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ASSESSMENT OF COASTAL WATER RESOURCES AND WATERSHED CONDITIONS AT CHANNEL ISLANDS NATIONAL PARK, CALIFORNIA

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Top Right: Brown Pelican, NPS photo
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WATER RESOURCES DIVISION

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EXECUTIVE SUMMARY

Channel Islands National Park (Park) was created in 1980 and comprises five islands off the coast of southern California (San Miguel, Santa Rosa, Santa Cruz[1], Anacapa, and Santa Barbara Islands) and the marine environment surrounding them from shore to 1 nautical mile seaward. The Northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz and Anacapa Islands) are separated from the mainland by the Santa Barbara Channel. A major international shipping lane traverses the channel and 19 active offshore oil and gas platforms are located in the channel between Point Arguello to the east and Point Mugu to the west. The waters surrounding all five islands of the Park, from the mean high tide line 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 commercial and recreational fishing are prohibited, or State Marine Conservation Areas (SMCAs), in which limited recreational and/or commercial take is allowed. The SMRs and SMCAs include Park waters. Coastal cliffs, rocky intertidal habitat, sandy beaches, and small embayments make up the islands' coastlines. The nearshore marine environment consists of offshore pinnacles and islets, rocky reefs, kelp forest, eelgrass beds, and soft (mostly sandy) bottom. Anacapa and Santa Barbara Islands have no freshwater features. Freshwater features on the other islands include springs, streams, vernal pools, small coastal wetlands, and small lagoons.

This report is a cooperative effort between the Marine Science Institute, University of California Santa Barbara, and the National Park Service, and provides a summary of the current status of aquatic resources (freshwater and marine) at Channel Islands National Park. The purpose of this report was to examine existing information pertaining to water quality, the condition of aquatic habitats and their biota, sources of point and non-point pollution in the region, avenues of transport of pollutants to Park waters, and threats to aquatic resources stemming from consumptive and non-consumptive uses of Park habitat. In addition, the report identifies current information gaps and makes recommendations for addressing them.

Owing to the availability of freshwater, Santa Cruz, Santa Rosa and San Miguel Islands supported permanent settlements of Chumash Indians dating back further than 10,000 years ago. Starting in the 1800s, the islands were occupied by ranchers and farmers and used for the rearing of sheep and cattle. This activity (and the introductions of rabbits on Santa Barbara I., feral pigs on Santa Cruz I., and elk and mule deer on Santa Rosa I.) profoundly altered land cover on the islands, causing significant upland erosion, damaging riparian zones, replacing much of the native vegetation with introduced grasses, invasive weeds, and non-native trees (such as *Eucalyptus*). During the past 40 years, sheep, cattle, and rabbits have been removed from the islands, eradication of non-native vegetation and feral pigs is underway, and native vegetation and normal stream function is returning in the Park[2]. Although the Park is large, its remote location (~24 km from the mainland to Anacapa I.), and limited public transportation (only two concessionaires land visitors on the islands) keeps visitation low. Annually, about 30,000 visitors land on the islands, and another 60,000 visitors enter the Park only via boat. Popular

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[1] Only the eastern 24% of Santa Cruz Island is included in the Park; the remainder is owned by The Nature Conservancy. However, the marine habitat surrounding the entire island is included in the Park.

[2] Stream function has only been formally studied on Santa Rosa Island.

activities at the Park are whale watching, diving, fishing, kayaking, sailing, surfing, camping and hiking.

The Park's rocky intertidal habitat, soft bottom subtidal habitat, subtidal reefs, and kelp forests support well over one thousand species of macroalgae, invertebrates, and fish. The islands straddle the transition zone between two major marine biogeographic zones (Oregonian and Californian). This geographical feature, and the fact that the Santa Barbara Channel is invaded by typically more tropical species of fish and invertebrates during strong El Niños, conspire to increase the overall diversity of marine biota within the Park.

The Park provides habitat and breeding grounds for a diverse array of marine mammals and seabirds, many of which are federally listed threatened or endangered species. Eleven seabird species commonly breed in the Park, and the islands are crucial breeding grounds for two species in particular: the endangered California brown pelican (*Pelecanus occidentalis californicus*), and Xantus's murrelet (*Synthliboramphus hypoleuca).* California brown pelicans currently breed at several locations in the Park, but nowhere else on the Pacific coast of the United States. Xantus's murrelets are considered a California species of special concern and are one of the ten rarest seabird species in the North Pacific. Six species of pinnipeds haul out on Park beaches and use Park waters. The four most abundant are the California sea lion, northern elephant seal, Pacific harbor seal and northern fur seal, all of which breed in the Park. Northern (Steller) sea lions and Guadalupe fur seals are observed very infrequently, although Steller sea lions used to breed on San Miguel I.. Ribbon seals have been observed in the Sanctuary on rare occasions. The westernmost beach on San Miguel I., Point Bennett, is the only place in the world where up to six different species of pinnipeds can be found. Thirty-three species of cetaceans have been reported in the Sanctuary. Federally listed endangered cetacea that visit Sanctuary waters (and presumably deeper Park waters) are the Northern right whale, the sperm whale, the blue whale, fin whale, sei whale, and humpback whale.

Since the mid 1980s, monitoring programs for rocky intertidal habitat, kelp forest, sand beaches, lagoons, and sea birds, have been in place at the Park. Pinniped colonies are monitored by the National Marine Fisheries Service, which has jurisdiction over them. The Sanctuary records sightings of cetaceans during weekly overflights as part of the Sanctuary Aerial Monitoring Spatial Analysis Program (SAMSAP).

Notable trends for marine taxa at the Park, and presumed causes (in parentheses), include:

- collapse of black abalone (fishing and disease)
- same, for white abalone - a federally endangered species (fishing)
- near disappearance of ochre sea stars, and declines of other sea stars, during recent El-Niños (bacterial disease)
- elimination of eelgrass beds at Anacapa Island (feeding fronts of white urchins)
- declines in numbers of warty sea cucumbers (mostly commercial harvest)
- declines in harvestable sizes of red urchins (commercial harvest)
- purple urchin population explosions, creating urchin barrens (trophic cascade related to lobster fishing [near term] and loss of sea otters [longer term])
- appearance of a wasting disease affecting purple sea urchins (unnaturally high densities)

- El-Niño related declines in extent of kelp forest (wave damage, higher temperatures, and lower nutrients)
- increasing numbers of typically more southern fish species (regime shift, beginning in 1977)
- decreases in primary productivity and zooplankton abundance (regime shift)
- declines in pelagic sea birds (regime shift)
- declines in commercial and recreational landings, and shifts in size structure, for many nearshore and shelf finfish species (fishing pressure and regime shift)
- occasional sightings of previously locally extinct sea otters (numbers expected to increase since the California Fish & Game Department ceased to relocate Park otters in 2001).
- ongoing recovery of breeding populations of California brown pelicans, peregrine falcons and bald eagles (in concert with reduced exposure to DDT in the marine food chain)

Marine water pollution is virtually unstudied at the Park itself. Concentrations of synthetic organic compounds and trace elements in seawater at the Park have not been measured. PCBs and p,p'-DDE occur in the milk and blubber of the Park's sea lions, but are suspected to originate from fish caught at polluted sites along the mainland coast - notably, the Santa Monica Bay and the Palos Verdes Shelf. It seems reasonable to expect that at least some of the DDT that damaged the reproductive abilities of bald eagles and pelicans at the Park came from contaminated fish caught by these birds within Park boundaries. PAH metabolites were detected in one groundfish species at the Park (Pacific sanddabs) - but it is not known whether the PAHs were from natural sources (oil seeps) or anthropogenic sources (combustion-related, or from offshore oil extraction). The only direct evidence that toxicants in the water column *within the Park* are contaminating marine food chains at the Park stems from analyses of sentinel mussels conducted by the State of California or NOAA. Using this basis, the following constituents resided at least part time in the water column at the Park as recently as 2002: (1) the trace metals Ag, Al, As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Zn; (2) DDT and its metabolic byproducts; (3) PCBs; (4) PAHs (at least 23 compounds), (5) biocides such as aldrin, dieldrin, tributyltin, chlordane, lindane, mirex and their metabolic byproducts; and (6) a suite of other organic compounds such as chrysene, hexachlorobenzene, and naphthalene.

Owing to its remote location and lack of development, direct sources of anthropogenic marine water pollution within Park boundaries are, practically speaking, limited to intentional or accidental discharges (i.e., sewage, fuel, bilge water) from private or commercial vessels that use Park waters. For example, bacterial contamination - presumably from sewage releases - is observed in Park anchorages during busy weekends. Natural oil seeps within Park boundaries are a presumed, but natural, source of PAH in the water column of the Park. Other potential sources of anthropogenic water contamination are indirect. They include terrestrial runoff from the mainland (mostly during winter), polluted sediments near the mainland coast, ocean outfalls for mainland wastewater treatment plants, chemical dumps in the ocean, dredge disposal sites, produced water discharges and drilling wastes from offshore oil and gas operations, oil spills, and discharges or spills from marine vessels (including sinkings and groundings). With regard to several sources outside Park boundaries, foraging for fish (primarily) outside of Park boundaries by sea birds and pinnipeds that return to Park islands may be the principal route by which many pollutants enter the marine ecosystem at the Park. Once there, the potential exists for pollutants

to circulate among the other compartments of the marine ecosystem. In this report, background information is presented for each of these potential sources of marine pollution, evidence of harmful consequences for marine biota is discussed, and the processes are examined by which distantly generated pollutants may enter the Park's marine ecosystem.

Periodic oceanographic cruises conducted by CalCOFI[3] and the University of California, Santa Barbara[4], provide time series measurements of basic oceanographic parameters (temperature, dissolved nutrients, salinity, chlorophyll-a) for stations near several of the islands. Additionally, continuous measurements of current speed and temperature are made by PISCO[5] using moored instruments near Santa Cruz I., and the Park has temperature logger data, going back to 1985 in some cases, from several kelp forest monitoring sites. No other routine measurements of marine water quality are available from the Park. Seasonal, interannual, and multidecadal variation in oceanographic parameters in Park waters are caused by natural phenomena, including seasonal (and smaller scale) shifts in ocean circulation patterns, El Niños and La Niñas, and regime shift[6]. Consequently, variation in these parameters is not indicative of anthropogenic influences at the Park, and oceanographic data are not evaluated in this report in that context. Instead, selected physico-chemical data from these research programs are used to evaluate the likelihood that mainland storm plumes, and associated pollutants, will spread across the coastal ocean far enough reach Park waters.

Commercial and recreational fishing is allowed by the State in Park waters, except in the areas included in the SMRs. The nearshore waters surrounding the islands, and especially the nearshore kelp beds, are especially well-exploited for market squid, sea urchins, sea cucumber, spiny lobster, red rock crab, rockfish (*Sebastes spp.*), and other nearshore finfish (especially California sheephead). Coastal pelagic species (such as anchovy, sardine, mackerel, and tuna), flatfish, and prawn are commercially important in the Sanctuary, but account for a smaller proportion of commercial harvest within Park waters. Recreational fishing in Park waters (via hook and line, and diving) primarily targets rockfish, barred sand bass, calico kelp bass, white sea bass, ocean whitefish, lobster, and scallops.

Fishing is implicated in the regional declines, in many cases starting in the 1970s, in the stocks of many fish and invertebrates that are harvested within Park waters. The Pacific Fisheries Management Council considers several groundfish species that occur in the Park to be regionally overfished including shelf rockfish spp. (canary, yelloweye, and widow rockfishes, cowcod, and bocaccio), lingcod, and Pacific whiting. California populations of lingcod appear to be less than 25% of their pre-1970s levels. Rockfishes (*Sebastes*) are particularly vulnerable to commercial and recreational fishing because they are long-lived (approximately 13-100 years), grow slowly, mature late (4-12 years), and have unpredictable recruitment. Declines of up to 50% have been observed in recent decades in the length and weight of some rockfish spp. taken in California. Recreational fishing dominates the take of many nearshore species (such as California scorpionfish, kelp greenlings, treefish, and calico, blue, olive, and kelp rockfishes), and recreational landings of nearshore species declined regionally by at least 65% from the 1980s to

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[3] California Cooperative Oceanic Fisheries Investigations

[4] UCSB's Santa Barbara Coastal Long Term Ecological Research Project and Plumes & Plooms Project

[5] Partnership for Interdisciplinary Studies of the Coastal Ocean

[6] *Regime shift* refers to a change in the atmosphere-ocean climate system of the North Pacific, starting in 1976, which led to an increase in mean ocean temperature (~1°C), and persistent decreases in primary and secondary production in the California Current.

the 1990s. Giant seabass have been in decline for several decades, and commercial catch is now prohibited. Catches of pelagic sharks have been in sharp decline since the 1970s. Fishing has altered the abundance and size structure of California spiny lobster populations at the Channel Islands, and populations of warty sea cucumber are also in decline in fished areas. Abalone stocks crashed in recent decades; commercial harvest has been closed in the State since 1997.

In 2003, the State designated 12 areas surrounding Park islands as Marine Protected Areas (MPAs); ten are State Marine Reserves (SMRs) and two are State Marine Conservation Areas (SMCAs). The SMRs are no fishing zones. The SMCA at Santa Cruz I. allows limited recreational fishing, and the SMCA at Anacapa I. allows limited recreational and commercial catch. The establishment of the reserves, combined with two decades of data from the Park's intertidal and kelp forest monitoring programs, has created an opportunity to evaluate whether fishing is responsible for some of the recent changes in nearshore communities at the Channel Islands (as opposed to natural phenomena, such as El Niños, and longer-scale regime shift). So far, comparison of monitoring data from inside versus outside the fishing refugia at the Park has revealed that (1) rocky reefs inside protected areas are more likely to support kelp forest than rocky reefs in fished areas, (2) harvest of lobsters indirectly increases epidemics in sea urchins; and (3) a commercial dive fishery has caused 33-83% of the declines in warty sea cucumbers at the Channel Islands.[7]

A review of the science of marine reserves, or of the anticipated ecological consequences of establishing the MPAs at the Channel Islands, is not provided in this report. Instead, an overview of commercial and recreational fishing in the Park is provided to address three questions concerning Park habitat where fishing still takes place:

(1) which Park species are harvested,
(2) where, within the Park, is fishing effort likely to be concentrated, and
(3) which regulations pertain to particular target species.

Information on statewide and local landings is used to rank commercially and recreationally harvested species. Spatial patterns of fishing effort within the Sanctuary, evaluated by NOAA shortly before the creation of the MPAs, are presented. State regulations pertaining to particular species, and groups of species, as contained in the California Code of Regulations, and the California Fish & Game Code, are assembled into tabular tools provided as Appendices. Detailed descriptions of the pertinent fisheries were available outside this report; links to these sources are provided in the body of the report and in appendices.

The freshwater resources at the Park are less well studied than the marine resources. Information about the condition of freshwater resources at the Park comes primarily from monitoring of basic water quality parameters in three streams on one island (Santa Rosa I.) starting in the 1990s, a twice-conducted study of riparian zone vegetation and hydrologic functioning for ten stream reaches on one island (Santa Rosa I.), routine water quality measurements and biological observations at three coastal lagoons on one island (Santa Rosa I.), and a one-time survey of two coastal wetlands on Santa Cruz I.. With the exception of the lagoon monitoring, these studies were motivated primarily by the need to to describe adverse affects caused by livestock grazing (streams on Santa Rosa I.), or alterations of wetland habitat (dredging, fill, grading) caused by

[7] In this case, the reserve utilized was a protected area at Anacapa Island that predated the establishment of the Anacapa SMR and SMCA.

past ranching operations (Santa Cruz I.), and to monitor recovery of stream habitat after livestock removal (Santa Rosa I.). Streams on Santa Cruz I. are virtually unstudied with respect to fauna, flora, or water quality, although they have surely been affected by the upland erosion and exotic plant invasions that accompanied the grazing of cattle and sheep in the past, and that have been exacerbated during the occupation of the island by feral pigs. Macroinvertebrate fauna and water quality in vernal pools on Santa Rosa were surveyed once, in 1995. Eighteen shallow ground water monitoring wells were installed at one of the altered coastal wetlands on Santa Cruz I. in 2005. Otherwise, groundwater is virtually unstudied in the Park. There is no logical reason to expect that groundwater quality on any of the islands has been compromised, but the influence of non-native *Eucalyptus* groves, and other non-native trees, on water balance in riparian corridors and coastal wetlands merits study.

Following cattle removal in 1998, there has been a substantial recovery of the riparian corridors on Santa Rosa I. Water quality has improved and stream beds have evolved from sediment-choked, braided channels with unvegetated banks to narrower, deeper, meandering channels with well developed floodplains and point bar development. Reestablishment of native woody riparian species has been impeded, presumably owing to a lack of seed sources in many reaches, and browsing of seedlings by the elk and deer that remain on the island. Elk and deer are slated for removal from Santa Rosa I. by 2011. Ongoing threats to freshwater resources in the Park are the spread of non-native weeds and shubs into coastal wetlands, vernal pool sites, and riparian corridors, and damage to streams and wetlands by road crossings that lack effective culverts.

Nonconsumptive use of aquatic resources in the Park include kayaking, whale watching, sailing, surfing, diving, beach and upland camping, and hiking. The Park protects important seabird and pinniped habitat through permanent and seasonal closures of certain trails, beaches, sea caves and sea cliffs. In addition, all access to offshore rocks and pinnacles is prohibited. Limited opportunities for primitive camping and hiking occur on all five Park islands. According to Park staff, kayakers, hikers and campers generally comport themselves in a manner which does not damage aquatic resources. During busy holiday weekends, illegal releases of sewage from private boats may be leading to short-term bacterial contamination in Park anchorages.

The known and suspected problems affecting aquatic resources at the Park are summarized in Table i. Recommendations for addressing information gaps are as follows:

- Continue all aspects of the Park's existing monitoring programs.
- Digitally map the coastal wetlands and lagoons in the Park.
- Rigorously monitor beaches, coastal wetlands and stream mouths for recruitment of highly invasive exotic plant species that directly affect aquatic habitats, such as *Arundo*.
- Discover the post-grazing status of vernal pools on Santa Rosa I.
- Evaluate stream function and riparian zone condition on Santa Cruz I.
- Prepare a strategy for enhancing recovery of native woody riparian vegetation on Santa Rosa and Santa Cruz Islands.
- Expand baseline data in anticipation of restoration work at Prisoner's wetland and in its watershed, Cañada del Puerto.
- Conduct a thorough survey of road crossings of water bodies.

- Better exploit sentinel mussels to map spatial variation and temporal changes in seawater contamination in the Park.
- Compare sediment loads of priority contaminants at sites within the Park reflecting different chronic exposure levels to potential sources such as ship traffic, mainland runoff, and seabird and pinniped colonies.
- Measure pollutants in the water column at the Park using moorable *in-situ* exposure samplers.
- Utilize NOAA's SAMSAP[8] data to map current patterns of fishing effort at the Park outside MPAs.
- Prioritize the synthesis of time series data from the Park's monitoring programs to discover the impacts of fishing on Park biota.

[8] Sanctuary Aerial Monitoring and Spatial Analysis Program

Table i. Existing and hypothesized degradations of aquatic resources at Channel Islands National Park. Codes are as follows: EP - existing problem based on direct evidence; PP - potential and likely problem; OK - not currently, or expected to be, a problem; Shaded - evidence is lacking, limited, or indirect; ? - not enough information available to categorize threat level; blank - not applicable

	Streams/Riparian Habitat			**Vernal Pools**			**Coastal wetlands**		**Lagoons**		**Ground-water**	**Rocky inter-tidal**	**Subtidal, Reefs, & Kelp**	**Seabirds, Pinnipeds**
Stressor	S.Mig.	S.Rosa	S.Cruz	S.Mig.	S.Rosa	S.Cruz	S.Rosa	S.Cruz	S.Rosa	S.Cruz				
Water Quality														
high N & P	OK	OK	PP	?	?	?	OK	?	OK	OK	?			
Low DO	OK	OK	OK	OK	OK	OK	?	?	OK	OK				
Turbidity	?	EP	PP	PP	PP	PP	?	?	OK	OK				
Water Quantity														
Altered depth/duration of flow	PP	PP	PP	?	?	?	PP	PP	OK	OK	?			
Pollutants														
Fecal bacteria	OK	OK	PP	OK	OK	PP	OK	PP	OK	PP	OK	OK	EP[1]	
Heavy metals/trace elements	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	EP	PP	PP
Pesticides & other organics	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	EP	PP	EP
Physical Disturbance														
Feral pigs (rooting)			EP			PP		PP		PP				
Lingering effects of past cattle & sheep	PP	EP	EP	PP	EP	PP	PP	EP	PP	PP				
Dredging/fill			EP					EP						
Road crossings	OK	EP	EP				EP	EP						
Watershed erosion	PP	EP	EP				EP	EP	EP					
Other														
Non-native flora or algae	PP	EP	EP	PP	EP	PP	PP	EP	PP	PP		PP	OK	
Elk & deer browsing		EP			PP		PP		PP					
Fishing - Direct												PP	EP	
Fishing - Indirect												PP	EP	EP[3]
El Niños	PP[2]	PP[2]	EP[2]				PP[2]	PP[2]				PP	EP	EP
Regime Shift												PP	EP	EP
Absence of sea otters													EP	
Disease												EP	EP	OK

[1]Refers to bacterial contamination at anchorages

[2]Refers to El Niño related floods, erosion, and landslides

[3]Refers to disruption of nocturnal seabird activity from squid boats (although ingestion of hooks and entanglement with gear is applicable, but not addressed in this report)