

INVENTORY AND MONITORING OF NATURAL RESOURCES

PAMPHLET
Management
Biosphere
Reserves
#15-19



Channel Islands

National
Park

National Park Service
U.S. Department of the Interior

INVENTORY AND MONITORING OF NATURAL RESOURCES

IN CHANNEL ISLANDS NATIONAL PARK CALIFORNIA

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Channel Islands National Park
1901 Spinnaker Drive
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PREFACE

It is with great pride and enthusiasm that I present this series of ten handbooks standardizing and documenting the inventory and monitoring program at Channel Islands National Park.

Channel Islands National Park is an excellent demonstration site for National Park Service inventory and monitoring activities because park resources include a diverse array of both terrestrial and marine ecosystems. Channel Islands is a world class conservation area -- designated as a State Area of Special Biological Concern and Ecological Reserve, a National Marine Sanctuary, and an International Biosphere Reserve in addition to its National Park status. This has focused attention and research on park resources, and resulted in development of an extensive cooperative network of researchers and a large body of information on various aspects of the marine and island systems.

Monitoring information is vital to the welfare of the natural resources of all park areas. It enables us to focus on real issues and increases our ability to distinguish natural variability and phenomena from man-made resource threats that require management action. I encourage all park managers to establish their own inventory and monitoring program using our model or others that fit your needs.

William H. Ehorn
Superintendent, Channel Islands National Park

October, 1988



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dedicated to the many generations

of resource managers who will actually monitor ecosystem health

and

of park managers who will use monitoring data to answer questions that have not yet been asked.

Editorial, publication, and graphics services for this series of handbooks were provided by:

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The Channel Islands,
an island chain lying just off California's southern coast,
provide habitat for marine life
ranging from microscopic plankton
to the largest creature on earth
-- the blue whale.

These same islands shelter
unique plant and animal life
found nowhere else on earth.

In 1980, Congress designated five of these islands

CHANNEL ISLANDS NATIONAL PARK

and mandated the inventory and protection
of the islands and surrounding waters.

A long-term monitoring system was therefore developed
to achieve the objectives of resource inventory
and increased ecological understanding
upon which to base
future resource management decisions.

A series of ten handbooks has been prepared as the result of an ongoing effort
to standardize the monitoring methods used and share these methods with
others who may benefit from them.

pinnipeds
sea birds
rocky intertidal communities
kelp forest
terrestrial vertebrates
land birds
terrestrial vegetation
fishery harvest
weather
visitors

INTRODUCTION

*parks --ecological
"miner's canaries"*

As large natural ecosystems, national parks have many values to society. They are pleasuring grounds for outdoor recreation and emotional retreats from the stresses of modern, urban life. National parks also protect the reservoirs of wild genetic material that are the basis of the nation's future in bioengineering, agriculture, aquaculture, and pharmaceuticals. Most importantly though, national parks are vital ecosystem standards that warn us of impending disasters, like ecological "miner's canaries". However, if we do not watch the canaries, their warnings will be lost.

Channel Islands National Park has designed and implemented this long-term monitoring program in response to Congressional concern -- as it were to "watch the canary". The park was established in 1980 "to protect the nationally significant natural, scenic, wildlife, marine, ecological... and scientific values of the Channel Islands in the State of California..." The park's enabling legislation specifically required development of "an inventory of all terrestrial and marine species, indicating their population dynamics, and probable trends as to future numbers and welfare", with biennial reports to Congress to include "recommendations as to what actions should be considered for adoption to better protect the natural resources of the park."

Channel Islands National Park consists of five of the eight California Channel Islands. The eight islands are divided into two groups -- four northern islands, Anacapa, Santa Cruz, Santa Rosa, and San Miguel islands, all of which are within the park boundaries; and four southern islands, of which only Santa Barbara Island is within the park. These islands lie 20 to 73 km off the coast of southern California and range in size from tiny 260-ha Santa Barbara Island to 25,000-ha Santa Cruz Island. The total area of the park is 100,000 ha, which is divided nearly equally between submerged lands and islands. Anacapa Island, the closest to the mainland, lies 22 km from the mainland headquarters of the park in Ventura, while the western outpost, San Miguel Island, is 100 km from Ventura (Figure 1).

The five park islands vary greatly in size and form. Anacapa Island, 283 ha in size and less than 1 km wide, is strung out in three narrow islets connected by shallow reefs over a distance of 8 km. Sheer cliffs and steep rugged slopes soar over rocky shores pockmarked with sea caves. The cliffs extend directly into the submerged regions of the park to depths exceeding 200 m.

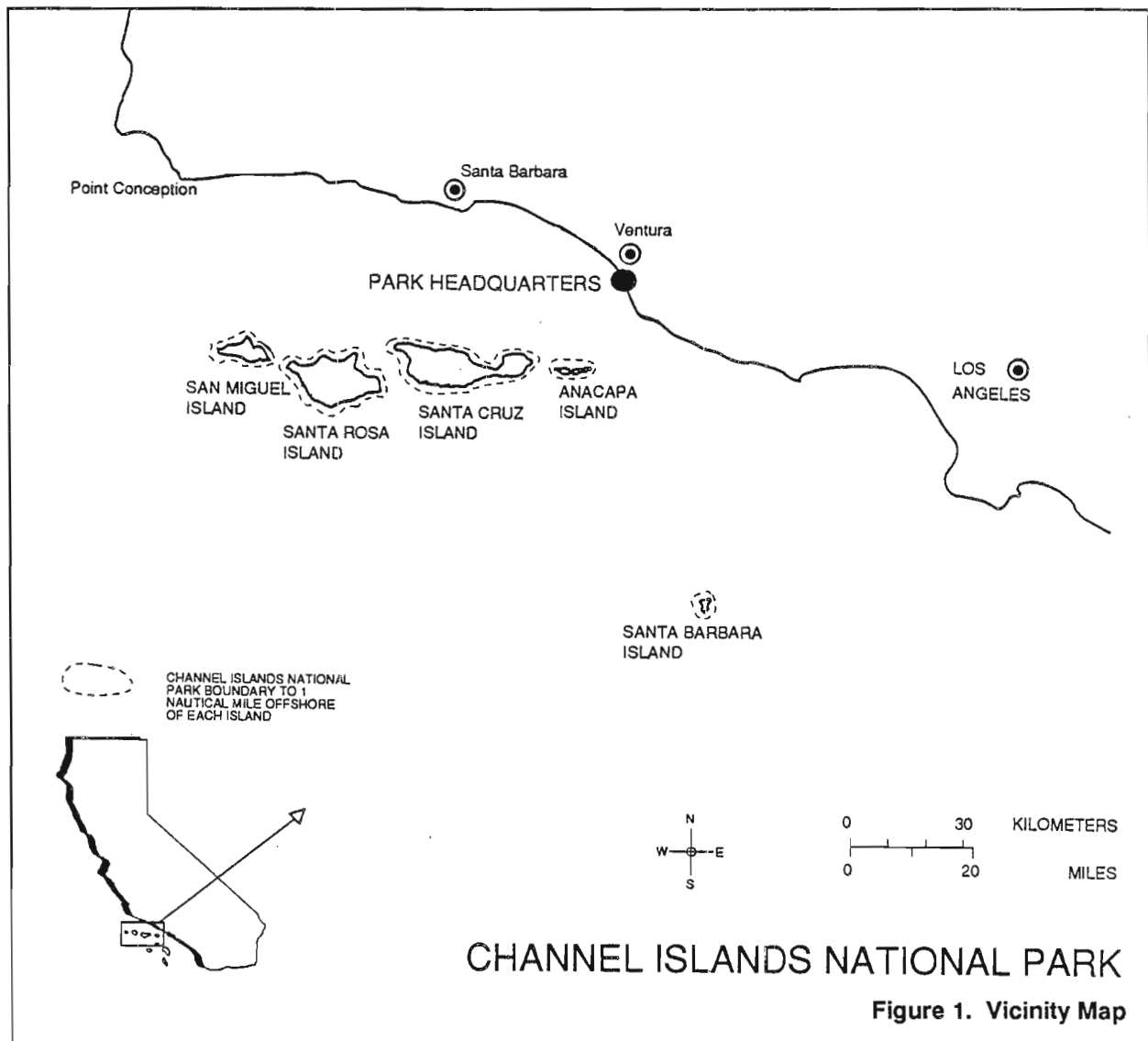
Santa Cruz Island lies just over 6 km to the west of Anacapa Island across the shallow Anacapa Passage. The largest of the islands, Santa Cruz is 25,000 ha in size and towers over 657 m above a coastline of cliffs, sea caves, and protected anchorages. The island is characterized by rugged slopes, steep canyons, fresh water streams, pine forests, and oak groves. Two volcanic ridges run much of the length of the island separated by a protected central valley. The steep north shore plunges abruptly into the Santa Barbara Channel, whereas a narrow shelf of sandstone extends several kilometers along the southern shore before falling away into the 2,000-m deep Santa Cruz Basin.

Santa Rosa Island, 8 km to the west of Santa Cruz Island, is 21,600 ha in size. Rolling coastal terraces, canyons deeply incised by perennial streams, and mountains to 550 m characterize the terrain. Wide sandy beaches and rocky

intertidal benches surround the island, with a unique coastal marsh on the east end. Offshore, broad shallow terraces support extensive giant kelp forests.

San Miguel Island, westernmost of the northern islands, covers 4,050 ha. It is a gently sloping plateau with long sandy beaches along the coastline. Jumbled submerged rock piles give witness to the high energy of northern storms that strike this exposed coast, giving it the look of central California at Big Sur and Monterey. Strong, nearly constant winds from the northwest mold the land. The combination of sand and wind has exposed an unusual geologic feature -- a caliche forest composed of sand casts of prehistoric vegetation.

Santa Barbara Island, only 263 ha in size, lies 65 km southeast of Anacapa Island and 73 km west of Palos Verdes. The island is a gently sloping plateau surrounded by towering sea cliffs. There are few sandy beaches and in many areas the rocky shores are virtually inaccessible from the land. Offshore, submerged rock arches and eroded reefs testify to dynamic sea levels and provide attachments for extensive kelp forests.



SIGNIFICANCE OF RESOURCES

*a resource of
superlatives*

Channel Islands National Park is one of the most biologically productive and diverse units in the National Park System. Isolation from the mainland has provided both protection from human disturbance and the opportunity for evolution of distinct taxa. The park's natural resources are of national and international significance in many respects. Many park resources can accurately be described in superlatives - "one of a kind", "the only place where...", "exceptional scientific value", "exists here and nowhere else in the world", "unparalleled opportunity", "wildlife spectacle".

Equally accurate superlatives can be used to describe the region adjacent to the park - "worst air quality in the nation", "one of the world's largest cities", "far exceeds allowable pollution standards", "fastest growing urban complex". There is a seemingly unsatiable demand for sun-belt living, recreation, energy, and harvest of marine products. The pressures of competing resource use further heighten the significance of park resources. Park islands support some of the last examples of natural Mediterranean-type ecosystems in North America and of coastal and marine ecosystems in southern California.

RESOURCE VALUES

Park waters harbor biota that are representative of nearly 1,600 km of the California coast from Ensenada, Mexico to San Francisco. The park lies on the boundary of two major marine biogeographical provinces: the Oregonian province to the north and the Californian to the south. The western islands of the park, San Miguel and Santa Rosa, are bathed by cold northern waters carried south by the California current and therefore reflect the biological assemblages of the Oregonian province. Waters around the eastern islands of Anacapa and Santa Barbara come from the south along the mainland coast and support the warm temperate biota characteristic of the Californian province. Around Santa Cruz Island, at the boundary of these two provinces, there is a broad transition zone where plants and animals from both provinces mingle and create a unique assemblage of species that are capable of adapting to the variable conditions of the transition zone.

Prevailing winds and the topography of the ocean floor of adjacent basins also greatly influence biological communities within the park. Winter storms bring rain and winds that buffet the northern shores, whereas biota of the southern coasts reflect their more sheltered position. The confluence of major oceanic currents and the shape of the continental shelf create a rare phenomenon of persistent upwelling near the park. Nutrient-rich water from the deep sea wells up near Point Conception (on the mainland coast to the north), and produces exceptionally productive food webs in the waters around San Miguel and Santa Rosa islands.

The richness and diversity of the marine communities are reflected by an abundance and diversity of marine plants, invertebrates, fish, mammals, and seabirds. One of the more prominent marine communities surrounding the islands is the giant kelp forest which occurs in relatively shallow rocky bottom areas. One third of the kelp beds in southern California are found in the park. These marine

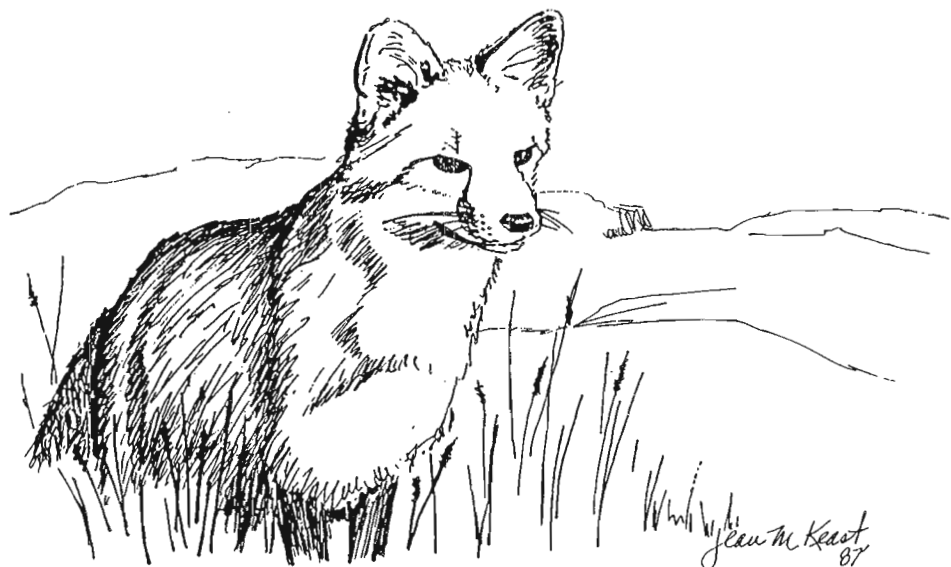
*Channel Islands --an
American Galapagos*

forests provide food and shelter for over 125 fishes, as well as habitat for scores of other animal and plant species, nearly 1,000 in all.

The richness of the marine environment also extends to seabirds and mammals. As many as 26 species of whales and porpoises can be found in the park, as well as six species of pinnipeds (seals and sea lions). San Miguel Island's Point Bennett is certainly one of the world's most outstanding wildlife displays. It is the only known place in the world where six pinniped species coexist and where four consistently breed. Park islands provide protected rookeries for eleven species of sea birds and are the only places in the United States where the endangered California Brown Pelican breeds.

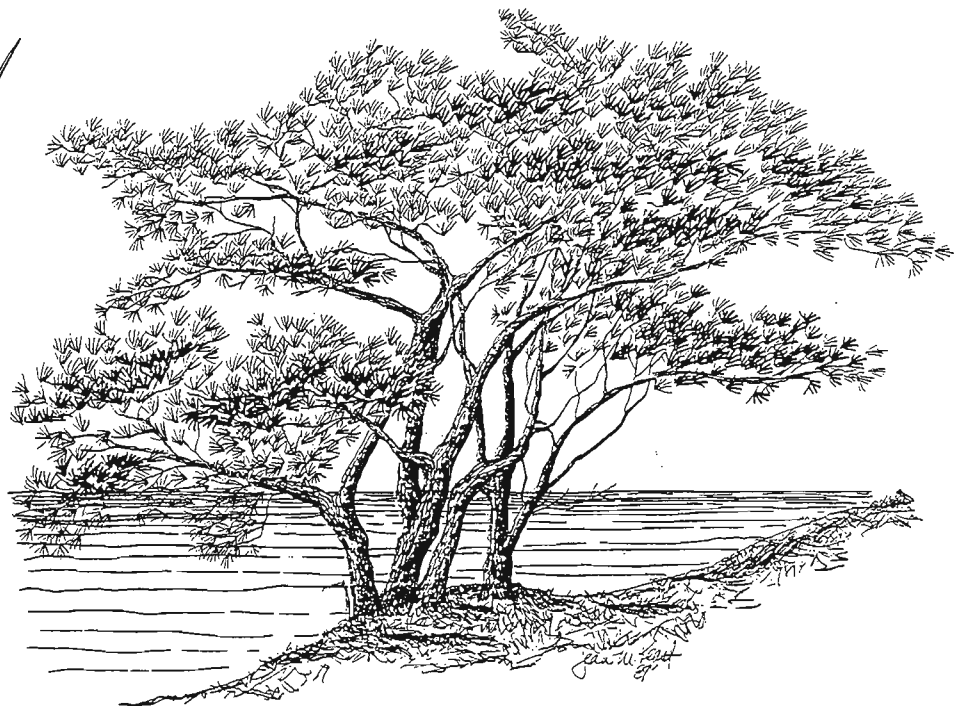
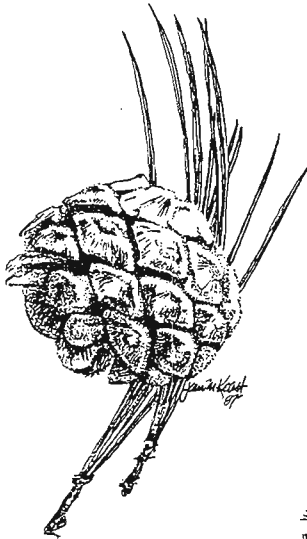
Many of the park's values are a product of isolation from the mainland. The most commonly-held hypothesis is that the northern islands were never linked to the mainland by a land bridge, but rather were joined with each other some 17,000 years ago when sea level was at its lowest. It is also thought that the southern islands were never linked to each other or to the mainland. The reputation of the Channel Islands as the "American Galapagos" is well deserved. Physical isolation from mainland ecosystems have allowed life forms on the islands to evolve independently from similar mainland forms. Difficulty of travel to and from the islands protects them from human disturbance even now. Benefits of isolation are particularly apparent with respect to sea birds and marine mammals that once bred in many areas of the mainland coast; today they find sufficient freedom from civilization and human disturbance only on the offshore islands.

The evolution of unique life forms on the islands, often coupled with recent habitat destruction elsewhere, has resulted in designations of rare, threatened, or endangered status for a relatively large number of species. For example, the island fox, a State of California rare species, is found on the three largest park islands. Each island supports a distinct subspecies of island fox. The island night lizard, a species listed by the federal government as threatened, is found in the park on only Santa Barbara Island. An endangered endemic subspecies of song sparrow that was found on Santa Barbara Island is now thought to be extinct.



Of the 800 plant taxa found on park islands, many are found nowhere else. Approximately 100 species and 30 subspecies of plants are endemic to the eight Channel Islands; in other words they do not occur naturally on the mainland and their entire distribution is confined to one or more of these islands. Many more island plant species have only very small or scattered mainland populations. Outstanding examples of these plant resources include the Torrey pine found in the wild only on Santa Rosa Island and in a small section of coast north of San Diego, and the giant coreopsis, a large tree-like sunflower found only on the islands and in small sections of the adjacent mainland coast. The succulent island live-for-ever (*Dudleya traskiae*) is listed as endangered by the federal government and is found only on Santa Barbara Island.

The islands are also significant for their vertebrate fossils and cultural resources. Fossil remnants of an endemic dwarf mammoth, a giant mouse, and an extinct gannet have been discovered on Santa Rosa and San Miguel islands. Anacapa, Santa Barbara, and San Miguel islands have been listed on the National Register of Historic Places due to the richness of their archaeological resources. San Miguel Island is thought to be the burial place of Juan Rodriguez Cabrillo who discovered California in 1542. Additionally, many midden and village sites of the seafaring Chumash people have been found. Some are thought to date back as far as 10,000 years and may be the earliest known evidence of man in North America. Recent historical structures such as the Coast Guard settlement on East Anacapa Island, built during the early 1930's, and the Nidever Adobe on San Miguel Island, are on the National Register of Historic places. Other historical settlement structures are found at historic ranches on Santa Cruz and Santa Rosa islands.

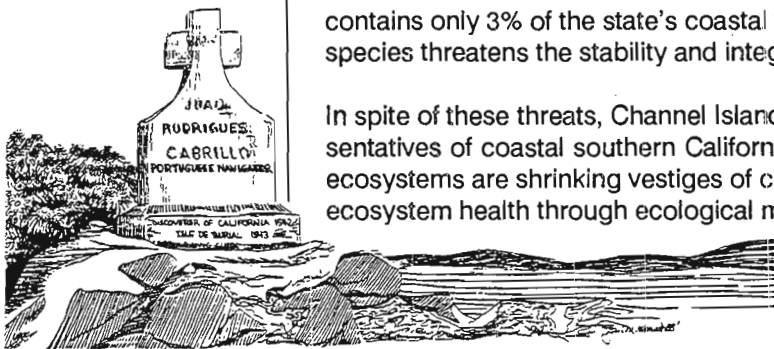


EFFECT OF MAN - PAST AND PRESENT

All of the park islands have been used for ranching and grazing to some extent in the past. These activities have significantly altered natural processes such as erosion and have affected native plants and animals through the introduction of alien plants and animals that out-compete, eat, and replace native species. Ranching activities have continued from 1843 to the present on Santa Rosa Island where a special use permit with the former owner (as provided for in the legislation that established the park) allows cattle ranching and commercial hunting for introduced elk and deer. Over 100 years of sheep and cattle grazing as well as a vineyard and orchards have modified Santa Cruz Island. Cattle and sheep grazing have recently been discontinued on the 90% of Santa Cruz Island owned by the Nature Conservancy however the remaining 10% of the island still under private ownership supports an abundance of feral sheep which remain from former ranch activities. San Miguel Island is in the process of recovering from sheep grazing which continued until 1968, and from feral burros that were removed in 1976. Anacapa Island was grazed and Santa Barbara Island was farmed and grazed until 1938 when Channel Islands National Monument was established. Even with national monument status, introduced rabbits were not removed from Santa Barbara Island until 1981. Feral pigs are still found on both Santa Cruz and Santa Rosa islands. Monitoring programs provide information needed to formulate and evaluate management strategies and tactics to restore island ecosystems and document their recovery from past land-use practices.

Channel Islands National Park exists on the edge of a human tide. Nearly 15 million people reside on the adjacent mainland coast. In the park, these neighbors seek solitude, recreation, and knowledge of their environment but bring with them threats of crowding, trampling, and disturbance of fragile and extremely limited island and marine habitats. Air quality in the nearby Los Angeles basin is among the worst on earth, exceeding federal ozone standards of 120 ppb more than 100 days a year. Strong seasonal easterly Santa Ana winds carry the polluted air offshore into the park (ozone levels on Anacapa Island have exceeded 200 ppb during these events) threatening sensitive plant communities like the rare Torrey pine forest on Santa Rosa Island. Near shore currents carry urban runoff and waste water effluent northwesterly from the metropolitan centers of Los Angeles and Orange counties to park waters. Major offshore petroleum exploration and development in the adjacent Santa Barbara Channel and up-current and upwind in the nearby Santa Maria Basin brings with it the potential of additional air and water pollution. According to the only data available, state managed fishery harvests in and near the park remove 4,500 to 6,800 mt (10-15 million pounds) of giant kelp, rock fish, halibut, angel shark, sea urchin, lobster, abalone, and dozens of other fish and shellfish each year. This biomass constitutes about 15% of California's total near shore harvest even though the park contains only 3% of the state's coastal waters. This selective removal of fishery species threatens the stability and integrity of park ecosystems.

In spite of these threats, Channel Islands National Park includes the best representatives of coastal southern California ecosystems that exist. Because park ecosystems are shrinking vestiges of coastal California, regular assessments of ecosystem health through ecological monitoring programs are vital.



ECOLOGICAL MONITORING DESIGN

"How can you tell how it
used to be when there's
nothing left to see?"

Refrain from
"The Prince of Tides"
Jimmy Buffett, 1988

The process to restore and preserve southern California coastal ecosystems took a great leap forward with establishment of Channel Islands National Park and the overlapping and surrounding Channel Islands National Marine Sanctuary in 1980. The keystone of this restoration and protection effort is an ecological monitoring program designed to provide park and sanctuary managers with regular assessments of ecosystem health. The monitoring program is also designed to determine limits of natural variation, diagnose abnormal conditions, identify potential agents of abnormal change, and prescribe potential remedial treatments.

Natural ranges of variation are poorly known in ecosystems and need to be determined by monitoring. Only if normal limits of variation are known can abnormal conditions be readily identified in time to take corrective action. Monitoring of resource conditions is analogous to physician conducted physical examinations and diagnostic investigations of patients which are the very basis of modern health maintenance practice. Long years of measuring blood pressure, pulse rate, blood chemistry, temperature, and other vital signs in a wide variety of people under many different conditions have given physicians accurate standards with which to judge a patient's condition and detect illness. The health of park ecosystems can be determined in the same way - by monitoring the systems' vital signs over a long period of time.

For a long-term ecological monitoring program to provide useful information, managers and scientists must together make a commitment to a process for future continuity and select appropriate vital signs, species, locations, and methods for monitoring. Once selected, procedures must be established and institutionalized to allow regular reliable sampling, data analysis, and reporting over the long term. Design of an ecological monitoring program for a national park area has five basic steps:

- Determine what, where, when, and how to monitor
- Establish data management procedures
- Establish reporting procedures
- Document monitoring protocols
- Implement and institutionalize monitoring

Subject experts designed the ecological monitoring program for Channel Islands National Park by addressing each of these basis steps. Considerations for each step in this design process included the following.

DETERMINE WHAT, WHERE, WHEN, AND HOW TO MONITOR

Selection of Vital Signs

Population dynamics -- ecological vital signs

Just as a physician monitors a patient's vital signs, natural resource managers need to monitor an ecosystem's vital signs. The long-term ecological monitoring program at Channel Islands National Park is based upon population dynamics of selected organisms - the ways in which populations change - as the ecological vital signs that indicate the health of the resources and/or measure ecological processes to be managed. Parameters of population dynamics that are amenable to monitoring include abundance, distribution, age structure, reproduction and recruitment, growth rates, mortality rates, and phenology.

Although other ecological approaches to describe and monitor ecosystems such as biodiversity, energy flux, or nutrient budgets could have been used (Odum 1959, Conant et al. 1983, Orians 1986), population dynamics of selected organisms were chosen as the most useful basis for monitoring at Channel Islands National Park because they best meet the following management requirements.

- Population dynamics accurately reflect ecosystem conditions because organisms integrate the effects of a vast array of ecological factors, including predation, competition, and environmental conditions that are expressed as changes in readily measured population parameters.
- Population dynamics permit projections into the future, providing early warning of adverse conditions through changes in parameters such as age structure and recruitment.
- Subtle, chronic stresses on the system are reflected in reduced growth rates and reproductive efforts long before mortality reduces abundance or distribution.
- Interpretation of these population changes is direct.
- Techniques for measuring changes are simple and well known.
- Population dynamics provide information at the species and population level, which is the level at which most management controls operate. Therefore the monitoring information is directly applicable to management concerns.

Selection of Ecological Components

Over 2,000 species from 34 phyla or divisions in all five kingdoms are known to occur in the park. Since it is not possible, or necessary, to monitor them all, individual species or assemblages of species were selected for monitoring.

Selection criteria were developed and applied to extant species lists to determine what organisms within classic taxonomic categories would be monitored. The criteria assured that monitored taxa would include:

- a broad array of ecological roles and examples of many different trophic levels and life forms (from primary producers to top carnivores, sessile invertebrates to wide ranging pinnipeds)
- species with special legal status (endangered, specified in park enabling legislation, or otherwise protected)
- endemic and alien species
- harvested taxa (for marine resources)
- taxa that dominate or characterize entire communities (giant kelp)
- taxa that are exceptionally common (purple sea urchin)
- popularly recognized or "heroic" species that have public support and understanding (island fox)

To determine what resources to monitor at Channel Islands National Park, all organisms within the park were listed and then divided into mutually exclusive taxonomic categories. A classic taxonomic division of park ecosystems was used to identify 15 kinds of system components that scientists are trained to study at the population level, such as pinnipeds, sea birds, terrestrial plants, and marine invertebrates. Physical environmental factors such as weather greatly influence biological components in ecosystems and are monitored in order to better understand system dynamics and behavior. In addition, human activities constitute a major source of impact on park ecosystems and therefore visitors and fishery harvest are also monitored.

For some taxa (amphibians, reptiles, and terrestrial invertebrates) even rudimentary information about presence or distribution was lacking and initial selections of taxa could not be made with existing knowledge. In these cases, field inventories to determine presence and distribution were made prior to initiation of design studies. These field surveys yielded enough information for selection of amphibians and reptiles, but information on terrestrial invertebrates and the monitoring design study is still incomplete. A summary of taxa selected for monitoring with population parameters, number of locations, and sampling frequency for each is presented in Appendix A.

Selection of Sites

Site selection criteria varied substantially among the taxa. Pinniped and seabird sites were dictated by rookery and haulout locations. Rocky intertidal, kelp forest, and terrestrial vegetation sites were selected to represent an entire range of biogeographical and environmental conditions which influence these communities. Terrestrial vertebrate sites were selected by evaluating species habitat requirements of the monitored species. Complete censuses of all individuals in certain locations (such as pelicans at nesting sites or visitors to each island) were deemed appropriate in some instances. In all cases, field experts made the selections.

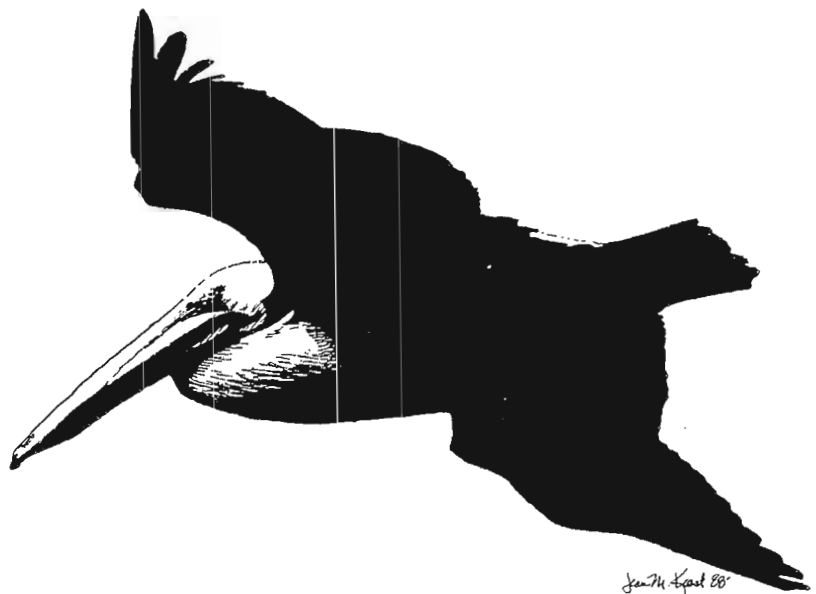
Selection of Sampling Frequency

Sampling frequencies were selected as appropriate for each ecological component. Natural history of monitored taxa, management issues, and practical logistics dictate sampling frequencies which range from once a year or even less frequently to continual monitoring. Vegetation mapping once every five years is sufficient to monitor changes in the boundaries between vegetation communities. Annual reproductive cycles of marine mammals, sea birds, and flowering plants permit annual measures of their populations. The shorter generation times of insects and seasonal variations in intertidal algae require more frequent sampling. Visitors are censused daily in order to determine patterns of visitor use and total visitation. Weather conditions are monitored continually.

Selection of Sampling Techniques

The best sampling techniques are those that are accurate, precise, and robust to observer variability. Techniques can sometimes be selected from the literature, but at other times must be modified or newly developed. Methods that are unambiguous can be carried out by trained park personnel, even when observers change over time. At Channel Islands, selection of sampling techniques also considered historical approaches to monitoring for each ecological component and the historical data base whenever available.

For efficiency, sampling techniques that measure more than one population parameter were favored. Population abundance or density was selected for virtually all taxa. In addition, a variety of sampling techniques were also selected to measure other population parameters, such as size or age structure and reproductive effort. Each method was field tested for at least one year in order to standardize the method and demonstrate its utility.



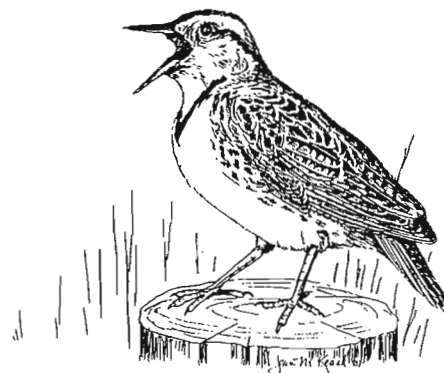
ESTABLISH DATA MANAGEMENT PROCEDURES

A data management system is an essential part of the monitoring design process. Once field sampling is complete, raw data are recorded, archived, entered into computer programs that assist in summarizing information, and analyzed through lists, charts, tables, graphs, and statistical calculations as appropriate. Descriptive measures of population dynamics parameters are the ultimate result. Data analysis is accomplished using standard software (such as dBase III + , Lotus 1-2-3, and SPSS).

ESTABLISH REPORTING PROCEDURES

Resource monitoring is not complete when the field observations and data analysis have been made. The establishment of a reporting procedure that archives data, disseminates information, and documents changes in monitoring protocols is therefore an important step in the monitoring design process. As part of reporting procedures, the format is defined, appropriate audience and distribution are determined, and review procedures and standards for review are established. A report series allows the monitoring program to adapt to changes in environmental conditions and take advantage of changing technology and knowledge without losing the continuity and integrity of the data record.

A report series was established at Channel Islands National Park to address these needs. Standards and guidelines have been prepared to assist authors and reviewers in organizing their thoughts and comments and to assure some consistency in the series. The reports are edited by two National Park Service research scientists, an academic (or other agency) subject area scientist, and an editorial review board composed of the park superintendent and division chiefs for resource management, ranger activities, and interpretation. The reports serve as a repository for monitoring observations, a vehicle for disseminating information locally, and a mechanism for documenting management recommendations, including changes in monitoring procedures. Reports are generally prepared each year at the end of the field season by the principle investigator of each monitoring component.



DOCUMENT MONITORING PROTOCOLS

At the completion of each design study, the monitoring protocol was documented in a standardized handbook. Handbooks allow others to continue the monitoring process over the long term by describing data collection and analysis techniques in detail. In this way, continuity and quality of future data collection by resource managers can be maintained. Handbooks will be reviewed and revised as field methods are further tested and experience allows for new insights. The monitoring report series provides a mechanism for documenting recommendations for revisions in the handbooks.

The ten monitoring protocol handbooks in this set document monitoring activities for Channel Islands National Park as of 1988. A separate handbook is available for each of the following:

- Pinnipeds (seals and sea lions)
- Seabirds
- Rocky Intertidal Community
- Kelp Forest (includes three resource categories - marine invertebrates, marine vegetation, and fishes)
- Terrestrial Vertebrates (includes reptiles, amphibians, and mammals)
- Land Birds
- Terrestrial Vegetation
- Fishery Harvest
- Visitors
- Weather

New handbooks for other ecological components (such as water and air quality and terrestrial invertebrates) may be added to the set as information is developed. The recent acquisition of Santa Rosa Island and pending acquisition of the eastern portion of Santa Cruz Island have prompted initiation of design studies related to their terrestrial resources which will result in an additional handbook and modifications of existing handbooks.

IMPLEMENT AND INSTITUTIONALIZE MONITORING

the park monitoring team

Park managers have a responsibility to base management decisions on a firm understanding of resource conditions and possible human impacts on the resources within their charge. Monitoring over time can provide that understanding. However, even the best designed monitoring program will fall far short of expectations unless adequate staffing, support, and long-term funding is obtained to implement the program.

The functional relationships among the monitoring team are important aspects of the ecological monitoring program at Channel Islands (Davis et al. 1988). The scientists, both resource managers and researchers who institutionalize and conduct the monitoring play discrete yet complementary roles. To again draw on a medical analogy, in many respects a natural ecosystem can be likened to a human body. Resource management agencies are analogous to health care organizations; both are designed to assure continued good health of their subjects. At Channel Islands National Park, resource managers act as family physicians for park ecosystems. They monitor ecosystem health with regular checkups. They recognize signs and symptoms and diagnose illnesses: sometimes acute, sometimes chronic. They prescribe treatments and evaluate the results of those treatments.

Park rangers serve as Emergency Medical Technicians for park ecosystems. They identify overt threats to the systems. They provide immediate, practical treatments to alleviate symptoms and stabilize vital signs. They protect ailing ecosystems until long-term treatments to cure or mitigate underlying causes can be instigated. Rangers are also like public health officials who prepare and distribute information about epidemics and recommend preventative actions and treatments. They interpret scientific findings regarding park ecosystems and explain their significance to the public. They also develop ways to explain park values, threats to those values, and ensure adequate understanding of resource issues by a wide cross section of the American public.

Research scientists act as medical researchers. They develop new techniques for assessing health. They identify new diseases and determine causative agents. They develop and test new treatments to cure or mitigate illness.

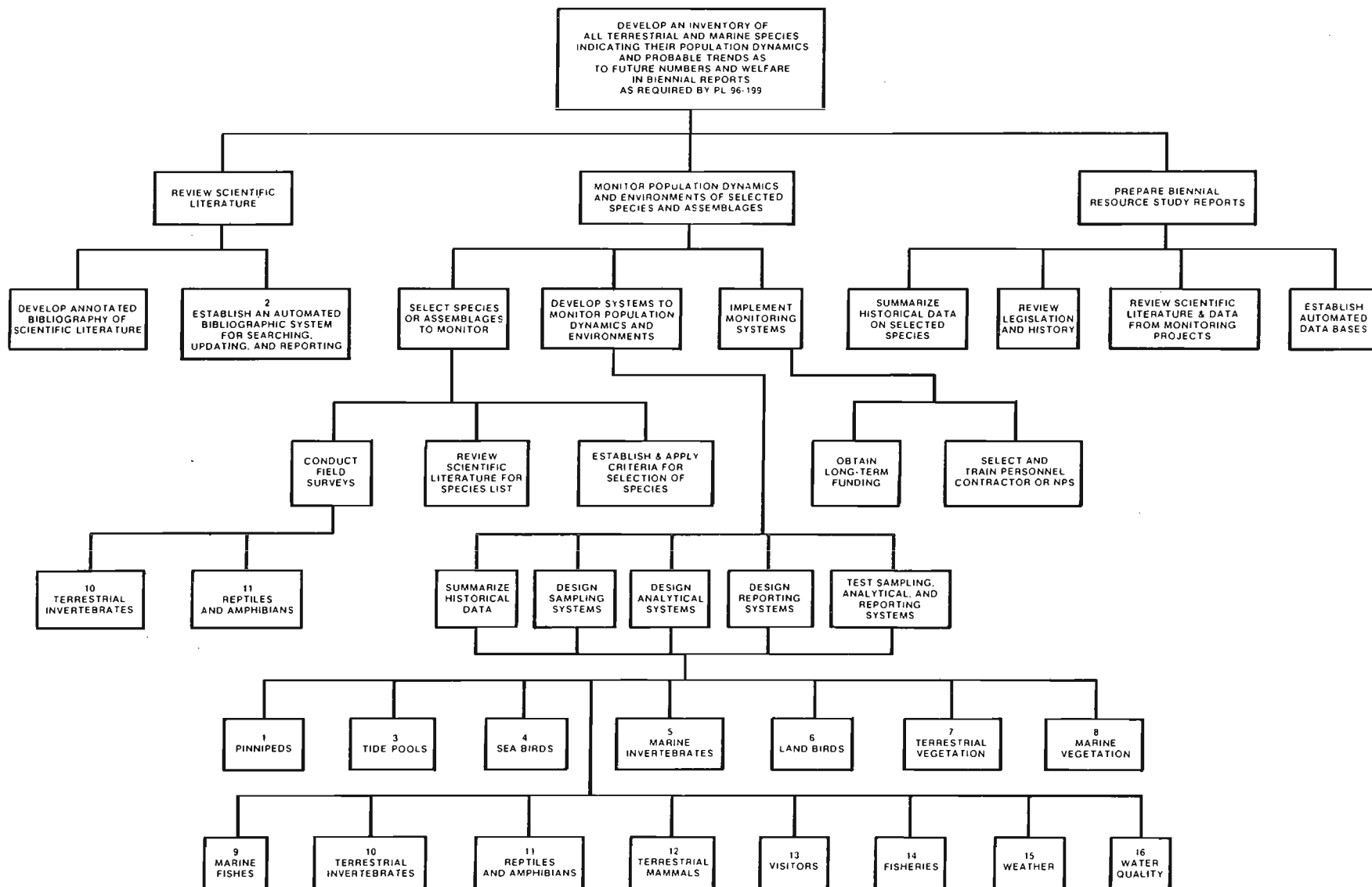
Natural resource management, like medicine, is an art practiced with a scientific basis. All of these professional specialists work toward the same goal, healthy park ecosystems, each contributing in their own way. Yet they all follow the scientific method, i.e. hypotheses are formulated, tested, and revised based on test results. Identifying and solving ecological problems in such extremely complex and poorly known systems as national parks is clearly an art.

Resource monitoring and management of Channel Islands National Park benefit from and require a cooperative approach with several regulatory and land management agencies and organizations due to the fact that much of the park is owned or under the jurisdiction of others. A brief summary of these external organizations and their role is included in Appendix B. The National Oceanic and Atmospheric Administration (National Marine Fisheries Service and Marine Sanctuary Program) and California Department of Fish and Game have been especially instrumental in the design studies and initiation of monitoring.

A step-down diagram (after Phenicie and Lyons 1973) illustrates the monitoring program design and development strategy and provides a useful summary of the monitoring design for Channel Islands (Figure 2). The program's goal is indicated at the top of the diagram, with all of the actions required to achieve the goal shown on the next lower level. The same pattern is repeated down the diagram until individual research projects or management actions were identified. The projects were then placed in priority by the park staff for funding.



STEP-DOWN PLAN FOR NATURAL RESOURCES MONITORING AT CHANNEL ISLANDS NATIONAL PARK, CALIFORNIA



NUMBERS INDICATE PRIORITY OF PROJECTS
ESTABLISHED BY SUPERINTENDENT CHIS AND
NATURAL SCIENCE DIVISION, WRO

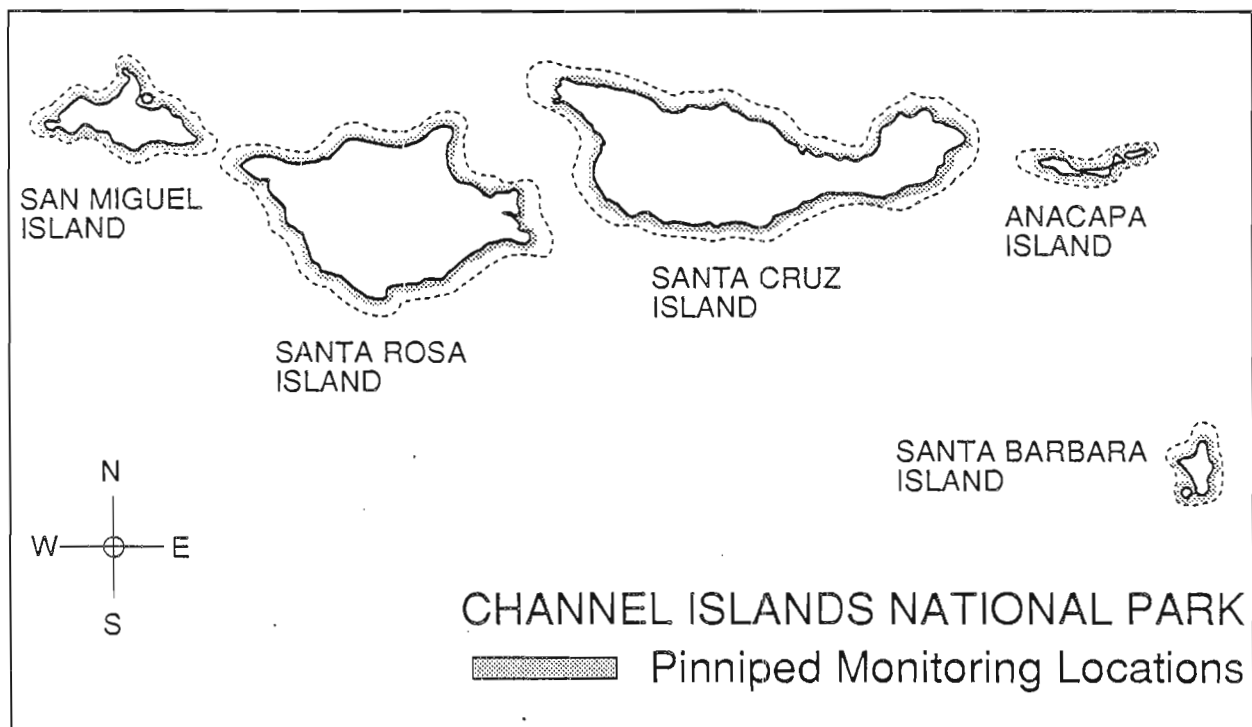
SUMMARY OF TEN MONITORING PROTOCOLS

The following abstracts of each monitoring handbook provide brief summaries of sampling techniques and indicate the distributions of monitoring sites for each resource category.

PINNIPEDS

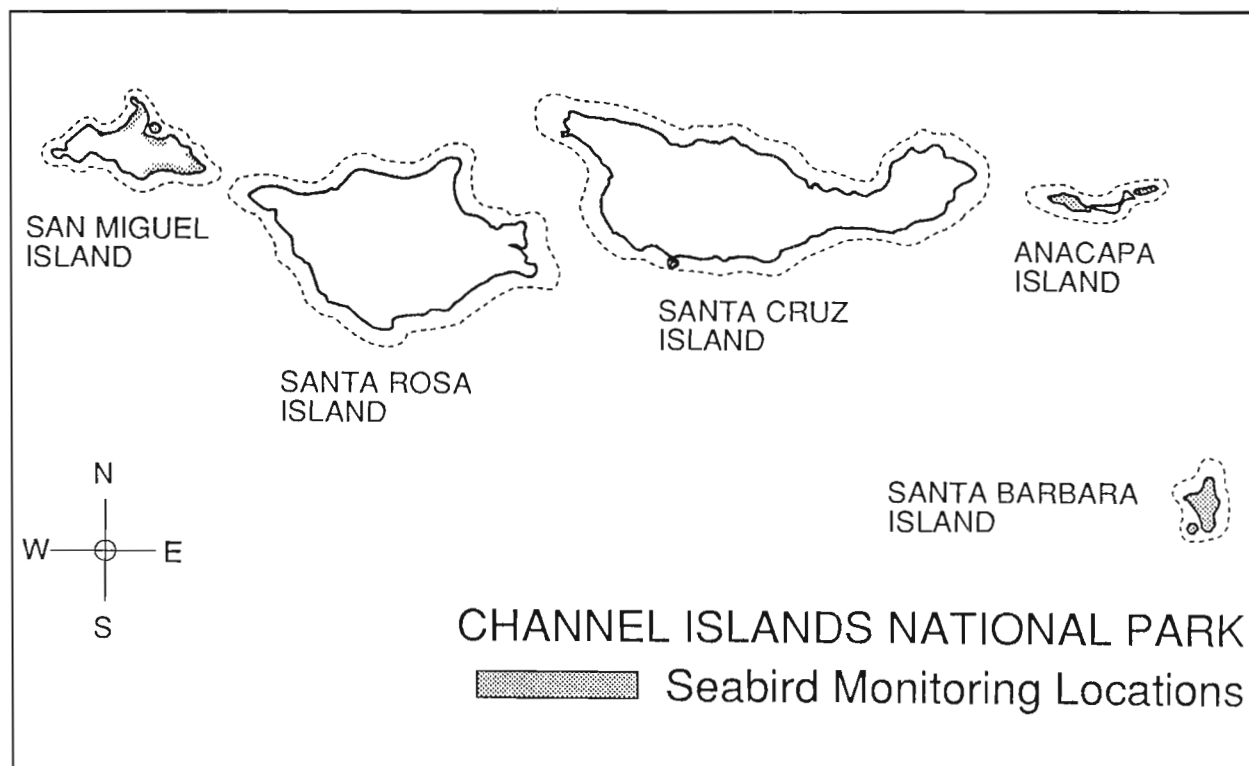
Six species of pinnipeds haul out on park beaches and use park waters. The four most abundant, California sea lion (*Zalophus californianus*), northern elephant seal (*Mirounga angustirostris*), harbor seal (*Phoca vitulina richardsi*), and northern fur seal (*Callorhinus ursinus*) were selected for long-term monitoring. Observations are also recorded for Northern (Steller) sea lion (*Eumetopias jubatus*) and Guadalupe fur seal (*Arctocephalus townsendi*), but they occur so infrequently that it is not feasible to routinely monitor their population dynamics.

Three sampling techniques gather information on the abundance, age structure, recruitment (pup production), and reproductive phenology of pinnipeds. Ground counts, conducted in mid-winter, late spring, and mid-summer are used primarily to measure pup production, but also provide opportunities to collect information on animal condition. Aerial counts, using oblique 35-mm photographs taken four times a year (February 14-28, April 14-28, May 25 - June 10, and July 15-30), are used to determine the number of adult pinnipeds and distribution of rookeries and hauling sites. Aerial counts from vertical, 5-inch transparencies taken in mid-winter and mid-summer are used to enumerate and determine size distributions of pinnipeds on relatively flat, open beaches, such as Pt. Bennett on San Miguel Island. Geographical distribution is recorded using the 94 zones or beach segments in the park defined by Bureau of Land Management contractors from the University of California and summarized in DeMaster et al. (1984).



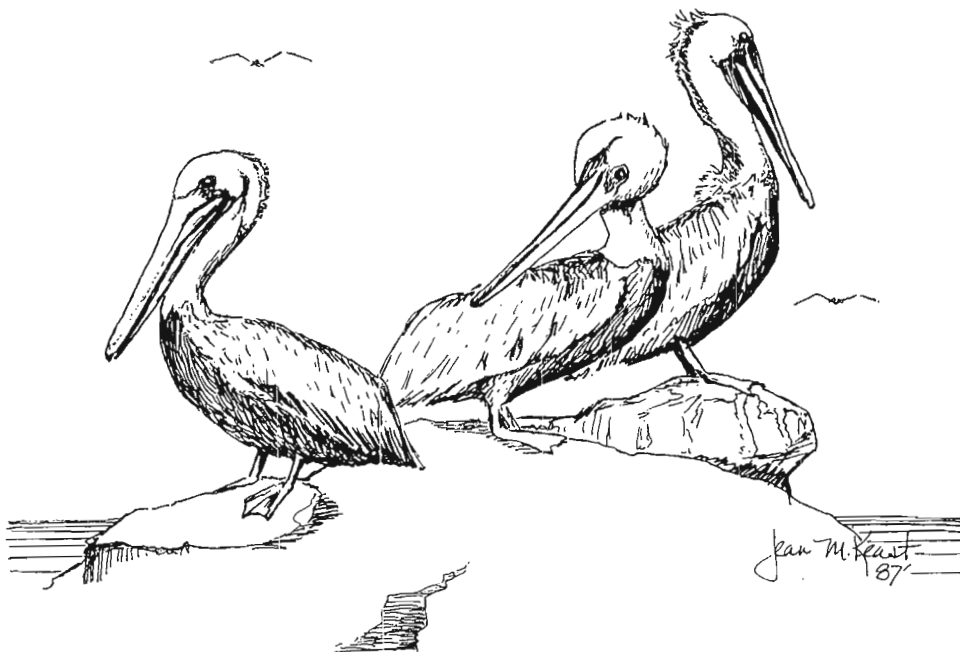
SEABIRDS

Eleven seabird species breed in the park (Hunt et al. 1980). Six of these seabirds and one shorebird, the Snowy Plover (*Charadrius alexandrinus*) were selected for long-term monitoring. The selected seabirds are: Double-crested Cormorant (*Phalacrocorax auritus*), Pelagic cormorant (*P. pelagicus*), California Brown Pelican (*Pelecanus occidentalis californicus*), Western Gull (*Larus occidentalis*), Xantus' Murrelet (*Synthliboramphus hypoleuca*), and Cassin's Auklet (*Ptychoramphus aleuticus*). The remaining seabirds, three Storm-Petrels (*Oceanodroma leucorhoa*, *O. homochroa*, and *O. melania*), Brandt's Cormorant (*P. penicillatus*) and the Pigeon Guillemot (*Cephus columba*) are nocturnal, secretive, poorly known in the park and/or difficult to observe and were therefore excepted from formal monitoring.



Field observations of nesting birds are used to gather information on the number of breeding birds (reproductive efforts), recruitment (fledging success), population age structure, growth rate, and reproductive phenology. Colony surveys of California Brown Pelicans are conducted on West Anacapa and Santa Barbara islands following the methods described by Anderson and Gress (1983). Double-crested Cormorant colonies on Santa Barbara, West Anacapa, and Prince islands are observed monthly from mid-April through August to determine abundance of breeding birds and chicks, brood sizes, and phenology. Similarly, Pelagic Cormorant nesting is observed on East and West Anacapa Island. Total nest counts of Western Gulls are made within ten days of peak egg laying on Santa Barbara Island and in mid-May on Gull Island (off Santa Cruz Island). Fixed plots (0.25-1.0 ha) are used to sample gull colonies on Santa Barbara, Anacapa, and Prince islands to determine reproductive effort, fledging success, chick growth rates, age structure, and phenology following the methods of Hunt

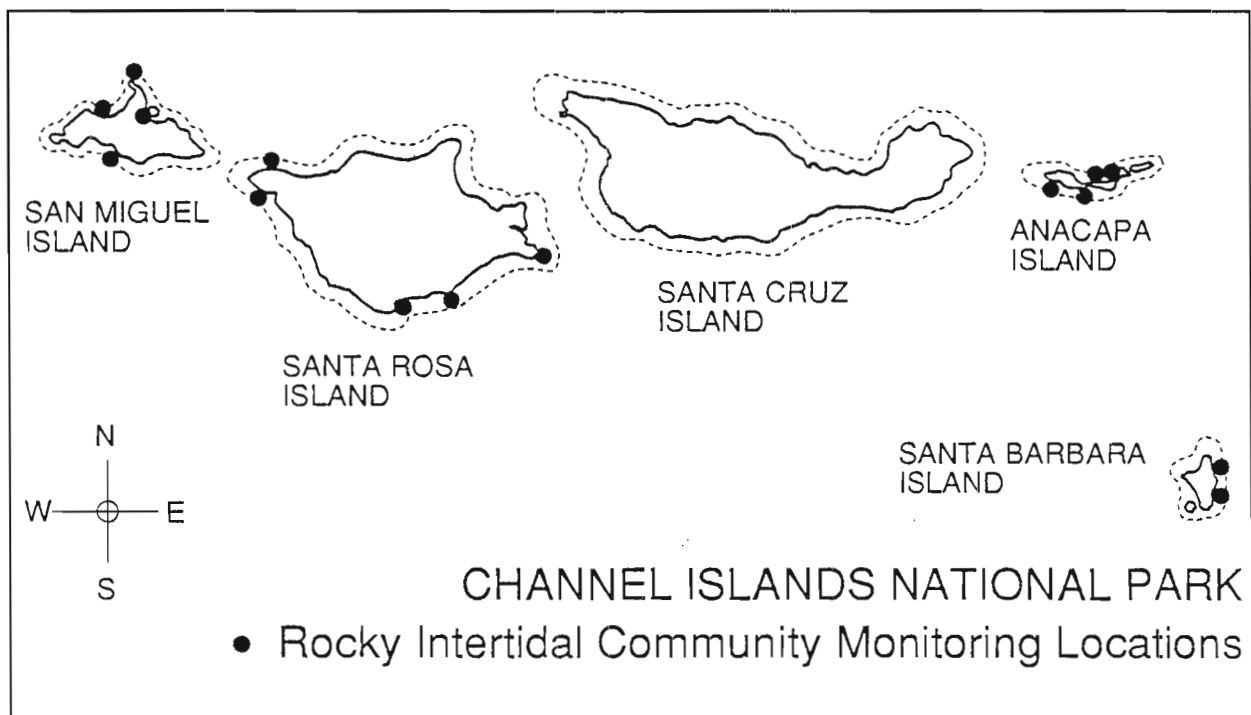
and Butler (1980). The abundance of nesting Xantus' Murrelets and their reproductive effort and phenology on Santa Barbara Island are determined from weekly examinations of marked nest burrows at two locations on the island from early March through mid-June. Burrow-dwelling sea birds are notoriously difficult to monitor (Hunter et al. 1982), especially those like the Cassin's Auklets on Prince Island which utilize loose, easily collapsed soil in high concentrations. To prevent the collapse of burrows during censuses, two boardwalks, each 10 m in length, were installed in the Prince Island colonies before nesting began in January, 1986. Beneath the platforms, 50 nest boxes with removable lids were installed to determine levels of nesting activity, reproductive effort and success, and phenology. Nest boxes are examined three or four times during the nesting season from late February to July. Snowy Plover abundance and reproductive activity is assessed by walking fixed courses along approximately 10 km of sandy beach on San Miguel Island and counting the number of adults, nests, eggs and chicks observed on five surveys during the nesting season from April through July.



ROCKY INTERTIDAL COMMUNITIES

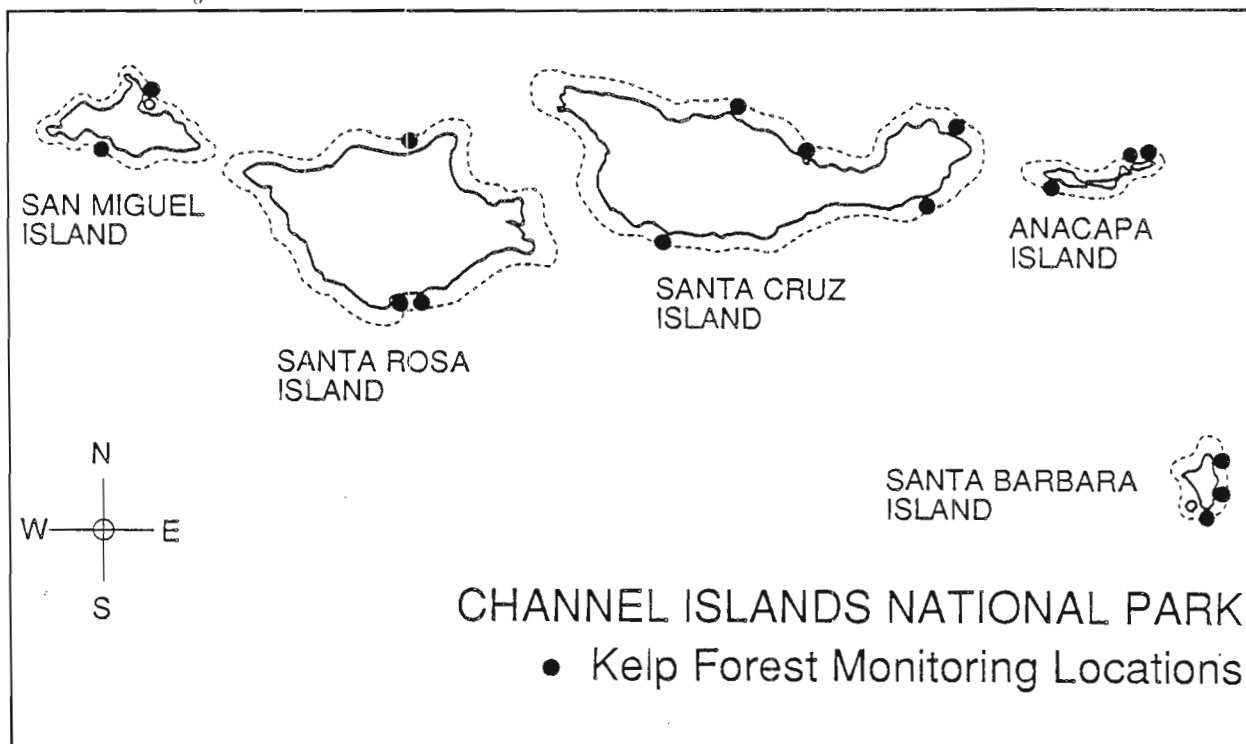
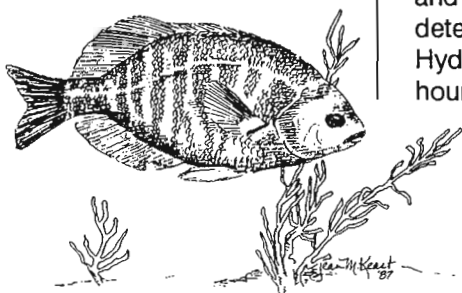
Following baseline studies of Littler (1980), 15 stations representing the range of biogeographical and ecological conditions found in the park were established on four park islands (excluding Santa Cruz Island) to monitor seasonal and annual changes in populations of rocky intertidal organisms. Organisms selected for monitoring represent tidal zones common throughout the park. Acorn barnacle (*Chthamalus fissus/dalli*) generally dominates the highest zone where it is commonly found with other barnacles, such as *Balanus glandula* and *Tetraclita rubescens*. A low turf-like red alga, *Endocladia muricata*, represents the next lowest zone. The rockweed zone is represented by brown algae, primarily *Pelvetia fastigata* and *Hesperophycus harveyanus*. At Santa Barbara Island, red algae *Gigartina canaliculata* and *Gelidium* are monitored in a zone below the rockweeds. The lowest zone monitored is represented by California mussel (*Mytilus californianus*). In addition to these index organisms, the abundance of tar and bare substratum are monitored. Black abalone (*Haliotis cracherodii*) support the largest portion of California's abalone fishery and are monitored in the park to evaluate fishery harvest as well as environmental conditions.

Fixed photogrammetric quadrats (50 x 75 cm) and plots (1 to 2 m²) for abalone (Richards 1987), owl limpet, and sea stars are used to determine abundance of intertidal organisms. At least five replicate photoquadrats were established to represent each of four zones at each site. The quadrats are photographed with color 35-mm slide film twice a year (each fall and spring) during the daylight low tides. Quadrat images are projected about life-size on a 100 point grid, and the number of points overlain by each of the monitored taxa is recorded to estimate abundance as percent cover. Five fixed replicate abalone plots of 30 to 100 abalone were randomly selected at several sites for long term monitoring. The number and sizes of abalone within each plot are recorded twice a year when the photoquadrats are sampled. Selected abalone were also marked with stainless steel wire and numbered tags to determine growth and movement.



KELP FORESTS

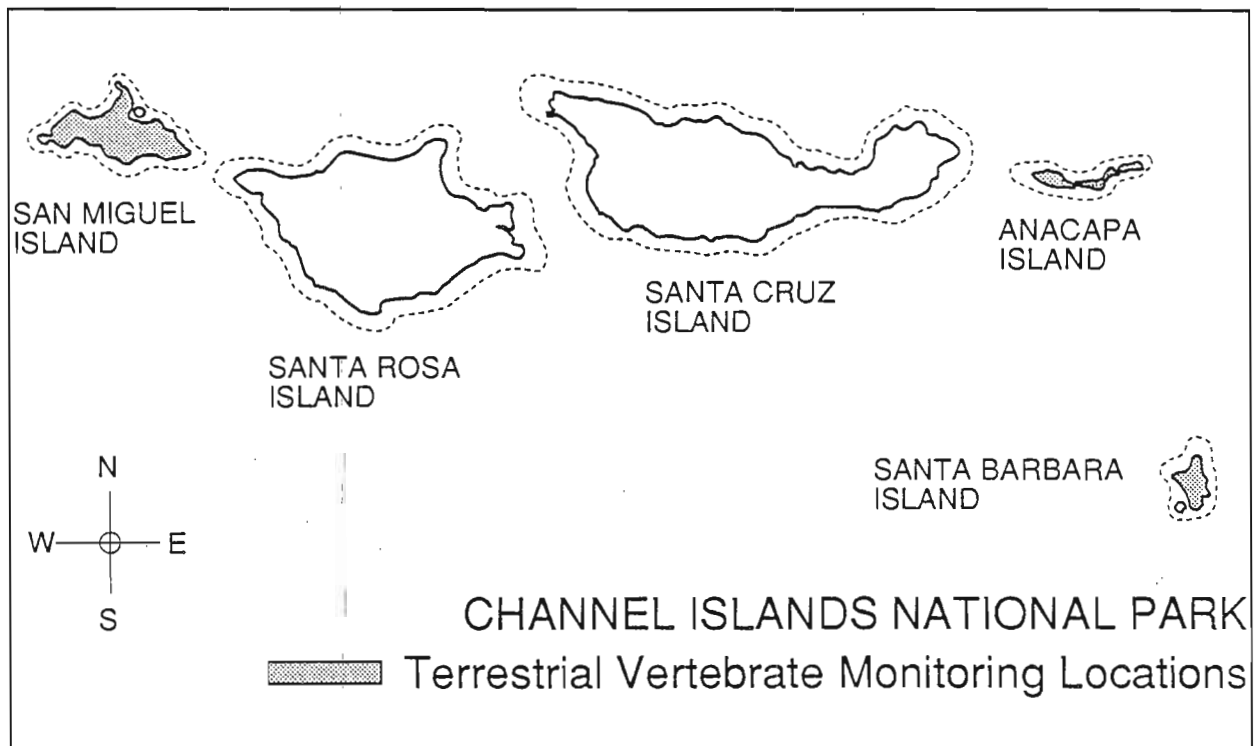
Nearly 1,000 species are known to inhabit kelp forests in the park (Woodhouse 1981, J. M. Engle pers. comm.). They are organized in assemblages representing a boreal, Oregonian biogeographical province, a temperate, Californian province, and a transition zone, intermediate between these provinces (Murray et al. 1980, Seapy and Littler 1980). Sixty-eight taxa were selected to represent kelp forests in the park: 15 algae, 15 fishes, and 38 invertebrates (Davis 1985). To represent the range of biogeographical and environmental conditions in which kelp forests occur in the park, 16 fixed sites were established. Each site was marked by a 100 m-long transect permanently affixed to the seabed with 11 stainless steel eyebolts and connected with 12-mm diameter lead-filled woven nylon line. Seven different sampling techniques are employed to gather information on population dynamics of kelp forest organisms at these stations annually from June through October. At each station, randomly placed 1 m x 2 m quadrats and 3 m x 20 m band transects are used to determine densities and distributions of discrete benthic organisms, 1,000 randomly selected points are used to estimate percent cover of colonial invertebrates and algae, 2 m x 3 m x 100 m fixed transects are used to estimate fish abundance and recorded on videotape to document site appearance, 20 m² photogrametric plots document abundance and distributions of benthic organisms, and size measurements are collected to determine age structure, population recruitment, and growth and mortality rates. Hydrothermographs record benthic sea temperatures and depth (tidal stage) hourly at six locations.



TERRESTRIAL VERTEBRATES

Seven species of native amphibians, reptiles, and terrestrial mammals on Anacapa, Santa Barbara, and San Miguel islands are monitored. The relative abundance of Pacific slender salamander (*Batrachoseps pacificus*), island night lizard (*Xantusia riversiana*), and the southern alligator lizard (*Gerrhonotus multicarinatus*) are monitored on all the islands where they occur using 15 transects of artificial cover (30 cm x 30 cm x 1 cm boards). Captured animals are counted, weighed, and measured. Data provide an uncalibrated index of population size for each transect to detect changes in population levels. The regression of weight on length provides an independent index of the condition of individuals within the population. The island night lizard is of particular interest because it is federally listed as a threatened species and is fully protected by the state. Both the island night lizard and the Pacific slender salamander are endemic to the Channel Islands. Observations are recorded for two other lizards, side-blotched lizards (*Uta stansburiana*) and western fence lizard (*Sceloporus occidentalis*) but because of their limited distribution and low capture rates the information is not adequate to monitor their populations. Population size of deer mice (*Peromyscus maniculatus*) is monitored using 12 trap grids of Sherman live traps. The 10 x 10 trap grids are spaced 7 m apart. One additional grid remains to be established on East Anacapa Island. Data on sex, age, weight, and reproductive condition are collected in order to evaluate the general health of the population.

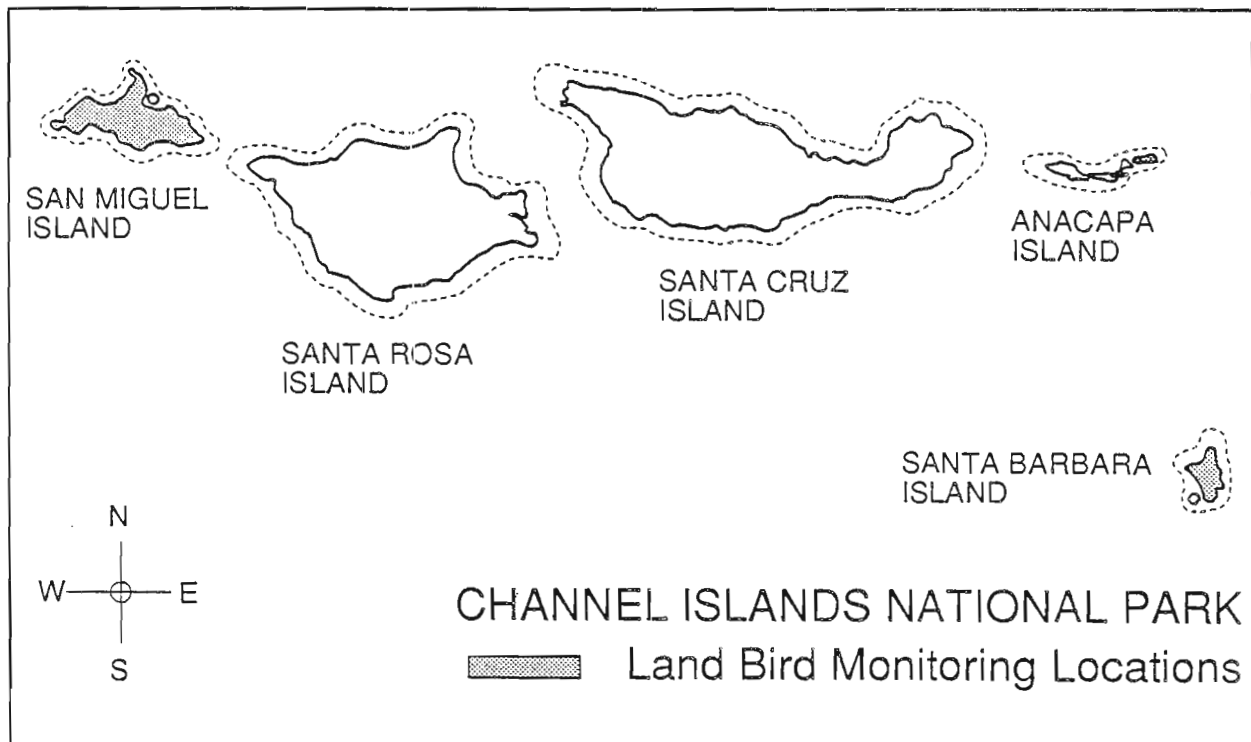
Island fox (*Urocyon littoralis*), a state listed threatened species and island endemic, is monitored at 5 locations on San Miguel Island with 25 live traps arranged in a 5 x 5 grid. The traps are placed 0.3 km (0.2 miles) apart. In addition to population size, data on sex, age, weight, and reproductive condition are collected to evaluate the general health of the population.



LAND BIRDS

Counts of species and numbers of breeding land birds are made on Anacapa, San Miguel, and Santa Barbara islands to provide information on absolute and relative abundances during breeding and nonbreeding periods. Birds are censused annually from already established trails and easily traveled canyons in order to reduce impact on other island resources at off-trail locations. Estimates of relative densities are obtained for 15 breeding birds by multiplying the count data by a correction factor determined through past censuses at stratified random stations. Every five years the station counts are undertaken simultaneously with the trail counts to ensure that the correction factor is still applicable on each island.

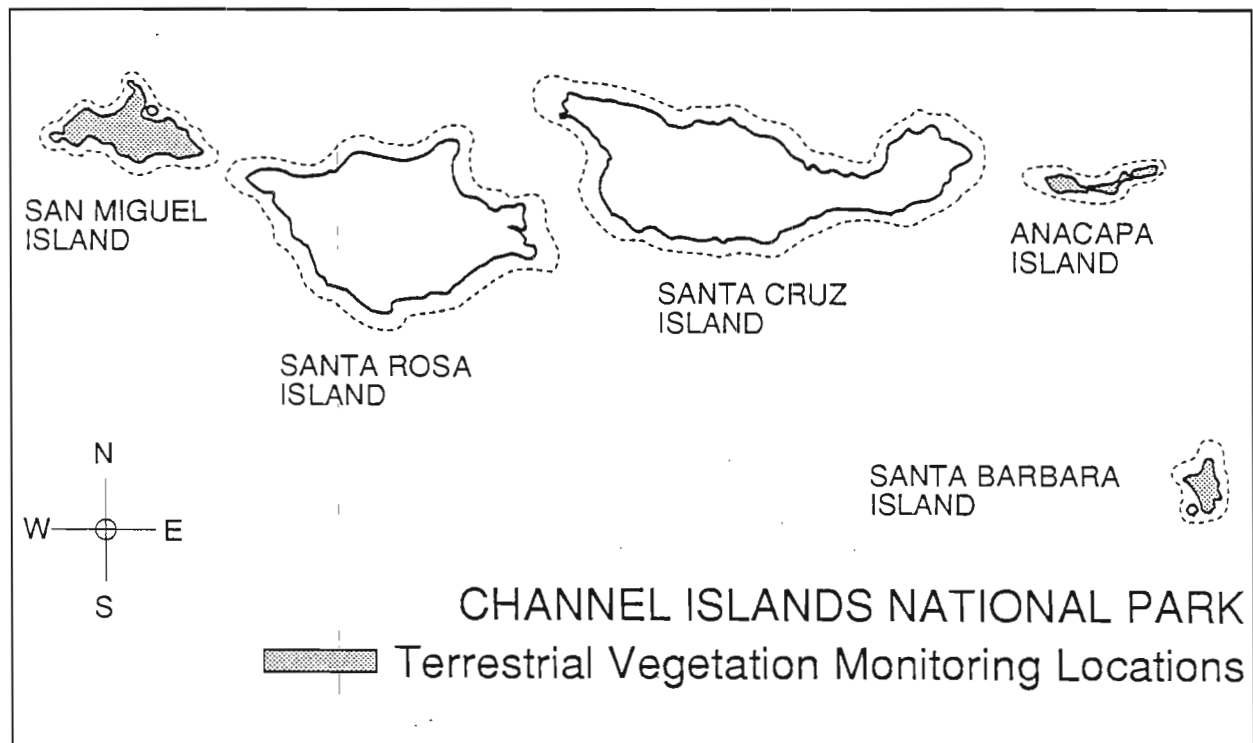
To determine information on reproductive success and age structure, three indicator species have been selected for detailed monitoring. During future monitoring, representatives from three major feeding guilds (a group of birds with similar nutritional requirements) will be observed throughout the breeding season. Species to be observed are American Kestrel (*Falco sparverius*) from the carnivorous guild, the Song sparrow (*Melospiza melodia*) from the granivorous guild, and the Orange-crowned Warbler (*Vermivora celata*) from the insectivorous guild. Indicator species from each major foraging guild will provide relative information on reproductive phenology and operative environmental constraints on all land bird species of that guild. The selected indicator species occur on all three islands with the exception of the Song Sparrow which only occurs on San Miguel Island.



TERRESTRIAL VEGETATION

Vegetation monitoring has been initiated on San Miguel, Anacapa, and Santa Barbara islands. The vegetation monitoring program was specifically designed to monitor the changes which are taking place in representative plant communities. Communities monitored include sand dune, sea cliff scrub, caliche scrub, *Coreopsis* scrub, coastal sage scrub, maritime cactus scrub, sea-blite scrub, box thorn scrub, *Haplopappus* scrub, island chaparral, island woodland, perennial and annual iceplant, and grassland/herbland.

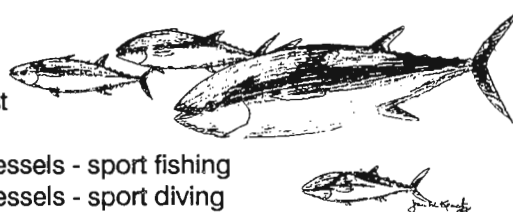
The vegetation monitoring program uses two methods to monitor changes in plant communities -- periodic vegetation mapping and monitoring of plant species height and presence along permanent transects. A total of 54 permanent transects were established; 22 on Santa Barbara Island, 16 on Anacapa Island, and 16 on San Miguel Island. A point-intercept method (30 m, 100 point transects) is used to sample and quantify plant communities along each transect. This method records species and their height occurring at regular, predetermined intervals along the transect. Ecological attributes that can be quantified from this method include species composition, frequency of occurrence, height, and cover.



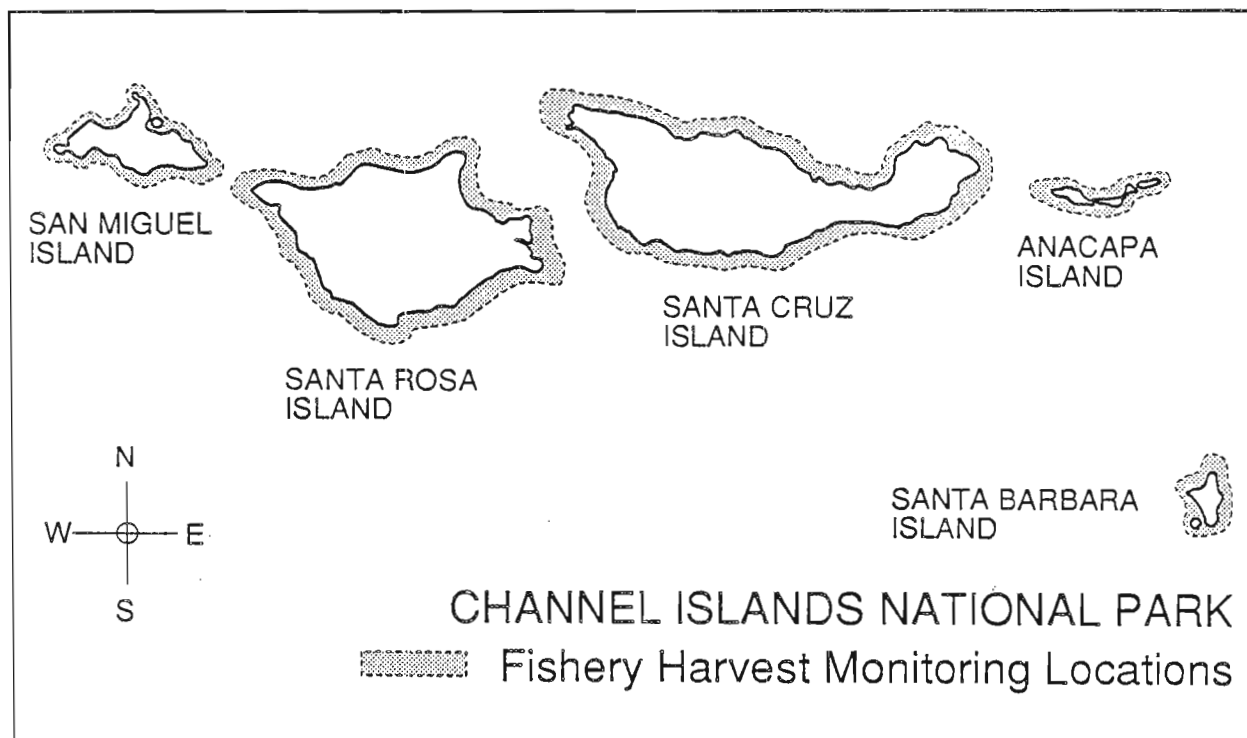
FISHERY HARVEST

The shallow shelves adjacent to the islands provide the primary southern California habitat for abalone, sea urchin, lobster, a variety of fin fish, and kelp, all of which have commercial and sport fishing value. General trends in fishery harvest from Channel Islands National Park may be discerned by analyzing data on commercial harvest that are collected by the California Department of Fish and Game. Fisheries data obtained are broken into the following five categories of commercial harvest:

- Commercial fishery harvest
- Commercial spiny lobster harvest
- Commercial kelp harvest
- Commercial passenger fishing vessels - sport fishing
- Commercial passenger fishing vessels - sport diving



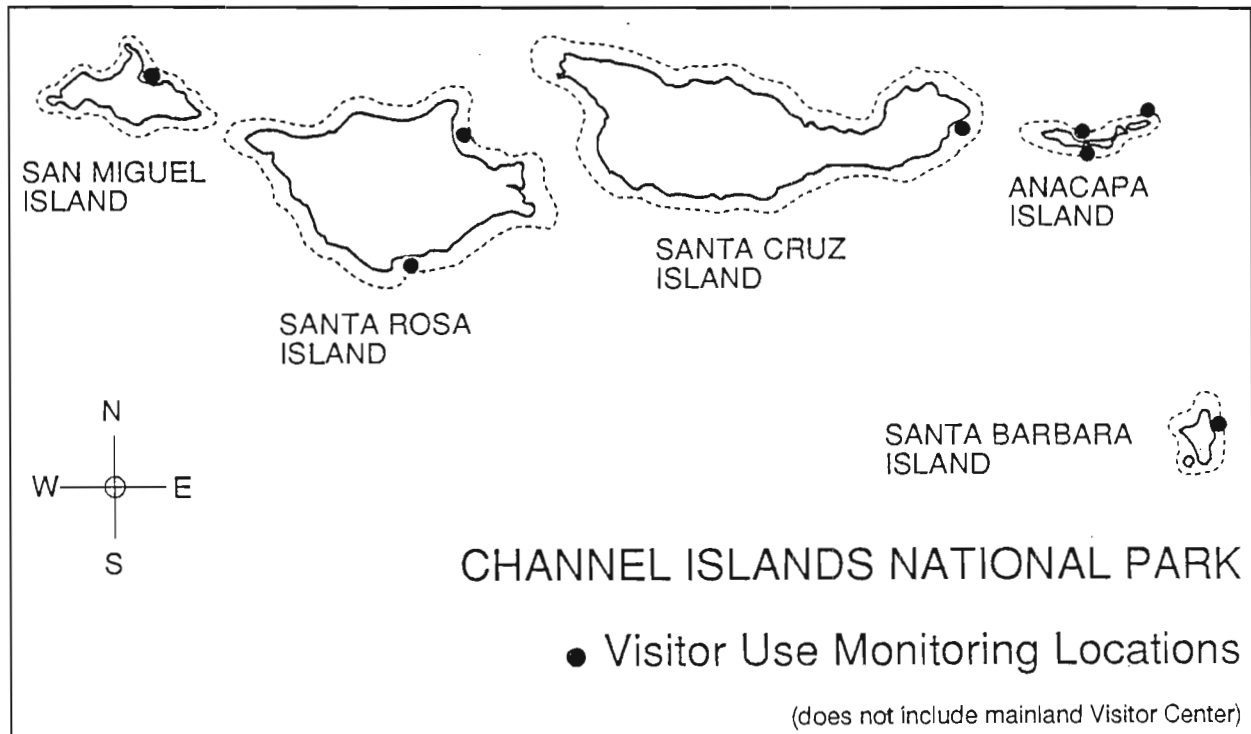
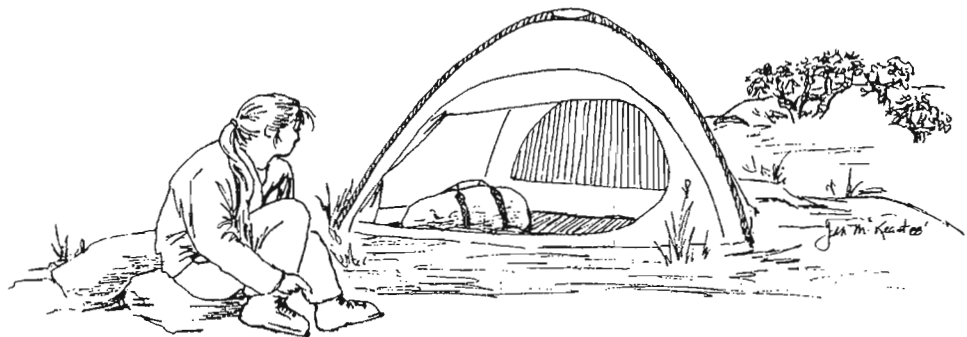
No data are available for recreational fishery harvest from private boats. Commercial fishermen report the source of their harvest in one of three ways: 1) by specific blocks (about 10 miles on a side) that identify where the harvest was taken, 2) by specific zones that include a series of specific blocks, or 3) by county-wide zones indicating where the harvest was landed. Information is collected for all California Fish and Game origin blocks for fish caught in areas that include some portion of Channel Islands National Park. Data are summarize by year, species group (23 groups), and location of harvest. Because most of the data are reported by general zones or by harvest landings in Santa Barbara, Ventura, or Los Angeles counties, harvest information underestimates landings for the park. Information reported by general zones is not included in data analysis of fishery harvest for the park.



VISITORS

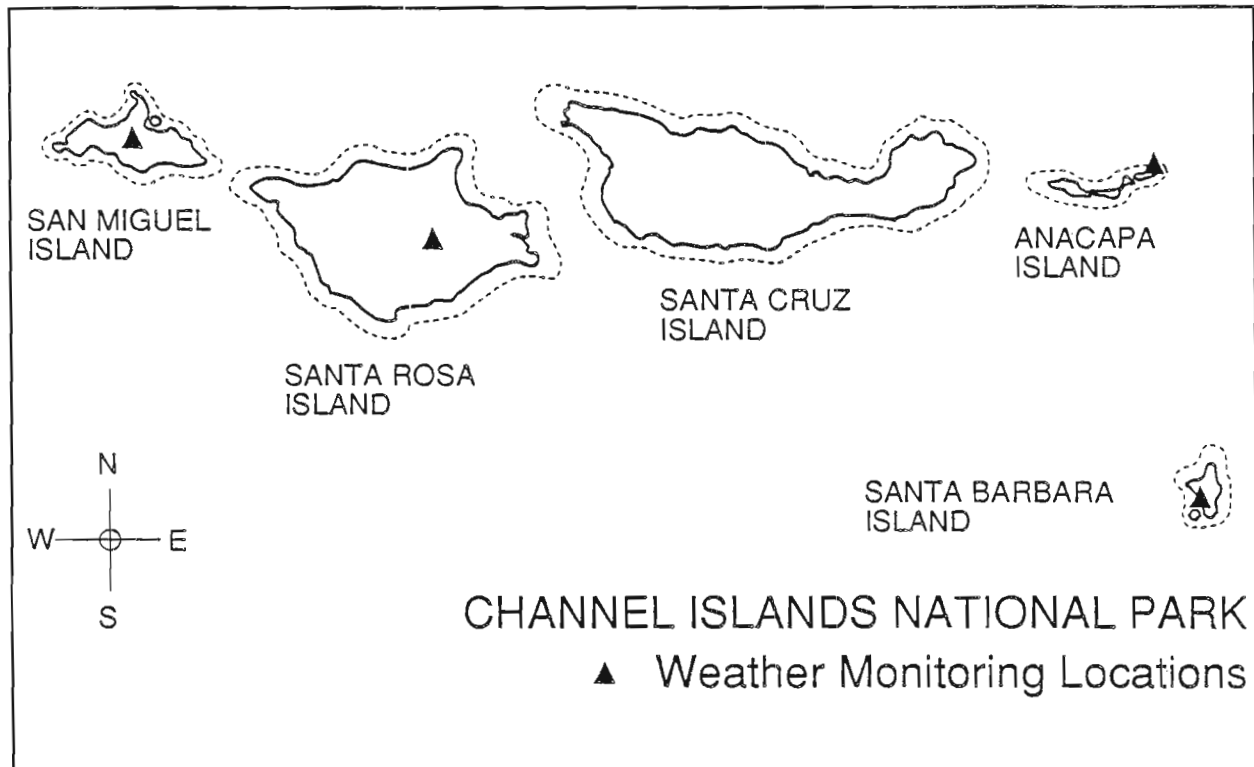
Patterns of visitor use and numbers of visitors have been selected for long-term monitoring. Information is recorded as numbers of visitors to the mainland visitor center and each island, counts of people participating in interpretive activities, and the amount of recreational and non-recreational boating activity. The counts are compiled as monthly public use reports, first in a detailed report for Channel Islands National Park, and then in a summary as part of a nationwide statistical report of park visitation.

The islands have an established carrying capacity, but boating activity within park boundaries is not regulated and constitutes a potential source of disturbance to marine life, as well as a way to enjoy the park. Actual daily observations of selected anchorages and a regression model, based upon aerial survey data, are used to estimate boating activity in the park and around each of the five islands.



WEATHER

Weather can dramatically affect biological components of marine and terrestrial ecosystems. A system of automated weather stations has been established on Anacapa, Santa Barbara, San Miguel, and Santa Rosa islands. The weather parameters that are measured and recorded are wind speed and direction, rainfall, relative humidity, temperature, barometric pressure, and soil moisture. All weather data are transmitted to a computer data receiving station at park headquarters and are accessible at the receiving station and via tele-communications. The handbook contains data access and data management information as well as maintenance requirements for sensing equipment.



SCHEDULING OF MONITORING

A complex monitoring program like the one described above requires a strong commitment to acquiring knowledge of resource conditions and strict adherence to a rigid schedule. Breeding birds, seasonal haulout of sea lions, flowering of plants, and a variety of cyclic processes are among the factors that determine appropriate monitoring times; logistical and monetary considerations are others. A generalized annual schedule for resources currently monitored has been included in Table 1. See individual handbooks for detailed descriptions of activities during each time period.

Table 1. Annual Schedule of Field Surveys for Resource Monitoring

Component Monitored	MONITORING SCHEDULE ¹											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
PINNIPEDS					****			**	*		****	
SEABIRDS		*		****	****	****	****	****	****	**	****	*
ROCKY INTERTIDAL COMMUNITIES	****	****	**			****	****	****				
KELP FOREST									*	****	****	****
Temp/Depth	****	****	****	****	****	****	****	****	****	****	****	****
Maintenance	**			**			**			**		
TERRESTRIAL VERTEBRATES			*	*	****	****	****	*	*		****	****
LAND BIRDS	****	**				****						
TERRESTRIAL VEGETATION						**	**	**				
FISHERIES										**		
VISITORS	****	****	****	****	****	****	****	****	****	****	****	****
WEATHER	****	****	****	****	****	****	****	****	****	****	****	****
Maintenance	*	*	*	*	*	*	*	*	*	*	*	*

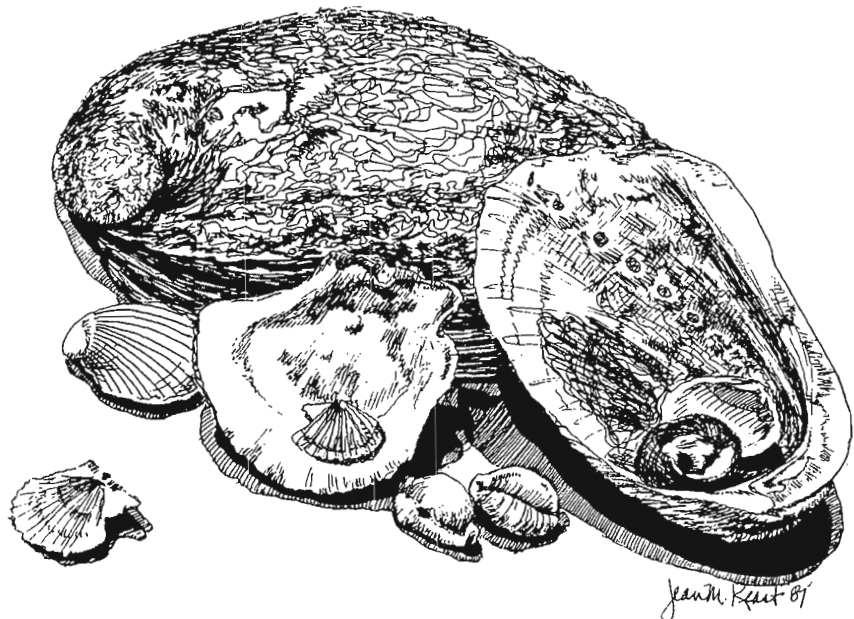
¹ Schedule is for data collection and maintenance of field equipment only. Does not include time spent on preparation and data analysis.

INTEGRATION OF MONITORING INFORMATION

The monitoring program was intended to assess the health of ecosystems. However, to design monitoring protocols, it was necessary to break park ecosystems into standard taxonomic components. Now the components must be recombined into ecological units to address management issues and facilitate understanding of ecosystem dynamics. For example, intertidal black abalone (*Haliotis cracherodierii*) support a large, valuable fishery, eat drift kelp produced in subtidal kelp forests, and are presently dying at an unprecedented rate, apparently unrelated to fishing mortality. Definition and investigation of this phenomenon will require linking information from at least the intertidal, kelp forest, and weather components of the monitoring program. El Niño, an infrequent (12 of the past 64 years) but natural warming of equatorial Pacific waters has recently altered major physical and biological components of Channel Islands National Park. This large scale phenomena increases rainfall, elevates sea temperature, reduces sea water nutrient levels, increases recruitment of temperate life forms, and results in the retreat of boreal species to the north. These conditions can readjust abundance and distribution patterns that persist for many years. Monitoring these conditions and their ecological effects is necessary to distinguish between natural variation and human perpetrated disturbances.

Integration of the monitoring program has been initiated by the preparation of these handbooks. The entire monitoring program as a sum of individual parts is now more readily visualized. More importantly, long-term monitoring will likely suggest cause and effect relationships through correlation, and indicate likely candidates for further controlled study and management treatment.

A data administration system and a report series will be developed to assist in developing such correlations. In addition, integrated data analysis and storage needs are being addressed through the development of a centralized data management system which includes a geographic information system as another phase of this project.



CONCLUSIONS

A diagnostic program to assess the natural integrity (health) of ecosystems was designed and initiated in Channel Islands National Park, California in 1982. The program uses population dynamics of selected taxa as the vital signs of ecosystem health. This approach was chosen because populations are basic units of ecosystems that are readily measured, interpreted, and managed. Populations integrate environmental influences, both natural and anthropogenic, and express their responses as changes in easily observed attributes, such as abundance, distribution, reproductive effort, recruitment, growth and mortality rates, age structure, and phenology. Population attributes such as age structure and recruitment permit projections of future conditions and provide early warnings of abnormalities. Changes in reproductive efforts and growth rates signal subtle, chronic environmental influences that may also provide early warnings of situations requiring management action that may be overlooked by less sensitive ecosystem parameters such as diversity indices.

The monitoring program is already providing park managers with useful products and providing the scientific community with an ecosystem-wide framework of population information with which to frame research questions and integrate experimental design. Terrestrial vegetation monitoring on Santa Barbara Island documented effectiveness of alien rabbit removal. Monitoring data were used to modify park visitor orientation prior to trips in rocky intertidal zones on Anacapa Island in an attempt to reduce impacts of trampling and rock turning. Kelp forest and intertidal monitoring identified and characterized alarming declines in abalone populations and guided hypothesis formulation and experimental design of specific research to resolve the cause of the observed decline. Successful management of ecosystems requires a more thorough understanding of long-term ecosystem dynamics than presently exists. Design and implementation of long-term ecological monitoring programs such as the one described here are essential to developing that understanding.



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APPENDIX A. Summary of population parameters monitored in Channel Islands National Park

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
MAMMALS									
Visitors	daily	9	total visitation	no	no	no	no	no	no
Island fox <i>Urocyon littoralis</i>	triannually	5	population size	yes	no	yes	yes	no	no
Deer mouse <i>Peromyscus maniculatus</i>	biannually	13	population size	yes	yes	yes	yes	no	yes
Harbor seal <i>Phoca vitulina richardsi</i>	quarterly	56	haul-out	yes	no	pups	no	no	pupping
Northern elephant seal <i>Mirounga angustirostris</i>	quarterly	47	haul-out	yes	no	pups	no	no	pupping
California sea lion <i>Zalophus californianus</i>	quarterly	64	haul-out	yes	no	pups	no	no	pupping
Northern fur seal <i>Callorhinus ursinus</i>	quarterly	2	haul-out	yes	no	pups	no	no	pupping
BIRDS									
Red-tailed Hawk <i>Buteo jamaicensis</i>	annual	9	relative	no	no	no	no	no	no
Peregrine Falcon <i>Falco peregrinus</i>	annual	9	relative	no	no	no	no	no	no
American Kestrel <i>Falco sparverius</i>	annual	9	relative	no	no	no	no	no	no
Short-eared Owl <i>Asio flammeus</i>	annual	9	relative	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
BIRDS (con't)									
Anna's Hummingbird <i>Calypte anna</i>	annual	9	relative	no	no	no	no	no	no
Allen's Hummingbird <i>Selasphorus sasin</i>	annual	9	relative	no	no	no	no	no	no
Black Phoebe <i>Sayornis nigricans</i>	annual	9	relative	no	no	no	no	no	no
Horned Lark <i>Eremophila alpestris</i>	annual	9	relative	no	no	no	no	no	no
Barn Swallow <i>Hirundo rustica</i>	annual	9	relative	no	no	no	no	no	no
Rock Wren <i>Salpinctes obsoletus</i>	annual	9	relative	no	no	no	no	no	no
Orange-crowned Warbler <i>Vermivora celata</i>	annual	9	relative	no	no	no	no	no	no
Song Sparrow <i>Melospiza melodia</i>	annual	9	relative	no	no	no	no	no	no
Western Meadowlark <i>Sturnella neglecta</i>	annual	9	relative	no	no	no	no	no	no
Lesser Goldfinch <i>Carduelis psaltria</i>	annual	9	relative	no	no	no	no	no	no
House Finch <i>Carpodacus mexicanus</i>	annual	9	relative	no	no	no	no	no	no
European Starling <i>Sturnus vulgaris</i>	annual	9	relative	no	no	no	no	no	no
California Brown Pelican <i>Pelecanus occidentalis californicus</i>	monthly	2	breeders	yes	yes	fledglings	no	yes	yes

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
BIRDS (con't)									
Double-crested Cormorant <i>Phalacrocorax auritus</i>	monthly	4	breeders	no	yes	chicks	no	no	yes
Pelagic Cormorant <i>Phalacrocorax pelagicus</i>	monthly	13	breeders	no	yes	chicks	no	no	yes
Western Gull <i>Larus occidentalis</i>	weekly	12	breeders	yes	yes	fledglings	yes	yes	yes
Xantus' Murrelet <i>Synthliboramphus hypoleuca</i>	weekly	2	breeders	no	yes	hatched	no	yes	yes
Cassin's Auklet <i>Ptychoramphus aleuticus</i>	monthly	2	breeders	yes	yes	hatched	yes	yes	yes
Snowy Plover <i>Charadrius alexandrinus</i>	monthly	3	adults	no	no	hatched	no	no	yes
REPTILES									
Southern alligator lizard <i>Gerrhonotus multicarinatus</i>	triannually	10	relative	yes	no	no	no	no	no
Western fence lizard <i>Sceloporus occidentalis</i>	triannually	5	relative	yes	no	no	no	no	no
Side-blotched lizard <i>Uta stansburiana</i>	triannually	5	relative	yes	no	no	no	no	no
Island night lizard <i>Xantusia riversiana</i>	triannually	5	relative	yes	no	no	no	no	no
AMPHIBIANS									
Pacific slender salamander <i>Batrachoseps pacificus</i>	triannually	5	relative	yes	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
FISHES									
Blue rockfish <i>Sebastes mystinus</i>	annual	16	relative	no	no	YOY*	no	no	no
Kelp rockfish <i>Sebastes atrovirens</i>	annual	16	relative	no	no	YOY	no	no	no
Olive rockfish <i>Sebastes serranoides</i>	annual	16	relative	no	no	YOY	no	no	no
Black perch <i>Embiotoca jacksoni</i>	annual	16	relative	no	no	YOY	no	no	no
Striped seaperch <i>Embiotoca lateralis</i>	annual	16	relative	no	no	YOY	no	no	no
Pile surfperch <i>Damalichthys vacca</i>	annual	16	relative	no	no	YOY	no	no	no
Opaleye <i>Girella nigricans</i>	annual	16	relative	no	no	YOY	no	no	no
California sheephead <i>Semicossyphus pulcher</i>	annual	16	relative	yes	no	YOY	no	no	no
Senorita <i>Oxyjulis californica</i>	annual	16	relative	no	no	no	no	no	no
Blackeye goby <i>Coryphopterus nicholsi</i>	annual	16	density	no	no	no	no	no	no
Bluebanded goby <i>Lythrypnus dalli</i>	annual	16	density	no	no	no	no	no	no
Island kelp fish <i>Alloclinus holderi</i>	annual	16	density	no	no	no	no	no	no

*YOY = Young of the year

TAXON	SAMPLING FREQUENCY	LOCATION	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
FISHES									
Blacksmith <i>Chromis punctipinnis</i>	annual	16	relative	no	no	YOY	no	no	no
Garibaldi <i>Hypsops rubicundus</i>	annual	16	relative	no	no	YOY	no	no	no
Kelp bass <i>Paralabrax clathratus</i>	annual	16	relative	no	no	YOY	no	no	no
INVERTEBRATES									
Orange puffball sponge <i>Tethya aurantia</i>	annual	16	density	size-freq	no	no	yes	yes	no
Aggregated vase sponge <i>Polymastia pachymastia</i>	annual	16	density	no	no	no	no	no	no
White calcareous sponge <i>Leucetta losangelensis</i>	annual	16	density	no	no	no	no	no	no
Misc. sponges	annual	16	% cover	no	no	no	no	no	no
California hydrocoral <i>Allopora californica</i>	annual	16	density	size-freq	no	no	no	no	no
La Jolla cup coral <i>Astrangia lajollensis</i>	annual	16	% cover	no	no	no	no	no	no
Orange cup coral <i>Balanophyllia elegans</i>	annual	16	% cover	no	no	no	no	no	no
Red gorgonian <i>Lophogorgia chilensis</i>	annual	16	density	size-freq	no	no	yes	yes	no
Brown gorgonian <i>Muricea fruticosa</i>	annual	16	density	size-freq	no	no	yes	yes	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
INVERTEBRATES (con't)									
Strawberry anemone <i>Corynactis californica</i>	annual	16	% cover	no	no	no	no	no	no
White-spotted rose anemone <i>Tealia lofotensis</i>	annual	16	density	no	no	no	no	no	no
Ornate worm tube <i>Diopatra ornata</i>	annual	16	% cover	no	no	no	no	no	no
Colonial sand-tube worm <i>Phragmatopoma californica</i>	annual	16	% cover	no	no	no	no	no	no
Acorn barnacle <i>Balanus glandula</i>	biannual	14	% cover	no	no	no	no	no	no
Acorn barnacle <i>Chthamalus fissus/dalli</i>	biannual	14	% cover	no	no	no	no	no	no
California spiny lobster <i>Panulirus interruptus</i>	annual	16	density	no	no	no	no	no	no
Giant keyhole limpet <i>Megathura crenulata</i>	annual	16	density	size-freq	no	no	yes	yes	no
Red abalone <i>Haliotis rufescens</i>	annual	16	density	size-freq	no	no	yes	yes	no
Pink abalone <i>Haliotis corrugata</i>	annual	16	density	size-freq	no	no	yes	yes	no
Green abalone <i>Haliotis fulgens</i>	annual	16	density	size-freq	no	no	yes	yes	no
Black abalone <i>Haliotis cracherodii</i>	biannual	11	density	size-freq	no	no	yes	yes	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
INVERTEBRATES (con't)									
Wavy top snail <i>Astrea undosa</i>	annual	16	density	size-freq	no	no	yes	yes	no
Red top snail <i>Astrea gibberosa</i>	annual	16	density	size-freq	no	no	yes	yes	no
Chestnut cowrie <i>Cypraea spadicea</i>	annual	16	density	size-freq	no	no	yes	yes	no
Kellet's whelk <i>Kelletia kelletii</i>	annual	16	density	size-freq	no	no	no	no	no
Scaled tube shell <i>Serpulorbis squamigerus</i>	annual	16	% cover	no	no	no	no	no	no
California mussel <i>Mytilus californianus</i>	biannual	13	% cover	no	no	no	no	no	no
Rock scallop <i>Hinnites giganteus</i>	annual	16	density	size-freq	no	no	yes	yes	no
California brown sea hare <i>Aplysia californica</i>	annual	16	density	no	no	no	no	no	no
Southern staghorn bryozoan <i>Diaperoecia californica</i>	annual	16	% cover	no	no	no	no	no	no
Misc. bryozoans	annual	16	% cover	no	no	no	no	no	no
Misc. tunicates	annual	16	% cover	no	no	no	no	no	no
Misc. marine invertebrates	annual	16	% cover	no	no	no	no	no	no
Giant red sea urchin <i>Strongylocentrotus franciscanus</i>	annual	16	density	size-freq	no	no	yes	yes	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
INVERTEBRATES (con't)									
Purple sea urchin <i>Strongylocentrotus purpuratus</i>	annual	16	density	size-freq	no	no	yes	yes	no
White sea urchin <i>Lytechinus anamesus</i>	annual	16	density	size-freq	no	no	yes	yes	no
Sunflower star <i>Pycnopodia helianthoides</i>	annual	16	density	size-freq	no	no	yes	yes	no
Sea bat <i>Patiria miniata</i>	annual	16	density	size-freq	no	no	yes	yes	no
Giant-spined sea star <i>Pisaster giganteus</i>	annual	16	density	size-freq	no	no	yes	yes	no
Warty sea cucumber <i>Parastichopus parvimensis</i>	annual	16	density	size-freq	no	no	yes	yes	no
Aggregated red cucumber <i>Pachythyone rubra</i>	annual	16	% cover	no	no	no	no	no	no
Stalked tunicate <i>Styela montereyensis</i>	annual	16	density	no	no	no	no	no	no
VASCULAR PLANTS									
<i>Abronia umbellata</i>	annual	54	% cover	no	no	no	no	no	no
<i>Achillea borealis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Achillea millefolium</i>	annual	54	% cover	no	no	no	no	no	no
<i>Allium praecox</i>	annual	54	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
VASCULAR PLANTS (con't)									
<i>Amblyopappus pusillus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Ambrosia chamissonis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Amsinckia intermedia</i>	annual	54	% cover	no	no	no	no	no	no
<i>Anagalis arvensis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Arctostaphylos confertiflora</i>	annual	54	% cover	no	no	no	no	no	no
<i>Artemisia californica</i>	annual	54	% cover	no	no	no	no	no	no
<i>Astragalus curtipes</i>	annual	54	% cover	no	no	no	no	no	no
<i>Astragalus miguelensis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Astragalus traskiae</i>	annual	54	% cover	no	no	no	no	no	no
<i>Atriplex californica</i>	annual	54	% cover	no	no	no	no	no	no
<i>Atriplex semibaccata</i>	annual	54	% cover	no	no	no	no	no	no
<i>Avena barbata</i>	annual	54	% cover	no	no	no	no	no	no
<i>Avena fatua</i>	annual	54	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
VASCULAR PLANTS (con't)									
<i>Avena</i> sp.	annual	54	% cover	no	no	no	no	no	no
<i>Baccharis pilularis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Bromus arizonicus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Bromus carinatus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Bromus diandrus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Bromus mollis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Bromus rigidus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Bromus rubens</i>	annual	54	% cover	no	no	no	no	no	no
<i>Bromus</i> sp.	annual	54	% cover	no	no	no	no	no	no
<i>Bromus trinii</i>	annual	54	% cover	no	no	no	no	no	no
<i>Calystegia macrostegia</i>	annual	54	% cover	no	no	no	no	no	no
<i>Camissonia cheiranthifolia</i>	annual	54	% cover	no	no	no	no	no	no
<i>Carpobrotus aequilateris</i>	annual	54	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
VASCULAR PLANTS (con't)									
<i>Castilleja affinis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Castilleja hololeuca</i>	annual	54	% cover	no	no	no	no	no	no
<i>Chenopodium californicum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Chenopodium murale</i>	annual	54	% cover	no	no	no	no	no	no
<i>Cirsium occidentale</i>	annual	54	% cover	no	no	no	no	no	no
<i>Claytonia perfoliata</i>	annual	54	% cover	no	no	no	no	no	no
<i>Convolvulus macrostegius</i>	annual	54	% cover	no	no	no	no	no	no
<i>Coreopsis gigantea</i>	annual	54	% cover	no	no	no	no	no	no
<i>Corethrogyne filaginifolia</i>	annual	54	% cover	no	no	no	no	no	no
<i>Cryptantha clevelandii</i>	annual	54	% cover	no	no	no	no	no	no
<i>Daucus pusillus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Delphinium parryi</i>	annual	54	% cover	no	no	no	no	no	no
<i>Dichelostemma pulchella</i>	annual	54	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
VASCULAR PLANTS (con't)									
<i>Diplacus parviflorus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Diplacus</i> sp. (dark red)	annual	54	% cover	no	no	no	no	no	no
<i>Distichlis spicata</i>	annual	54	% cover	no	no	no	no	no	no
<i>Dodecatheon clevelandii</i>	annual	54	% cover	no	no	no	no	no	no
<i>Dudleya caespitosa</i>	annual	54	% cover	no	no	no	no	no	no
<i>Dudleya greenei</i>	annual	54	% cover	no	no	no	no	no	no
<i>Elymus condensatus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Encelia californica</i>	annual	54	% cover	no	no	no	no	no	no
<i>Erigeron glaucus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Eriogonum arborescens</i>	annual	54	% cover	no	no	no	no	no	no
<i>Eriogonum giganteum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Eriogonum grande</i>	annual	54	% cover	no	no	no	no	no	no
<i>Eriophyllum confertiflorum</i>	annual	54	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
VASCULAR PLANTS (con't)									
<i>Eriophyllum staechadifolium</i>	annual	54	% cover	no	no	no	no	no	no
<i>Erodium cicutarium</i>	annual	54	% cover	no	no	no	no	no	no
<i>Erodium moschatum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Eschscholtzia californica</i>	annual	54	% cover	no	no	no	no	no	no
<i>Frankenia grandifolia</i>	annual	54	% cover	no	no	no	no	no	no
<i>Galium angustifolium</i>	annual	54	% cover	no	no	no	no	no	no
<i>Galium aparine</i>	annual	54	% cover	no	no	no	no	no	no
<i>Galium</i> sp.	annual	54	% cover	no	no	no	no	no	no
<i>Gillia nevinii</i>	annual	54	% cover	no	no	no	no	no	no
<i>Gnaphalium luteo-album</i>	annual	54	% cover	no	no	no	no	no	no
<i>Gnaphalium microcephalum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Grindelia latifolia</i>	annual	54	% cover	no	no	no	no	no	no
<i>Haplopappus detonsus</i>	annual	54	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
VASCULAR PLANTS (con't)									
<i>Haplopappus</i> sp.	annual	54	% cover	no	no	no	no	no	no
<i>Haplopappus venetus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Hemizonia clementina</i>	annual	54	% cover	no	no	no	no	no	no
<i>Hordeum brachyantherum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Hordeum californicum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Hordeum murinum</i> ssp. <i>glaucum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Hordeum murinum</i> ssp. <i>leporinum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Hordeum pusillum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Hordeum</i> sp.	annual	54	% cover	no	no	no	no	no	no
<i>Juncus mexicanus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Lamarckia aurea</i>	annual	54	% cover	no	no	no	no	no	no
<i>Lasthenia chrysostoma</i>	annual	54	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
VASCULAR PLANTS (con't)									
<i>Lathyrus laetiflorus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Layia platyglossa</i>	annual	54	% cover	no	no	no	no	no	no
<i>Lepidium nitidum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Lotus dendroideus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Lotus scoparius</i>	annual	54	% cover	no	no	no	no	no	no
<i>Lupinus albilfrons</i>	annual	54	% cover	no	no	no	no	no	no
<i>Lupinus arboreus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Lupinus bicolor</i>	annual	54	% cover	no	no	no	no	no	no
<i>Lupinus succulentus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Lycium californicum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Malacothrix implicata</i>	annual	54	% cover	no	no	no	no	no	no
<i>Malacothrix incana</i>	annual	54	% cover	no	no	no	no	no	no
<i>Malacothrix philbrickii</i>	annual	54	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
VASCULAR PLANTS (con't)									
<i>Malacothrix saxatilis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Malacothrix succulentus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Malaphora crocea</i>	annual	54	% cover	no	no	no	no	no	no
<i>Malva parviflora</i>	annual	54	% cover	no	no	no	no	no	no
<i>Marah macrocarpa</i>	annual	54	% cover	no	no	no	no	no	no
<i>Marrubium vulgare</i>	annual	54	% cover	no	no	no	no	no	no
<i>Medicago hispida</i>	annual	54	% cover	no	no	no	no	no	no
<i>Medicago polymorpha</i>	annual	54	% cover	no	no	no	no	no	no
<i>Melica impertecta</i>	annual	54	% cover	no	no	no	no	no	no
<i>Melilotus indicus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Mesembryanthemum crystallinum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Mesembryanthemum nodiflorum</i>	annual	54	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
VASCULAR PLANTS (con't)									
<i>Mirabilis californica</i>	annual	54	% cover	no	no	no	no	no	no
<i>Mirabilis laevis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Muhlenbergia microsperma</i>	annual	54	% cover	no	no	no	no	no	no
<i>Nemophila pedunculata</i>	annual	54	% cover	no	no	no	no	no	no
<i>Opuntia littoralis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Opuntia prolifera</i>	annual	54	% cover	no	no	no	no	no	no
<i>Parapholis incurva</i>	annual	54	% cover	no	no	no	no	no	no
<i>Parietaria hespera</i>	annual	54	% cover	no	no	no	no	no	no
<i>Pellaea andromedaefolia</i>	annual	54	% cover	no	no	no	no	no	no
<i>Pellaea</i> sp.	annual	54	% cover	no	no	no	no	no	no
<i>Pennisetum clandestinum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Perityle emoryi</i>	annual	54	% cover	no	no	no	no	no	no
<i>Phacelia distans</i>	annual	54	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
VASCULAR PLANTS (con't)									
<i>Pholistoma auritum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Pholistoma racemosum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Pityrogramma triangularis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Platystemon californicus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Poa douglasii</i>	annual	54	% cover	no	no	no	no	no	no
<i>Poa scabrella</i>	annual	54	% cover	no	no	no	no	no	no
<i>Polypodium californicum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Polypogon monspeliensis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Pterostegia drymarioides</i>	annual	54	% cover	no	no	no	no	no	no
<i>Sanicula arguta</i>	annual	54	% cover	no	no	no	no	no	no
<i>Scleranthus annuus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Selaginella biglovii</i>	annual	54	% cover	no	no	no	no	no	no
<i>Senecio vulgaris</i>	annual	54	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
VASCULAR PLANTS (con't)									
<i>Silene gallica</i>	annual	54	% cover	no	no	no	no	no	no
<i>Silene lacinata</i>	annual	54	% cover	no	no	no	no	no	no
<i>Silene laciniata major</i>	annual	54	% cover	no	no	no	no	no	no
<i>Sisyrinchium bellum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Solanum douglasii</i>	annual	54	% cover	no	no	no	no	no	no
<i>Sonchus oleraceus</i>	annual	54	% cover	no	no	no	no	no	no
<i>Spergularia macrotheca</i>	annual	54	% cover	no	no	no	no	no	no
<i>Stellaria media</i>	annual	54	% cover	no	no	no	no	no	no
<i>Stipa lepida</i>	annual	54	% cover	no	no	no	no	no	no
<i>Stipa pulchra</i>	annual	54	% cover	no	no	no	no	no	no
<i>Stipa</i> sp.	annual	54	% cover	no	no	no	no	no	no
<i>Suaeda californica</i>	annual	54	% cover	no	no	no	no	no	no
<i>Tillaea erecta</i>	annual	54	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
VASCULAR PLANTS (con't)									
<i>Torilis nodosa</i>	annual	54	% cover	no	no	no	no	no	no
<i>Trifolium amplexens</i>	annual	54	% cover	no	no	no	no	no	no
<i>Trifolium tridentatum</i>	annual	54	% cover	no	no	no	no	no	no
<i>Vicia exigua</i>	annual	54	% cover	no	no	no	no	no	no
<i>Vulpia dertonensis</i>	annual	54	% cover	no	no	no	no	no	no
<i>Vulpia megalura</i>	annual	54	% cover	no	no	no	no	no	no
<i>Vulpia myuros</i>	annual	54	% cover	no	no	no	no	no	no
<i>Vulpia</i> sp.	annual	54	% cover	no	no	no	no	no	no
<i>Zauschneria californica</i>	annual	54	% cover	no	no	no	no	no	no
<i>Zigadenas fremontii</i>	annual	54	% cover	no	no	no	no	no	no
ALGAE									
Rockweed <i>Pelvetia fastigiata</i>	biannual	14	% cover	no	no	no	no	no	no
Rockweed <i>Hesperophycus harveyanus</i>	biannual	14	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
ALGAE (con't)									
Bladder chain kelp <i>Cystoseira osmundacea</i>	annual	16	% cover	no	no	no	no	no	no
Acid weed <i>Desmarestia ligulata</i>	annual	16	% cover	no	no	no	no	no	no
Southern sea palm <i>Eisenia arborea</i>	annual	16	density & % cover	no	no	no	no	no	no
Oar weed <i>Laminaria farlowii</i>	annual	16	density & % cover	no	no	no	no	no	no
Giant kelp <i>Macrocystis pyrifera</i>	annual	16	density & % cover	size-freq	yes	no	no	no	no
California sea palm <i>Pterygophora californica</i>	annual	16	density & % cover	no	no	no	no	no	no
Sargassum weed <i>Sargassum muticum</i>	annual	16	% cover	no	no	no	no	no	no
Turfweed <i>Endocladia muricata</i>	biannual	14	% cover	no	no	no	no	no	no
Sea tongue <i>Gigartina canaliculata</i>	biannual	1	% cover	no	no	no	no	no	no
Sea tongue <i>Gigartina</i> spp.	annual	16	% cover	no	no	no	no	no	no
Agar weed <i>Gelidium robustum</i>	annual	16	% cover	no	no	no	no	no	no
Crustose coralline algae Corallinaceae	annual	16	% cover	no	no	no	no	no	no

TAXON	SAMPLING FREQUENCY	LOCATIONS	ABUNDANCE	SIZE/AGE STRUCTURE	REPROD. EFFORT	RECRUIT	GROWTH RATE	MORT. RATE	PHENOLOGY
ALGAE (con't)									
Articulated coralline algae Corallinaceae	annual	16	% cover	no	no	no	no	no	no
Misc. brown algae	annual	16	% cover	no	no	no	no	no	no
Misc. red algae	annual	16	% cover	no	no	no	no	no	no
Green algae (marine)	annual	16	% cover	no	no	no	no	no	no
Misc. marine plants	annual	16	% cover	no	no	no	no	no	no

APPENDIX B

Management Jurisdiction

Management of Channel Islands National Park requires a cooperative approach with several other regulatory, management agencies, and other organizations due to the fact that much of the park is owned or under the jurisdiction of others. These jurisdictions affect monitoring programs and overall management within the park.

Not all of the land surface of the park is owned or managed by the federal government. At this date, Santa Cruz Island is privately owned and managed and most of the island (90%) is owned by the Nature Conservancy, the remaining 10% is to be purchased by the National Park Service in the near future.

The U.S. Navy currently owns San Miguel and nearby Prince Island but through a memorandum of agreement, the National Park Service jointly manages these two islands. Although resource management and protection are under the purview of the park service, military activities continue to take precedence.

Anacapa, Santa Barbara and Santa Rosa islands are owned and managed by the National Park Service.

The living marine resources within the park are managed by the State of California, Department of Fish and Game, and harvest of fish, lobster, abalone and other marine organisms are allowed under state regulation. The one mile offshore park boundary enables the National Park Service to cooperate in research and law enforcement efforts, but not to make management decisions pertaining to marine resources.

Submerged lands and tide lands (between the mean high tide line and seaward three miles) are the responsibility of the California State Lands Commission. The commission retains authority for mineral development and disturbance of the sea floor and has prohibited oil and gas development in state owned waters around the islands.

Channel Islands National Marine Sanctuary encompasses the water area for six nautical miles around all of the park islands. The National Oceanic and Atmospheric Administration, Marine Sanctuary Program (within the Department of Commerce) administers the sanctuary and cooperates with the California Department of Fish and Game and the National Park Service in management, research and interpretation of the area. Regulations provide additional resource protection by restricting new oil and gas development.

The National Marine Fisheries Service is charged with enforcement of the Fur Seal Treaty Act of 1911 and the Marine Mammal Protection Act of 1972, both of which give it lead agency status for management of all seals, sea lions, sea otters, dolphins, porpoise and whales. When on park islands, these animals are cooperatively managed by the National Park Service and National Marine Fisheries Service.