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List of Abbreviations

ABLM	Ambient Bay and Lagoon Monitoring Program
ASBS	Areas of Special Biological Significance
AVHRR	Advanced Very High Resolution Radiometer
Bight	Southern California Bight
BOD	Biological Oxygen Demand
BPTCP	Bay Protection and Toxic Cleanup Program
Cal EPA	California Environmental Protection Agency
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CA-SMWP	California State Mussel Watch Program
CCC	California Coastal Commission
CCR	California Code of Regulations
CF&G	California Department of Fish and Game
CFR	Code of Federal Regulations

Commission	California Fish and Game Commission
CPFV	Commercial Passenger Fishing Vehicle
CTD	conductivity/temperature/density instrument
CZMA	Coastal Zone Management Act
DDD	Dichloro-diphenyl-dichloroethane
DDE	Dichloro-diphenyl-dichloroethylene
DDT	dichloro-diphenyl-trichloroethane
DMT	Donnan membrane technique
DGT	diffusion gradient thin-film gel
DO	Dissolved Oxygen
EEZ	United States Exclusive Economic Zone
ERL	Effects Range Low
ERM	Effects Range Medium
FACs	Fluorescent aromatic compounds
FGC	Fish & Game Code
HCH	hexachlorocyclohexane
HFPLM	hollow fiber permeation liquid membranes
HU	Hydrologic Unit
JWPCP	Joint Water Pollution Control Plant
LTER	Long Term Ecological Research Project
LwN(555)	Normalized water-leaving radiance at 555 nm
MEP	Maximum Extent Practicable
MGD	Million Gallons per Day
MLPA	Marine Life Protection Act
MLMA	Marine Life Management Act
MMS	U.S. Mineral Management Service
MODIS	Moderate Resolution Imaging Spectroradiometer
MPA	Marine Protected Area
MRPA	Marine Resources Protection Act
MS4	Municipal Separate Storm Sewer System
MTRL	Maximum Tissue Residue Level
Navy	U.S. Navy
nm	nautical mile
NMFS	NOAA National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration

NOAA-MWP	NOAA Mussel Watch Project
NPDES	National Pollution Discharge Elimination System
NPS	National Park Service
NRT	Natural Resources Trustees
NS&T	National Status and Trends
OCS	Outer Continental Shelf
PAH	Polycyclic aromatic hydrocarbons
Park	Channel Islands National Park
PCB	polychlorinated biphenyl compounds
PFMC	Pacific Fishery Management Council
PISCO	Partnership for Interdisciplinary Studies of Coastal Oceans
PnB	UCSB Plumes & Blooms Project
POTW	Publically Owned Treatment Plant
ppb	parts per billion
ppt	parts per thousand
PSMFC	Pacific States Marine Fisheries Commission
psu	practical salinity unit
RWQCB	Regional Water Quality Control Board
SAMSAP	Sanctuary Aerial Monitoring Spatial Analysis Program
Sanctuary	NOAA Channel Islands National Marine Sanctuary
SCB	Southern California Bight
SCCWRP	Southern California Coastal Water Research Project
SeaWiFS	Sea-viewing Wide-Field-of-View sensor
SLC	California State Lands Commission
SRM	State Marine Reserve
SMCA	State Marine Conservation Area
SMWP	State Mussel Watch Program
SPMD	semi-permeable membrane device
SST	sea surface temperature
State Board	California SWRCB
SWMP	Storm Water Management Plan
SWRCB	State Water Resources Control Board
SWQPA	State Water Quality Protection Area
TBT	Tributyltin
TDS	Total Dissolved Solids

TNC	The Nature Conservancy
TMDL	Total Maximum Daily Load
TN	Total nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
UCSB	University of California, Santa Barbara, CA
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey
WMA	Watershed Management Area

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I. PARK DESCRIPTION

A. BACKGROUND

A.1. Location and Key Features

Channel Islands National Park (Park) was created in 1980 and comprises five islands off the coast of southern California (Figure 1) and the marine environment surrounding them from shore to 1 nautical mile seaward. San Miguel, Santa Rosa, Santa Cruz, and Anacapa Islands (hereinafter, San Miguel, Santa Rosa, Santa Cruz and Anacapa) form the southern boundary of the Santa Barbara Channel (Channel), and are referred to as the Northern Channel Islands. The Northern Channel Islands are a structural element of the Western Transverse Ranges Province and are considered an extension of the Santa Monica Mountains to the south. They are a mix of volcanic and volcaniclastic sediments of Miocene age and pre-Cretaceous crystalline basement, which are typically overlain by marine and non-marine sedimentary and volcaniclastic Tertiary deposits (Dibblee 1982; Jones and Grice 1993). Santa Barbara Island (hereinafter, Santa Barbara) was formed by underwater volcanic activity, and lies south of the other islands of the Park, approximately 40 miles from the mainland. The waters surrounding all five islands of the Park, from mean high tide to six nautical miles offshore, constitute the Channel Islands National Marine Sanctuary (Sanctuary), which is administered by the National Oceanic and Atmospheric Administration (NOAA). Subsets of Sanctuary waters are State Marine Reserves (SMRs) , in which all fishing is prohibited, or State Marine Conservation Areas (SMCAs), in which limited recreational or commercial take is allowed.

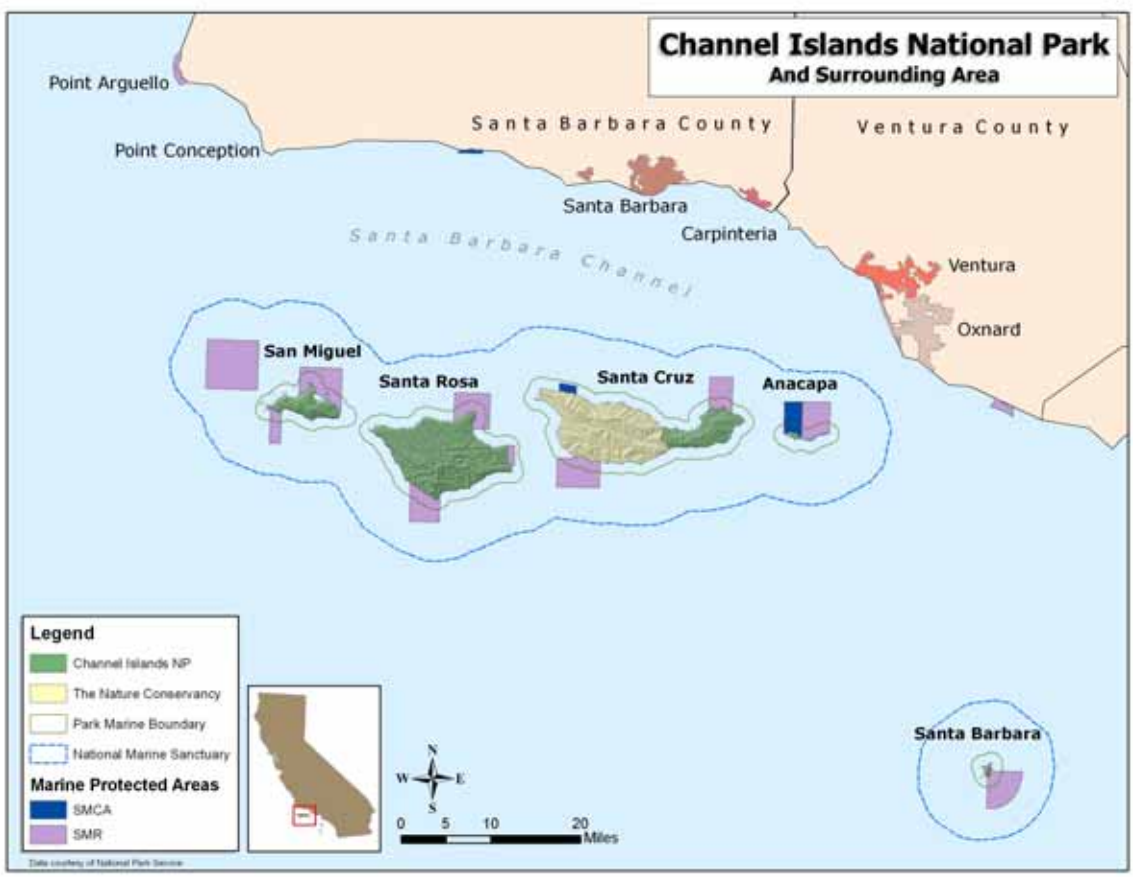


Figure 1. Channel Islands National Park and its environs.

San Miguel. Fifty-five miles from the city of Ventura, San Miguel (9,325 acres) is the farthest west of the Channel Islands. Because of its location in the open ocean, it experiences high winds and lots of fog. The island is mostly a tableland with 27 miles of jagged, rocky coastline interspersed with sandy white beaches. The westernmost of these beaches, Point Bennett, is the only place in the world where up to six different species of pinnipeds (seals and sea lions) can be found. Principal land covers on San Miguel are grassland, haplopappus scrub, coastal sage scrub, and unstabilized sand dunes (Figure 2a). The U.S. Navy owns San Miguel, however, the NPS manages the island.

Santa Rosa. Santa Rosa, the second largest of the Channel Islands (52,794 acres), is 40 miles west of the city of Ventura. It is a diverse island of grass-covered rolling hills, steep canyons, creeks, rocky intertidal areas and sandy beaches. Principal land covers on Santa Rosa are grassland, coastal sage scrub and chaparral (Figure 2b). Vail & Vickers Co., the former owners of the island, have a special use permit, that expires in 2008, to use and occupy 7.6 acres of the island, and to conduct trophy hunts for elk and deer that were introduced to the island. The Park may extend the hunts until 2011.

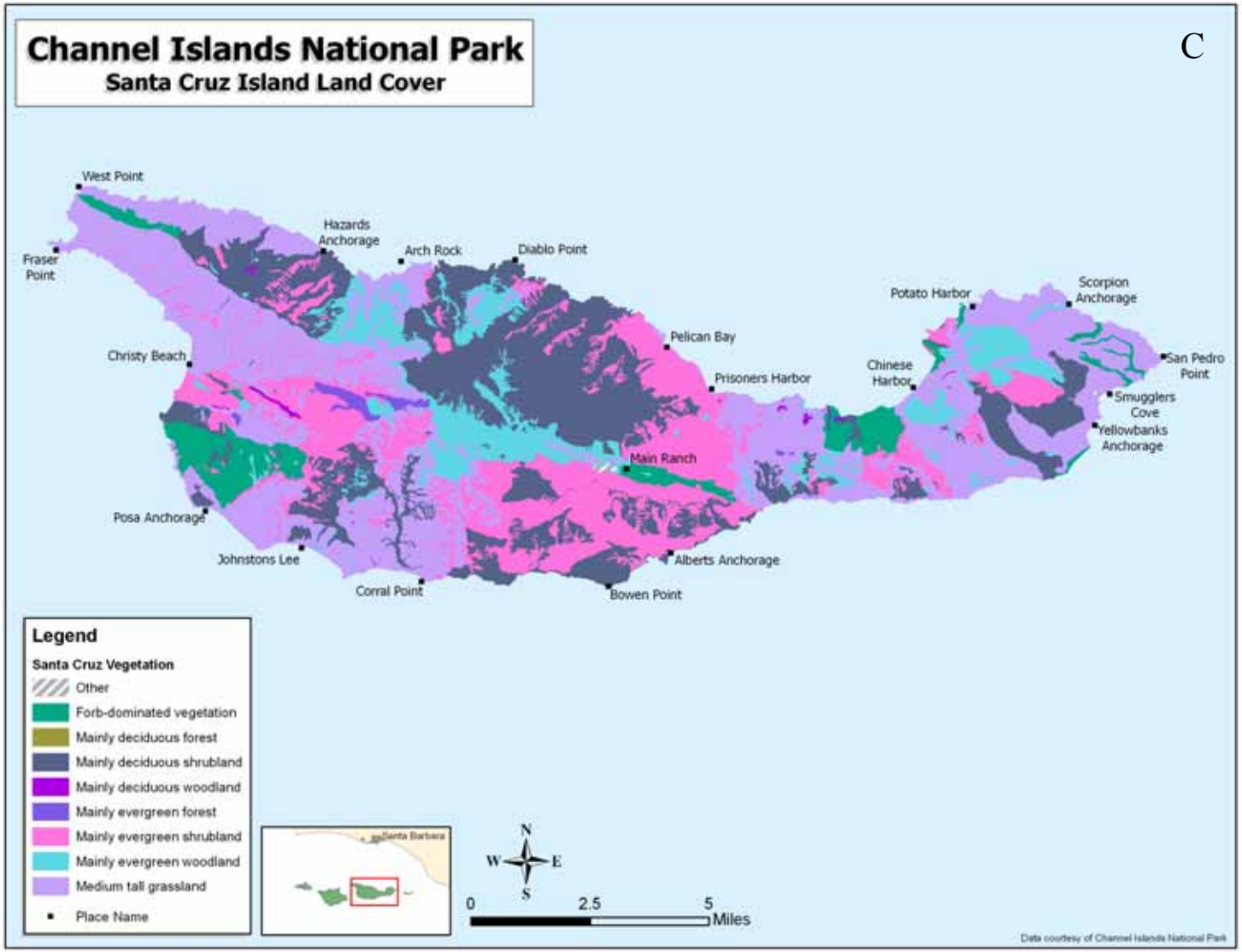
Santa Cruz. Santa Cruz is the largest of all the Channel Islands (60,645 acres), and is also the most diverse. Two east/west trending mountain ranges rise over 2000 feet above sea level creating a large central valley, many interior and coastal canyons, fresh water springs, streams, small coastal wetlands, coastal cliffs, sandy beaches, and rocky intertidal areas. Land ownership on Santa Cruz is split between the Park, which owns and manages the eastern 24% of the island, and The Nature Conservancy (TNC), which owns and manages the remaining 76% of the island. Over the past 150 years, feral sheep and pigs have dramatically affected the land cover on Santa Cruz, removing the native vegetation and contributing to high rates of erosion. Non-native plants, including highly invasive fennel, have capitalized on these disturbances, occupying between 25 to 80 percent of the island's ground cover. Today, Santa Cruz harbors at least 170 introduced plant species, making up 26 percent of the island's total flora (CINP 2002a). Principal land cover categories on Santa Cruz are grassland, and deciduous and evergreen shrubland (Figure 2c).

Anacapa. Anacapa is a chain of three small islets extending four and a half miles from east to west, and totalling 699 acres. East Anacapa is one mile long, a quarter of a mile wide, and rises 250 feet above the water. Middle Anacapa is one and a half miles long, a quarter of a mile wide and 325 feet at its highest point. Western Anacapa, the largest island of this group, is two miles long by six tenths of a mile wide, and rises to a peak of 930 feet. Important land covers on Anacapa are coastal sage scrub, grassland, island chapparal, iceplant, and *Coreopsis* dominated bluffs (Figure 2d).

Santa Barbara. Thirty-eight miles west of Palos Verdes Point, Santa Barbara (639 acres) is the smallest of the Park islands. The island is roughly triangular in outline and emerges from the ocean as a twin-peaked mesa with steep cliffs. Santa Barbara has a few narrow rocky beaches, six canyons, and a badlands area. The steep cliffs and isolation from mainland predators provide safe breeding sites for thousands of sea birds. Principal land covers on Santa Barbara are grassland, iceplant and native shrubland (Figure 2d).

Figure 2. Land cover on San Miguel Island (A), Santa Rosa Island (B), Santa Cruz Island (C), Anacapa and Santa Barbara Islands (D).

Figure 2. (continued).



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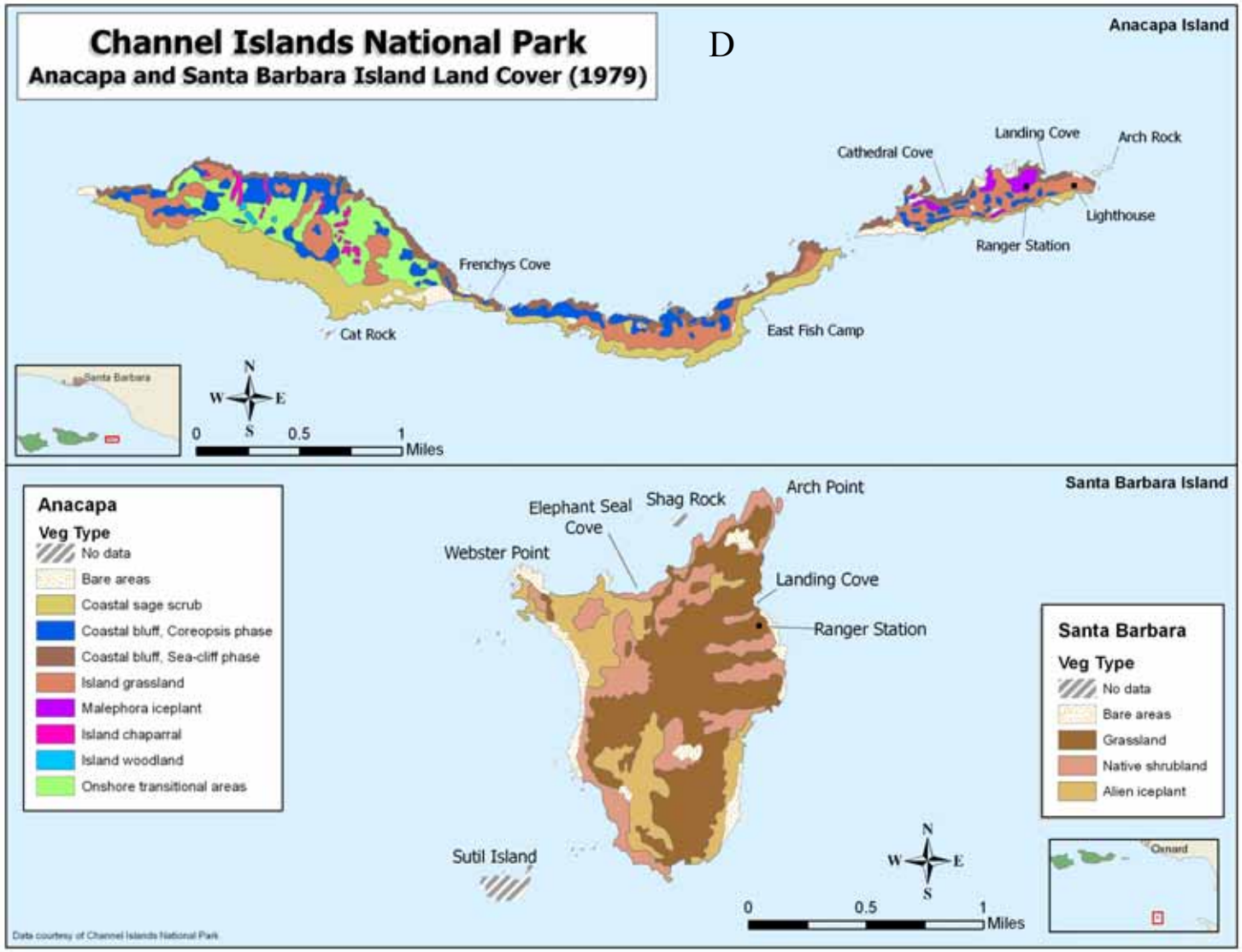

Figure 2. (continued).

A.2. Territorial Designations

Although the marine habitat of the Park is situated entirely within California state waters, the park is hydrologically and ecologically connected to both state and federal waters, and an international shipping lane. Marine jurisidictions that pertain to offshore ownership, sovereignty, mineral, fishery, and national security rights and regulatory control in and near the Park are summarized below.

State Waters

State Tidelands Submerged Lands

Coastal states are given ownership of lands and resources within three nautical miles (nm) of mean high tide line. State control and regulation of the development of resources such as oil and gas, and fisheries, in state waters was confirmed by the Federal Submerged Lands Act of 1953.

Federal Waters

Outer Continental Shelf

The Outer Continental Shelf Lands Act of 1953 confirmed federal jurisdiction over the resources beyond 3 nm from shore

Territorial Seas

Pursuant to a 1988 presidential proclamation, the United States asserts sovereign rights over the lands and waters out to 12 nm from shore. The rights of the States out to 3 nm from shore are not disturbed by this proclamation.

Exclusive Economic Zone (EEZ)

Persuant to a 1983 presidential proclamation, the U.S. asserts jurisdiction over the living and non-living resources from 3-200 nm offshore. The Coastal Zone Management Act (CZMA), which provides for the California Coastal Commission, gives coastal states substantial authority to influence federal actions beyond 3 nm from shore. (An example germaine to the Park is the California Coastal Commission's influence in the handling of offshore oil and gas leases in federal waters of the Santa Barbara Channel).

Contiguous Zone

From 12 to 24 nm offshore, the United States can exercise control over customs, fiscal, immigration, and sanitary matters.

High Seas

Beyond 12 nm from shore, the United States maintains the right to freely navigate its vessels (including war vessels).

A.3. Regulatory Bodies and Management Entities

Listed below are federal, state and local entities which exercise authority over, or have management responsibilities for, the freshwater (streams/wetlands/groundwater) and marine resources in or near the Park. Entities marked by arrows (**»**) have mandates that extend directly into land and water *within Park boundaries*, and thus technically share management of parts of the Park with the National Park Service. Other entities either (1) manage marine species that move in and out of Park boundaries (birds, fish, marine mammals), (2) manage activities outside

the Park that influence biological resources (such as fishing, recreation, oil and gas extraction), (3) manage direct discharges of wastewater into the coastal ocean, or (4) manage the quality of mainland runoff.

California State Lands Commission (SLC)

The SLC has jurisdiction over all of California's tidal and submerged lands up to 3 nm from the California shore (and the beds of naturally navigable rivers and lakes, which are not relevant to the the Park). The SLC currently has no program for offshore oil and gas leases in state waters.

California Coastal Commission (CCC)

The CCC addresses public access and recreation, natural resource protection, agricultural operation, coastal development projects, port activities and energy production. Its jurisdiction extends up to 5 miles inland from mean high tide and into the ocean up to the federal waters limit.

»NOAA Channel Islands National Marine Sanctuary (the Sanctuary)

The Sanctuary is one of four National Marine Sanctuaries offshore from California (the others are the Monterey Bay, Gulf of the Farallons, and Cordell Bank sanctuaries). The Sanctuary extends from the mean high tide line to 6 nm offshore of the five islands of the Park. The marine habitat of the Park (the first mile offshore) is fully contained within the Sanctuary. The primary purpose of the National Marine Sanctuary program is resource protection (USC Section 1431b). Prohibitions in the Sanctuary that are relevant to aquatic resources in the Park are:

1. Exploring for, developing, and producing hydrocarbons except pursuant to leases executed prior to March 30, 1981, and except the laying of pipeline (a number of stipulations regarding oil spill equipment apply to laying pipeline)
2. Discharge of Substances. Exceptions are fish, fish parts, bait, water and other biodegradable effluents incidental to vessel use of the sanctuary generated by marine sanitation devices, routine vessel maintenance (e.g., deck wash down), engine exhaust; meals aboard vessels
3. Alteration of, or construction on, the seabed (precludes drilling, dredging - but anchoring and commercial trawling is allowed)
4. Commercial vessels are prohibited within one nautical mile of an island (cargo, tankers, etc.) except to transport persons or supplies to or from an island. Does not apply to fishing (including kelp harvesting), recreational or research vessels.
5. Motorized aircraft are prohibited less than 1,000 feet over the waters within one nautical mile of any island except for enforcement purposes, to engage in kelp bed surveys, to transport persons or supplies to or from an island.

»National Marine Fisheries Service (NMFS)

NMFS is contained within NOAA, and manages the sea's living resources with the EEZ. NMFS has lead management responsibility for anadromous fisheries (salmon), sea turtles (at sea) and all marine mammals, except sea otters, walrus, manatees and polar bears (which are under the authority of the U.S. Fish and Wildlife Service [USFWS]). Seabirds are managed by the USFWS. Pinnipeds at the Park are monitored by the NMFS.

»Pacific Fishery Management Council (PFMC)

The federal government manages the marine resources and fishing activities of the United States through the Magnuson-Stevens Fishery Conservation and Management Act of 1976

and the Sustainable Fisheries Act of 1996 (now called the Magnuson-Stevens Fishery Conservation and Management Act). The purposes of the acts are to provide conservation and management of fishery resources, develop domestic fisheries, and phase out foreign fishing activity within the EEZ. Eight Regional Fishery Management Councils implement the goals of the Act in coordination with the NMFS. The PFMC manages the fisheries resources off Washington, Oregon, and California by developing Fisheries Management Plans for the EEZ. The PFMC is funded through the Department of Commerce. Management plans adopted and implemented to date include one for the:

Pacific Coast Groundfish Fishery

Pacific Coast Salmon Fishery

Coast Pelagic Species Fishery

A management plan for *West Coast Highly Migratory Species* (tunas, sharks, billfish/swordfish, and dorado (also known as dolphinfish and mahi-mahi) was partially approved in 2004. California state fishing regulations (such as the Nearshore Fishery Management Plan as it applies to groundfish species, see below) must be consistent with federal law for species managed by the PFMC.

»U.S. Fish and Wildlife Service (USFWS)

The USFWS is responsible for protecting and conserving fresh water and estaurine fisheries, certain marine mammals (southern sea otter, walrus, manatees, and polar bears), migratory birds, sea birds, sea turtles on shore, threatened and endangered species - and their habitats - for the benefit of the public. Activities of the USFWS include restoration programs; listing, protection, and development of recovery programs under the Federal Endagered Species Act for candidate species; and commenting on federal proposals and federally permitted projects. USFWS provides research and support for international negotiation regarding fisheries, migratory wildlife, and protected species.

»California Fish and Game Commission (Commission)

The Commission is not synonymous with the California Department of Fish and Game. The Commission was created by the State Constitution and is composed of up to five members, appointed by the Governor and confirmed by the Senate. The Commission meets at least eleven times each year to publically discuss various proposed regulations, permits, licenses, management policies and other subjects within its areas of responsibility. It also holds a variety of special meetings to obtain public input on items of a more localized nature, requests for use permits on certain streams, or establishment of new ecological reserves. Probably the best known responsibility of the Commission is its general regulatory powers function, under which it decides seasons, bag limits and methods of take for game animals and sport fish.

»California Department of Fish and Game (CF&G) - Marine Region

The Marine Region is responsible for protecting and managing California's marine resources under the authority of laws and regulations created by the state legislature, the Commission, and the PFMC. CF&G enforces the regulations created by the Commission. Recreational fishing regulations are provided in Fish and Game Code (FGC) Sections 7100-7400 and the California Code of Regulations (CCR), Title 14, Chapter 4. Commercial fishing regulations

are provided in FGC Sections 7600-9101 and CCR, Title 14, Chapter 6. Selected code relevant to the Park is summarized in Appendices B and C.

»State Water Resources Control Board (SWRCB), California Environmental Protection Agency (Cal EPA)

The SWRCB oversees California's compliance with the Federal 1972 Clean Water Act and the California Porter-Cologne Water Quality Control Act. Through nine Regional Water Quality Control Boards (RWQCBs), the SWRCB regulates offshore drilling activities, discharges from cruise lines, and ocean dumping, and oversees the State's nonpoint source pollution, stormwater and wastewater discharge programs. Two regional boards are pertinent to the Park:

Region 3: Central Coast RWQCB

includes San Miguel, Santa Rosa, and Santa Cruz Islands, and the coastline and coastal watersheds of Santa Barbara County

Region 4: Los Angeles RWQCB

includes Anacapa and Santa Barbara Islands, and the coastline and coastal watersheds of Ventura and Los Angeles County

»U.S. Navy

The U.S. Navy owns San Miguel , but the National Park Service manages the island. The waters surrounding the Park are sometimes closed for military operations. Bechers Bay, on Santa Rosa, is a naval operating area.

»U.S. Coast Guard

The U.S. Coast Guard owns East Anacapa Island.

»Santa Barbara and Ventura Counties

San Miguel, Santa Rosa, Santa Cruz, and Santa Barbara Islands are in Santa Barbara County. Anacapa Island is in Ventura County.

»The Nature Conservancy (TNC)

TNC owns 76% of Santa Cruz . During the 1980s they eliminated feral sheep from their portion of the island, and are now cooperating with the NPS in efforts to restore native fauna and flora on the island, including the relocation of golden eagles, reintroduction of bald eagles, and eradication of feral pigs.

»University of California Santa Cruz Island Nature Reserve

The Santa Cruz Island Nature Reserve is part of the Natural Reserve System of the University of California. The Reserve is owned and managed by TNC. The Reserve has a field station in the island's central valley which includes a dormitory, kitchen, dining hall, laundry, library/conference room, wet and dry lab; four-wheel-drive vehicles; a 17-foot Boston whaler; and a 5-person inflatable boat.

U.S. Environmental Protection Agency

The U.S. EPA has no direct ocean resource management responsibilities. However, it regulates the use of tributyltin, a component of ship bottom antifoulant paint - which has adverse effects on nontarget marine life.

Minerals Management Service (MMS)

Minerals Management Service (MMS) is the Federal agency responsible for managing the nation's mineral resources offshore of the United States, commonly referred to as the Outer Continental Shelf (OCS), and for collecting and disbursing the revenues from the production of all mineral resources on federal lands, offshore and onshore. The MMS conducts environmental studies on the potential and real effects of offshore mineral development, issues offshore mineral leases to companies, and regulates the operations conducted under MMS permits on the OCS. The Pacific OCS Region of the MMS extends from the California-Mexico border to the Washington-Canada border.

International Maritime Organization

The International Maritime Organization designated the voluntary vessel traffic separation scheme to guide large vessel traffic running through the Santa Barbara Channel.

A.4. Selected Pertinent State Legislation

Marine Life Management Act (MLMA). The MLMA became state law on January 1, 1999, and grants the Commission with additional broad authority to regulate commercial fisheries. The MLMA includes a number of innovative features and goals:

Non-Consumptive Values: The MLMA applies not only to fish and shellfish taken by commercial and recreational fishermen, but to all marine wildlife. Marine life need not be consumed to provide important benefits to people, including aesthetic and recreational enjoyment as well as scientific study and education.

Conserves Entire Systems: It is not simply exploited populations of marine life that are to be conserved, but the species and habitats that make up the ecosystem of which they are a part. Rather than focusing on single fisheries management, the MLMA requires an ecosystem perspective including the whole environment. The habitat of marine wildlife is to be maintained, restored or enhanced, and any damage from fishing practices is to be minimized.

Sustainability: Rather than assuming that exploitation should continue until damage has become clear, the MLMA shifts the burden of proof toward demonstrating that fisheries and other activities are sustainable. Depressed fisheries are to be rebuilt within a specified time. The bycatch of marine living resources in fisheries is to be limited to acceptable types and amounts.

Fishery Management Plans: Rather than ad hoc and piecemeal decisions on individual fisheries, the aim is to base decisions on comprehensive reviews of fisheries and on clear objectives and measures for fostering sustainable fisheries. The vehicle for this objective is a fishery management plan.

Status of the Fisheries Report: Annually, CF&G will prepare a report on the status of California's fisheries and the effectiveness of management programs.

The Legislature called initially for the adoption of only two Fishery Management Plans, for (1) the *white sea bass fishery*, and (2) the *nearshore finfish fishery* (rules for the latter apply to state waters from shore to 1 nm from land). However, the process has led to the development of management plans, or at least electronically posted fishery data, for other taxa important in the Park: abalone, market squid, sea urchins. A draft Market Squid Fishery Management Plan was submitted to the Commission for adoption in early 2006.

Marine Resources Protection Act of 1990. This state law prohibited the use of gill nets and trammel nets to take any species of rockfish south of Point Arguello. In addition, gill nets and trammel nets cannot be used for any species in the Marine Resources Protection Zone, which

includes waters within one nautical mile (or 70 fathoms, whichever is less) around San Miguel, Santa Rosa, Santa Cruz, Anacapa, San Nicolas, Santa Barbara, Santa Catalina, and San Clemente Islands (plus ocean waters within 3 nautical miles of the mainland between the Mexican border and Point Arguello).

Marine Life Protection Act (MLPA). The MLPA was passed by the State in 1999 and is codified in FGC Chapter 10.5, Sections 2850 to 2863. The purpose of the MLPA is to improve the array of marine protected areas (MPAs) existing in California waters through the adoption of a Marine Life Protection Program and a comprehensive master plan. The MLPA introduced a three-tiered system of State Marine Protected Areas (State Marine Reserves, State Marine Parks, State Marine Conservation Areas). For more, see http://www.dfg.ca.gov/mrd/mlpa/index.html.

Channel Islands Marine Protected Areas (MPAs). In 2003, a network of 10 State Marine Reserves (SMRs) (in which no fishing is allowed) and 2 State Marine Conservation Areas (SMCAs) (in which limited recreational and/or commercial take is allowed) were established by the Commission in subsets of state waters around all five of the Park islands. The MPAs extend seaward from shore, thus they include portions of the Park. The two SMCAs at the Channel Islands are (1) a recreational-only fishing zone (lobster and pelagic finfish only) off Santa Cruz straddling the site of Painted Cave, and (2) an area with limited commercial (lobster only) and recreational fishing (lobster and pelagic finfish) off Anacapa. Nineteen percent of the state waters within the Sanctuary are included in the MPAs. NOAA's National Marine Sanctuary Program is considering expanding the boundaries of the MPAs into the federal waters of the Sanctuary (see Section III.B).

A.5. Human Utilization

Santa Cruz. Santa Cruz supported sizable human populations over 10,000 years before present. By the time Europeans arrived in the late 1700s, approximately 2,000 Chumash lived on the island, at 11 coastal village sites. By 1807, however, epidemic diseases had decimated the island population. Spanish missionaries relocated the Chumash to mainland missions by 1822. The Chumash population of Santa Cruz settled primarily in and around the Spanish Missions in Santa Barbara and San Buenaventura. Physical remnants of Chumash culture are still preserved on Santa Cruz at more than 3,000 archaeological sites.

Although sea otter hunters, smugglers, and others left traces on Santa Cruz, permanent European settlement did not occur on the islands until the mid-1800s. Beginning in 1830, the island briefly served as a prison colony for 100 convicts, for whom cattle and horses were supplied, which is the first known reference to livestock on Santa Cruz (Junak et al. 1995). In 1839, the Mexican government granted title to the island to Andres Castillero, who became the first private owner of

Santa Cruz. In 1853, Dr. James Barron Shaw, acting as agent for Castillero and the island's subsequent owners, the Barron and Forbes Company, began stocking the island with sheep, horses, cattle and hogs. In 1869, ten San Francisco investors purchased the island and formed the Santa Cruz Island Company. In 1870s Justinian Caire acquired the majority of the shares in the company and became sole owner of the island by the end of the 1880s or early 1890s. Caire and his descendants continued and expanded the sheep ranching and agricultural enterprises on the island.

The heart of Shaw's and (later) Caire's operation was located in the island's central valley. The operation was a largely self-sustaining community that supported a diversity of permanent and seasonal employees, which included a blacksmith, carpenters, painters, team drivers, dairymen, cooks, stone cutters and masons, gardeners, dairymen, vintners, grape pickers, sheep shearers, wagon and saddle makers, a cobbler, a butcher, a baker, and a sea captain and sailors. The main ranch and the outranches at Scorpion, Prisoner's and Christy harbors remained the primary ranches through the Caire period. The island's sheep population reached 40,000-50,000 head under Caire, their wool and meat being shipped to market from Scorpion Ranch and Prisoners Harbor. Their numbers on the island were allowed to grow fairly unchecked with periodic round-ups to shear and slaughter some of the stock. By 1875 there were an estimated 60,000 sheep on the island, only half of which could be rounded up for shearing annually (Sauer 1988). During drought years tens of thousands were slaughtered to forestall starvation. Domestic pigs were introduced to Santa Cruz in 1852 (Schuyler 1988). By 1857 pigs had escaped and become feral on Santa Cruz.

After Caire died in 1897, lengthy litigation among his heirs resulted in the island being divided among his heirs into several parcels. The western 90% (54,500 acres) was sold in 1937 to Edwin L. Stanton. Stanton attempted unsuccessfully to revive the island's sheep business, which had declined dramatically after Justinian Caire's death, and then switched to cattle ranching. He, and later his son, began a concerted effort to install fencing and to round up all the sheep on their part of the island. By the 1970's over 263,000 sheep had been captured and sent to market or slaughtered (CINP 2002a). Nevertheless, from the 1920s to the early 1980s, the island supported the largest single population of feral sheep in the world (Van Vuren and Coblentz 1989). Overgrazing led to the expansion of the native coastal prickly pear (*Opuntia littoralis*), which by 1939 had rendered 40% of the rangeland on the island unusable. Eventually biological control was used to control the *Opuntia*, and since 1951, the scale insect, *Dactylopius opuntiae* has destroyed most of the dense *Opuntia* populations on the island (Sauer 1988).

By 1978, TNC acquired a conservation easement on the Stanton holdings. By this time, tens of thousands of roving feral sheep and pigs had reduced much of the island's native vegetation to stubble or bedrock and widespread erosion led to massive landslides. In 1981, TNC began an intensive program of fencing, trapping, and hunting to remove the remaining feral sheep on the Stanton portion of the island. A fence was built to separate TNC's holdings from east Santa Cruz In early 1987, TNC became the sole owner and manager of the western 90% of Santa Cruz. Between 1981-and June 1989, 37,171 sheep had been eradicated from the western 90% of SCI (Schuyler 1993), and 1,500 cattle were removed in a 6 month period in 1988. At this juncture, the remaining herbivores on the island were feral pigs and sheep, although by now the feral sheep were largely confined to the eastern 10% of Santa Cruz.

The east end of the island remained a ranch operation until the island was converted to a private hunting, camping and recreational venture in the early 1980s. The National Park Service

acquired full ownership of the east end of the island in 1997. At that time, the NPS began removing sheep within its boundary. The NPS removed 9,270 sheep from the east end between 1997 and 1999. In 2000, TNC conveyed an additional 8,500 acres to the NPS. Today TNC and the NPS own 76% and 24% of Santa Cruz, respectively. As of 2005, thousands of feral pigs occupied the island, rooting up soil, causing substantial erosion, threatening archeological sites, and facilitating the spread of fennel, an invasive weed. Golden eagles, which fed on feral pigs and which were encouraged by the disappearance of bald eagles from the Channel Islands, proceeded to hunt the endemic island foxes to the brink of extinction. An effort to exterminate feral pigs on the entire island, using professional hunters, began in March 2005.

Anacapa. The Indian influence on Anacapa dates back more than 10,000 years ago. The Chumash Indians who occupied Anacapa were of the same villages that inhabited Santa Cruz , although travel between all the Channel Islands was common. It is not known if Chumash Indians lived year-round on Anacapa in permanent settlements. They did occupy all three islets at least seasonally, however. There is evidence of at least twenty-three kitchen midden areas. A lack of a dependable supply of fresh water was a likely deterrent to year-round occupation. There are no Spanish accounts of people living on Anacapa .

Juan Rodriguez Cabrillo was the first European to pass by Anacapa in 1542. Most early explorers failed to specifically mention Anacapa in their charts or logs. The islands were called Las Mesitas, or the Little Tables, by Portola in 1769. Captain George Vancouver renamed them Anacapa from the Canalino Indian name of Enecapah. During the 19th century, seasonal fisherman used Anacapa as a base. In 1848, Anacapa became the property of the United States Government with the Treaty of Guadalupe Hidalgo. Captain George Nidever was one of the first persons after the collapse of Chumash Indian culture to have interests on Anacapa where he raised sheep, even though it was government property.

There have been over a dozen major shipwrecks on Anacapa, the most famous of which was the S.S. General Winfield Scott on December 2, 1853. Shortly after the wreck of the Winfield Scott, Anacapa was surveyed by the U.S. Coast and Geodetic Survey to determine the need for a lighthouse. In 1854, Anacapa was set aside for lighthouse purposes, and was administered by the Lighthouse Bureau.

During the next forty years Anacapa was ranched by several parties - most notable was the Pacific Wool Growing Company. It was not until 1902 that the U.S. Government took an active role as land owner and began to lease the island to a series of sheep operations. One of these, Captain Eaton, had a resort operation on Santa Cruz and used Anacapa as a storage place for bootlegged liquor during prohibition. In 1911 funds became available for the erection of the first lighthouse, which was unmanned. The current lighthouse on Anacapa was turned on for manned operation on March 25, 1932. The site included a 30,000 square foot concrete pad for collecting rain, a water tank, light tower, powerhouse, a fog signal building and several lighthouse keepers' dwellings. The Coast Guardsmen and their families of the light station resided in four large Spanish style white stucco houses with red tile roofs before the light station was automated in December 1968.

In 1937 it was decided that no further leasing be allowed. However, from 1928 to 1956, Raymond "Frenchy" Le Dreau lived as a hermit in one of several cabins built in a cove on West Anacapa which now bears his name. In 1938 President Franklin D. Roosevelt designated Channel Islands National Monument, encompassing both Anacapa and Santa Barbara Islands. In

1939 the Lighthouse Bureau went out of existence, and Anacapa was assigned to National Park Service management. The light station on East Anacapa Island continued to be managed by the U.S. Coast Guard. Frenchy Le Dreau became the unofficial Park Service representative, reporting on acts of vandalism and island activities

In 1980, Anacapa's status changed to that of National Park. The U.S. Coast Guard retained ownership of East Anacapa Island. The buildings other than the lighthouse are now being utilized by the NPS.

Santa Rosa. More than 600 archeological sites have been mapped on Santa Rosa. These include several associated with very early human presence in North America. Chumash Indian villages and camps of early explorers and fur hunters are evident. With Mexico's successful revolt against Spain in 1821, unoccupied Santa Rosa Island became subject to the Mexican flag, and 22 years later, with the Treaty of Guadalupe Hidalgo, the Carrillo brothers became the island's first private owners. In the 1840s and 1850s, Santa Rosa was a cattle ranch. After the cattle industry of old Spanish California collapsed in the 1860s, sheep were brought to Santa Rosa and soon became its economic mainstay. By 1862, the More family owned all of Santa Rosa Island. During the next four decades, the island was used primarily as a sheep ranch. The U.S. Civil war brought with it a great demand for wool used in the manufacture of soldiers' uniforms. In 1874, 300,000 pounds of wool was produced on Santa Rosa.

In 1901, Walter L. Vail and J. V. Vickers bought their first shares in Santa Rosa Island. Most of the sheep were removed and the island was stocked with 1,891 head of cattle from the Empire Cattle Company. It took an additional 30 years for the Vail and Vickers partnership to acquire the remaining shares of Santa Rosa Island. Commercial hunting for introduced Roosevelt elk and kaibab mule deer began in 1979. In March 1980, the United States Congress established Channel Islands National Park. As a result of this legislation, in 1986, the federal government purchased Santa Rosa Island from Vail & Vickers. In executing the sale, Vail & Vickers retained a right to use and occupy 7.6 acres of the island until 2008. Feral pigs were present on the island until 1993. In 1998, the NPS removed the remaining cattle from the island. Vail & Vickers continue to run commercial hunts for trophy elk and mule deer, through a company called called Multiple Use Managers Inc.. The hunts are scheduled to terminate in 2011. Major reductions in the numbers of elk and deer on the island are expected starting in 2008.

San Miguel. A radiocarbon date of 8900 years before present establishes human presence on San Miguel but human occupation on the island may date as back more than 10,000 years ago. Archaeological surveys have mapped 542 sites on the island, evidence that occupation on the island was more than casual or temporary. The first European to land on San Miguel (in 1542) was Juan Rodriguez Cabrillo, the Portuguese explorer credited as the "discoverer" of California. Cabrillo is believed to have wintered and died at Cuyler Harbor in 1543. As on various other Channel Islands, squatters, fisherman and otter hunters lived on the island during historic times. In the 18th and 19th centuries, sea mammal hunters were drawn to the island in search of sea otters. Yankees, Russian sponsored Aleuts, Kanakas and others were among those who came to hunt.

By the mid-1800s, sheep ranchers had replaced the Chumash on San Miguel. The early "owners" of the islands were not legal owners, but owners by possession only. The first sheep rancher on the island was Samuel C. Bruce, who sold his operation to George Nidever, a famous

mountainman, sea otter hunter, and later renowned as the man who discovered "The Lone Woman of San Nicholas Island" (about whom the book and movie Island of the Blue Dolphins was based). In 1852 George Nidever built the first European structure on the island, an adobe house, in what is now called Nidever Canyon. Nidever and his sons lived there, and raised sheep and cattle until 1870. During a drought in 1863, Nidever's herd of sheep stripped the island of most of its vegetation, and 5000 sheep and 180 cattle died. Starting in 1869, ownership of San Miguel passed from Nidever to several owners, until in 1890 it was in the sole possession of William G. Waters. Detecting that San Miguel was inadvertently omitted from the the Treaty of Guadalupe, Waters claimed San Miguel as a sovereign territory. In 1896 President Cleveland sent a federal marshal to discuss matters with the "sovereign" of San Miguel. Its ownership was disputed until President Taft signed a bill in 1909 reserving the island for lighthouse use. The U.S. government then took possession of the island, offering Waters leasing rights, which he took. After Waters died, the government leased the island to a succession of ranchers. By the 1930s the island was so overgrazed that barren sands swept from one side of the island to the other. In 1934 President Franklin Roosevelt moved jurisdiction of the island from the Secretary of Commerce to the Secretary of the Navy. In 1938 Anacapa and Santa Barbara Islands became a national monument, but San Miguel was turned down for inclusion.

In 1948, the final tenant ranch family was hastily evicted and the Navy began using San Miguel for target practice. Until the 1960s, planes, ships, and missiles bombarded the island. The island continued to be a central point for naval training well into the 1970's and naval aircraft practiced strafing on a target south of Cardwell Point until 1988. Sheep grazed undisturbed until the 1960s when the Navy ordered the elimination of all the animals. In 1966 the last 148 sheep were hunted and eliminated. In 1980, San Miguel became part of Channel Islands National Park. Although the National Park Service has managed the island since 1963, the Navy still owns San Miguel .

Santa Barbara. Santa Barbara was named by Sebastian Vizcaina, who arrived there in 1602. Because of the lack of fresh water, Native Americans did not reside on the island, but they stopped off on journeys to other islands. Not until the 20th century was Santa Barbara settled to any extent. During the 1920s, farming, grazing, intentional burning by island residents, and the introduction of rabbits severely damaged the native vegetation. During World War II the U.S. Navy used the island as an early warning outpost. Although non-native grasses including oats, barley, and brome, dominate the landscape, the native vegetation, including stands of giant coreopsis up to ten feet tall, is starting to recover.

Current Park Visitation. Concessionaires offer year-round transportation to the islands for day visits and camping trips. Visitation to the islands and waters is low, consisting annually of about 30,000 visitors that go on land, and another 60,000 who go only into park waters. All rock islets within Park boundaries are closed to access above mean high tide. Shore fishing is prohibited on San Miguel. Camping is available on all five islands in NPS-managed campgrounds (Figure 3). No camping is allowed on TNC's portion of Santa Cruz. Several outfitters offer a variety kayak trips to the Channel Islands from May through October. Visitors with their own kayaks can transport them to the islands using the Park's concessionaires.

Santa Cruz has one campground in Scorpion Canyon with 40 sites spread out along the valley floor 1/2 to 1 mile up from the beach landing, and a backcountry campsite at Del Norte on the

north side of the island 3.5 miles by trail from Prisoner's Harbor. Anacapa has hiking trails, a visitor center, lighthouse exhibits, a primitive campground, and picnic area. The campground is on East Anacapa, up 154 stairs and 1/2 mile from the dock landing. There are 7 campsites with a campground capacity of 30 people. West Anacapa (except at Frenchy's Cove) is a protected research area and is closed to visitor access. Visitors are allowed on Middle Anacapa only when accompanied by a park ranger. There are two moorings near the landing cove at East Anacapa. These are reserved for use by the National Park Service, the Coast Guard and the park concessionaire. Santa Barbara has 5 miles of hiking trails, a visitor center, and a picnic area. The campground is 1/2 mile uphill from the dock landing. There are 8 campsites with a campground capacity of 30 people. Santa Rosa has hiking trails and a primitive campground and offers ranger-led hikes, vehicle tours, and kayak beach-camping. The campground in Water Canyon is 1.5 mile across the flats from the pier landing, or 1/4 mile from the airstrip. There are 15 campsites with a campground capacity of 50 persons. The campground has windbreaks and running water (most people bring drinking water). Camping on the beaches on Santa Rosa is available with a permit for experienced kayakers and boaters on a seasonal basis. San Miguel has a primitive campground, hiking trails and offers ranger-led hikes, marine-mammal observation, beach exploration, and bird watching. Hiking beyond the beach and campground on San Miguel is on ranger-guided hikes only. The campground is a one mile uphill from the beach landing and has windbreaks. There are 9 campsites with a total campground capacity of 30 people. Fewer than 200 people per year camp on San Miguel.

Figure 3. Park infrastructure on San Miguel Island (A), Santa Rosa Island (B), Santa Cruz Island (C), Anacapa and Santa Barbara Islands (D).

Channel Islands National Park
Santa Rosa Island Infrastructure
B
Carrington Point
Corral Point
Northwest Anchorage
Brockway Point
Sandy Point
Pocket Field
Bechers Bay*
Southeast Anchorage
Skunk Point
Black Mountain (1298')
Soledad (1574')
East Point
Grouse (1048')
Lopez (1088')
Cluster Point
China Camp
Ford Point
Johnsons Lee
South Point
Legend
Roads
Restroom
Campground
Ranger Station
Anchorage
Picnic Area
Historic Building
Airstrip
* Location of Pier
Santa Barbara
N
W
E
S
0
2.5
5
Miles
Data courtesy of Channel Islands National Park

Figure 3b.

Channel Islands National Park
Santa Cruz Island Infrastructure
C
West Point
Fraser Point
Cueva Valdez Anchorage
Diablo Anchorage
Frys Harbor
Pelican Bay
Prisoners Harbor*
Potato Harbor
Scorpion Anchorage*
Little Scorpion Anchorage
Christy Beach
Chinese Harbor
Smugglers Cove
Main Ranch
Yellowbanks Anchorage
Johnstons Lee
Corral Point
Coches Prietos Anchorage
Legend
Place Name
Roads
TNC
NPS
Restroom
Campground
Ranger Station
Anchorage
Picnic Area
Historic Building
Airstrip
* Pier located here
Santa Barbara
N
W
E
S
0
2.5
5
Miles
Data courtesy of Channel Islands National Park

Figure 3c.

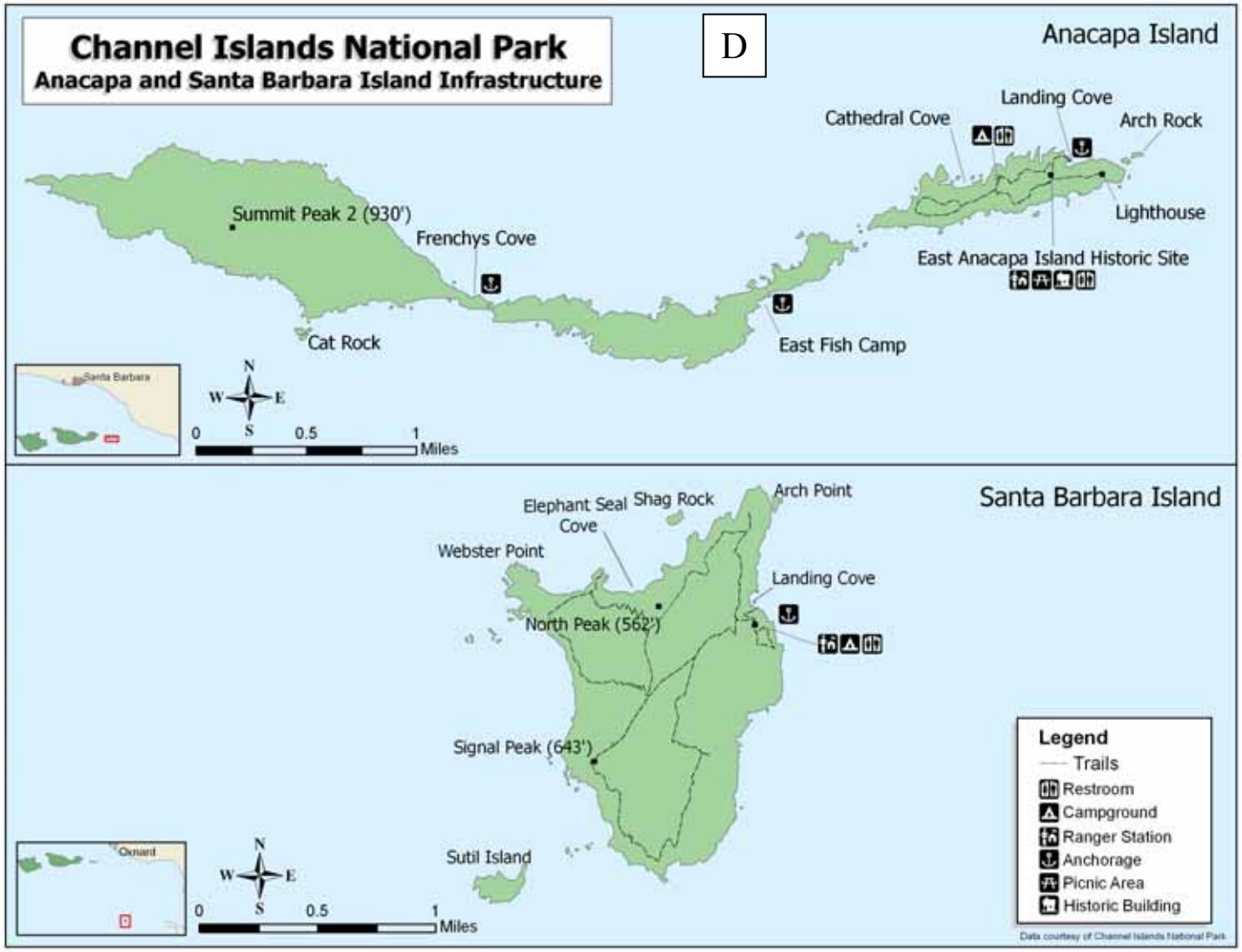
Channel Islands National Park
Anacapa and Santa Barbara Island Infrastructure
D
Anacapa Island
Landing Cove
Cathedral Cove
Arch Rock
Summit Peak 2 (930')
Frenchys Cove
Lighthouse
East Anacapa Island Historic Site
Cat Rock
East Fish Camp
Santa Barbara
N
W
E
S
0
0.5
1
Miles
Santa Barbara Island
Elephant Seal Cove
Shag Rock
Arch Point
Webster Point
Landing Cove
North Peak (562')
Signal Peak (643')
Sutil Island
Oxnard
Legend
Trails
Restroom
Campground
Ranger Station
Anchorage
Picnic Area
Historic Building
Data courtesy of Channel Islands National Park

Figure 3d.

B. HYDROLOGIC INFORMATION

B.1. Oceanographic Setting

a. The Southern California Bight

The Southern California Bight (SCB, or Bight) is a 100,000-square-mile body of water and submerged continental shelf that extends from Point Conception, California, in the north to Cabo Colnett, Baja California, Mexico, in the south (Noblet et al. 2003). It is bounded offshore to the west by the Santa Rosa-Cortes ridge (Figure 4). Within the Bight are submarine valleys and mountains, the peaks of which form the various offshore islands. The ridges and troughs generally run northwest to southeast, with the exception of the Channel, which runs east to west. The Channel is ~100 km long and 40 km wide with a central basin depth of ca. 500 m, and a narrow shelf on both sides ranging in width from 3-10 km. The sills at the eastern and western entrances of the Channel are 220 and 430 m deep, respectively. The passages between the islands are about 40 m deep (Harms and Winant 1998).

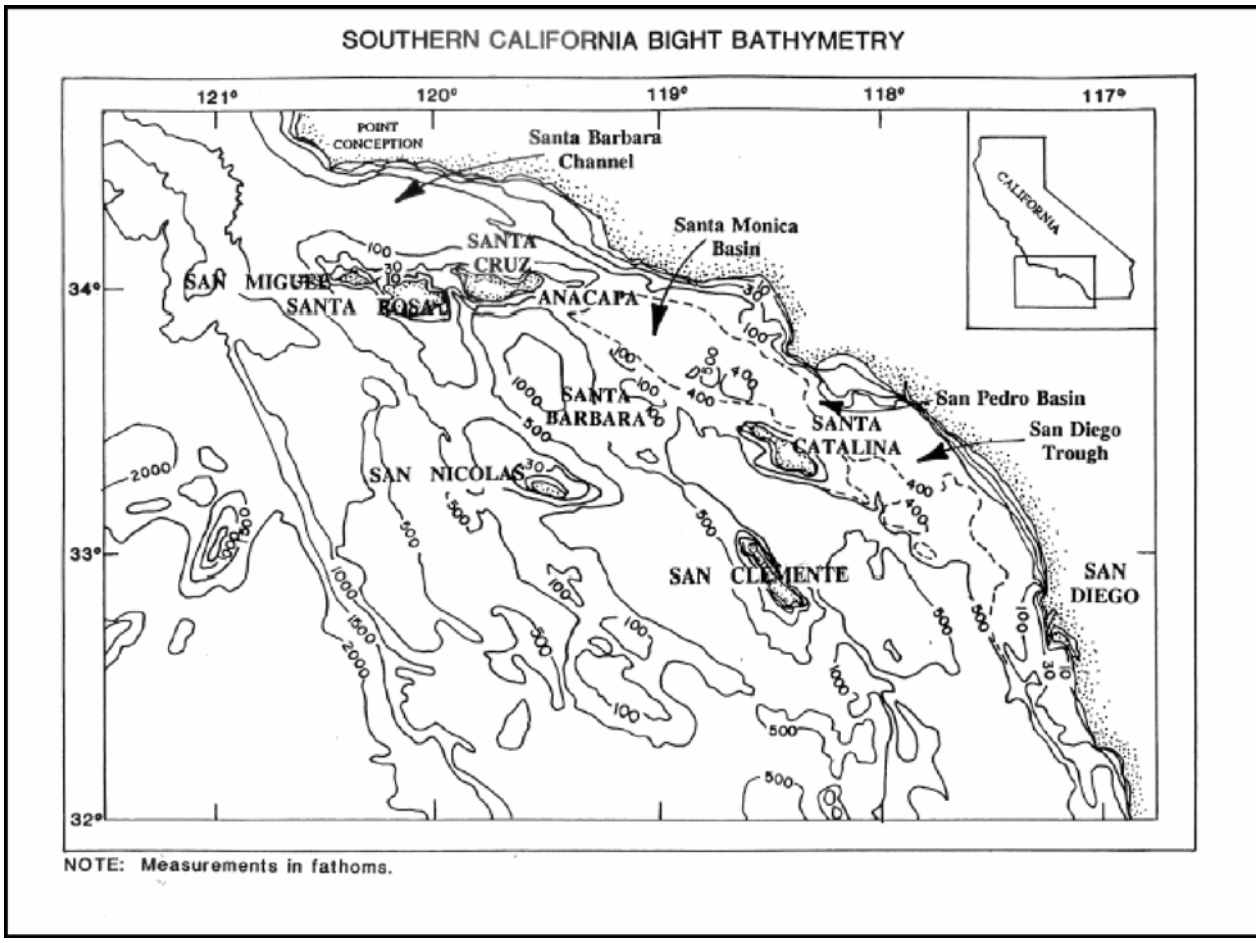

Figure 4. Landmasses and bathymetry of the Southern California Bight (from MMS 2001).

b. Circulation in the Bight

Circulation in the Bight is complex owing to its composite bottom topography. Any water flow entering the 12 basins making up the Bight at depths below 250 m must do so from the southeast along the San Diego Trough and into the Santa Monica–San Pedro basins. The Santa Monica–San Pedro basins act as a conduit for water flow into the rest of the Bight, opening up to the southeast at 737 m, to the northwest into the Santa Barbara Basin at 250 m, and to the west into the Santa Cruz Basin at 650 m. Together, the Santa Monica-San Pedro Basins are 100 km long, 40 km wide, and 900 m deep at the deepest point (Browne 1994).

The sources of ocean water in the Bight are (1) cold, low salinity, highly oxygenated sub-arctic water brought in by the California Current, and ultimately the California Counter-Current; (2) the moderate, saline, central north Pacific water advected into the Bight from the west; and (3) the warm, highly saline, low oxygen content (Equatorial) water entering the Bight from the south, principally by way of the California Undercurrent (at 300 m depth). The California Current carries subarctic water equatorward throughout the year, extends offshore to a distance of about 400 km, and to a depth of 300 m. Maximum speeds of the California Current are found at the surface with the strongest equatorward flow occurring during the spring and summer. When the California Current relaxes, poleward flows are observed nearshore within the Bight (Hickey 1979). The California Current mixes with the warm, saline, north-central Pacific water coming in from the west. South of San Diego, part of the California Current spins eastward into the Bight and then poleward forming the Countercurrent. The Countercurrent is strongest during the fall and winter, with its poleward flow reaching its maximum speeds typically within 50 km offshore of the coast. It joins the poleward California Undercurrent which is deeper and inshore of the Countercurrent.

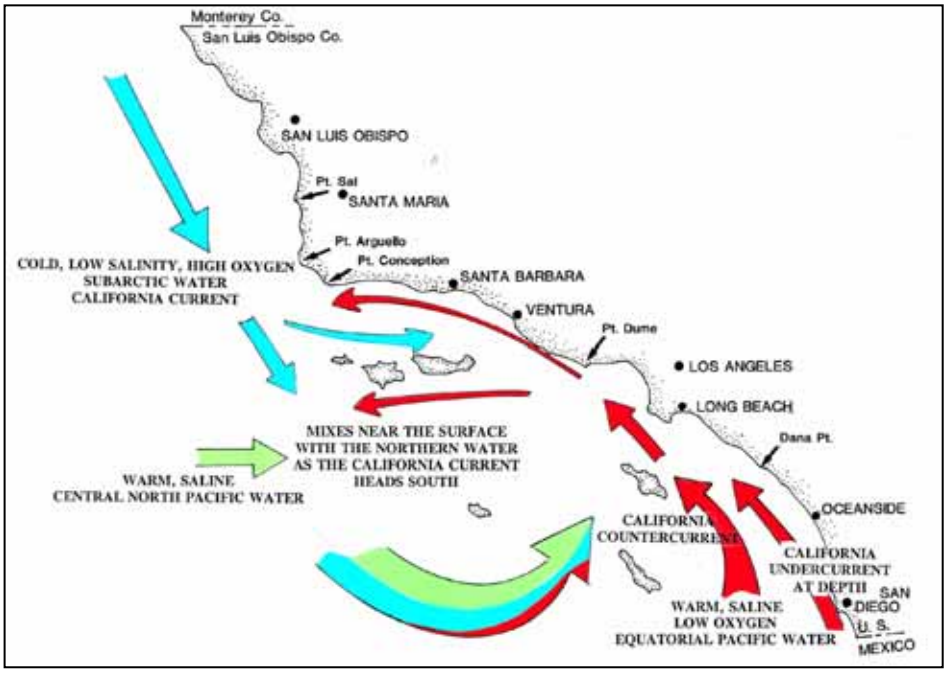

Figure 5. General circulation patterns in the Southern California Bight (Browne 1994).

c. Mean Wind Fields in the Channel

The large-scale wind field is driven by the relative strength of the North Pacific High over the subtropical Pacific Ocean (Reid et al. 1958). During fall and winter, the North Pacific High is relatively weak and the passage of mid-latitude storms dominates the wind climate. These storm systems pass over the Channel in 2-4 days and are large in size compared to the Channel. However, during the spring, strong, persistent equatorward winds occur along the U.S. west coast, continuing through the summer. These winds are called upwelling-favorable winds because their consistent southeast direction moves surface waters offshore. This gives rise to upwelling of cold, nutrient-rich, bottom water at the coast (especially at headlands such as Points Sal, Arguello and Conception), that, in turn, moves this water mass offshore in a continual cycle. At Point Conception, strong wind gradients occur as the equatorward winds detach from the coast (Winant and Dorman 1997). The Santa Ynez mountains at the northern part of the Bight shield Bight waters from this strong wind pattern, causing the winds inside the Bight to be moderate and directed east to southeast throughout the year (Figure 6). The Channel lies in the transition between strong winds to the north and sheltered waters to the south. In the eastern portion of the Channel, wind speeds are much lower, resulting in a large and persistent wind stress curl over the Channel (Dorman and Winant 2000, Oey et al. 2001).

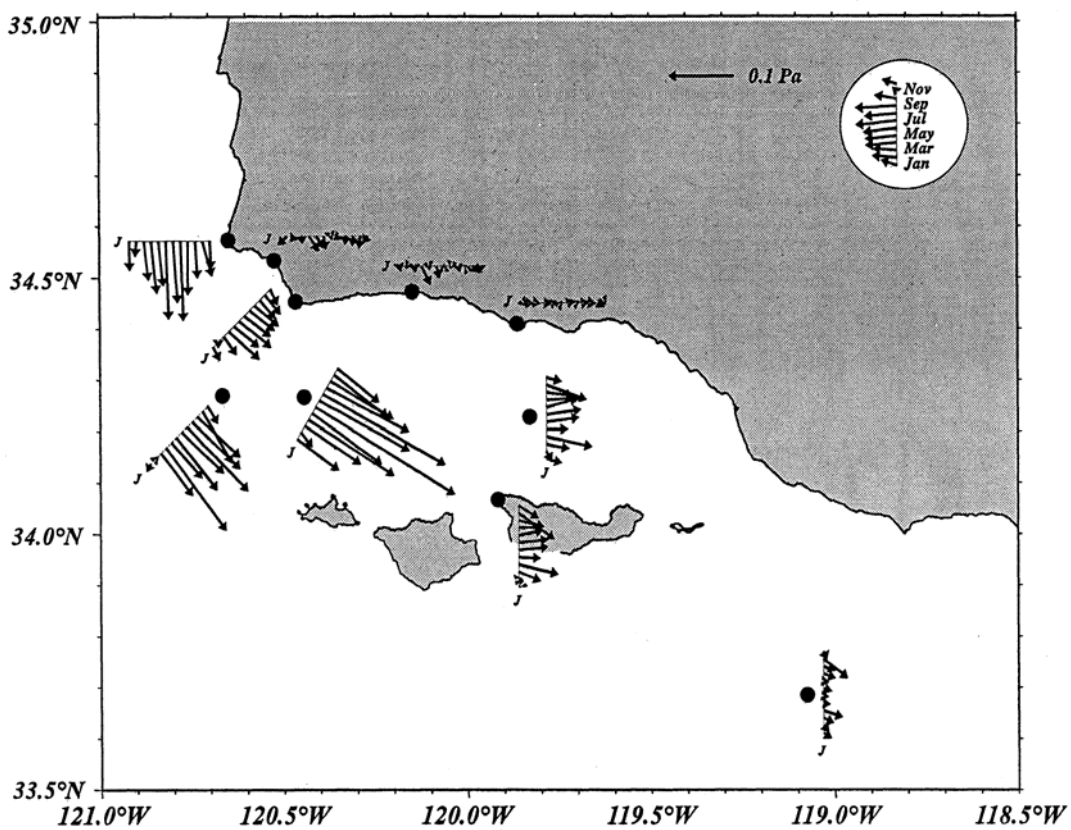

Figure 6. Seasonal cycle of wind stress in the Santa Barbara Channel region. The monthly mean time series are rotated for convenience. The direction of each arrow is the actual direction of the mean wind stress for that month. Arrows are proportional to the wind stress magnitude in pascals. Solid circles show the measurement sites. The beginning of the year is indicated by "J" (January) (Harms and Winant, 1998).

d. Circulation Patterns in the Channel

The mean flow at 5 m depth in the Channel consists of a concentrated jet flowing westward on the northern shelf and a weaker eastward return flow on the southern shelf (Figure 7). These opposing flows result in a mean cyclonic (counterclockwise) circulation concentrated in the western part of the Channel. Mean westward currents on the northern shelf strengthen between the eastern entrance of the Channel and Point Conception. West of Point Conception, mean westward currents drop sharply as the flow out of the Channel encounters equatorward flow from the California Current. The mean flow at 45 m depth is similar to the flow at 5 m with three exceptions: (1) between Port Hueneme and Point Conception, mean westward flow is continuous and uniform, (2) westward flow at 45 m appears to continue north of Points Conception and Arguello, and (3) north of San Miguel, mean 45 m currents are directed eastward rather than southeastward (Harms and Winant 1998).

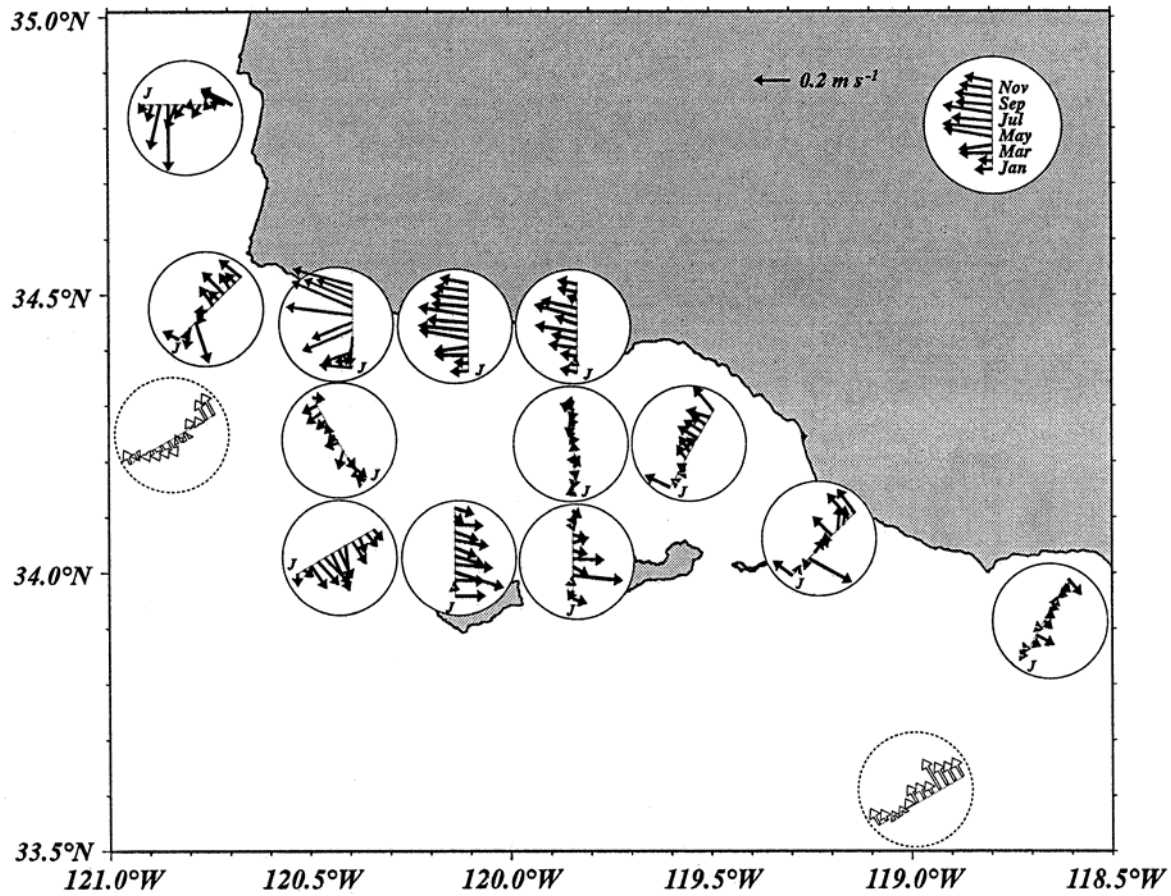

Figure 7. Seasonal cycle of 5-m currents in the Santa Barbara Channel region. The direction of each arrow is the actual direction of the mean current for that particular month. Arrows are proportional to the current magnitude in m/s. The locations of the time series correspond to buoy locations. The beginning of the year is indicated by "J". Open arrows are monthly averaged alongshelf geostrophic velocities at the surface relative to 500 dbar computed from California Cooperative Oceanographic Fisheries Investigations (CalCOFI) observations from 1949-1995 (Harms and Winant 1998).

Circulation in the Channel always tends to be cyclonic. The cyclonic flow is strongest in summer and weakest in winter. About 60% of surface current observations in the Channel can be sorted into six different states or synoptic modes: Upwelling, Relaxation, Cyclonic, Propagating Cyclones, Flood East, and Flood West (Figure 8) (Harms and Winant 1998).

Upwelling. The Upwelling state gets its name from upwelling of cold (approximately 11°C) subsurface waters near Pt. Conception which often occurs during it. The Upwelling state occurs primarily in spring, though it has also been observed in other seasons. It occurs when strong (10 m/s or more) persistent (several days or more) upwelling favorable (equatorward) winds overwhelm any poleward along-shelf pressure gradient. During the Upwelling state, strong equatorward currents occur along the southern boundary of the Channel, and west poleward flow occurs along the northern boundary.

Relaxation. The Relaxation state gets its name from the fact that it generally occurs when winds off Pt. Conception "relax" from their usual equatorward direction. The Relaxation state occurs primarily in fall and early winter. It occurs when poleward along-shelf pressure gradients overwhelm upwelling favorable or weak winds. The most characteristic feature of the resulting flow field is a strong westward flow (50 cm/s or more) along the northern shelf of the Channel, and west equatorward currents at the southwest end of the Channel.

Cyclonic and Propagating Cyclones. The Cyclonic state consists of currents with opposite directions, but similar speeds, on opposite sides of the Channel. Propagating Cyclones involves smaller cyclonic eddies which appear to slowly drift toward the west. During both the Cyclonic and Propagating Cyclones states, a cold 'squirt" (the Santa Rosa cold squirt) is frequently observed on the southeastern side of the cyclonic eddy - as colder water is drawn eastward on the southern shelf of the Channel.

In spring, the Upwelling mode is dominant at 5 m depth. In summer and fall, the 5 m circulation patterns fluctuates from the Upwelling mode, to the Cyclonic mode, to the Relaxation mode, over a period of 2-3 weeks. During these cycles, the Propagating cyclones mode is superposed on the other three, larger scales modes of circulation.

Flood East and Flood West. Flood East and Flood West are alternating states that occur during winter. During the Flood East and Flood West states, currents are in the same direction on both sides of the Channel. In this way, they contrast with the Upwelling and Relaxation states.

Free-floating drifters designed to follow the top meter in the water column were constructed and deployed in support of the Santa Barbara Channel-Santa Maria Basin Circulation Study jointly conducted by the MMS and Scripps Institute of Oceanography. Twenty-nine drifter deployments either from 12 or 24 locations in the Channel and the Santa Maria Basin were conducted from 1993 to 1999 in a manner that would allow a reasonable sampling over the four seasons. The tracks of these drifters can be sorted into categories which support the six Channel circulation modes described above (MMS 2001). Drifter tracks can be viewed at http://ccs.ucsd.edu/research/sbcsmb/drifters/.

Adding a final layer of complexity to circulation patterns in the Channel, high frequency (HF) current-measuring radar observations show that small, sub-mesoscale, anti-cyclonic eddies 4-15 km in diameter, lasting usually about two days, occur over the slope and inner shelf along the northern coast of the Channel (Bassin et al. 2005). No clear seasonal trend is apparent for the formation of

these smaller eddies. HF radars on the mainland coast at Refugio State Beach, Coal Oil Point Reserve, Summerland Sanitary District and Reliant Energy's Mandalay Bay Generation Station are used by researchers at the University of California Santa Barbara (UCSB) to monitor surface currents (to 1 m) in the Channel. Real time and daily average surface currents in the coverage area are posted on the project website (Southern Central California CODAR project, www.icess.ucsb.edu/iog/codar_realtime.htm). Extensive HF radar coverage of the California coast, and monitoring of surface currents, is anticipated in the future owing to a recently funded research multi-institution project called the Coastal Ocean Current Monitoring Project (www.cocmp.org).

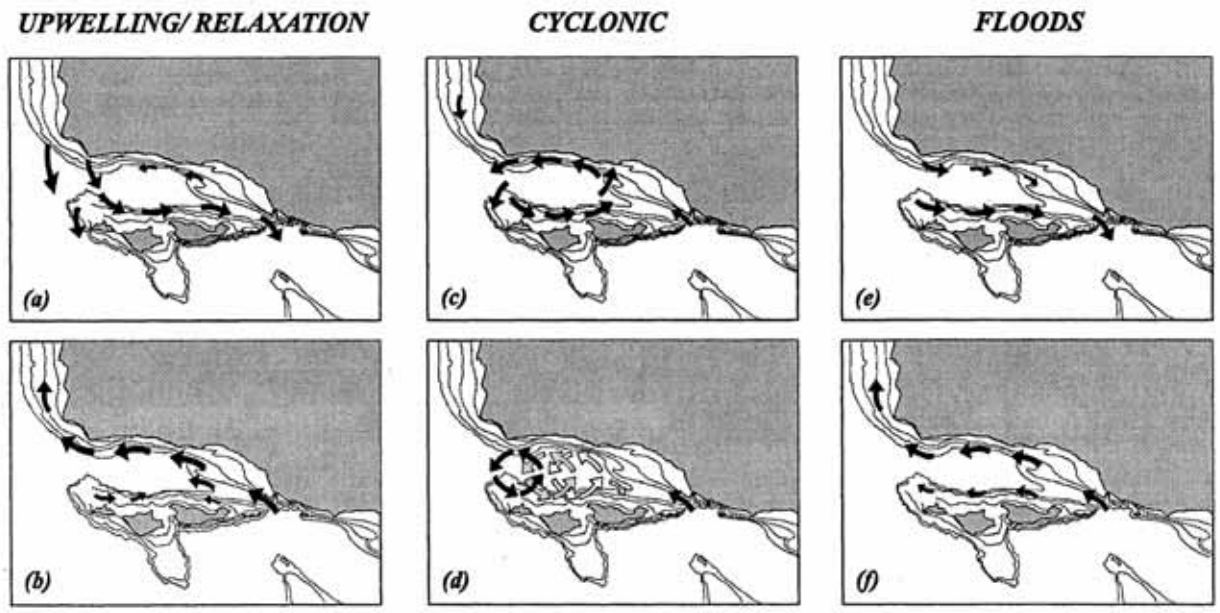

Figure 8. Diagrams of the six synoptic modes of circulation in the Santa Barbara Channel. (a) Upwelling, (b) Relaxation, (c) Cyclonic, (d) Propagating Cyclones, (e) Flood East, and (f) Flood West. (Harms and Winant 1998)

e. SST in the Channel

Figure 9 depicts average monthly SST in the region. In the spring when the upwelling favorable wind forcing is dominant, cold water is upwelled at Pts. Arguello and Conception and spreads eastward into the Channel, with the coldest water appearing along the southern Channel shelf. In the late spring and summer the currents at the eastern entrance to the Channel reverse to the poleward direction and warmer Bight water is introduced along the northern shelf of the Channel continuing to Pt. Conception. Maximum poleward flow within the Bight in summer, combined with seasonal warming, results in the warm SST values from July to October (Otero and Siegel 2004). In mid-fall along shelf temperature gradients in the Channel decrease as warmer Bight water replaces the cold waters offshore Pts. Conception and Arguello and the southern central California coast. Temperature gradients decrease further as Channel SST declines to its winter values.

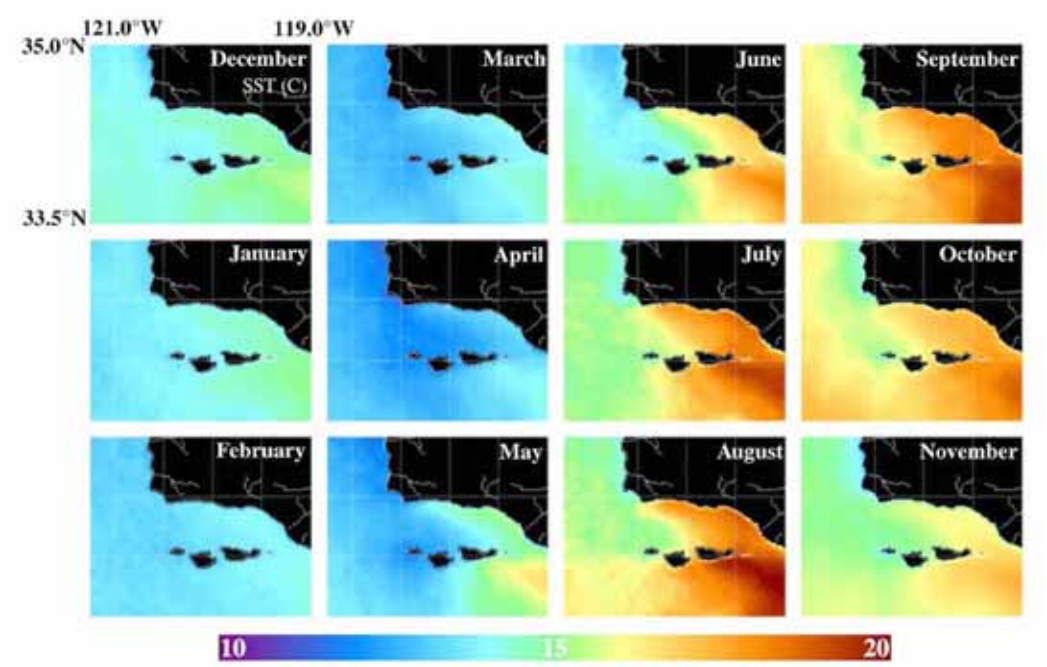

Figure 9. Monthly mean annual cycle for SST computed from AVHRR and SeaWiFS images from October 1997-June 2001 (Otero and Siegel 2004).

f. Regional Consequences of El Niño Southern Oscillation Events

El Niño Southern Oscillation Events (El Niño) events occur irregularly at intervals of 2-7 years, although the average is about once every 3-4 years. They typically last 12-18 months. A "California El Niño " is characterized by warm sea surface temperatures, a deeper surface mixed layer, a depressed thermocline, nutrient-poor water, greater poleward flow, and an anomalously high sea level (Barber and Chavez 1983; Dayton and Tegner 1984; Tegner and Dayton 1987). In the Bight, El Niños can result in little or no production of giant kelp canopies, depending upon the severity of the event. Deepened isotherms associated with El Niño result in severe nutrient limitation and very low kelp productivity. Frond growth rates can be so low during El Niños that terminal blades are formed before the frond reaches the surface (Zimmerman and Robertson 1985). Swell from El Nino-related storms can cause substantial physical damage to giant kelp.

Species more commonly found in tropical waters may migrate to, or be advected into, the Channel during El Niño events (Barry et al. 1995). For example, red crabs (*Pleuroncodes planipes*), pelagic tunicates, and fishes such as albacore, barracuda, dorado, yellowfin tuna, marlin, and triggerfish have occurred far to the north of their usual range during El Niños. In general, highly migratory species like yellowtail and some pelagic species such as barracuda and sardines thrive during warm water events, and the higher water temperatures probably enhance the reproductive success of sardines (Ugoretz 2002). The displacement of species during El Niño events is reflected in depressed commercial catches of temperate-water species such as salmon, northern anchovy, lingcod, sablefish, rockfishes, dungeness crab, market squid, and shrimp (Smith 1985).

g. Regime Shift

Multi-decadal shifts in the physical and biological processes of the Bight can lead to changes in the distribution and abundance of marine species within the Channel. The 32-year period from 1944 to 1975 was characterized by cooler than average temperatures in the Bight, except for the 1957 to 1959 El Niño years (Ugoretz 2002). In contrast, the 23-year period from 1976 to 1998 was warmer than the 78-year mean, with a few minor exceptions. This change, referred to as a regime shift, began when mean annual SST rose an average of nearly 1°C above the mean from the previous 15 years (Hollbrook et al. 1997). The warming coincided with a shift in the basic state of the atmosphere-ocean climate system of the North Pacific in the 1976-1977 winter season (Miller et al. 1994). The shift in SST was accompanied by increases in the intensity and frequency of El Niño episodes, winter storms and upwelling events, and declining nutrient availability in surface waters.

Myriad biological changes in the Channel and the Bight have accompanied the regime shift since 1977. Lowered productivity of the photic zone has coincided with a decrease in macrozooplankton abundance in the upper 200 m of the nearshore pelagic environment. Since the late 1970s, macrozooplankton volume in the California Current has declined by over 70 percent (Roemmich and McGowan 1995, McGowan et al. 1996, McGowan et al. 1998). Smith and Kaufmann (1994) show a corresponding long-term deficit in the supply of food necessary to meet the metabolic demands of the sediment community. CF&G data show decreases over this time period in landings for several categories of groundfish, California sea urchin, swordfish, selected shark species, Pacific mackerel, Pacific herring, California halibut, market squid (Ugoretz 2002). Dugan and Davis (1993) document the general decline in long-term productivity in 19 species of nearshore fishes and invertebrates in California from 1947 to 1986. A study by Love et al. (1998) of long-term trends in the Channel's commercial rockfish fishery shows a substantial decline from 1980 to 1996, with extremely low catches from 1993 to 1996. Holbrook et al. (1997) showed that the density of benthic crustaceans consumed by surfperches at Santa Cruz, and the biomass of understory algae harboring these prey, both fell by ~80% between 1982 and 1995. During the same period, the density of adult and young-of-year surfperch dropped at Santa Cruz (Holbrook et al. 1997). Tegner et al. (1997) show a two-thirds reduction in standing biomass since 1957 in southern California kelp forests. There is also evidence that the abundance of oceanic birds in the region and the Bight have declined steadily since 1988 (Veit et al. 1996, 1997). For example, the sooty shearwater, the most abundant bird in the Channel, has declined by 90 percent.

B.2. Freshwater Features

a. Rainfall and Runoff

The Park experiences a mediterranean climate with mild, wet winters and moderately warm, generally rainless summers. The majority of terrestrial runoff occurs during winter storms from December to March (Mertes et al. 1998). Approximate average annual precipitation is 8 inches on Santa Barbara, 12 inches on Anacapa, 23 inches on Santa Rosa (values for these three islands were obtained from NOAA's Western Regional Climate Center, www.wrcc.dri.edu/channel_isl, accessed 8/3/2006), and 20 inches on Santa Cruz (Junak et al. 1995).

Owing to generally steep terrain in drainages, intensity of rainfall, and thin soil cover, there is typically a very short time lag (several hours) from rainfall to runoff. A flashy precipitation regime, along with rapidly rising, rugged topography, and fractured sedimentary rocks combine to yield large sediment loads in streams in the region (Mertes et al. 1998). Interannual variability in precipitation and streamflow is high, some of which is associated with El Niño events - although a robust local relationship between El Niño and precipitation has not been found (Haston and Michaelsen 1994).

Figure 10. Topography (based on 30 m digital elevation models [DEMs]), streams, wetlands, and key features of San Miguel Island (A), Santa Rosa Island (B), and Santa Cruz Island (C). Unmapped vernal pools occur on San Miguel and Santa Rosa Islands. Many small coastal lagoons or wetlands are not depicted. DEMs were not available for Anacapa and Santa Barbara Islands. No freshwater features occur on Anacapa and Santa Barbara Islands.

Channel Islands National Park
Santa Rosa Island Topography and Land Features
B
Carrington Point
Corral Point
Northwest Anchorage
Brockway Point
Sandy Point
Bechers Bay
Southeast Anchorage
Skunk Point
East Point
Ford Point
Johnsons Lee
South Point
China Camp
Cluster Point
Pocket Field
Garanon Canyon
Tecolote Canyon
Arlington Canyon
Soledad Canyon
Dry Canyon
Verde Canyon
Cow Canyon
Lobo Canyon
Windmill Canyon
Cherry Canyon
Black Mountain (1298')
Box Canyon
Water Canyon
Quemada Canyon
Old Ranch House Canyon
Soledad (1574')
Bee Canyon
Whelstone Canyon
Acapulco Canyon
Tranquilon Canyon
Grouse (1048')
Lopez (1068')
Jara Vieja Canyon
Wreck Canyon
San Augustin Canyon
Legend
Streams
Wetlands
Santa Barbara
N
W
E
S
0
2.5
5
Miles
Data courtesy of Channel Islands National Park

Figure 10b.

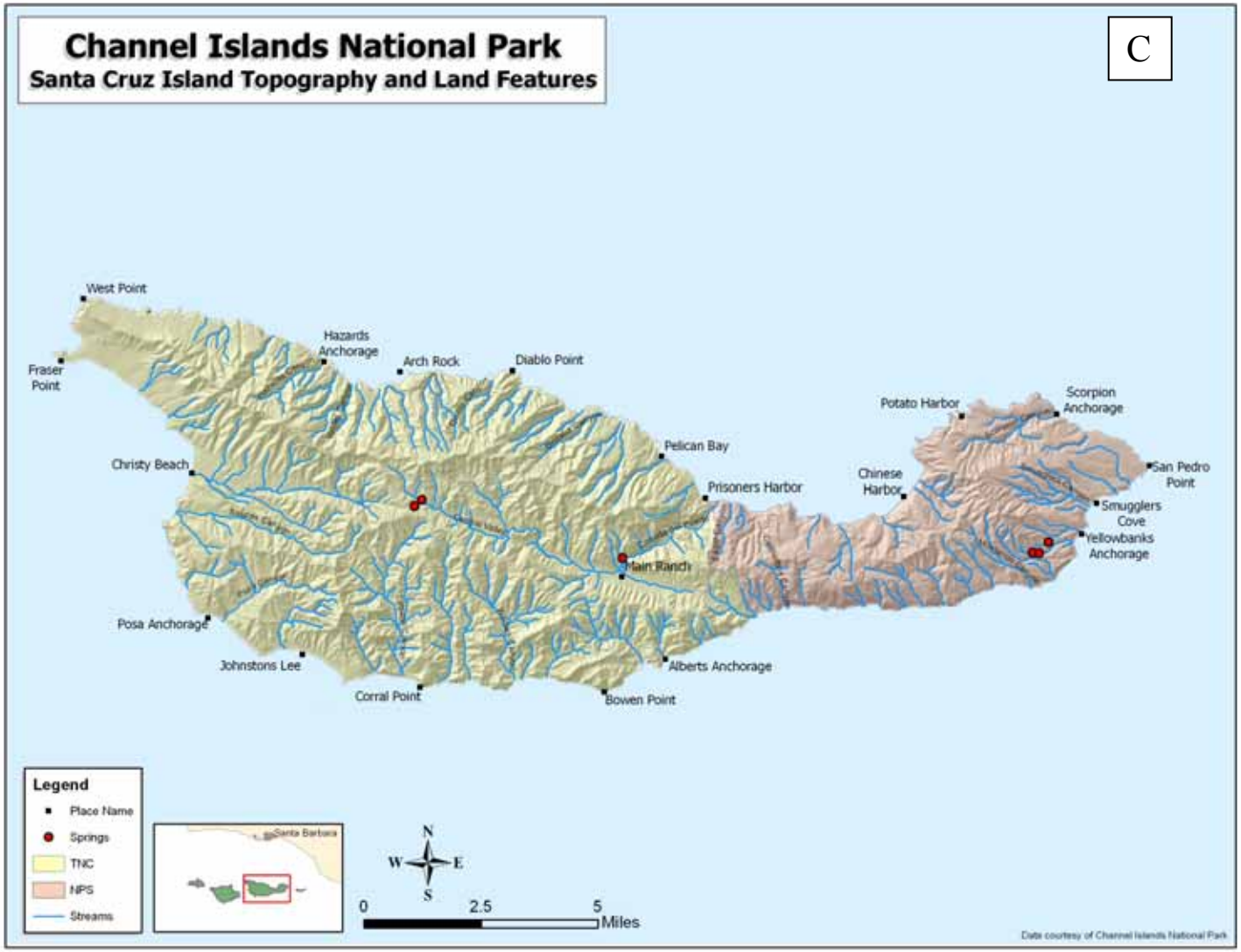
Channel Islands National Park
Santa Cruz Island Topography and Land Features
C
West Point
Fraser Point
Hazards Anchorage
Arch Rock
Diablo Point
Christy Beach
Pelican Bay
Prisoners Harbor
Potato Harbor
Scorpion Anchorage
Chinese Harbor
San Pedro Point
Smugglers Cove
Yellowbanks Anchorage
Main Ranch
Posa Anchorage
Johnstons Lee
Corral Point
Alberts Anchorage
Bowen Point
Legend
Place Name
Springs
TNC
NPS
Streams
Santa Barbara
N
W
E
S
0
2.5
5
Miles
Data courtesy of Channel Islands National Park

Figure 10c.

b. Surface Water Features

Freshwater resources in the Park include seasonal and permanent streams, riparian corridors, coastal lagoons or wetlands at the mouths of several canyons, coastal seeps, and vernal pools (Figure 10). Santa Barbara and Anacapa have no streams or other freshwater bodies. The freshwater features of other three islands in the Park are described below. The biological aspects of freshwater habitats are discussed in Section I.C.

Santa Cruz. Streams occur in numerous canyons on the island (Table 1), however none have been the subject of routine sampling or study. The largest watershed is the Central Valley, which runs east/west and drains out to the north shore at the base of the isthmus at Prisoner's Harbor. Santa Cruz watersheds are characterized by steep, highly dissected subdrainages. Most of the steep slopes show many mass slope failures that result in high erosion and sedimentation in the valleys. Most of the major watersheds have a mix of vegetation community types, with coastal sage scrub on south facing slopes, chaparral on north facing slopes on volcanic substrates, and woodland communities in the higher elevations with steeper slopes. Incised gullies are commonplace throughout the drainages (CINP 2002a).

The highly dissected drainages typically have V-shaped valley-bottoms. These drainages are highly efficient at delivering sediment. These valley-bottom types, coupled with low vegetation cover, are capable of causing “flash flood” events (such as the "Scorpion Flood", December, 1997, CINP 2002a). Most drainages have only intermittent above-ground stream flow. However, the larger watersheds have perennial flow in normal precipitation years. Even the largest watershed on the island (Central Valley) has intermittent flow, where stream flow alternates above and below ground throughout its length. Since the removal of grazers, many temporary streams are experiencing longer flow (Kate Faulkner, Chief of Natural Resources, Channel Islands National Park, pers. comm.). Junak et al. (1995) record many freshwater seeps and springs throughout the island. One of the largest springs on the island is located in Aguaje Canyon near Yellowbanks Anchorage (CINP 2002a).

Past livestock grazing, pig rooting, and extensive vegetation changes have caused localized downward trends in soil resources on the island. Gully and sheet erosion is still actively occurring throughout the island, especially within the sedimentary Monterey formations found on the isthmus and east end of the island. The El Niño winter storm events of 1997-98 caused hundreds of small and large landslides throughout the island. This was particularly noticeable in the Scorpion Canyon watershed, one of the most disturbed watersheds on the island (CINP 2002a). Owing to the fact that sheep were removed from the western 90% of Santa Cruz (the TNC-owned portion) before they were removed from eastern 10% (the NPS-owned portion), Pinter and Vestal (2005) were able to compare slope failures on both portions after the 1997-98 storms. Although sheep-grazed land comprised only 10% of the island at that time, 80% of all slope failures occurred in those areas.

Persistent wetlands occur along the lower reaches of the streams in Canada del Puerto (at Prisoner's Harbor), Scorpion Canyon (landward of Scorpion Bay), and Smuggler's Canyon (Noon 2003). The wetlands at the first two sites contain freshwater during the majority of the year. Sand and gravel bars prevent connection with the intertidal, except occasionally during wave overwash during extreme tides. Dredging and grading of stream beds and filling of wetland areas occurred during the ranching era at the Scorpion and Prisoner's wetlands (see

Section I.C.2 for more detail). Small wetlands occur at the mouths of many of the other streams on Santa Cruz. These are sometimes little more than freshwater seeps. At other times, wave overwash produces small (tens of square meters) saline lagoons at these sites. After sufficient runoff, these sites occasionally become fresh and often support cattails or pickleweed (Dan Richards, Marine Biologist, Channel Islands National Park, pers. comm.). Small, but persistent, lagoons occur at the mouths of Willows and Laguna Canyons, and at Christy Beach (Dan Richards, Marine Biologist, Channel Islands National Park, pers. comm.). Several vernal pools occur at the western end of the isthmus near China Harbor (CINP 2002a), and a temporary pond occurs near Frazer Point (Soiseth 1994).

Santa Rosa. As on Santa Cruz, streams, creeks, or washes occur in numerous canyons on the island (Table 1). The major drainages originate from a single central highland, producing long stream lengths and many fourth order stream segments (Mertes et al. 1998). Owing to efforts to characterize the impacts of cattle grazing and deer and elk on water quality and riparian zones, several streams on Santa Rosa have been monitored at intervals since 1993 (CINP 2002b). In addition, the vegetation and physical condition of the riparian corridors of several of these streams were compared before and after cattle were removed from the island (Wagner et al. 2004); more detail is contained in Sections I.C.1 and II.C.3. A small, vernal brackish wetland occurs at Oat Point (referred to as Oat Point Wetland in Park monitoring reports, and sometimes as Oak Point in other sources) that fills either with rain or wave overwash on extreme tides, but does not receive creek input and is hypersaline most of the time (Dan Richards, Marine Biologist, Channel Islands National Park, pers. comm.). Persistent coastal lagoons, or brackish wetlands, occur at the mouths of six canyons: Old Ranch, Old Ranch House, Water, La Jolla Vieja, and Arlington Canyons, and Canada Tecelote. The lagoons in the latter two canyons are brackish most of the time (except during winter runoff), have sparse aquatic vegetation, but are consistently used by ducks (Dan Richards, Marine Biologist, Channel Islands National Park, pers. comm.). Unmapped vernal pools occur in Pocket Field (at least six pools), in the west end of the island (one pool located at 33°50'33"N, 120°13'09"W, according to Soiseth, 1994), and at Skunk Point (at least four pools), between Abalone Rocks and Old Ranch House Lagoon (one pool located at 33°57'22"N, 119°58'31"W according to Soiseth, 1994), and in Water Canyon just west of a stand of Torrey Pines (one pool), in the east end of the island (Furlong 1996; Dan Richards, Marine Biologist, Channel Islands National Park, pers. comm.). During Apr. 1995, when they were first surveyed, these vernal pools ranged in depth from 10-150 cm, and in size from approximately 1500 to >3000 m^2. Pools in Pocket Field were used by cattle at that time, and had mostly mud and introduced grasses at their margins. Pools on the east end of the island were bordered by chapparal or dune vegetation, or emergent aquatic species. Macroinvertebrate species of the vernal pools are discussed in Section I.C.2.

San Miguel. Two named drainages, Nidever and Willow Canyons, occur on the island (Table 1), although Willow Canyon may not have surface water at its mouth most of the year. North Green Mountain Canyon has a seep much of the year. A dry lake bed occurs on the western part of the island, south of Otter Harbor. On occasion it floods to form a fairly large wetland, which remains unstudied (Kate Faulkner, Chief of Natural Resources, Channel Islands National Park, pers. comm.). At least one small vernal pool, containing fairy shrimp, occurs southeast of Green Mountain (located at 34°02'03"N, 120°22'37"W, Soiseth 1994). Some small coastal seeps occur along the Simonton Beach area, providing enough freshwater to support cattails and duckweed (Dan Richards, Marine Biologist, Channel Islands National Park, pers. comm.). As on Santa

Cruz and Santa Rosa, some small, unstudied coastal seeps occur at the mouths of several canyons on the island, which occasionally form small freshwater pools, or become filled with brackish water owing to wave overwash during extreme high tides.

c. Groundwater

No principal aquifers underlie the islands of the Park (Planert and Williams 1995) and groundwater from the mainland does not discharge into the Park. A search of the USGS ground water site inventory yielded no well water, test bore, or other ground water data for the Park. The Park draws from wells on Santa Cruz (at Prisoner's Harbor and Scorpion Bay), on Santa Rosa (in Windmill Canyon), and on San Miguel (in Nidever Canyon). Other than bacterial levels, water quality is not monitored at these sites (Kate Faulkner, Chief of Natural Resources, Channel Islands National Park, pers. comm.).

Table 1. Principal coastal drainages on Santa Cruz, Santa Rosa and San Miguel Islands. Many support seasonal or perennial streams. Dozens of small, unnamed drainages (probably containing dry washes) occur around the periphery of all three islands.

Island	Canyon	Additional Freshwater Feature	Sampling History[a]
Santa Cruz	Scorpion Canyon	wetland occurs on lower reach of stream	
	Little Scorpion Canyon		
	San Pedro Canyon		
	Smuggler's Canyon	wetland occurs on lower reach of stream	
	Canada del Aguaje	springs occur in watershed	
	Cardiac Canyon		
	Montanon Canyon		
	Ceanothus Canyon		
	Three Pork Canyon		
	Canada Pomada		
	Willows Canyon	coastal lagoon at mouth	
	Horqueta Canyon		
	Alamos Canyon		
	Laguna Canyon	coastal lagoon at mouth	
	Canada de Malva Real		
	Johnston Canyon		
	Posa Canyon		
	Alegria Canyon		
	Canada de los Sauces		
	Canada Christy	coastal lagoon at mouth	
	Black Point Canyon		
	Red Rock Canyon		
	Rancho Nuevo Canyon		
	Canada del Agua Santa		

Island	Canyon	Additional Freshwater Feature	Sampling History[a]
	Painted Cave Canyon		
	Hazard Canyon		
	Valdez Canyon		
	Little Valdez Canyon		
	Diablo Canyon		
	Orizaba Canyon		
	Canada del Puerto - drains the large Central Valley	wetland at mouth at Prisoner's Harbor	
	Eagle Canyon		
	Canada del Agua		
	Canada de la Calera		
Santa Rosa	Canada Garanon		
	Canada Tecelotito		
	Canada Tecelote	small coastal lagoon or wetland at mouth	2005
	Arlington Canyon	small coastal lagoon or wetland at mouth	2005
	Canada Soledad		
	Dry Canyon		
	Canada Verde (Trap Canyon connects upstream)		2005
	Cow Canyon		
	Lobo Canyon		1990s, 2002, 2005
	Windmill Canyon (Cherry Canyon connects upstream)		2005
	Water Canyon	small coastal lagoon or wetland at mouth	1990s, 2002, 2005
	Old Ranch Canyon (Box Canyon and Quemada Canyon connect upstream)	coastal lagoon at mouth, which is monitored	1990s, 2002, 2005 ("Quemada Canyon")
	Old Ranch House Canyon	coastal lagoon at mouth, which is monitored	
	San Augustin Canyon		
	Wreck Canyon		2005
	La Jolla Vieja Canyon	small coastal lagoon at the mouth of the canyon	2005 ("La Jolla")
	Trancion Canyon		
	Acapulco Canyon		
	Whetstone Canyon		
	Bee Canyon		
San Miguel	Nidever Canyon		
	Willow Canyon		

C. BIOLOGICAL RESOURCES

C.1. Streams and Riparian Corridors

The native island riparian vegetation can be divided into two components: herbaceous vegetation and woodland vegetation. Herbaceous riparian vegetation occurs in canyon bottoms where soil moisture is available for most of the year. The more common plant species in this community include Mexican rush (*Juncus mexicanus*), common threesquare (*Scirpus pungens*), smooth scouring rush (*Equisetum laevigatum*), sticky Baccharis (*Baccharis douglasii*), saltgrass (*Distichlis spicata*), California bulrush (*Scirpus californicus*), brown-head rush (*Juncus phaeocephalus*), California maidenhair (*Adiantum jordanii*), mule fat (*Baccharis salicifolia*), toad rush (*Juncus bufonius*), common monkey flower (*Mimulus guttatus*), rabbitsfoot grass (*Polypogon monspeliensis*), and cattail (*Typha domingensis*). Water bent grass (*Agrostis viridis*) and Australian brass buttons (*Cotula australis*) are non-native herbaceous species that occur in many of the riparian corridors. Woody vegetation native to the riparian corridors in the Park includes arroyo willow (*Salix lasiolepis*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), Mexican elderberry (*Sambucus mexicana*), and coast live oak (*Quercus agrifolia*).

Riparian woodland can be found along some permanent streams on the islands. On Santa Cruz, this habitat is found especially on the north side between Cueva Valdez and Canada del Agua at the western end of the isthmus. Although heavily disturbed, Canada del Agua contains native riparian woodland species such as big-leaf maple (*Acer macrophyllum*), stream orchid (*Epipactus gigantea*), and California bulrush (*Scirpus californicus*) (CINP 2002a). On the south side of Santa Cruz, riparian woodlands are found in Alamos Canyon and in the Coches Prietos drainage. The understory of this community is comprised of species found in the herbaceous riparian community as well as honeysuckle (*Lonicera hispidula* var. *vacillans*), blackberry (*Rubus ursinus*), and giant chain fern (*Woodwardia fimbriata*) in the wetter drainages. Stands of introduced *Eucalyptus* trees along some riparian corridors on Santa Cruz (such as in Scorpion Canyon, the Central Valley, and near Prisoner's Harbor) may have reduced flow in some streams, compared to pre-settlement conditions (Noon 2003).

Riparian corridors in the Park were substantially altered during decades of sheep and cattle grazing, and through the ongoing activities of feral pigs (Santa Cruz), and introduced elk and deer (Santa Rosa). On Santa Rosa, cattle grazing on uplands and extensive use of streams by cattle, elk and deer transformed streams into sediment-choked, braided channels with unvegetated banks (Wagner et al. 2004). The native woody species and perennial herbaceous riparian wetland species - that would ordinarily stabilize the banks, shade the streams, trap the sediment accompanying winter runoff, and dissipate the energy of storm flows - were practically eliminated. Natural riparian vegetation was relegated to portions of canyons too steep for livestock, elk or deer.

Cattle were removed from Santa Rosa in 1998. Following cattle removal in 1998, there has been a substantial recovery of the riparian corridors on Santa Rosa, which was documented in a pre-removal (1995) and post-removal (2004) study of ten reference stream reaches on the island (Wagner et al. 2004). The result of cattle removal has been a transition from the stream conditions described above toward streams with narrower, deeper, meandering channels with well developed floodplains and point bar development (Wagner et al. 2004). Water quality has improved in the streams (see Section II.C). Although the return of native perennial herbaceous species is widespread, the reestablishment of woody species (especially arroyo willow and black

cottonwoods) is still hindered by browsing by deer and elk, and a postulated lack of seed sources. Cottonwood and willow seeds are short-lived (~1-2 weeks) and do not enter the seedbank. The paucity of willow and cottonwood stands on the islands after decades of grazing may necessitate the cultivation and transplantation of cuttings in order to facilitate reestablishment of these species (Wagner et al. 2004).

Feral sheep and pigs caused dramatic landscape alteration on Santa Cruz. In many areas of Santa Cruz the native riparian plant species have been locally extirpated and non-native plants and grasses occupy the riparian zone (CINP 2002a). Sheep were removed from TNC's portion of Santa Cruz in the 1980s and from NPS's portion of the island in 1999. Following the removal of feral sheep, there has been a substantial recovery of native upland vegetation on Santa Cruz (CINP 2002a).

Feral pigs are found in all locations and habitat types on Santa Cruz (Schuyler 1988). They favor oak woodland throughout the year, but especially during the fall when the acorn crop is available. Pig utilization of chaparral and grassland increases in winter and spring when grasses and forbs emerge. Coastal areas are the least utilized, year-round. Ridge tops and higher slopes are utilized primarily during the wetter, cooler months. During the dry months pigs are typically found in canyon bottoms or on middle or lower slopes, and are most likely to directly affect riparian corridors at that time. Extensive rooting by feral pigs has facilitated invasion of aggressive non-native weeds (notably fennel), and purportedly accelerated soil erosion and sediment transport into streams (CINP 2002a). A program to eradicate feral pigs did not begin on the island until 2005, and was still in progress as of this writing.

The amphibians in the Park are the black-bellied slender salamander (*Batrachoseps nigriventris*), the Pacific slender salamander (*Batrachoseps pacificus*), the Channel Islands slender salamander (*B. pacificus pacificus*), the Pacific treefrog (*Hyla regilla*), and the red-legged frog (*Rana aurora*). The Channel Islands slender salamander is endemic to the Channel Islands and is a Federal Species of Special Concern. Little appears to be known about the within-stream biota of Park streams. Some stream invertebrate sampling on Santa Cruz comprised part of a biogeographical study in the early 1980s, but the authors did not publish a taxon list for Santa Cruz (Pereira et al. 1982). The invertebrate fauna of Park streams has not been monitored. Water quality information for streams on Santa Rosa is presented in Section II.C.

C.2. Vernal Pools

Vernal pools are scattered on Santa Cruz and, more specifically, at the western end of the isthmus near China Harbor. It is presumed that these vernal pools once supported an assemblage of native flora but because of the intensive grazing history of the islands, most of the plant species that occur within these pools are weedy nonnatives. Non-native species identified by Junak et al. (1995) occurring in the vernal ponds near China Harbor include: Australian saltbush (*Atriplex semibaccata*), bindweed (*Convolvulus arvensis*), short-podded mustard (*Hirschfeldia incana*), common plantain (*Plantago major*), curly dock (*Rumex cripus*), common sow thistle (*Sonchus oleraceus*), and annual exotic grasses (CINP 2002a). At least twelve vernal pools occur on Santa Rosa (see Section I.B.2.b). When they were studied in April 1995, about half of the pools, on the west end of the island in Pocket Field, were being used by cattle and were bordered mostly by introduced grasses and mud (Furlong 1996). Pools that were less affected, or unaffected, by cattle at that time were bordered by chapparal or dune vegetation and emergent

aquatic plants. The macroinvertebrate fauna (> 500 nm) of the Santa Rosa vernal pools is summarized in Table 2. Insect taxa were more diverse in the pools which were unused by cattle at that time, although microcrustacean diversity was similar in both categories of pools. Fairy shrimp (*Branchinecta lindahli*), the only obligate vernal pool species encountered, were observed in ponds on Santa Rosa (Furlong 1996, Soiseth 1994) and in a pond near Fraser Point on Santa Cruz (Soiseth 1994). Unidentified anostracans were collected from the vernal pool near Green Mountain on San Miguel (Soiseth 1994). Tadpoles were encountered in the vernal pools by Furlong (1996), but not identified to species.

Table 2. Macroinvertebrate fauna observed in a survey of 12 vernal pools on Santa Rosa Island in April, 1995. Adapted from Furlong (1996).

Class	Order	Genus or species
Crustacea	Anostraca	*Branchinecta lindahli*
	Copepoda	*Diaptomus franciscanus*
	Cladocera	*Daphnia magna*
		Moina
	Ostracoda	*Cypris*
		Cyprinotus
Insecta	Ephemeroptera	*Callibaetis*
	Odonata	*Sympetrum corruptum*
	Hemiptera	*Cenocorixa blaisdelli*
		Cenocorixa
		Corisella inscripta.
		Corisella sp.
		Trichocorixa
		Notonecta kirbyi
	Coleoptera	*Agabinus*
		Deronectes striatellus
		Hydroporus
		Hygrotus lutescens
		Laccophilus
		Liodessus
		Rhantus
		Berosus
		Enochrus hamiltoni pacifica
		Tropistemus
		Emplenote pacifica
		Narpus
	Diptera	*Culex*
		Culiseta
		Procladius
		Cricotopus
		Chironomus
		Orthocladium
		Microtendipes
		Corynoneura
		Tanytarsus
		Dolichopidid larva
		Eristalis

C.3. Coastal Wetlands and Lagoons

Small wetlands or marshes occur at the mouths or lower reaches of streams in several canyons on Santa Cruz including at Prisoner's Harbor, Scorpion Bay, and Smuggler's Cove (Noon 2003) and, according to CINP (2002a), at Canada de los Sauces and Canada de Malva Real. During the majority of the year, sand and gravel bars prevent intertidal exchange at the Prisoner's Harbor and Scorpion Bay wetlands (Noon 2003, Noon et al. 2005). Native plant species that can be found at one or more of the wetlands include California bulrush, cattail, arroyo willow, sticky Baccharis, mule fat (*Baccharis salicifolia*), alkali heath (*Suaeda taxifolia*), California saltbush

(*Atriplex californica*), Coulter's saltbush (*A. coulteri*), Brewer's saltbush (*A. lentiformis*), sandspurry (*Spergularia macrotheca*, and *S. marina*), saltgrass, rabbitsfoot grass, sour clover (*Melilotus indica*), alkali weed (*Cressa truxillensis*), alkali heath (*Frankenia salina*), and sea-blite (*Suaeda taxifolia*). Non-native plant species that occur at one or more of the wetlands include Australian saltbush, brassbuttons (*Cotula coronopifolia*), kikuyu grass (*Pennisetum clandestinum*), sicklegrass (*Parapholis incurva*), sea rocket (*Cakile maritima*), loosestrife (*Lythrum hysopifolium*), curly dock, yerba manse (*Anemopsis california*), weedy cudweed (*Gnaphalium luteo-album*), English plantain (*Plantago lanceolata*), goosefoot (*Chenopodium murale*), Boccone's sandspurry (*Spergularia bocconii*), and foxtail barley (*Hordeum murinum*) (CINP 2002a, Noon 2003). *Eucalyptus*, olive (*Olea europaea*) and tree tobacco (*Nicotiana glauca*) are non-native species that either dominate (in the case of *Eucalyptus*) or are rapidly colonizing the riparian floodplain terraces along several lower stream reaches (Noon 2003).

The ranching era resulted in substantial alterations of the wetlands on Santa Cruz. Some of them were extensively used by feral sheep. Since the removal of the sheep, vegetative cover, duration of flooding, and the depth of standing water has increased dramatically, especially in the estuaries on the south side of the island (Junak et al. 1995). Over the last 100 years, dredging has occurred in the lower reach of Scorpion Creek confining flow to a 35-foot wide, 800-foot long channel (Noon 2003). Much of the original floodplain and estuary has filled with sediment, or was graded by previous settlers. Currently, vehicles are driven across the floodplain to a storage area for a concessionaire's kayaks. In Smuggler's Creek, Park staff stabilized 75 feet of the north side of the channel in order to protect an archeological site. Dredging and filling of the wetland at Prisoner's Harbor also took place during the last 100 years, resulting in a 1,500 foot long, 40-foot wide channel bordered by berms. At this site, historic photographs indicate that gravel and sand fill were used to create a complex of corrals (which remain). Fill apparently came from both the dredged stream and nearby hillsides (Noon 2005). There is debate about whether this activity destroyed a small estuary at the site, or decreased the size of the palustrine wetland that occurs there now (Young 2004). The feasibility of restoring pre-settlement wetland geomorphology at these sites on Santa Cruz was recently investigated by Park personnel, and described in a series of reports (Noon 2003, 2005; Young 2004). In anticipation of a restoration project at Prisoner's Harbor, a series of 18 shallow ground water monitoring wells were installed in July 2005 in the lower floodplain of Canada del Puerto Creek, and soil and fill characteristics were described (Noon 2005).

Small wetland areas occur at the mouths of other streams on Santa Cruz and Santa Rosa Islands. As indicated in Section I.B., the status of these sites can alternate from freshwater seeps; to impounded winter runoff with palustrine vegetation; to small, brackish or saline lagoons produced by wave overwash. Small, but persistent, lagoons occur at three sites on Santa Cruz (at the mouths of Willows and Laguna Canyons, and at Christy Beach), and at six sites on Santa Rosa (at the mouths of Old Ranch, Old Ranch House, Water, El Jolla Vieja, and Arlington Canyons and Canada Tecelote). Lagoons on Santa Rosa are usually separated from the ocean by a sandy berm, and water levels are above sea level (Dugan and Hubbard 1990). Tidal exchange is infrequent, and salinity ranges from 0-150 ppt. Halophytic vegetation common at these lagoons includes saltgrass, jaumea (*Jaumea carnosa*), alkali heath, and pickleweed (*Salicornia virginica*). Wigeongrass (*Ruppia maritima*) can occupy up to 60% of some lagoon sites on Santa Rosa in the spring (Dugan and Hubbard 1990). Silver burr ragweed (*Ambrosia chamissonis*) can occur on the sand spit at Old Ranch House Canyon Lagoon (Cole and Liu 1994).

Water boatman (*Trichocorixa reticulata*) is the most common and ubiquitous macrofauna species inhabiting lagoons on Santa Rosa (Dugan and Hubbard 1990). Brine flies (*Ephydra packardii*) are abundant in the lagoons seasonally. Other fly larvae, such as ceratopogononid, chironomid, and chloropid larvae, *Coelopa vanuzei*, *Brachysia* sp. *Nemotelus* sp., *Tabanus*, and *Limonia marmora* are less frequently encountered (Dugan and Hubbard 1990, Richards 2004). Tiger beetles (*Cicindela hemorrhagica*, *C. hirticolis*, *C. roseiventris*) are common. Less frequent beetles include *Dyschirius marinus*, *Hydaticus* sp., *Oreodytes* sp., *Thinusa maritima*. The tube building polychaete (*Polydora cornuta*) can be abundant on the berm separating Old Ranch House Canyon lagoon from the beach. Topsmelt (*Atherinops affinis*) invades Old Ranch House Canyon lagoon during wash overwash in the spring, and can survive long enough to reproduce. The arrow goby (*Clevelandia ios*) also occurs in this lagoon.

The highest numbers of shorebird and waterfowl species are observed in the lagoons in September during migration. Least sandpipers, great blue herons, western sandpipers, killdeer, long-billed dowitchers, greater yellowlegs, and song sparrows were most frequently observed at lagoons (Table 3). American widgeon and northern pintail may overwinter at the lagoons. Ducks utilize the lagoons in winter months, and mallard ducks have been nesting in several of the lagoons in recent years. Snowy plovers breed in the lagoon areas and surrounding beaches on Santa Rosa during April-June (Dugan and Hubbard 1990). California brown pelicans sometimes feed in lagoons on Santa Rosa, and osprey and peregrine falcons are attracted to the areas (Dugan and Hubbard 1990).

Long-term monitoring of beaches and lagoons on Santa Rosa began in 1994 (Dugan et al. 1990). The lagoon habitats at the eastern end of Santa Rosa (Old Ranch Canyon Lagoon, Old Ranch House Canyon Lagoon, and Oat Point wetland) are surveyed annually for depth, transparency, salinity, and temperature (see Section II.C.6).

Table 3. Bird inventory for Old Ranch, Old Ranch House lagoons and Oat Point Wetland during 1988/89 survey by Dugan and Hubbard (1990)

Table . List of bird species observed at the three coastal lagoons during the study.

Species	Number of days sighted
Pied-billed Grebe	1
Brown Pelican	3
Brandt's Cormorant	3
Great Blue Heron	20
Black-crowned Night Heron (KD)	1?
Brant(DF)	1?
Mallard	2
Green-winged Teal	3
American Widgeon	11
Northern Pintail	6
Blue-winged Teal	3
Cinnamon Teal	2
Ruddy Duck	6
Surf Scoter	3
American Coot	14
Snowy Plover	12
Semipalmated Plover	10
Killdeer	25
Black-bellied Plover	5
Marbled Godwit	1
Whimbrel	1
Willet	4
Greater Yellowlegs	20
Wilson's Phalarope	3
Red-necked Phalarope	10
Red Phalarope	1
Long-billed Dowitcher	17
Common Snipe	1
Ruddy Turnstone	2
Dunlin	2
Western Sandpiper	18
Least Sandpiper	29
Baird's Sandpiper	5
Pectoral Sandpiper	4
Mew Gull	2
California Gull	1
Western Gull	10
Peregrine Falcon	2
Osprey	2
Red-tailed Hawk	2
American Kestrel	1
Mourning Dove	1
Black Phoebe	5
Say's Phoebe	2
Barn Swallow	13
Common Raven	8
Water Pipet	1
Chipping Sparrow	1
Song Sparrow	28+
Brewer's Blackbird	1

C.4. Sandy Beaches

Sandy beaches are a major component of the intertidal region of the northern Channel Islands. Sandy beaches dominate portions of Santa Cruz, Santa Rosa and San Miguel's shorelines. On Santa Rosa, sandy beaches make up approximately 30 km of shoreline, encompassing a wide variety of exposures and beach types. Approximately 20% of the shoreline of the California Channel Islands are sandy beach, in comparison to 80% of the shoreline of the southern California mainland coast (Richards 2004).

Macrophyte debris, primarily algal wrack, serves as a major source of energy for the beach communities. High depositional beaches, such as Sandy Point and Soledad West on Santa Rosa, face northwest into the prevailing winds and swell. Consequently, they receive large quantities of marine debris, carcasses, and macrophyte wrack, primarily *Macrocystis pyrifera* (Richards 1994, Dugan *et al.* 1993, Lerma and Richards 2002, Richards and Rich 2004). As a result of this allochthonous input, these tend to be the most productive beaches; however, they are also the most vulnerable to an oil spill (Richards 2004). There is a direct relationship between amphipod abundance and macrophyte wrack cover (Lerma and Richards 2000, Dugan et al. 2000, Richards 2004). Macrophyte wrack cover has increased at the beaches of Santa Rosa Islands from 1994-2004 (Richards 2004).

Key invertebrate fauna on sand beaches are sand crabs (*Emerita analoga* and *Blepharipoda occidentalis*), bloodworms (*Euzonus mucronata)*, isopods (Excirolana chiltoni), beachhoppers (*Megalorchestia* spp.), purple olive snails (*Olivella biplicata*) and Pismo clams (*Tivella stultorum*). Sandy beaches provide foraging and resting habitat for a number of shorebirds including black-bellied plover, willet, whimbrel, long-billed curlew, gulls, and sanderlings. Invertebrates in wrack on the upper beaches attract black and ruddy turnstones, dowitchers, and other shorebird species. Other birds observed at the sand beaches are black oystercatchers, common ravens, killdeer, snowy plovers, song sparrows, western gulls, and western sandpipers. Gulls and ravens are most common when there are carcasses on the beach. Song sparrows and black phoebes are often seen catching flies (Richards 2004). Snowy plovers nest on some beaches on San Miguel and Santa Rosa; visitor use of these areas is restricted during the nesting season. Pinnipeds haul out on sandy beaches, and breeding occurs at sites on San Miguel and Santa Rosa.

Five beaches (Abalone Rocks, Becher's Pier, China Camp, Sandy Point, and Soledad West) on Santa Rosa are surveyed annually by Park staff (Figure 11). Methods include bird censuses, physical measurements, clam gun (cores) transects of upper beach and washzone habitats, and point contact transects to determine macrophyte wrack cover. Annual reports describing data from the intertidal monitoring program from 1994-2004 are available at: http://www.nature.nps.gov/im/units/chis/HTMLpages/AnnlReports/MarineReports.htm.

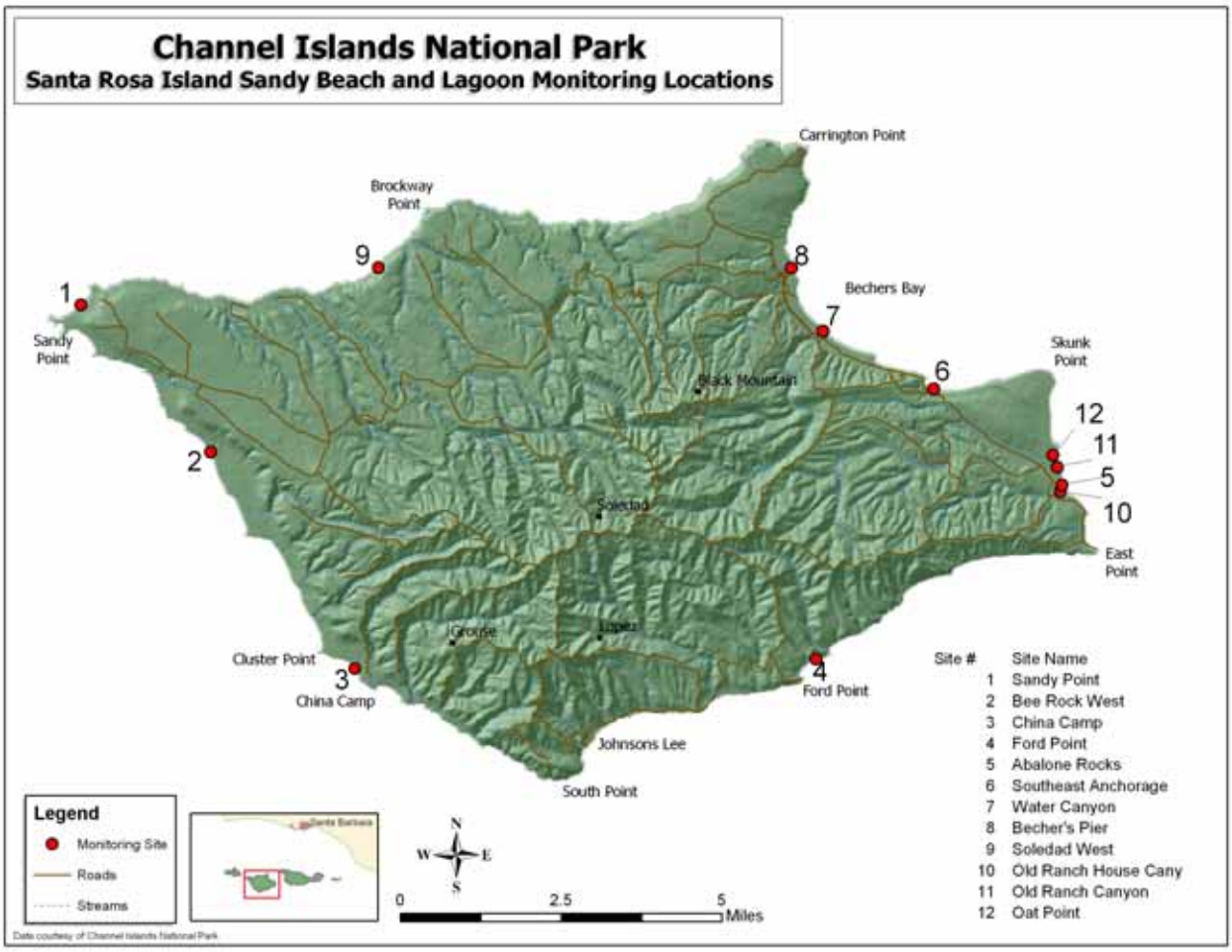

Figure 11. Sandy beach monitoring sites on Santa Rosa Island.

C.5. Intertidal Habitat[9]

The intertidal zone is the strip of shore ranging from the uppermost surfaces wetted during high tides to the lowermost areas exposed to air during low tides. The vertical extent of tidal change within the Channel Islands can be as high as 3 meters (+2.4 to -0.6 m) during full or new moon periods. On surf-swept rocky cliffs, the wave splash can extend the marine influence upward another 5 meters or more. Lower gradients can result in intertidal regions tens of meters wide. Bottom substrate in the intertidal of the Park may consist of fine muds, sand, gravel, cobble, boulders, and bedrock. Rocky shoreline exceeds sandy shoreline in the Park. On a per island basis, the percent of shoreline consisting of bedrock ranges from 74% (Santa Barbara) to 62% (Santa Rosa). The contribution of boulder beaches to island coastline ranges from 22% (Santa Barbara Islands) to 0.2% (San Miguel). San Miguel and Santa Rosa Islands have the most sandy beaches (36% and 33%, respectively) (Ugoretz 2002). Sandy intertidal habitat occurs primarily

[9] Some of the material under Intertidal Habitat, Nearshore Subtitdal Habitat, and Deeper Water and Shelves, is modified from Ugoretz (2002).

on the southern shores, except for at San Miguel and Santa Rosa, which have sandy beaches on north and south shores.

Figure 12. Rocky intertidal monitoring sites at Channel Islands National Park.

In sandy and muddy intertidal zones, infauna - such as worms, crustaceans, snails, and clams - are more important than sessile or mobile epifuana. Rocky intertidal at the Park supports surfgrass and macroscopic crusts and turfs of green, brown and red algae. Sessile invertebrates include mussels, barnacles, limpets, and abalone (although the latter are less abundant now). Mobile invertebrates include snails, crabs, and sea stars. Acorn barnacles (*Chthamalus* spp.) generally dominate the upper rocky intertidal zone, and are commonly accompanied by other barnacles, such as *Balanus glandula* and *Tetraclita rubescens*. The next lower zone is dominated by a turf-like red alga (*Endocladia muricata*). The lowest zone is typified by the California mussel (*Mytilus californianus*). Only six fish are common inhabitants of the intertidal: wooly sculpin (*Clinocotus analis*), reef finspot (*Paraclinius integrippinus*), rockpool blenny (*Hypsoblennius gilberti*), spotted kelpfish (*Gibbonsi elegans*) and California clingfish (*Gobiesox rhessodon*) (Cross and Allen 1993).

Long term monitoring of rocky intertidal habitat began at the Park in 1982. Currently, the program consists of annual sampling at twenty-one permanent sampling sites (Figure 12) (Richards and Lerma 2005). Cover of dominant and target organisms are determined in fixed (50 x 75 cm) plots either in the field or from photographs. Black abalone (*Haliotis cracheroidii*) are counted and measured in fixed 1-11 m^2 plots, or in a search of a defined area of the reefs. Giant owl limpets *(Lottia gigantea)*, are measured within fixed circular plots of one-meter radius. Ochre sea stars *(Pisaster ochraceus*) are counted in a general search of the reef. Surfgrass cover, cover (*Phyllospadix* spp.) is measured in fixed point-intercept transects. Currently, motile invertebrates (small snails, chitons, limpets, etc.) are counted in the photoplots. Annual reports describing data from the intertidal monitoring program from 1982-2000 are available at: http://www.nature.nps.gov/im/units/chis/HTMLpages/AnnlReports/MarineReports.htm..

Appendix A lists common or significant marine plants and macroscopic algae found at the Park, including taxa monitored by the Park. Among these algal species, 6 species of green algae, 19 species of brown algae (including giant kelp, *Macrocystis porifera*, and feather boa kelp, *Egregia menziesii*), and 60 species of red algae are monitored at rocky intertidal sites by the Park (Richards and Lerma 2005). Appendix B lists over 130 species of marine invertebrates of particular interest or concern that occur in a variety of habitats at the Park. Among these, 4 species of anemones, 11 species of hydroids, 3 species of sponges, 4 species of polychaetes, 1 species of flat worms, 1 genus of ribbon worms, 5 species of barnacles, 8 species of crabs, 33 species of molluscs, 6 species of sea slugs, 3 species of chitons, 5 species of bivalves, and 7 species of sea star are currently monitored by the Park in the rocky intertidal (Richards and Lerma 2005). The most common shorebird that frequents the intertidal is the black oystercatcher (*Haematopus bachman).* Other shorebirds that frequent the rocky intertidal of the Park include black turnstones (*Arenaria melanosephala*), willets (*Cataptrophorus semipalmatus)*, wandering tattler (*Heteroscelus incanus)*, ruddy turnstones (*Arenaria interpres),* and western sandpipers (*Calidris mauri*), and (rarely) surf scoters (*Melanitta perspicullata*). Some sites that have headlands or reefs that extend out to sea are used as roosting areas by western gulls (*Larus occidentalis*), various cormorants (*Phalacrocorax* spp.) and California brown pelicans, (*Pelicanus occidentalis californicus*). Elephant seals (*Mirounga angustirostris*), California sea lions (*Zalophus californianus*) and harbor seals (*Phoca vitulina*) haul out on many exposed rocky benches.

Intertidal species of special concern. Black abalone and sea stars are both slow-growing, long-lived taxa with variable recruitment success. Black abalone populations in southern California suffered catastrophic declines since the mid-1980s that have resulted in nearly complete disappearance of the species along mainland shores south of Point Conception (Miller and Lawrenz-Miller 1993), as well as at many of the Channel Islands (Lafferty and Kuris 1993; Richards and Davis 1993). Commercial landings of black abalone peaked in 1973 and declined thereafter (Leet et al. 1992). Black abalone is now a candidate Federally Endangered Species. Mortality was associated with "withering syndrome", in which the foot shrinks and weakened individuals lose their grip on rock surfaces (Antonio et al. 2000; Friedman et al. 1997; Gardner et al. 1995). Overfishing also played a role in population declines. Sport and commercial black abalone fisheries have been closed since 1993. Sea star diseases, usually observed in warmer waters, have been anecdotally reported in southern California a number of times since 1978 (Dungan et al. 1982), especially during the 1982-1984 El Niño (Eckert et al. 2000). A number of sea star species, including *Pisaster ochraceus* (ochre sea stars), *P. giganteus*, and *Asterina miniata*, were struck by a wasting disease in CHIS in 1997 (Eckert et al. 2000). An urchin-

specific bacterial disease entered the Channel Islands region after 1992 and has acted since then as a density-dependent mortality source (Lafferty 2004, Behrens and Lafferty 2004).

C.6. Nearshore Subtidal Habitat

Nearshore subtidal habitats range from the lower limit of the intertidal zone down to a depth of 30 m. In the Park, nearshore subtidal substrates include mud, sand, gravel, cobble, and bedrock. Light is sufficient within this zone to support kelp, eelgrass, surfgrass, and a variety of other algae. Protected embayments and estuaries contain mostly fine particulate substrates, while outer coast shores range in composition from sand to various rock types. Though less variable than intertidal habitats, shallow-water shores are subject to dynamic physical processes, including wave exposures, along-shore currents, upwelling, temperature/salinity/nutrient differentials, and suspended sediment loads.

a. Soft Bottoms

Nearshore soft bottom habitats in the Park consist mostly of sand. Epifauna adapted to shifting sand include sea pens, sea pansies, sand crabs, moon snails, sand dollars, sand stars, bottom-dwelling sharks and rays, and flatfishes. Infauna include worms, crustaceans, snails, and clams. Many sandy habitats at Park islands have relatively steep slopes. The sand is often coarse, shelly debris because there is little sediment runoff from land and strong water currents sweep organic material away. Stable sand habitats with fine grain sediments generally are limited to sheltered coves at canyon mouths, such as those found around Santa Cruz. A few of these locations have well-developed eelgrass meadows. Many other sandy habitats consist of patches of shelly sand between rock reefs, forming mosaics of hard and soft substrata. Some low-relief rock/cobble/sand habitats in high current areas are dominated by large numbers of filter-feeding brittle stars (*Ophiothrix spiculata*) or sea cucumbers (*Pachythyone rubra*). Invertebrates from the soft bottom subtidal habitat that are harvested in commercial or sport fisheries are geoduck (*Panopea abrupta*), warty sea cucumber (*Parastichopus parvimensis*), and the yellow rock crab (*Cancer anthonyi*).

b. Eelgrass beds

Eelgrass (*Zostera* spp.) has been found at 10 locations around the Northern Channel Islands at depths of 3 to 15 meters (Engle et al. 1998). The *Zostera* sites occur on both north and south sides of the islands in coves sheltered from west and northwest swells. The largest beds (approximately 3 to 12 ha) occur at Smugglers Cove, Canada del Agua, and Prisoners Harbor on Santa Cruz and at Bechers Bay on Santa Rosa. Moderately sized beds (approximately 0.3 to 0.7 ha) are found at Scorpion and Forney Coves on Santa Cruz and at Johnsons Lee on Santa Rosa. A few small patches of eelgrass exist at Cathedral Cove and Cat Rock on Anacapa and at Yellowbanks Anchorage on Santa Cruz. Feeding "fronts" of white urchins, which prefer soft substrates, are believed to have eliminated eelgrass beds on the north side of Anacapa (Engle 1994). The single patch at Cathedral Cove is the only known remnant of widespread beds once scattered there (Ugoretz 2002).

A total of 278 species (and higher taxa) have been identified from eelgrass beds in the Park (number excludes most infauna, species requiring laboratory identification, or minute species, J. Engle and others, unpublished data). The diversity of conspicuous plant, invertebrate, and fish epibiota has been found to be nearly twice as high within eelgrass beds (approximately 150

species) as on surrounding sand habitats (approximately 80 species). Important invertebrates include sea anemones, worms, crabs, snails, clams, and seastars. Some species are obligate dependents on *Zostera*. In the Channel Islands a brown alga (*Punctaria occidentalis*), a flatworm, (Phylloplana viridis), the sea hare (*Phyllaplysia taylori*), and a limpet (*Tectura depicta*), are epiphytes unique to *Zostera*. The red algae, *Smithora naidum* and *Melobesia mediocris*, also occur on eelgrass and surfgrass (*Phyllospadix spp*.). The isopod, *Idotea resecata*, pipefish (*Syngnathus sp.*) and giant kelpfish (*Heterostichus rostratus*), are closely associated with eelgrass, often appearing grass green in color. *Zostera* meadows are nursery habitats for a variety of fishes, including bottom-dwellers (e.g., flatfishes and gobies) and epibenthic swimmers (e.g., clinids, seaperches, and basses). Eelgrass beds at the Channel Islands are habitat for juvenile fishes, especially giant kelp fish, surf perches, senoritas, olive rockfish, and kelp bass (J. Engle, unpublished data). Eelgrass habitats are vulnerable to oil spills, but the impacts are not well understood. Unlike slime-producing algae that can slough off oil, eelgrass has non-mucilaginous leaves to which oil quickly adheres (Ugoretz 2002).

c. Subtidal Rocky Reefs

High-relief subtidal volcanic reefs with walls, ledges, caves and pinnacles are widespread in the Park. Low-relief sedimentary reefs exist as well, particularly on Santa Rosa. The distribution of subtidal reefs at the Park is less well known than the distribution of the rocky intertidal reefs. However, nearshore reefs are often found offshore from the rocky intertidal habitat. Kelp beds generally are good indicators of subtidal reefs (except for beds of the *Macrocystis angustifolia* form that occur on sand). Numerous green, brown, and red algae occur, as well as surfgrass. Algal forms included are crusts, turfs, large blades, stalked plants (palm kelp), or kelp forest (giant kelp). Boring clams and sea urchins create holes and depressions in reefs comprised of softer sedimentary rock. Other common reef fauna are worms, crustaceans, molluscs, brittle stars, and fishes. Deeper current-swept reefs with less light have well developed attached suspension-feeding invertebrate cover, including sponges, sea anemones, sea fans, plume worms, bryozoans, and tunicates.

Invertebrates from subtidal reefs that are now, or were historically, harvested in commercial or sport fisheries are California hydrocoral (*Stylaster californicus*), brown rock crab (*Cancer antennarius*), red rock crab (*Cancer productus*), green, pink, red and white abalone (*Haliotus fulgens*, *H. corrugata*, *H. rufescens*, and *H. sorensen*, respectively), rock scallops (*Crassedoma giganteum*), red urchins (*Strongylocentrotus franciscans*), purple urchins (*Strongylocentrotus purpuratus*), spiny lobster (*Panulirus interruptus*). White abalone was declared an endangered species under the Federal Endangered Species Act in 2000. Owing to its persistent purple color, California hydrocoral used to be harvested for sale in shell shops, however the fishery is currently closed. In the Park, it is known from only a few deep reefs at Santa Barbara, Santa Cruz and San Miguel (J. Engle, unpublished data). Commercial divers harvest red urchins using hookah gear and rakes down to 33 m. Harvestable sizes of red urchins declined in the Park between 1985-1995 (decreasing from 15% to 7% of the total population at survey sites, Leet et al. 2001). Coincident with the decline of red urchins, purple urchins have increased markedly in number at many sites in the Park creating vast areas denuded of macroalgae, or "urchin barrens" (see *kelp forest* below) (Harold and Reed 1985, Ambrose et al. 1993, Engle 1994, Richards et al. 1997, Carroll et al. 2000, Lafferty and Kushner 2000). However, a poorly understood type of wasting disease was first noticed in subtidal populations of purple sea urchins in 1992 (Richards and Kushner 1994). A trophic cascade (commercial harvest of lobster -» release of predation

pressure on urchins by lobster -» increases in urchin size and density -» density dependent mortality from disease) is postulated as the cause of epidemics affecting purple sea urchins in the Park (Lafferty 2004) and why rocky reefs inside fishing refugia are more likely to support kelp forest than reefs in fished areas (Behrens and Lafferty 2004). Only a small commercial harvest of purple urchin comes from the Channel Islands (Ugoretz 2002). The Channel Islands are a primary harvest location for the regional commercial rock crab trap fishery.

Nearshore reef fish. About 30 percent of the species and 40 percent of fish families in the Bight occupy hard substrate habitat (Cross and Allen 1993). The composition of reef fish assemblages is influenced by the physical characteristics of the reef (Ebeling et al. 1980a,b; Larson and DeMartini 1984), and by water temperatures (Stephens and Zerba 1981; Stephens et al. 1984). Shelter-seeking species such as blacksmith (*Chromis punctipinnis*), garibaldi (*Hypsopops rubicundus*), grass rockfish, (*Sebastes rastrelliger*) brown rockfish (*Sebastes auriculatus*) and gopher rockfish (*Sebastes carnatus*) are abundant on high-relief reefs, but they are rare or absent on low-relief reefs (Larson and DeMartini 1984).

Surfgrass (*Phyllospadix spp.*) Surfgrass attaches by short roots to rock on surf-swept shores from the low intertidal zone to depths of 10 to 15 m. Surfgrass beds are highly productive ecosystems, providing structurally complex microhabitats for a rich variety of epiphytes, epibenthos, and infaunal species. For example, Stewart and Myers (1980) identified 71 species of algae and 90 species of invertebrates associated with surfgrass habitats in San Diego. Some organisms, such as the red algae *Smithora naiadum* and *Melobesia mediocris*, are exclusive epiphytes on surfgrass (or eelgrass) (Abbott and Hollenberg 1976). Also, *Phyllospadix spp.* beds provide nursery habitat for various fishes and invertebrates, including the California spiny lobster (*Panulirus interruptus*). Spiny lobster juveniles shelter in the thicket of leaves and forage on a variety of tiny snails and clams.

Surfgrass beds are persistent (Turner 1985) and can preempt space from other plants, including boa kelp (Black 1974) and sargassum weed (Deysher and Norton 1982). Surfgrass cannot tolerate much heat or drying; the leaves will bleach quickly when midday low tides occur during hot, calm-water periods. Surfgrass can be particularly sensitive to sewage discharge (Littler and Murray 1975) and oil pollution (Foster et al. 1988). Recovery can be relatively rapid if the rhizome systems remain functional, but it might take many years if entire beds are lost because recruitment is irregular and must be facilitated by the presence of perennial turf algae to which surf grass seeds attach (Turner 1983, 1985). Transplant projects undertaken to speed recovery of *Phyllospadix spp.* beds destroyed by shoreline construction in other regions have been largely unsuccessful.

d. Kelp Forest

Giant kelp (*Macrocystis pyrifera*) forms extensive underwater beds on subtidal reefs (except the *M. angustifolia* form on the south coast occurs on sand) between depths of 3 to 30 m throughout the Park. The complex vertical structure of highly productive kelp ecosystems provide food, attachment sites, and shelter for a diverse assemblage of plants and animals, many of which are targeted for sport and commercial harvest. Kelp itself is harvested commercially for use in a wide variety of food and industrial products. Although kelp has been harvested in the past in the Park, currently it is not (see Section III.B).

Kelp forests in the Park occur along two biogeographic and physical gradients (Davis 2005). Kelp forest assemblages of algae, invertebrates, and fishes in the cold, nutrient-rich waters of the

western islands in the Oregonian zone (stretching north to Alaska) are distinct from those in the warm waters around the southeastern islands in the Californian zone (extending southward to the middle of Baja California in Mexico). A third assemblage occupies a transition zone between these two extremes (Figure 13). Physically, kelp forests north of the islands are exposed to winter storm waves from the Gulf of Alaska, while those on the southern shores are protected from winter storms. The islands' south coast kelp forests are exposed to large summer swells generated from winter storms in the Southern Hemisphere and nourished by seasonal upwelling from adjacent oceanic basins. These different physical settings created six discrete kelp forest zones (three biogeographic zones by two exposure zones).

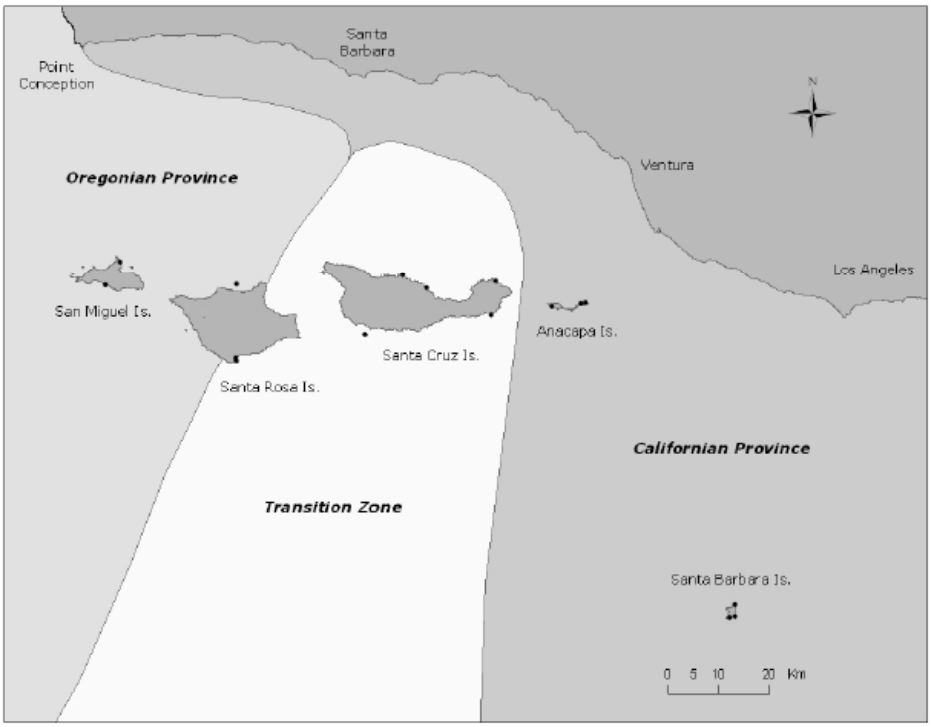

Figure 13. Biogeographic provinces in the Southern California Bight (Davis 2005).

Vertical structure. Kelp forest typically has several layers of understory algae that increase habitat heterogeneity (Dayton et al. 1984). Boa kelp, palm kelps, and bladder weeds can rise one or more meters off the bottom like bushes. Below these are smaller prostrate or low-growing algae less than one meter in height. Next lower can be a turf layer, and finally a crust layer often dominated by pink coralline algae (Ugoretz 2002). Kelp beds also are foraging habitats for seabirds and marine mammals. Cormorants dive through the forests seeking fish; while gulls, pelicans, and terns hunt surface fishes in or near the canopy. Where sea otters occur, they are closely associated with kelp beds, diving for a variety of invertebrates. Sea lions, seals, and occasionally whales use kelp beds as foraging areas.

Kelp forest monitoring. Nearly 1,000 species of marine fish, invertebrates, and algae occur in extensive kelp forests of *Macrocystis pyrifera* surrounding the islands (Davis et al. 1997). Since 1982, the Park has conducted long-term ecological monitoring of 63 kelp forest taxa on all five islands using permanent transects at 16 sites (Figure 14). Divers using SCUBA or surface-supply-air conduct surveys using random and fixed quadrats, band transects, random point

contacts, photogrammetric plots, fish transects, roving diver fish counts, artificial recruitment modules (ARMs) and video transects. In 2005, 16 new monitoring sites were added to the long-term kelp monitoring program. These sites were added as part of a three year (2005-2007) study to collect baseline information inside and adjacent to four of the new marine protected areas. Annual reports produced by the kelp forest monitoring program from 1982-1999 are available on line at: http://www.nature.nps.gov/im/units/chis/HTMLpages/AnnlReports/MarineReports.htm.

Kelp mortality. Significant fluctuations in kelp abundance occur in the Park, related to both physical and biological factors. El Niños lead to significant losses of giant kelp for two main reasons; (1) higher temperatures and lower nutrient concentrations produced by intrusions of water masses from the South decrease kelp growth rates (Tegner and Dayton 1987), and (2) swell during powerful winter storms physically detaches and tears kelp plants. The impact of the El Niño in California depends on the strength of the event. Mild El Niños, that slowed kelp growth, were felt along the coast of California during 1977-1978 and 1992-1993. Especially strong events impacted kelp resources and stopped commercial kelp harvesting off California in 1941, 1957-1959, and 1982-1984. Storms associated with the 1982-1984 El Niño devastated kelp beds throughout California.

Overgrazing by urchins contributes to fluctuations in kelp extent at the Park. Red and purple urchins ordinarily subsist on drifting kelp fragments that settle into rock crevices. When drift plants are scarce, urchins emerge from crevices and become efficient grazers of kelp holdfasts, causing detached plants to drift away. Population explosions of urchins can denude entire kelp beds, creating "urchin barrens" (Ebeling et al. 1985, Murray and Bray 1993). Urchin barrens can persist because high densities of urchins are capable of surviving in a near-starvation state while consuming any edible plants that settle from the plankton (Carroll et al. 2000). Essentially absent for almost the last century in the Park, sea otters were historically important keystone predators of urchins in the Bight and at the Channel Islands. Their absence has likely contributed to the formation of urchin barrens. In addition there is now evidence that lobster harvest in the Park is linked to urchin barren development (Behrens & Lafferty 2004). Urchin barrens became increasingly common during the 1980s and 1990s at the Channel Islands. For example, as recently as 1999, 11 of the Park's 16 kelp monitoring sites were dominated by sea urchins, or were urchin barrens (Kushner et al. 2001).

Kelp forest fish. In the northern Bight, the kelp canopy is dominated by plankton-eating and kelp-browsing species such as blacksmith, kelp surfperch, blue rockfish (*Sebastes mystinus*) juvenile olive rockfish and senorita (Ebeling et al. 1980a, 1980b). The canopy assemblage is made up of large populations of just a few species of fish (Cross and Allen 1993). The most common, conspicuous fish in the canopies of kelp beds on high-relief bench reefs off Santa Barbara and Santa Cruz are blue rockfish (41 percent) and kelp surfperch (35 percent) respectively (Ebeling et al. 1980a). Blacksmith represent 36 and 33 percent of the assemblages at these locations, respectively. Other fish common in the water column of kelp forest are kelp bass (*Paralabrax clathratus*), giant kelpfish (*Heterostichus rostratus*), and kelp rockfish (*Sebastes atrovirens*). Fish that ambush their prey or graze, such as pile surfperch, (*Damalicthys vacca*) black surfperch, garibaldi, California sheephead (*Semicossphylus pulcher*) gopher rockfish (*Sebastes carnatus*) and black-and-yellow rockfish (*Sebastes chrysomelas*) occupy the reef itself. The kelp bed bottom assemblages consist of smaller populations of a relatively larger number of fish species. The most common fishes near the bottom of the Santa Barbara kelp beds are black surfperch (28 percent); at Santa Cruz, kelp bass (14 percent). Kelp beds are important

spawning areas for obligate species such as tubesnouts and, possibly, giant kelp fish, and are important nursery areas for juvenile fishes of many species (Carr 1989).

Figure 14. Original (red) and new (yellow) kelp forest monitoring sites at Channel Islands National Park. The new sites were added to the monitoring program in 2005 to better evaluate the effects of the Marine Protected Areas on kelp forest biota.

C.7. Deeper Water Shelves and Slopes

The deeper offshore habitats in the Sanctuary consist of offshore shelves, ridges, and banks (50 to 500 m deep), basin slopes (150 to 600 m deep), and basin floors (deeper than 600 m). Owing to bathymetry within Park boundaries, deep slopes are of less importance in the Park than offshore shelves. Except for a small area south of Anacapa, all of the marine habitat in the Park is <300 m (50 fathoms) in depth, and most of the waters within Park boundaries are <100 m (17 fathoms) deep. Well over 90 percent of deep-water benthic habitats around the Channel Islands consists of fine sands in shallower portions, grading into silt and clay-dominated sediments in deeper portions (SAIC 1986). Coarse sediments occur near Point Conception, and north of San Miguel (Blake and Lissner 1993). Fine sediments occur on the sill at the western end of the Santa Barbara Channel, and in the Santa Barbara Basin.

Records of the bottom composition for the remaining hard-bottom areas are incomplete and are based on old lead-line soundings, snags reported by fishermen, and geophysical surveys

conducted by the USGS and oil companies (Ugoretz 2002). Direct observations revealed that many previously reported hard-bottom areas are not exposed rock; instead, the reefs are covered by soft sediments (SAIC 1986). Deep rock bottoms often are located offshore from major headlands and islands, and on the highest parts of undersea ridges, banks, and pinnacles. Most of the deep-water hard bottom substrates are low-relief reefs less than 1 meter in height; some reefs have 1- to 5-meter high features. Boulders and bedrock outcrops are the predominant rocky substrates. Higher relief pinnacles and ridges occur in some areas, such as off the northwest end of San Miguel .

Soft bottom fauna. Most deep muddy-bottom invertebrates are detritus feeders. The stability of most deep-water soft-bottom habitats permits greater diversity of infauna and epifauna (life on or just above the substrate) compared to shallow particulate substrates disturbed by waves and surge. Typical infaunal on deep fine-sediment habitats include sea pens (*Stylatula elongata* and *Ptilosarcus gurneyi*), polychaete worms (*Heteromastus sp.*, *Prionospio lobulata*, and *Chloeia pinnata*), echiuran worms (*Urechis sp.*), amphipods (*Orchestoidea spp., Photis spp., Polycheria sp., Oligochinus sp.,* and *Caprella spp.*), brittle stars (*Amphiodia squamata* and *A. urtica*), and small snails and clams. Epifauna include shrimp (*Pandalus spp.*), octopus (*Octopus spp.*), California sea cucumbers (*Parastichopus spp.*), seastars (Class Asteroidea), heart urchins (*Lovenia spp.*), and flatfishes (Families Bothidae and Pleuronectidae). Invertebrates from the deep water soft bottom that are harvested in commercial fisheries are California sea cucumbers, ridgeback prawns (*Sicyonia ingentis*) and spot prawns (*Pandulus platyceros*).

Hard bottom fauna. Deep water rocky-substrate invertebrates are predominantly suspension-feeders. Common invertebrates include sponges, anemones, cup corals, sea fans, bryozoans, feather stars, brittle stars, sea stars, and lamp shells. Demersal fishes can be common, especially various species of rockfishes. In the northern Santa Barbara Channel, three principal hard bottom assemblages were described for outer shelf-upper slope depths (105-213 m) in MMS surveys (SAIC 1986): (1) a low-relief assemblage dominated by anemones, brittle stars, and lamp shells; (2) a medium relief assemblage characterized by the anemone *Corynactis californica* and deep-water coral *Lophelia californica*); and (3) a broadly distributed community composed of the anemone *Metridium senile*, cup corals, and the feather star *Florometra serratissima*.

C.8. Fish Fauna

About 481 species of fish inhabit the Bight (Cross and Allen 1993). This diversity of species in the area occurs for several reasons: (1) the ranges of many temperate and tropical species extend into and terminate in the Bight, (2) the area has complex bottom topography and a complex physical oceanographic regime that includes several water masses and a changeable marine climate (Cross and Allen 1993; Horn and Allen 1978), and (3) the islands and nearshore areas provide a diversity of habitats that include soft bottom, rock reefs, extensive kelp beds, and estuaries, bays, and lagoons. The fish species found around the Channel Islands generally are representative of fish assemblages that occur along the southern California coast, with the addition of some central California species.

Table 4 provides an overview of the fish species reported for the Park by the Inventory and Monitoring Program of the National Park Service (NPSpecies). Appendix C provides more detail for fish species that are targeted by commercial or sport fishermen, including regulatory

actions, fishing regulations, and sources of on-line profiles of biology, fishing effort and stocks for individual species.

Table 4. Fish Fauna of Channel Islands National Park. All species listed appear on the NPSpecies list for the Park. Species marked by asterisks were on the list, but indicated as unconfirmed. Species indicated as taken by sport or commercial fishermen are explicitly referred to in the California Code of Regulations, Fish & Game Code, and the California Ocean Sport Fishing or Commercial Fishing Digests. Other finfish may be minor elements of the recreational or commercial catch. For details on fishing regulations see Section III.B and Appendix C.

Common Name	Scientific Name	Taken for Sport?	Taken Commercially?	Where Found
NEARSHORE SPECIES				
NEARSHORE ROCKFISH - (State designated category of species)				
Black and yellow rockfish	Sebastes chrysomelas	Yes	Yes	Intertidal-36m
China rockfish	Sebastes nebulosus	Yes	Yes	9-90m
Gopher rockfish	Sebastes carnatus	Yes	Yes	9-36m, reefs
Grass rockfish	Sebastes rastrelliger	Yes	Yes	Intertidal-6m
Kelp rockfish	Sebastes atrovirens	Yes	Yes	5-15m, water column in kelp
Black rockfish	Sebastes melanops	Yes	Yes	Intertidal-91m, kelp canopy
Blue rockfish	Sebastes mystinus	Yes	Yes	Intertidal-91m, kelp canopy
Brown rockfish	Sebastes auriculatus	Yes	Yes	3-55m, subtidal reefs
Calico rockfish	Sebastes dalli	Yes	Yes	20-280m
Copper rockfish	Sebastes caurinus	Yes	Yes	3-182m
Olive rockfish	Sebastes serranoides	Yes	Yes	1-121m
Quillback rockfish	Sebastes maliger	Yes	Yes	23-273m
Treefish	Sebastes serriceps	Yes	Yes	3-45m
Whitebelly rockfish	Sebastes vexilaris	Yes	Yes	
NEARSHORE GROUNDFISH				
California Halibut	Paralichthys californicus	Yes	Yes	usually < 100m, most abundant <30m
Starry Flounder	Platichthys stellatus	Yes	Yes	(down to 300m), but usually more shallow, esp. in bays
Sanddab, Pacific	Citharichthys sordidus	Yes	Yes	sand, mud 30-1800 ft
Sanddab, Speckled	Citharichthys stigmaeus	Yes	Yes	sand, mud surface to 1200 ft
Sanddab, Longfin	Citharichthys xanthostigma	Yes	Yes	sand, mud 7-660 ft
Sanddab, Gulf	Citharichthys fragilis	Yes	Yes	sand, mud 59-1140 ft
NEARSHORE CROAKERS				
*California Corbina	Menticirrhus undulatus	Yes	PROHIBITED	sandy beaches to 15m
*Spotfin Croaker	Roncador stearnsii	Yes	PROHIBITED	sand and mud 1-17m
Queenfish	Seriphus politus	Yes		
White Seabass	Atractoscion nobilis	Yes	Yes	rocky bottoms and kelp beds
White Croaker	Genyonemus lineatus	Yes	Yes	sand and mud, usually 3-30m
Yellowfin Croaker	Umbrina roncador	Yes	PROHIBITED	mostly <10m
Black Croaker	Cheilotrema saturnum			
SURFPERCHES (family Embiotocidae)				
Barred surfperch	Amphistichus argenteus	Yes	Yes	beaches
Black perch	Embiotoca jacksoni			rock and kelp
Calico surfperch	Amphistichus koelzi			beaches
Dwarf perch	Micrometrus minimus			rock and kelp
*Reef perch	Micrometrus aurora			
*Dwarf perch	Micrometrus minimus			
Zebra perch	Hermosilla azurea			
Island seaperch	Cymatogaster aggregata gracilis			
Kelp perch	Brachyistius frenatus			water column in kelp
Pile perch	Rhachochilus vacca			various shallow
Pink seaperch	Zalembius rosaceus			deep water
Shiner perch	Cymatogaster aggregata			various shallow
Sharpnose seaperch	Phanerodon atripes			rock and kelp
Striped seaperch	Embiotoca lateralis			rock and kelp

Common Name	Scientific Name	Taken for Sport?	Taken Commercially?	Where Found
Silver surfperch	Hyperprosopon ellipticum			beaches
Spotfin	Hyperprosopon anale			beaches
White seaperch	Phanerodon furcatus			various shallow
Walleye surfperch	Hyperprosopon argenteum			various shallow
Rainbow seaperch	Hypsurus carvi			rock and kelp
*Redtail surfperch	Amphistichus rhodoterus			beaches
Reef perch	Micrometus aurora			rock and kelp
Rubberlip	Rhacochilus toxotes			various shallow
OTHER REGULATED NEARSHORE FISH				
Cabezon	Scorpaenichthys marmoratus	Yes	Yes	Intertidal-76m
California Scorpionfish	Scorpaena guttata	Yes	Yes	3-182m
California Sheephead	Semicossyphus pulcher	Yes	Yes	3-55m
Greenling, Kelp	Hexagrammos decagrammus	Yes	Yes	Intertidal-50m, common 3-20m
*Greenling, Rock	Hexagrammos lagocephalus	Yes	Yes	Intertidal-shallow
Greenling, Painted	Oxylebius pictus	Yes	Yes	
*Greenling, Whitespotted	Hexagrammos stelleri	Yes	Yes	
Monkeyface Prickleback	Cebidichthys violaceus	Yes	Yes	Intertidal-24m
Southern spearnose poacher	Agonopsis sterletus		PROHIBITED	demersal, 42-91m, soft bottom
Lingcod	Ophiodon elongatus	Yes	Yes	mostly 10-110m
Giant Seabass	Stereolepis gigas	PROHIBITED	PROHIBITED	prefer nearshore rocky reefs 12-43m
Kelp Bass	Paralabrax clathratus	Yes	PROHIBITED	shallow to 50m, water column in kelp
Barred Sand Bass	Paralabrax nebulifer	Yes	PROHIBITED	usually < 30m
Spotted Sand Bass	Paralabrax maculato-fasciatus	Yes	PROHIBITED	shallow sandy-mud bays with surfgrass or eelgrass
Garibaldi	Hypsypops rubicundus	PROHIBITED	PROHIBITED	subtidal reefs
Wolf eel, northern wolfish	Anarrhichthys ocellatus		PROHIBITED	
California lizardfish	Synodus lucioceps	Yes		shallow sand, 1-50m
Opaleye	Girella nigricans	incidental	incidental	kelp beds, found to 30m
Spotted ratfish	Hydrolagus colliei		Yes	
UNHARVESTED NEARSHORE FISH				
Longspine combfish	Zaniolepis latipinnis			37-200m
Shortspine combfish	Zaniolepis trenata			
High cockscomb	Anoplarchus purpurescens			
Black prickleback	Xiphister atropurpureus			
Crisscross prickleback	Plagiogrammus hopkinsi			
Twoline prickleback	Esselenia laurae			
Threeline prickleback	Esselenia carli			
Masked prickleback	Ernogrammus walkeri			
Mosshead warbonnet	Chirolophis nugator			
Zebra perch	Hermosilla azurea			
Senorita	Oxyjulius californica			kelp canopy
Wooly sculpin	Clinocotius analis			rocky intertidal
Spotfin sculpin	Icelinus tenuis			
Lavender sculpin	Leiocottus hirundo			
Coralline sculpin	Artedius corallinus			
Scalyhead sculpin	Artedius harringtoni			
Smoothhead sculpin	Artedius lateralis			
Bonehead sculpin	Artedius notospilotus			
Roughback sculpin	Chitonotus pugetensis			
Calico sculpin	Clinocottus embryum			
Mosshead sculpin	Clinocottus globiceps			
Bald sculpin	Clinocottus recalvus			
Bull sculpin	Enophrys taurina			
Brown Irish Lord	Hemilepidotus spinosus			
Pit head sculpin	Icelinus cavifrons			
Threadfin sculpin	Icelinus quadriseriatus			
Yellowfin sculpin				
Rosy sculpin	Oligocottus rubellio			

Common Name	Scientific Name	Taken for Sport?	Taken Commercially?	Where Found
Fluffy sculpin	Oligocottus snyderi			
Snubnose sculpin	Orthonopias triacis			
Darter sculpin	Radulinus boleoides			
Smoothgum sculpin	Radulinus vinculus			
Roughcheek sculpin	Ruscarius creaseri			
Sailfin sculpin	Nautichthys oculofasciatus			
sculpin sp.	Artedius creaseri			
Reef finspot	Paraclinus integripinnis			rocky intertidal
*Rockpool blenny	Hypsoblennius gilberti			rocky intertidal
*Bay blenny	Hypsoblennius gentilus			
*Mussel blenny	Hypsoblennius jenkinsi			
High cockscomb	Anoplarchus purpurescens			
rockweed gunnel	Apodichthys fucorum			
Kelp gunnel	Ulvicola sanctaerosae			
Guadaloupe cardinalfish	Apogon guadalupensis			
Porcupinefish	Diodon hystrix			
Slimy snailfish	Liparis mucosus			
Spiny boxfish	Ostracion diaphanum			
Red brotula	Brosmophycis marginata			
Finescale triggerfish	Balistes polylepis			
Rock wrasse	Halichoeres semicinctus			
Blacksmith	Chromis punctipinnis			kelp canopy
Pacific butterfish	Peprilus simillimus			
Kelp gunnel	Ulvicola sanctaerosae			
Island kelpfish	Alloclinus holderi			
Crevice kelpfish	Gibbonsia montereyensis			
Giant kelpfish	Heterostichus rostratus			water column in kelp
Spotted kelpfish	Gibbonsia elegans			intertidal
Striped kelpfish	Gibbonsia metzi			
kelpfish sp.	Gibbonsia erythra			
Orangethroat pikeblenny	Chaenopsis alepidota			
Smooth ronquil	Rathbunella hypoplecta			
*Northern ronquil	Ronquilus jordani			
*Rough ronquil	Rathbunella alleni			
*Stripedfin ronquil	Rathbunella hypoplecta			
Sarcastic fringehead	Neoclinus blanchardi			
Yellowfin fringehead	Neoclinus stephensae			
Onespot fringehead	Neoclinus uninotatus			
California clingfish	Gobiesox rhessodon			intertidal
Northern clingfish	Gobiesox maeandricus			intertidal
Lined clingfish	Gobiesox eugrammus			
Kelp clingfish	Rimicola muscarum			
Slender clingfish	Rimicola eigenmanni			
California moray	Gymnothorax mordax			
Pacific saury	Coloabis saira			
Sargo	Anisotremus davidsoni	Yes		
Spotted cusk eel (1)	Chilara taylori			
Spotted cusk eel (2)	Otophidium taylori			
Tube snout	Aulorhynchus flavidus			
Ocean whitefish	Caulolatilus princeps			rocky reefs and sand
Scythe butterflyfish	Chaetodon falcifer			rocky reefs
*Mosshead warbonnet	Chirolophis nugator			
Snubnose pipefish	Cosmocampus arctus			
Barred pipefish	Syngnathus auliscus			
Great pipefish	Syngnathus californiensis			
Bay pipefish (1)	Syngnathus leptorhynchus			
Bay pipefish (2)	Syngnathus griseolineatus			
pipefish sp.	Syngnathus arctus			
Chocolate pipefish	Syngnathus euchrous			
Barcheek pipefish	Syngnathus exilis			
Deepwater blenny	Cryptotrema corallinum			

Common Name	Scientific Name	Taken for Sport?	Taken Commercially?	Where Found
Bay blenny	Hypsoblennius gentilis			
Salema	Xenistius californiensis	Yes		
Half Moon	Medialuna californiensis	incidental	incidental	shallow subtidal and kelp beds, found to 30m
SKATES and RAYS				
Shovelnose guitarfish	Rhinobatos productus	Yes		sand and mud to 17m
Banded guitarfish	Zapteryx exasperata			
Piked dogfish	Squalus acanthias	Yes	Yes	
Bat ray	Myliobatis californica	Yes		mud, sand, rocks and kelp; down to 50m
California Skate	Raja inornata	Yes	Yes	common <20m, (but may occur to 733m)
Thornback	Platyrhinoidis triseriata			shallow to 50m in sand
Pacific electric ray	Torpedo californica			3-467m, sand, rocky areas, kelp beds
Round stingray	Urolophus halleri			mostly < 17m, loose sand and mud
*California butterfly ray	Gymnura marmorata			shallow bays, sandy beaches
SILVERSIDES				
Jacksmelt	Atherinopsis californicus	Yes	Yes	bays and up to few miles offshore, spawn in eelgrass
Topsmelt	Atherinops affinis	Yes	Yes	bays and nearshore
Grunion	Leuresthes tenuis	Yes		nearshore down to 20m
GOBIES				
Bluebanded goby	Lythrypnus dalli		minor aquarium trade	hard substrates
Zebra goby	Lythrypnus zebra			hard substrates
Arrow goby	Clevelandia ios			
Cheekspot goby	Ilypnus gilberti			
Bay goby	Lepidogobius lepidus			
Halfblind goby	Lethops connectens			
Shadow goby	Quietula y-cauda			
Blind goby	Typhlogobius californiensis			
Tidewater goby	Eucyclogobius newberryi			
Blackeye goby	Coryphopterus nicholsi			hard substrates
NEARSHORE SHARKS				
Pacific Angel Shark	Squatina californica	Yes	Yes	range from 1-200m, remain buried in sand during day
Leopard Shark	Triakis semifasciata	Yes	Yes	most common in intertidal to 5 m, in CNIP in kelp beds, sandy bottoms near rocky reefs and surf zone on sandy beaches
*Soupfin Shark	Galeorhinus galeus	Yes	Yes	females <15m, males >22m, close inshore up to 500m
Swell shark	Cephaloscyllium ventriosum			
Horn shark	Heterodontus francisci			2-150m, demersal
Bronze whaler, copper shark	Carcharhinus brachyurus			reef associated 0-100m
Brown smoothhound	Mustelus henlei			
Gray Smoothhound	Mustelus californicus	Yes		
DEEPER FISH				
DEEPER GROUND FISH				
Longspine thornyhead	Sebastolobus altivelis	Yes	Yes	deep water, 600-1000m
Shortspine thornyhead	Sebastolobus alascanus			
Dover sole	Microstomus pacificus			60-1600m on mud bottoms
Sablefish	Anoplopoma fimbria			400-1400m
Pacific hake (whiting)	Merluccius productus			
Petrale sole	Eopsetta jordani			found 20-500 m
SHELF ROCKFISH (State designated category of species)				
Greenspotted rockfish	Sebastes chlorostictus	Yes	Yes	49-201 m

Common Name	Scientific Name	Taken for Sport?	Taken Commercially?	Where Found
Starry rockfish	Sebastes constellatus	Yes	Yes	24-274m, rocky reefs
Squarespot rockfish	Sebastes hopkinsi	Yes	Yes	18-183 m, reefs
Bocaccio ("red snapper")	Sebastes paucispinis	Yes	Yes	adults caught on rocky reefs 83-250m, kelp beds are nurseries
Cowcod	Sebastes levis	PROHIBITED	Yes	deep offshore on rocky habitat
Chilipepper	Sebastes goodei	Yes	Yes	deep offshore
Canary rockfish	Sebastes pinniger	PROHIBITED	Yes	common only to 166m
Shortbelly rockfish	Sebastes jordani	Yes	Yes	mostly at 133-233m over smooth bottom
Rockfish, Halfbanded	Sebastes semicinctus	Yes	Yes	
Rockfish, Rosy	Sebastes rosaceus	Yes	Yes	
Rockfish, Stripetail	Sebastes saxicola	Yes	Yes	
Rockfish, Vermillion	Sebastes miniatus	Yes	Yes	shallow subtidal to 466m
*Yelloweye Rockfish	Sebastes ruberrimus	PROHIBITED	Yes	
Yellowtail Rockfish	Sebastes flavidus	Yes	Yes	deep reefs near shelf break, down to 600m
Greenblotched rockfish	Sebastes rosenblatti	Yes	Yes	61-396m, demersal
Widow rockfish	Sebastes entomelas	Yes	Yes	pelagic, 0-549m
Pink rockfish	Sebastes eos	Yes	Yes	demersal, 76-366m
Rosethorn rockfish	Sebastes helvomaculatus	Yes	Yes	demersal, 25-549m, soft bottom
Speckled rockfish	Sebastes ovalis	Yes	Yes	30-366m, rocky reefs
Flag rockfish	Sebastes rubrivinctus	Yes	Yes	0-302m, rocky bottom
SLOPE ROCKFISH (State designated category of species)				
Blackgill Rockfish	Sebastes melanostomus	Yes	Yes	deep water offshore
Splitnose rockfish	Sebastes diploproa	Yes	Yes	bathydemersal, 0-800m
Redbanded rockfish	Sebastes babcocki	Yes	Yes	49-625 m, soft bottom
Bank Rockfish	Sebastes rufus	Yes	Yes	deep water offshore
DEEPER FLATFISH, generally				
Pacific Halibut	Hippoglossus stenolepsis	Yes	Yes	shallow to 1000m
Rex sole	Errex zachirus, Glyptocephalus zachurus	Yes	Yes	
English sole	Pleuronectes vetulus	Yes	Yes	40-300m
*Rock Sole	Pleuronectes bilineatus	Yes	Yes	shallow to 1000m
*Butter Sole	Pleuronectes isolepsis	Yes	Yes	
Fantail Sole	Xystreurys liolepis			
Sand Sole	Psettichthys malanostictus	Yes	Yes	
Slender Sole	Lyopsetta exilis			
Lefteyed flounders	Bothidae			
Bigmouth Sole	Hippoglossina stomata			
California tonguefish	Symphurus atricauda			
Curlfin turbot	Pleuronichthys decurrens	Yes	Yes	
Hornyhead turbot	Pleuronichthys verticalis			
Spotted turbot	Pleuronichthys ritteri			
Diamond turbot	Hypsopsetta guttulata			
C-O sole	Pleuronichthys coenosus			
*Arrowtooth flounder	Atheresthees stomias	Yes	Yes	
SKATES and RAYS				
Big skate	Raja binoculata	Yes	Yes	3m-867m
Longnose Skate	Raja rhina	Yes	Yes	27m-750m
*Sandpaper Skate	Bathyraja interrupta			moderate depth
Starry skate	Raja stellulata			moderate depth
OTHER DEEPER FISH: Benthopelagic/Bathypelagic/Bathydemersal				
Smooth stargazer	Kathetostoma averruncus			
Blacktip poacher	Xeneretmus latifrons		PROHIBITED	bathydemersal 18-400m, soft bottom
Pygmy poacher	Odontopyxis trispinosa		PROHIBITED	demersal, 9-373 m
Bluespotted poacher	Xeneretmus triacanthus		PROHIBITED	bathydemersal, 73-373 m
Fitch's scabbardfish	Lepidopus fitchi			100-500 m, usually sandy bottom
Bigfin eelspout	Lycodes cortezianus			73-620 m
ragfish	Icosteus aenigmaticus			0-1420 m

Common Name	Scientific Name	Taken for Sport?	Taken Commercially?	Where Found
Silvery hatchetfish, Sladen's hatchetfish	Argyropelecus sladeni			bathypelagic 0-2926 m
half-naked hatchetfish	Argyropelecus hemigymnus			bathypelagic 100-700 m
Bigeye lightfish	Danaphos oculatus			bathypelagic 183-914m
Showy bristlemouth	Cyclothone signata			bathypelagic 0-800m
Specklefin midshipman	Porichthys myriaster			
Plainfish midshipman	Porichthys notatus			
black-belly dragonfish	Stomias atriventer			bathypelagic, 100-1500m
Pacific blackdragon	Idiacanthus antrostomus			bathypelagic
Shiny loosejaw	Aristostomias scintillans			bathypelagic, 29-1010m
North-Pacific argentine	Argentina sialis			11-274m
Filetail catshark	Parmaturus xaniurus			91-1251m, demersal
Yellowtail jack	Seriola dorsalis	Yes		3-835m bentho-pelagic, and off kelp beds and rocky areas
*Great amberjack, yellowtail	Seriola lalandi	Yes	Yes	3-825m, bentho-pelagic, and off kelp beds and rocky areas
California smoothtongue	Bathylagus stilbius			bathypelagic, to 690m
Snubnose blacksmelt	Bathylagus wesethi			bathypelagic
California headlightfish	Diaphus theta			
Broadfin lampfish	Lampanyctus ritteri			
Pearly lanternfish	Myctophum nitidulum			
Flashlightfish	Protomyctophum crockeri			
Northern lampfish	Stenobrachius leucopsarus			0-3400m
Mexican lampfish	Triphotarus mexicanus			
Pacific hagfish	Eptatretus stoutii			demersal, 16-633 m
Spiny dogfish	Squalus acanthias	Yes	Yes	
EPIPELAGIC AND COASTAL PELAGIC SPECIES				
Pacific Bonito	Sarda chiliensis	Yes	Yes	deep coastal waters and open ocean
California Barracuda, Pacific Barracuda	Sphyraena argentea	Yes	Yes	
Pacific Sardine	Sardinops sagax	Yes	Yes	
Northern Anchovy, Californian anchoveta	Engraulis mordax	Yes	Yes	
Pacific mackerel	Scomber japonicus	Yes	Yes	
Jack Mackerel	Trachurus symmetricus	Yes	Yes	
Green jack	Caranx caballus			3-100m
*Mobula	Manta japonica			
*Pacific manta	Manta birostris			
*Pelagic stingray	Pteroplatytrygon violacea			
*King Salmon (Chinook)	Onchorhynchus tshawytscha	Yes	Yes	
*Steelhead trout	Onchorhynchus mykiss	PROHIBITED	PROHIBITED	
Ocean sunfish	Mola mola		PROHIBITED	
Great white shark	Carcharodon carcharias	PROHIBITED	PROHIBITED	
California flying fish	Cypselurus californicus			
Medusafish, brown rudderfish	Icichthys lockingtoni			pelagic to 91m, young hide in jellies
Basking shark	Cetorrhinus maximus		PROHIBITED	
Whiptail ribbonfish	Desmoderma lorum			
King-of-the-salmon	Trachipterus altivelis			
HIGHLY MIGRATORY PELAGIC FISHES				
*Albacore	Thunnus alalunga	Yes	Yes	
Broadbill swordfish	Xiiphias gladius	Yes	Yes	
*Pacific Northern Bluefin Tuna	Thunnus orientalis	Yes	Yes	
*Skipjack Tuna	Katsuwonus pelamis	Yes	Yes	
*Yellowfin Tuna	Thunnus albacares	Yes	Yes	
Striped Marlin	Tetrapturus audax	Yes	PROHIBITED	
Shortfin Mako Shark	Isurus oxyrinchus	Yes	Yes	

Common Name	Scientific Name	Taken for Sport?	Taken Commercially?	Where Found
Common Thresher Shark	Alopius vulpinus	Yes	Yes	
Bigeye Thresher	Alopias superciliocus	Yes		
Blue Shark	Prionace glauca	Yes	as bycatch	
*Opah	Lampris guttatus			
*Louvar	Luvarus imperialis			
*Dolphinfish (Mahi-Mahi, Dorado)	Coryphaena hippurus	Yes	Yes	

C.9. Seabirds and Shorebirds

Over 195 species of birds use open water, shore, or island habitats in the Bight south of Point Conception (Ugoretz 2002). The Park is located along the Pacific Flyway, a major migratory route for birds, and acts as a stopover during both north (April through May) and south (September through December) migrations. The months of June and July are peak months for transient shorebirds (Lehman 1994). The Channel Islands provide breeding and nesting sites for many species and large numbers of seabirds, including many threatened and endangered species. The diversity of habitats provided both on- and offshore also contributes to the high species diversity in the region. Sandy beaches provide foraging and resting habitat for a number of shorebirds including black-bellied plover, willet, whimbrel, long-billed curlew, gulls, and sanderlings. The upland portions of the beach provide kelp deposits (wrack) that attract invertebrates where black and ruddy turnstones, dowitchers, and other shorebird species forage.

Seabirds and shorebirds reported from the Park are listed in Appendix D. Eleven seabird species commonly breed in the park, and the islands are crucial breeding grounds for two species in particular: the California brown pelican and Xantus's murrelet (*Synthliboramphus hypoleuca)*. California brown pelicans are a federally listed endangered species. West Anacapa, Middle Anacapa (in 2006), East Anacapa (since 2005), Prince Island (an islet off of San Miguel, in 2006), and Santa Barbara Island are the only locations on the west coast of the United States where California brown pelicans breed[10]. Xantus's murrelets are considered a California species of special concern and are a globally rare seabird species (one of the ten rarest seabird species in the North Pacific, Ugoretz 2002). The world's population of Xantus's murrelet only breeds from the Channel Islands south to Central Baja Calfornia, Mexico. Eighty percent of the United States breeding population and 33.5 percent of the world's breeding population of Xantus's murrelet nests at the Channel Islands, primarily at Santa Barbara (Ugoretz 2002). Although it is not discussed further in this report, light pollution from squid boats is of concern in the Park, as the bright lights used to attract squid are believed to disturb the social interactions, foraging, and possibly the nest-tending behaviors of Xantus's murrelets, and other nocturnally active seabirds.

Seabird Monitoring. In 1985, the Park established a Seabird Monitoring Program. Monitoring protocols (locations, species) have varied from 1985 to the present. Since 1997, monitoring efforts have been concentrated at Santa Barbara. Breeding colonies, or nests, are monitored for the following species: double-crested (*Phalacrocorax auritus*), Brandt's (*Phalacrocorax penicillatus*), and pelagic (*Phalacrocorax pelagicus*) cormorants; pigeon guillemot (*Cepphus columba*); Leach's (*Oceanodroma leucorhoa),* ashy *(Oceanodroma homochroa),* and black

[10] California brown pelicans began nesting at Prince Island (a small islet off San Miguel Island) in 2006, for the first time in over 70 years.

(Oceanodroma melania) storm-petrels; western gulls (*Larus occidentalis*), Xantus's Murrelet, and California brown pelican. Annual reports from the seabird monitoring program for 1990-1999 are available at:
http://www.nature.nps.gov/im/units/chis/HTMLpages/AnnlReports/MarineReports.htm.

Bald Eagles. Bald eagles are currently listed as threatened under the Endangered Species Act, but have been proposed for de-listing. They formerly bred on all of the Channel Islands, but were extirpated in the mid-20th century due to persecution and the effects of DDT and other related compounds (Kiff 1980). Santa Cruz regularly supported at least five pairs of bald eagles, which nested in niches and potholes on the sea cliffs. Known nesting areas included Pelican Bay, San Pedro Point, Blue Banks, Valley Anchorage, Chinese Harbor, Potato Harbor, and Middle Grounds. Anacapa had as many as three nesting pairs in some years. Kiff (1980) estimates that the Northern Channel Islands supported at least 10 nests, and probably more, at any one time. In 2002, a multi-agency effort to reintroduce bald eagles to the Northern Channel Islands began, using money obtained in the Montrose Chemical Company contaminant case settlement (see Section II.B.1). In that year 12 juvenile bald eagles were released on Santa Cruz, and similar releases occurred in the next four summers. As of January 2005, over 25 of the young. transplanted, bald eagles remained on the northern islands. (Some have left the area, the whereabouts of a few others are unknown, and a small number have died). Because bald eagles don't breed until 4-5 years of age, the first breeding attempts by the transplanted birds should occur in 2006 (CINP 2002a). On April 12, 2006, a bald eagle chick was successfully hatched by a pair of eagles that had been raised in captivity on Catalina Island, but which flew to Santa Cruz and made a nest there. This chick was the first bald eagle to hatch in the wild on the Channel Islands in over 30 years. One other chick, from a second nest, was successfully hatched in 2006.

C.10. Marine Mammals

Cetaceans. At least 33 species of cetaceans have been reported in the Sanctuary (Leatherwood et al. 1982; Leatherwood et al. 1987). Most of the reports involve live sightings although a few are known only from strandings. The toothed whales, or odontocetes, number 25 species (Table 5). Only eight species of baleen whales, or mysticetes, have been reported. Two of these are in their own families. The northern right whale (*Eubalaena glacialis*) is the only representative of the family Balaenidae that has been reported in the Sanctuary. The California gray whale (*Eschrichtius robustus*) is the sole surviving representative of the family Eschrichtiidae. The other six species are all members of the family Balaenopteridae, or rorquals.

Of the odontocetes, seven species are commonly seen, either during certain seasons or year-round. They are the long-beaked common dolphin (*Delphinus capensis*), the short-beaked common dolphin (*Delphinus delphis*), the onshore and offshore stocks of bottlenose dolphins (*Tursiops truncatus*), Risso's dolphin (*Grampus griseus*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), northern right whale dolphin (*Lissodelphis borealis*), and Dall's porpoise (*Phocoenoides dalli*). The latter two species are generally associated with colder water masses (approximately 16°C). All cetaceans are protected under the Marine Management Protection Act. Additional protection status is conferred to some species under federal or state authority (Table 5).

Table 5. Cetacea occurring in the Channel Islands National Marine Sanctuary. Adapted from Ugoretz (2002).

Common Species Name (Scientific Name)	Pop. or Stock Size	Protected Status [a]	Relative Abundance	Seasonality	Normal Habitat
Odontocetes - Oceanic Dolphins and toothed whales					
Baird's Beaked whale (Berardius bairdii)			Rare		
Long-beaked common dolphin *(Delphinus capensis)*	Stock size: 89,800		Common	Year round	Coastal - up to 300 nautical miles offshore
Short-beaked common dolphin (*Delphinus delphis)*	Stock size: 372,000		Common	Year round	Coastal - up to 50 nautical miles offshore
Bottlenose dolphin *(Tursiops truncatus)* Offshore stock	Stock size: 2,555		Common	Year round	Shelf, slope and offshore
Bottlenose dolphin *(Tursiops truncatus)* Coastal stock	Stock size: 140		Common	Year round	Surf zone up to 1km offshore
Pacific white-sided dolphin (Lageno-*rhynchus obliquidens*)	Population: 12,1693		Sporadically abundant	Usually summer and fall	Shelf to farther offshore
Rough-toothed dolphin *(Steno bredanensis)*	Not available for area		Known only from a few strandings		Pelagic
Striped dolphin (*Stenella coeruleoalba)*	Not available for area				Pelagic
Long-snouted spinner dolphin *(Stenella longirostris*)	Not available for area		Possible during El Ni□o events		Pelagic
Spotted dolphin *(Stenella attenuata)*	Not available for area		Known only from strandings		Pelagic
Northern right whale dolphin (*Lissodelphis borealis)*	Stock size: 21,332		Sporadically abundant	Winter and spring	Continental shelf and slope
Risso's dolphin *(Grampus griseus)*	Stock size: 32,376		Common	Year round	Shelf, slope and
Short-finned pilot whale *(Globicephala macrorhynchus)*	Stock size: 970		Uncommon	Most often summer and fall	Shelf, slope and offshore
Orca or Killer whale *(Orcinus orca)*	Stock size: 336		Uncommon	Year round	Shelf, slope and offshore
False killer whale *(Pseudorca cressidens)*	Not available for region		Rare		Shelf to offshore and pelagic
Cetaceans: Mysticetes - Right Whales					
Northern right whale *(Eubalaena glacialis)*	Not available for region	FE, DEP, SS	Extremely rare		Coastal
Cetaceans: Odontocetes - True Porpoises					
Dall's Porpoise *(Phocoenoids dalli)*	Stock size: 47,661		Uncommon	Winter and spring	Shelf to well off-shore
Harbor Porpoise *(Phocoena phocoena)*	Stock size: 5,732	SS	Uncommon		Shallow coastal
Cetaceans: Odontocetes - Sperm Whales					
Sperm Whale *(Physeter macrcephalus)* Family Physeteridae	Stock size: 1,191	FE, DEP, SS	Rare	April to mid June and August to mid November	Deep sea
Pygmy sperm whale *(Kogia breviceps)* Family Kogiidae	Stock size: 3,145		Uncommon		Deep sea, pelagic
Dwarf sperm whale *(Kogia simus)* Family Kogiidae	Stock size: 891		Known from three strandings		Deep sea, pelagic
Cetaceans: Mysticetes - Gray Whales					
California gray whale *(Eschrichtius robustus)*	Population: 26,600	Delisted from the Federal Endangered Species List in 1994	Common	December through May; occasionally rest of year	Coastal
Cetaceans: Mysticetes – Rorquals					
Blue whale *(Balaenoptera musculus)*	Stock size:1,785 to 2,200	FE, DEP, SS	Common in Season	June to September; occasionally through November	Shelf and slope

Common Species Name (Scientific Name)	Pop. or Stock Size	Protected Status [a]	Relative Abundance	Seasonality	Normal Habitat
Fin Whale *(Balaenoptera physalus)*	Stock size: 933	FE, DEP, SS	Uncommon	Summer, fall; possible year-round	Shelf and slope
Sei whale *(Balaenoptera borealis)*	Not available for region	FE, DEP, SS	Very Rare		
Bryde's whale *(Balaenoptera edeni)*	Stock size: 24		Rare		Shelf and slope
Minke whale *(Balaenoptera acutorostrata)*	Stock size: 631	SS	Uncommon	Year-round; Most abundant in summer and fall	Coastal to slope
Humpback whale *(Megaptera novaeangliae)*	Stock size: 843	FE, DEP, SS	Common in Season	May to September	Shelf and slope

[a]All pinnipeds and cetaceans are protected under the Marine Mammal Protection Act of 1972 (MMPA).
FE - Federally listed as endangered under FESA
FT- Federally listed as Threatened under FESA
DEP- Listed as a depleted stock under MMPA
SS- Listed as a strategic stock under MMPA
ST- State-listed as Threatened under the California Endangered Species Act
PRO- Fully protected mammal under CA Fish and Game Code 4700

Pinnipeds

Six species of pinnipeds haul out on park beaches and use park waters (Table 6). The four most abundant are the California sea lion, northern elephant seal, harbor seal and northern fur seal. Northern (Steller) sea lions and Guadalupe fur seals are observed very infrequently. Ribbon seals have been rarely observed in the Sanctuary. The westernmost beach on San Miguel, Point Bennett, is the only place in the world where up to six different species of pinnipeds can be found. In the winter, as many as 50,000 individuals seals, sea lions, and northern elephant seals can be seen at one time on Point Bennett, where they breed and where the pups are born. The beaches on the south side of San Miguel, and Cardwell Point on the east end of San Miguel, are important habitat for both northern elephant seals and California sea lions.

[The following summaries are largely drawn from Ugoretz, 2002]

California sea lion (*Zalophus californianus* California sea lions have two main rookeries at the Channel Islands, one at San Miguel, the other at San Nicolas Island (the latter outside of the Park). As many as 95% of the 16,000-17,000 pups born in the Channel Islands can be from these two rookeries (McGinnis 2000). Other rookeries exist at Santa Barbara and San Clemente islands (the latter outside of Park). Several haul-out sites exist on Santa Cruz and Anacapa Islands.

Northern (Steller) sea lion (*Eumetopias jubata*). The National Marine Fisheries Service manages the northern sea lion as two stocks. The eastern, or "*San Miguel"*, stock (which includes those in California waters) is federally listed as threatened. The Steller sea lion once had two rookeries on San Miguel. After the El Niño event of 1982/1983, these rookeries were abandoned. Only one sighting of a Steller sea lion has been reported at the Channel Islands since that time.

Northern fur seal (*Callorhinus ursinus*) The northern, or Alaskan, fur seal has two rookeries of approximately 4,500 animals at San Miguel. These were reestablished in the late 1950s. The two rookeries have grown over the years to an estimated 4,300 animals (Barlow et al. 1997). At

San Miguel, adult males usually arrive in May and stay through August. Some will stay as late as November, along with the females, although they will not maintain territories much beyond August. By November, most adults have left for the open ocean, where they will spend the next 7 to 8 months. Many pups will spend the next 22 months at sea after they have been weaned, finally returning to the rookeries where they were born. Northern fur seals are pelagic, frequenting offshore waters in search of fish and squid.

Guadalupe fur seal (*Arctocephalus townsendi*). The Guadalupe fur seal is federally listed as threatened. It is considered depleted under the MMPA and is also fully protected under Fish and Game Code (Section 4700). The California-Mexico stock is considered strategic under the MMPA. The latest estimate of this population is 6,443 animals (Barlow et al. 1997), virtually all of which are found in Mexican waters at Guadalupe Island. A pup was born on San Miguel in 1997.

Northern elephant seal (*Mirounga angustirostris*). The California population is considered a separate stock (Barlow et al. 1997). Northern elephant seals have two large rookeries on San Miguel (Point Bennett) and San Nicolas Islands. On San Miguel, the south side beaches, and Cardwell Point on the east end, are also important areas (Dan Richards, Marine Biologist, Channel Islands National Park, pers. comm.). Smaller rookeries are found on Santa Barbara (especially at Webster Point and the Southeast Sea Lion Rookery) and Santa Rosa (at Sandy Point and Cluster Point in the southwest). They have also been reported at Santa Cruz and Anacapa Islands but have not established rookeries there. Barlow et al. (1995) indicate that the Channel Islands rookeries account for 85% of the births in California. The California stock was estimated at 84,000 animals in 1996 (Forney et al. 2000).

Northern elephant seals migrate to California twice from feeding grounds as far north as the Aleutian Islands and the Gulf of Alaska (for the males) and to areas off the Oregon coast (for the females). They migrate once to bear their young and breed, then a second time to molt. The pupping and breeding season extends from December through March. The molting season is between March and August. Males generally arrive later than the females. Northern elephant seals feed on deepwater organisms including bony fish, sharks, skates, rays, and squid, and octopus.

Pacific harbor seal (*Phoca vitulina richardsi*). The Pacific harbor seal is well-distributed in California, with 400 to 500 haulout sites along the mainland coast at river mouths, estuaries, beaches, offshore rocks, and islands, including San Francisco Bay, as well as at the Channel Islands. Harbor seals usually do not roam far from their haulout and rookery areas, although a few individuals may wander a few hundred kilometers. One estimate of the California stock is 30,293 animals (Forney et al. 2000). Harbor seals breed on all the islands, however, they do not form the large colonies that the other species do (Dan Richards, Marine Biologist, CINP, pers. comm.). Harbor seals pup from February through May. Some pups have been reported in December and January at several rookeries. The highest numbers are seen ashore at the Channel Islands during the molting season, which peaks from late May to early June. Harbor seals prey mostly on various species of bottom fish and octopi.

Table 6. Pinnipeds occurring in the Channel Islands National Marine Sanctuary. Adapted from Ugoretz (2002).

Common Name (Scientific Name)	Pop. or Stock Size	Protected Status[a]	Relative Abundance	Seasonality	Normal Habitat
California sea lion *(Zalophus californianus c.)*	Stock Size: 167,000 to 188,000		Common	Year round	Coastal
Steller sea lion *(Eumetopias jubata)*	No stock size available	FT, DEP, SS	Now extremely rare		Coastal
Northern fur seal *(Callorhinus ursinus)*	Stock size: 12,704		Uncommon	May to November	Pelagic
Guadalupe fur seal *(Arctocephalus townsendi)*	Population: 6443	FT, ST, SS, PRO	Extremely rare		Pelagic
Northern elephant seal (Mirounga *angustirostris)*	Stock size: 84,000	PRO	Common in season	December to August	Pelagic, Highly migratory
Pacific harbor seal *(Phoca vitulina richardsi)*	Stock size: 30,293		Common	Year round	Coastal
Ribbon seal *(Histriophocal fasciata)*	Not applicable		Extremely rare		

[a]All pinnipeds and cetaceans are protected under the Marine Mammal Protection Act of 1972 (MMPA).
FE - Federally listed as endangered under FESA
FT- Federally listed as Threatened under FESA
DEP- Listed as a depleted stock under MMPA
SS- Listed as a strategic stock under MMPA
ST- State-listed as Threatened under the California Endangered Species Act
PRO- Fully protected mammal under CA Fish & Game Code 4700

Southern Sea Otter

Once common around the islands, the southern sea otter (*Enhydra lutris nereis*) was hunted to local extinction by the end of the 1800's. Now, a few are spotted in the Park. The southern sea otter is considered protected, depleted and strategic under the MMPA, is a fully protected species under the California Endangered Species Act, and is a federally listed Endangered Species. Population size is ca. 2100 (USFWS 2003). From 1987-2001, USFWS caught and relocated all sea otters that appeared south of a line drawn from Pt. Conception to San Miguel. Relocation areas were near the city of Santa Cruz and Moss Landing to the north, and San Nicolas Island to the south. This activity was part of a political compromise designed to placate commercial fishermen of crab, urchins and lobsters in the Santa Barbara area, who were competing with the otters for crab, urchins and lobsters. As of 2003, the translocated colony at San Nicolas Island contained about 27 sea otters (USFWS 2003). On October 5, 2005, the USFWS announced its intent to end the relocation program and to allow sea otters to recolonize the Southern California coast at a natural rate. As a result, although sea otters have been essentially absent from the Park for almost a century, it is reasonable to expect that they will begin to recolonize the Channel Islands at some point in the future.