepta californía	R			X										
Thysanozoon californicum	R									1	1			2
PHYLUM ANNELIDA (segmented worms)														
CLASS POLYCHAETA (polychaete worms)														
Arctonoe pulchra (cucumber worm)	R,S												2	2
Chaetopterus variopedatus (parchment worm)	S				2								3	2
Circeis americana	R			X*										
Diopatra ornata (gray tube worm)	S	1	3	X	3	2	2			2	2	2	2	
Myxicola infundibulum	R,S								1				2	
Phragmatopoma californica	R,S									2				
Sabellaria cementarium	R			X*										
Spiochaetopterus costarum	S				1	2					2	2	4	
Spirobranchus spinosus (calcareous tube worm)	R	2		X		3	3	X	2	3	3	2	2	3
Spirobidae	R	3				2				2	3			
Terebellidae	S			X*						1			1	

	R/S	NW LH	CM LH	GL LH	LH SC	SW SC	NW CC	UT CC	SR	SW BW	SW NN	Subarea IV CR	EE	RQ
CLASS POLYCHAETA (continued)														
Thelepus crispus	*R*			*X*										
PHYLUM ARTHROPODA														
CLASS CRUSTACEA														
SUBCLASS CIRRIPEDIA (barnacles)														
Megabalanus californicus (red-and-white barnacle)	*R*									*2*	*2*	*2*	*1*	
Tetraclita rubescens elegans	*R*			*X**										
SUBCLASS MALACOSTRACA														
ORDER STOMATOPODA (mantis shrimps)														
Hemisquilla ensigera	*S*												*2*	
ORDER AMPHIPODA														
Ampeliscidae (tube-dwelling amphipods)	*S*											*3*	*2*	
ORDER MYSIDACEA (mysid shrimps)														
Mysidae	*S*							*3*					*2*	
ORDER DECAPODA (shrimp, lobster, crabs, etc.)														
Alpheus clamator (snapping shrimp)	*R*			*X**										
Betaeus harfordi (abalone shrimp)	*R*			*X**										
Betaeus macginitieae (urchin shrimp)	*R*					*3*				*3*	*3*			
Blepharipoda occidentalis (sand crab)	*S*												*1*	
Cancer gracilis (rock crab)	*S*												*2*	
Crangon sp. (sand shrimp)	*S*				*2*							*2*	*3*	
Heptacarpus sp. (shrimp)	*R*													*2*
Herbstia parvifrons (crab)	*R*													*3*
Lysmata californica (red rock shrimp)	*R*					*2*								*2*
Paguristes sp. (hairy hermit crab)	*R,S*			*X**		*2*				*2*	*2*	*2*	*2*	
Panulirus interruptus (California spiny lobster)	*R,S*	*2*	*X*			*2*	*2*		*2*	*2*	*2*	*2*	*2*	*2*
Paraxanthias taylori (bumpy crab)	*R*					*2*				*2*	*2*			*2*
Pilumnus spinohirsutus (crab)	*R*			*X**										
Portunus xantusii (swimming crab)	*S*			*X*									*2*	
Pugettia dalli (masking crab)	*R*			*X**										
Randallia ornata (bulb crab)	*S*												*2*	
PHYLUM MOLLUSKA														
CLASS GASTROPODA														
SUBCLASS PROSOBRANCHIA (snails)														
Astraea gibberosa (red turban)	*R*										*2*			
Astraea undosa (wavy top turban)	*R*	*3*	*X*	*3*		*3*	*3*	*X*	*3*	*3*	*3*	*2*	*2*	*2*
Bursa californica (California frog shell)	*S*		*X*										*2*	
Ceratostoma nuttalli (Nuttall's hornmouth)	*R*					*2*	*2*		*1*	*3*	*3*		*1*	*2*
Conus californicus (California cone snail)	*R,S*	*1*		*X*		*2*			*1*	*2*	*2*		*2*	*2*
Crassispira semiinflata	*R,S*		*X*	*X*										
Crepidula adunca (hooked slipper shell)	*R*			*X*										
Crepidula dorsata (half slipper shell)	*R*			*X**										*2*
Crepidula sp.	*R*			*X*		*2*								
Cypraea spadicea (chestnut cowrie)	*R*					*1*			*1*	*2*	*1*			
Dendropoma lituella (tube snail)	*R*					*2*								
Fissurella volcano (volcano limpet)	*R*									*2*				
Fusinus luteopictus (painted spindle)	*S*			*X*									*1*	
Haliotis corrugata (pink abalone)	*R*	*1*	*X*	*X*	*2*	*3*	*2*	*X*	*1*	*3*	*2*	*2*	*2*	
Haliotis cracherodii (black abalone)	*R*					*2*			*2*		*1*			
Haliotis fulgens (green abalone)	*R*	*2*	*X*	*3*	*3*	*3*	*2*	*X*	*2*	*3*	*2*	*2*	*2*	*1*
Haliotis sorensoni (white abalone)	*R*			*X*										
Kelletia kelletii (Kellet's whelk)	*R,S*	*2*	*X*			*2*	*2*		*2*	*3*	*2*			*2*
Macron lividus	*R*									*1*				
Maxwellia gemma (gem murex)	*R*	*2*				*2*			*2*	*2*				
Maxwellia santarosana	*R*					*1*					*1*			
Megasurcula carpenteriana	*S*		*X*										*2*	
Megathura crenulata (giant keyhole limpet)	*R*	*3*	*X*	*X*	*2*	*2*	*3*	*X*	*2*	*3*	*3*	*2*	*3*	*2*
Mitra idae	*R*										*1*			

		NW	CM	GL	LH	SW	NW	UT		SW	SW	Subarea IV		
	R/S	LH	LH	LH	SC	SC	CC	CC	SR	BW	NN	CR	EE	RQ
SUBCLASS PROSOBRANCHIA (continued)														
Nassarius perpinguis	S												1	
Norrisia norrisi (kelp turban)	R	3	X	X		2	3		2	2	2	3	1	2
Olivella sp. (olive snail)	S		4	4	4	2				1	2		3	
Polinices lewisii (moon snail)	S			X									1	
Pteropurpura trialata (three-winged murex)	R					2			1	1	1			
Serpulorbis squamigerus (tube snail)	R	2	X	X	2	3	3	X	3	3	3	3	2	4
Tegula aureotincta (guilded turban)	R	3				2	2		3	2	3		2	2
Tegula eiseni (banded turban)	R	1				3	3		3	2	3		2	2
Tegula regina (queen truban)	R	1				2	2		3	2	2		1	2
Trivia solandri (coffee bean snail)	R		X			1								
SUBCLASS OPISTHOBRANCHIA (sea slugs)														
Acanthodoris rhodoceras	R													1
Aplysia californica (sea hare)	R,S			X					1		1		2	
Aplysia vaccaria (sea cow)	R,S			X										2
Armina californica	S			X									2	
Berthellina citrina (apricot slug)	R													1
Bulla gouldiana (California bubble)	S												2	
Cadlina luteomarginata	R		X											
Flabellinopsis iodinea (iodine sea slug)	R		X			2		X	1	2	1	2	1	2
Hermissenda crassicornis	R,S												2	1
Hypselodoris californiensis	R			X										
Jorunna n. sp.	R										1			
Laila cockerelli	R												1	
Navanax inermis	S			X									3	1
Pleurobranchus sp.	S		X											
Polycera atra	R													1
Rictaxis punctocelatus	S												2	
CLASS PELECYPODA (clams and mussels)														
Chama arcana (rock oyster)	R	3		X						3	3	3		1
Hinnites giganteus (rock scallop)	R	2	X	X		2	2	X	2	2	2	2	1	2
Lima hemphilli (file shell)	R													2
Lithophaga plumula (date mussel)	R			X*										
Panopea generosa (geoduck)	S												3	
Pitar newcombianus (clam)	R,S					1								2
Semele sp. (clam)	R,S					2					2			
Tagelus sp. (jackknife clam)	S												3	
Ventricoloria fordii (clam)	R,S										1			
CLASS CEPHALOPODA (octopus and squid)														
Loligo opalescens (market squid)	S		4*										2	
Octopus bimaculatus (two-spot octopus)	R					2		X			3			3
Octopus rubescens (red octopus)	S												1	
PHYLUM ECTOPROCTA (bryozoans)														
Aetea anguina	R			X*										
Antropora tincta	R,S			X										
Bugula sp.	R	1		X*		2			1	1	1	3	2	3
Celleporaria brunnea	R			X*										
Celleporina robertsoniae	R			X*										
Crisia sp.	R			X*										
Crisulipora occidentalis	R			X*										
Diaperoecia californica (staghorn bryozoan)	R	1		X		3	2	X	2	2	2	2	2	1
Disporella separata	R			X*										
Hippodiplosia insculpta (fluted bryozoan)	R			3					1	1	2	2	1	
Lichenopora novae-zelandiae	R								1	1	2	2	1	2
Membranipora sp. (frost bryozoan)	R	3			2	3	3				3	4	3	3
Pherusella brevituba	R			X*										
Phidolopora labiata (lacy bryozoan)	R			X					1	1	2	2		
Rhynchozoon/Parasmittina (pink encrusting bryozoan)	R	3		X*		2	3		3	3	2	3	2	3

	R/S	NW LH	CM LH	GL LH	LH SC	SW SC	NW CC	UT CC	SR	SW BW	SW NN	Subarea IV CR	EE	RQ
PHYLUM ECTOPROCTA (continued)														
Schizomavella auriculata	R			X										
Schizoporella sp.	R													2
Scrupocellaria sp.	R			X*										3
Tubulipora sp.				X*										
PHYLUM PHORONIDA (phoronid worms)														
Phoronopsis californica	S		X										4	3
PHYLUM ECHINODERMATA														
CLASS ASTEROIDEA (sea stars)														
Astrometis sertulifera (soft spiny star)	R		X											
Astropecten armatus (sand star)	S			X								3	2	
Linckia columbiae (comet star)	R	1	X	X		2	1		2	2	2	1	1	
Mediaster aequalis (red star)	S													1
Patiria miniata (bat star)	R,S													2
Pisaster brevispinis (pink star)	S													1
Pisaster giganteus (blue star)	R	2	X	X	1	2	1	X	2	2	2	1		3
CLASS ECHINOIDEA (sea urchins and sand dollars)														
Centrostephanus coronatus (black urchin)	R	1		X		3	2	X	2	2	1	2	2	3
Dendraster sp. (sand dollar)	S			X	3								2	
Lovenia cordiformis (heart urchin)	S											3	2	
Lytechinus anamesus (white urchin)	S		X	X									4	
Strongylocentrotus franciscanus (red urchin)	R	4	X	3	3	3	4	X	4	3	4	3	2	1
Strongylocentrotus purpuratus (purple urchin)	R	2	X	3	2	3	2	X	2	2	3	2	2	1
CLASS OPHIUROIDEA (brittle stars)														
Amphiodia sp.	S												1	
Amphipholis squamata	R													2
Ophioderma panamense	R			X										2
Ophiopsila californica	S												3	
Ophiopteris papillosa	R													2
Ophiothrix spiculata	R		X	X*		2	3			2	2		1	4
CLASS HOLOTHUROIDEA (sea cucumbers)														
Cucumaria salma (salmon cucumber)	R	2		X		2	2		2	2	2	2	2	
Leptosynapta albicans (white cucumber)	R			X										
Parastichopus californicus (northern cucumber)	S													1
Parastichopus parvimensis (southern cucumber)	R,S	3	X	X	2	3	3	X	3	3	2	2	2	3
PHYLUM CHORDATA														
CLASS ASCIDIACEA (tunicates)														
Aplidium sp.	R			X*										
Clavelina huntsmani (light bulb tunicate)	R										2			
Cystodytes lobatus	R			X										
Euherdmania claviformis (sand tunicate)	R,S	1		X		2	2		2	3	2		3	
Metandrocarpa dura (orange tunicate)	R,S					2				2	2			
Metandrocarpa taylori	R	1		X					1	2	1			2
Pycnoclavella stanleyi	R			X*										
Pyura haustor	R			X						2	3			
Ritterella pulchra	R			X*										
Tridemnum opacum (white tunicate)	R	3		X*		3	3	X	3	3	3	3	2	2
CLASS CHONDRICHTHYS (sharks and rays)														
Cephaloscyllium ventriosum (swell shark)	R,S		X						1					
Heterodontus francisci (horn shark)	R,S		X						1	1	2	1	2	2
Myliobatis californica (bat ray)	S		X	X									2	
Platyrhinoides triseriata (thornback ray)	S				1		1	X					2	
Rhinobatos productus (shovelnose guitarfish)	S								1					
Squatina californica (angel shark)	S									1		1	2	
CLASS OSTEICHTHYES (bony fishes)														
ORDER ANGUILLIFORMES (eels)														
Gymnothorax mordax (moray eel)	R				1	2		X	1		1		1	2

	R/S	NW LH	CM LH	GL LH	LH SC	SW SC	NW CC	UT CC	SR	SW BW	SW NN	Subarea IV CR	Subarea IV EE	RQ
ORDER GOBIESOCIFORMES (clingfishes)														
Gobiesox sp.	*R*							X						1
ORDER GADIFORMES														
Chilara taylori (spotted cusk-eel)	*S*		X*											
ORDER ATHERINIFORMES														
Atherinids	*R,S*	1			1	1		X	1			2	1	2
ORDER GASTEROSTEIFORMES														
Syngnathus sp. (pipefish)	*R,S*		X										1	
ORDER PERCIFORMES														
FAMILY BLENNIDAE (blennies)														
Hypsoblennius sp.	*R*													2
FAMILY BRANCHIOSTEGIDAE														
Caulolatilus princeps (ocean whitefish)	*R,S*		X						1					
FAMILY CLINIDAE (clinids)														
Alloclinus holderi (island kelpfish)	*R*	1	X*			3	3		3	3	3	2	2	2
Chaenopsis alepidota (orangethroat pikeblenny)	*S*												3	
Gibbonsia elegans (spotted kelpfish)	*R*	1	X*	X		1						1	1	1
Gibbonsia erythra (scarlet kelpfish)	*R*		X*											
Heterostichus rostratus (giant kelpfish)	*R*		X*	X		1		X	1	2	1	1	1	1
FAMILY COTTIDAE (sculpins)														
Artedius creaseri (roughcheek sculpin)	*R*		X*											
FAMILY EMBIOTOCIDAE (surf perches)														
Brachystius frenatus (kelp perch)	*R*	2	X*	X		2	2		2	2	2	1	2	2
Cymatogaster gracilis (island perch)	*S*			X										
Damalichthys vacca (pile perch)	*R*		X*	X							2	1	2	2
Embiotoca jacksoni (black perch)	*R*	3	X*	X	1	3	2	2	2	2	2	2	2	2
Hyperprosopon argenteum (walleye perch)	*S*												1	
Hypsurus caryi (rainbow perch)	*R*											1		
Phanerodon sp.	*R*												1	
Rhacochilus toxotes (rubberlip perch)	*R*		X*	X		2					2	1		
FAMILY GOBIIDAE (gobies)														
Corphopterus nicholsii (blackeye goby)	*R,S*	1	X*	X	1	2	2		2	2	2	1	2	3
Lethops connectens (kelp goby)	*R*		X*											
Lythrypnus dalli (bluebanded goby)	*R*		X*	X		3	1		1	1	2	1	1	3
Lythrypnus zebra (zebra goby)	*R*		X*											1
FAMILY HEXAGRAMMIDAE (greenlings)														
Oxylebius pictus (convict fish)	*R*		X*	X		1					1			
FAMILY KYPHOSIDAE (sea chubs)														
Girella nigricans (opaleye)	*R,S*	1	X	X		3	2	2	3	3	2	3	2	3
Hermosilla azurea (zebraperch)	*R*												1	
Medialuna californiensis (halfmoon)	*R*	3	3	X	1	3	3	2	2	3	3	2	2	2
FAMILY LABRIDAE (wrasses)														
Halichoeres semicinctus (rock wrasse)	*R,S*	2	X*	X	1	2	1	2	2	1	2	2	3	2
Oxyjulis californica (senorita)	*R,S*	3	X*	X	2	2	3	3	3	3	4	3	3	2
Semicossyphus pulcher (sheephead)	*R,S*	4	4*			3	3		4	3	4	3	3	2
FAMILY POMACENTRIDAE (damselfishes)														
Chromis punctipinis (blacksmith)	*R*	3	4*	X		2	3	3	3	2	3	3	3	4
Hypsypops rubicundus (garibaldi)	*R*	3	X*	X	1	3	3	X	3	3	3	3	2	3
FAMILY POMADASYIDAE														
Anisotremus davidsonii (sargo)	*R,S*	1	X	X				1		2	1	1	2	
FAMILY SCIAENIDAE (croakers)														
Cheilotrema saturnum (black croaker)	*R*					1				1				1
Roncador stearnsi (spotfin croaker)	*R*					1								
Seriphus politus (queen fish)	*S*			X										
Umbrina roncador (yellowfin croaker)	*S*			X										

		NW	CM	GL	LH	SW	NW	UT		SW	SW	Subarea IV		
	R/S	LH	LH	LH	SC	SC	CC	CC	SR	BW	NN	CR	EE	RQ
FAMILY SCORPAENDIDAE (rockfishes)														
Scorpaena guttata (sculpin)	*R*		*X**											*1*
Sebastes atrovirens (kelp rockfish)	*R*		*X*	*X*		*1*			*1*	*1*	*1*			
Sebastes rastrelliger (grass rockfish)	*R*						*1*		*1*	*1*		*1*		*1*
Sebastes serranoides (olive rockfish)	*R*		*X**								*1*			
Sebastes serriceps (treefish)	*R*		*X**	*X*		*2*		*X*	*1*	*1*	*1*			*2*
FAMILY SERRANIDAE														
Paralabrax clathratus (kelp bass)	*R,S*	*2*	*X**	*X*	*1*	*3*	*3*	*3*	*3*	*3*	*3*	*2*	*2*	*3*
Paralabrax nebulifer (barred sand bass)	*S*		*X*										*1*	
Stereolepis gigas (giant sea bass)	*R,S*			*X*										
ORDER PLEURONECTIFORMES (flatfishes)														
FAMILY BOTHIDAE														
Citharichthys sordidus (Pacific sanddab)	*S*		*X*									*1*		
Citharichthys sp.	*S*												*2*	
Paralichthys californicus (California halibut)	*S*			*X*										
FAMILY PLEURONECTIDE														
Pleuronichthys coenosus (c-o turbot)	*R,S*		*X**									*1*	*2*	
CLASS MAMMALIA														
ORDER CARNIVORA														
Phoca vitulina (harbor seal)	*R,S*									*2*	*2*			*2*
Zalophus californianus (California sea lion)	*R,S*		*X*									*1*	*2*	*1*

APPENDIX 3. Intertidal Organisms Found within Santa Catalina Island ASBS Subareas II and IV during the ASBS Survey and by Previous Investigators.

SURVEYS

1) **ASBS SUB II:** Intertidal survey of ASBS Subarea II conducted by one of the investigators (J. Engle) and Dr. Carlos Robles (CSULA) on February 14, 1981.

2) **CMSC CLASSES:** Various intertidal surveys conducted by Catalina Marine Science Center Phycology classes within Subarea II. Collected specimens are archived in the CMSC Herbarium.

3) **GIVEN (1967):** Intertidal surveys at Little Harbor (Subarea II) conducted by Dr. R. Given and D. Lees on November 28-29, 1966, and January 10, 1967, for the Catalina Marine Science Center (SCIBS 67:66, 68:66, 1:67).

4) **STRAUGHAN (1978):** Intertidal sandy beach surveys at Little Harbor and Shark Cove conducted by Dr. D. Straughan on October 10, 1977, and February 7, 1978, for the Bureau of Land Management.

5) **ASBS SUB IV:** Intertidal survey of ASBS Subarea IV conducted by the investigators on May 12, 1980.

KEY

R=Rock habitat
S=Sand habitat
1=Rare
2=Present
3=Common
4=Abundant
X=Abundance not determined
*=Laboratory identification (voucher specimens preserved)

	R/S	ASBS Sub II	CMSC Classes	Given (1967)	Straughan (1978)	ASBS Sub IV
PHYLUM CHLOROPHYTA (green algae)						
Chaetomorpha sp.	R	X	X*	X*		
Cladophora graminea	R		X*			
Codium cuneatum	R	2				2
Codium fragile	R	2	X	2		2
Enteromorpha sp.	R	1				X
Ephemeral green turf	R	X				3
Ulva californica	R	X	X			X
PHYLUM PHAEOPHYTA (brown algae, kelp)						
Colpomenia sinuosa/Hydroclathrus clathratus	R	1	X*	X*		2
Cylindrocarpus rugosus (spongy algae)	R	2	X*	X		3
Cystoseira sp. (bladder kelp)	R	X	X			X
Dictyota/Pachydictyon	R	X	X	X		X
Egregia menziesii (feather-boa kelp)	R	2	X*			2
Eisenia arborea (southern sea palm)	R	4	X*	3		2
Endarachne binghamiae	R	2	X			3
Halidrys dioica	R	3	X*	3		3
Hesperophycus harveyanus	R	1	X	X		
Leathesia difformis	R	1	X			
Macrocystis pyrifera (giant kelp)	R	2	X	X		2
Pelvetia fastigiata	R	1	X*			1
Petalonia fascia	R		X*			
Pseudolithoderma nigra	R	2	X			2
Ralfsia sp. (tar-spot algae)	R	2	X			2
Sargassum agardhianum	R	3	X	X*		2
Sargassum muticum (sargassum weed)	R,S	3	X*			2
Sargassum palmeri	R	X	X*	X		
Scytosiphon lomentaria	R,S	1	X*			3
Zonaria farlowii	R,S	2	X*	X		X
PHYLUM RHODOPHYTA (red algae)						
Chondria californica	R	X	X*	X*		
Corallina officinalis chilensis	R	3	X	X*		X
Corallina vancouveriensis	R	2	X	X*		X
Corallines-encrusting	R,S	2	X	X		3
Corallines-erect	R,S	3	X	X		3
Endocladia muricata	R	2	X*			2
Gastoroclonium coulteri	R	2	X*			
Gelidium pusillum	R	3	X*			X
Gelidium sp.	R	2	X	X		2
Gigartina canaliculata	R	3	X*	X		2
Gigartina leptorhynchos	R	2	X*	X*		X
Gigartina spinosa	R	2	X*	X*		
Gloiopeltis furcata	R	3	X*			
Jania spp.	R	2	X*	X*		
Laurencia pacifica	R	3	X*	X		X
Lithothamnion/Lithophyllum	R	2	X	X		3

	R/S	ASBS Sub II	CMSC Classes	Given (1967)	Straughan (1978)	ASBS Sub IV
PHYLUM RHODOPHYTA (continued)						
Lithothrix aspergillum	R,S	2	X	X*		X
Melobesia mediocris	R	X				X
Nemalion helminthoides	R	X				2
Plocamium cartilagineum	R	2	X*	X*		X
Porphyra perforata	R	1	X*			X
Pterocladia capillacea	R	2	X*	X*		X
Rhodoglossum affine	R	2	X*	X*		X
Rhodymenia californica	R	2	X*			X
Rhodymenia pacifica	R	2	X*			X
PHYLUM TRACHEOPHYTA (vascular plants)						
Phyllospadix torreyi (surf grass)	R,S	4	X	3		2
PHYLUM PORIFERA (sponges)						
CLASS DEMOSPONGIAE (common sponges)						
Hymeniacidon sinapium	R			X*		
Lissodendoryx firma	R			X*		
Ophlitaspongia pennata	R			X*		
Plocamia karykina	R			X*		
Stelleta estrella	R			X*		
Verongia aurea (sulphur sponge)	R			X		
CLASS CALCAREA (calcareous sponges)						
Leucetta losangeles	R			X*		
PHYLUM CNIDARIA (coelenterates)						
CLASS ANTHOZOA						
ORDER ACTINIARIA (sea anemones)						
Anthopleura elegantissima (green anemone)	R,S	1	X	X		3
PHYLUM PLATYHELMINTHES (flatworms)						
Enchiridium punctatum	R			X*		
Notoplana acticola	R			X*		
PHYLUM ANNELIDA (segmented worms)						
CLASS POLYCHAETA (polychaete worms)						
Platynereis bicanaliculata	R			X*		
Spirobranchus spinosus (calcareous tube worm)	R	2	X	X		3
Thelepus crispus	R			X*		
PHYLUM ARTHROPODA						
CLASS CRUSTACEA						
SUBCLASS CIRRIPEDIA (barnacles)						
Balanus glandula (acorn barnacle)	R	2	X			2
Chthamalus fissus (acorn barnacle)	R	4	X	X*		3
Megabalanus californicus (red-and-white barnacle)	R	1	X			2
Pollicipes polymerus (gooseneck barnacle)	R	2	X			3
Tetraclita rubescens (thatched barnacle)	R	3	X	3		3
SUBCLASS MALACOSTRACA						
ORDER ISOPODA (isopods)						
Cirolana harfordi	R			X*		
Ligia occidentalis (rock slater)	R	3	X	X		3
Tylos punctatus (sand isopod)	S				X	
ORDER AMPHIPODA (amphipods)						
Eohaustorius sawyeri	S				X	
Mandibulophoxus gilesi	S				X	
Orchestoidea benedicti (beach hopper)	S				X	
Orchestoidea sp.	S	X	X		X	X
ORDER DECAPODA (shrimp, crabs, etc.)						
Betaeus longidactylus (shrimp)	R			X*		
Callianassa californiensis (ghost shrimp)	S			1		
Emerita analoga (sand crab)	S				X	
Heptocarpus pictus (shrimp)	R			X*		
Lophopanopeus frontalis (crab)	R			X*		
Pachygrapsus crassipes (lined shore crab)	R	3	X	X		3
Pagurus samuelis (hermit crab)	R	2	X	X		X
Paraxanthias taylori (bumpy crab)	R		X	X		
Petrolisthes cabrilloi (porcelain crab)	R	2	X	X		X
Pilumnus spinohirsutus (hairy crab)	R			X*		
Pugettia dalli (masking crab)	R	1		X*		
Taliepus nuttalli (southern kelp crab)	R	1		X*		
CLASS INSECTA						
Carabidae-larvae (ground beetle)	S				X	
Coleopa vanduzeei (kelp fly)	S	3			X	2
Histeridae (hister beetle)	S				X	
Phaleria rotundata (darkling beetle)	S				X	
Staphylinidae (rove beetle)	S				X	
PHYLUM MOLLUSKA						
CLASS GASTROPODA						
SUBCLASS PROSOBRANCHIA (snails)						
Astraea undosa (wavy top turban)	R	X	X	X		X
Ceratostoma nuttalli (nuttall's hornmouth)	R	2	X			
Collisella digitalis (fingered limpet)	R	2	X			2
Collisella limatula (smooth limpet)	R	3	X	3		3
Collisella scabra (rough limpet)	R	3	X	X*		3
Dendropoma lituella (tube snail)	R			X*		
Fissurella volcano (volcano limpet)	R	2	X	X*		

	R/S	ASBS Sub II	CMSC Classes	Given (1967)	Straughan (1978)	ASBS Sub IV
SUBCLASS PROSOBRANCHIA (continued)						
Haliotis cracherodii (black abalone)	R	3	X	3		2
Hipponix tumens (ribbed hoof shell)	R	1		X*		
Littorina planaxis (eroded periwinkle)	R	4	X	X		3
Littorina scutulata (checkered periwinkle)	R	3	X	X		2
Lottia gigantea (owl limpet)	R	3	X	X*		2
Serpulorbis squamigerus (tube snail)	R	3	X	3		3
Tegula eiseni (banded turban)	R	2	X	X*		X
Tegula funebralis (black turban)	R	2	X	X*		2
SUBCLASS OPISTHOBRANCHIA (sea slugs)						
Aplysia californica (California sea hare)	R	1	X	X		
CLASS PELECYPODA (clams and mussels)						
Brachidontes adamsianus (ribbed mussel)	R	2	X	X		2
Mytilus californianus (California mussel)	R	3	X			2
Pseudochama exogyra (reversed rock oyster)	R	2				
CLASS POLYPLACOPHORA (chitons)						
Cyanoplax hartwegii	R	2	X	X*		X
Lepidozona mertensii	R			X*		
Mopalia muscosa (mossy chiton)	R	X		X*		X
Nuttalina californica	R			X*		
Stenoplax conspicua	R			X*		
CLASS CEPHALOPODA						
Octopus bimaculatus/bimaculoides (octopus)	R,S			X		
PHYLUM ECHINODERMATA						
CLASS ASTEROIDEA (sea stars)						
Astrometis sertulifera (soft spiny star)	R			X		
Pisaster ochraceus (ochre star)	R	X	X			
CLASS ECHINOIDEA (sea urchins)						
Strongylocentrotus franciscanus (red urchin)	R	1	X	X		
Strongylocentrotus purpuratus (purple urchin)	R	2	X	X		1
CLASS OPHIUROIDEA (brittle stars)						
Ophioderma panamense	R			X*		
Ophionereis annulata	R			X*		
Ophiopteris papillosa	R			X*		
Ophiothrix spiculata	R			X*		
CLASS HOLOTHUROIDEA (sea cucumbers)						
Parastichopus parvimensis (southern cucumber)	R	X	X	X		X
PHYLUM CHORDATA						
CLASS ASCIDIACEA						
Aplidium sp.	R			X*		
Metandrocarpa taylori (orange tunicate)	R			X*		
CLASS OSTEICHTHYES						
ORDER GOBIESOCIFORMES (clingfishes)						
Gobiesox rhessodon (California clingfish)	R			X*		
ORDER ATHERINIFORMES						
Leuresthes tenuis (California grunion)	S		X			
ORDER PERCIFORMES						
FAMILY COTTIDAE (sculpins)						
Clinocottus analis (wooly sculpin)	R	X	X			
FAMILY KYPHOSIDAE						
Girella nigricans (opaleye)	R	X	X			

Appendix 4. Sea Birds Observed on Santa Catalina Island. Data from unpublished checklists of Dainty, Diamond, and Lees (18-20 March 1968), Cody, Diamond, and Lees (29 April-2 May 1968), and Haufler (1978).

Podilymbus podiceps (pied-billed grebe)

Podiceps caspicus (eared grebe)

Puffinus puffinus (manx shearwater)

Puffinus creatopus (pink-footed shearwater)

Puffinus griseus (sooty shearwater)

Loomelania melania (black petrel)

Pelecanus occidentalis (brown pelican)

Phalacrocorax auritus (double-crested cormorant)

Phalacrocorax penicillatus (Brandt's cormorant)

Phalacrocorax pelagicus (pelagic cormorant)

Haematopus bachmani (black oystercatcher)

Larus argentatus (herring gull)

Larus californicus (California gull)

Larus canus (mew gull)

Larus glaucescens (glaucous-winged gull)

Larus heermanni (Heermann's gull)

Larus occidentalis (western gull)

Larus philadelphia (Bonaparte's gull)

Thalasseus maximus (royal tern)

Endomychura hypoleuca (Xantus' murrelet)

Ptychoramphus aleutica (Cassin's auklet)

Appendix 5. Typical Species in the Eight Plant Communities Encountered within One-half Mile of Santa Catalina Island ASBS Subareas II and IV. Plant community designations were taken from Munz (1968) and Thorne (1967). Common names and relative abundance information were taken from Thorne (1967).

	Relative Abundance
I. Coastal Sage Scrub	
Opuntia littoralis (prickly pear)	abundant
Artemisia californica (California sagebrush)	abundant
Rhus integrifolia (lemonade berry)	common
Rhus laurina (laurel sumac)	common
Encelia californica (bush daisy)	abundant
Selaginella bigelovii (spike moss)	common
Mimulus puniceus (bush monkey flower)	common
Salvia mellifera (black sage)	abundant
Haplopappus venetus furfuraceus	common
Lotus argophyllus ornithopus (silver clover)	common
Cleome isomeris (bladder-pod)	common
Zauschneria californica californica (California fuchsia)	infrequent
Crossosoma californicum (wild apple)	common
Achillea millefolium (yarrow)	frequent
Castilleja spp. (paint brush)	common
Lupinus spp. (lupine)	frequent
Galium spp. (bredstraw)	common
Cirsium spp. (thistle)	frequent
Calystegia macrostegia (bindweed)	common
Marah macrocarpus (wild cucumber)	common
II. Chaparral	
Salvia mellifera (black sage)	abundant
Rhus integrifolia (lemonade berry)	common
Rhus laurina (laurel sumac)	common
Rhus ovata (sugar bush)	infrequent
Adenostoma fasciculatum (chamise)	common

	Relative Abundance
II. Chaparral (continued)	
<u>Quercus</u> <u>dumosa</u> (scrub oak)	abundant
<u>Ceanothus</u> <u>megacarpus</u> <u>insularis</u> (white lilac)	frequent
<u>Heteromeles</u> <u>arbutifolia</u> (toyon)	common
<u>Cercocarpus</u> <u>betuloides</u> <u>blancheae</u> (mountain mahogany)	common
<u>Baccharis</u> <u>pilularis</u> <u>consanguinea</u> (coyote brush)	infrequent
<u>Rhamnus</u> <u>pirifolia</u> (island buckthorn)	common
<u>Crossosoma</u> <u>californicum</u> (wild apple)	common
<u>Mimulus</u> <u>puniceus</u> (bush monkey flower)	common
<u>Haplopappus</u> <u>venetus</u> <u>furfuraceus</u>	common
<u>Gnaphalium</u> spp. (everlasting)	common
III. Scrub Oak/Southern Woodland	
<u>Quercus</u> <u>dumosa</u> (scrub oak)	abundant
<u>Salvia</u> <u>mellifera</u> (black sage)	abundant
<u>Heteromeles</u> <u>arbutifolia</u> (toyon)	common
<u>Rhus</u> <u>integrifolia</u> (lemonade berry)	common
<u>Rhus</u> <u>laurina</u> (laurel sumac)	common
<u>Rhus</u> <u>ovata</u> (sugar bush)	infrequent
<u>Prunus</u> <u>ilicifolia</u> <u>lyonii</u> (Catalina cherry)	common
<u>Rhamnus</u> <u>pirifolia</u> (island buckthorn)	common
<u>Eriogonum</u> <u>giganteum</u> <u>giganteum</u> (St. Catherine's lace)	common
<u>Artemisia</u> <u>californica</u> (California sagebrush)	abundant
<u>Ceanothus</u> <u>arboreus</u> (California lilac)	frequent
<u>Ceanothus</u> <u>megacarpus</u> <u>insularis</u> (white lilac)	frequent
<u>Crossosoma</u> <u>californicum</u> (wild apple)	common
IV. Coastal Grassland	
<u>Avena</u> <u>barbata</u> (slender wild oat)	abundant
<u>Avena</u> <u>fatua</u> (wild oat)	common

	Relative Abundance
IV. Coastal Grassland (continued)	
Bromus rubens (foxtail cheat)	common
Bromus mollis	common
Bromus diandrus (ripgut grass)	common
Hordeum glaucum (foxtail)	common
Distichlis spicata stolonifera (salt grass)	frequent
Poa scabrella (malpais bluegrass)	frequent
Erodium cicutarium (storksbill)	common
Elymus condensatus (ryegrass)	frequent
Festuca megalura	common
Lamarckia aurea (goldentop)	common
Lasthenia chrysostoma (gold fields)	abundant
Lotus argophyllus ornithopus (silver clover)	common
Lupinus spp. (lupine)	frequent
Amsinckia intermedia (common fiddleneck)	common
Castilleja spp. (paint brush)	common
Bloomeria crocea (golden stars)	frequent
Dichelostemma puchellum (blue dicks)	common
Layia platyglossa campestris (tidy-tips)	common
Astragalus leucopsis (rattle weed)	common
Eschscholzia spp. (poppy)	frequent
Dodecatheon clevelandii insulare (shooting star)	frequent
Gilia spp.	common
Calochortus catalinae (mariposa lily)	common
Calochortus splendens	frequent
Viola pedunculata (yellow pansy)	infrequent
V. Maritime Desert Shrub	
Opuntia littoralis (prickly pear)	abundant
Opuntia prolifera (cholla)	locally abundant
Bergerocactus emoryii (columnar cactus)	locally abundant
Lycium californicum (box thorn)	abundant

Appendix 5 (continued)

	Relative Abundance
V. Maritime Desert Shrub (continued)	
<u>Artemisia</u> <u>californica</u> (California sagebrush)	abundant
<u>Encelia</u> <u>californica</u> (bush daisy)	abundant
<u>Rhus</u> <u>integrifolia</u> (lemonade berry)	common
<u>Atriplex</u> <u>californica</u>	frequent
<u>Atriplex</u> <u>coulteri</u>	frequent
<u>Atriplex</u> <u>semibaccata</u> (Australian saltbush)	abundant
<u>Dudleya</u> <u>hassei</u>	frequent
<u>Amblyopappus</u> <u>pusillus</u>	frequent
<u>Haplopappus</u> <u>venetus</u> <u>furfuraceus</u>	common
<u>Gasoul</u> <u>crystallinum</u> (ice plant)	locally abundant
<u>Gasoul</u> <u>nodiflorum</u>	common
<u>Mirabilis</u> <u>laevis</u> (four-o'clock)	common
<u>Dichelostemma</u> <u>puchellum</u> (blue dicks)	common
<u>Calystegia</u> <u>macrostegia</u> (bindweed)	common
VI. Coastal Strand	
<u>Gasoul</u> <u>crystallinum</u> (ice plant)	locally abundant
<u>Gasoul</u> <u>nodiflorum</u>	common
<u>Atriplex</u> <u>semibaccata</u> (Australian saltbush)	abundant
<u>Atriplex</u> <u>leucophylla</u>	frequent
<u>Cakile</u> <u>maritima</u> (sea rocket)	infrequent
<u>Abronia</u> <u>maritima</u> (sand verbena)	locally abundant
<u>Distichlis</u> <u>spicata</u> <u>stolonifera</u> (salt grass)	frequent
<u>Haplopappus</u> <u>venetus</u> <u>furfurcatus</u>	common
<u>Ambrosia</u> <u>chamissonis</u>	infrequent
<u>Heliotropium</u> <u>curassavicum</u> <u>oculatum</u> (wild heliotrope)	frequent
<u>Cressa</u> <u>truxillensis</u> <u>vallicola</u> (alkali weed)	infrequent
VII. Riparian Woodland	
<u>Populus</u> <u>trichocarpa</u> (black cottonwood)	frequent
<u>Populus</u> <u>fremontii</u> (cottonwood)	locally common

Appendix 5 (continued)

	Relative Abundance
VII. Riparian Woodland (continued)	
Salix lasiolepis (arroyo willow)	common
Sambucus mexicana (elderberry)	common
Quercus macdonaldi (oak)	frequent
Clematis ligusticifolia (virgin's bower)	infrequent
Ambrosia psilostachya (western ragweed)	infrequent
Artemisia douglasiana	infrequent
Baccharis douglasii (mule fat)	locally abundant
Baccharis viminea (mule fat)	infrequent
Xanthium strumarium (cocklebur)	frequent
Urtica dioica holosericea (tall nettle)	frequent
Verbena robusta	frequent
Elymus condensatus (ryegrass)	frequent
Elymus triticoides	infrequent
VIII. Aquatic	
Potamogeton pectinatus (sage pondweed)	infrequent
Ruppia maritima (ditch grass)	infrequent
Azolla filiculoides (water fern)	locally abundant
Equisetum laevigatum (scouring rush)	locally abundant
Equisetum telmateia braunii (giant horsetail)	locally abundant
Cotula coronopifolia	common
Rorippa nasturtium-aquaticum (watercress)	frequent
Mentha spicata (spearmint)	locally abundant
Mentha piperata (peppermint)	locally abundant
Rumex crispus (curled dock)	frequent
Rumex salicifolius (willowdock)	frequent
Mimulus cardinalis (red monkey flower)	frequent
Juncus acutus sphaerocarpus (bulrush)	locally abundant
Polypogon interruptus (beard grass)	common
Polypogon monspeliensis	frequent
Typha latifolia (cattail)	infrequent