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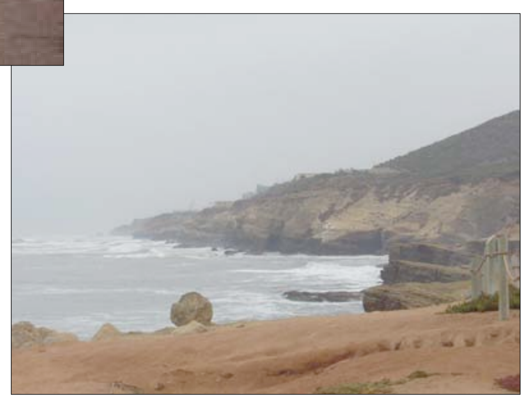
ASSESSMENT OF COASTAL WATER RESOURCES AND WATERSHED CONDITIONS AT CABRILLO NATIONAL MONUMENT, CALIFORNIA

Dr. Diana L. Engle and Dr. John Largier





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Assessment of Coastal Water Resources and Watershed Conditions at Cabrillo National Monument, California

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WATER RESOURCES DIVISION

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EXECUTIVE SUMMARY

Cabrillo National Monument (CABR, or Monument) is located at the end of the Point Loma Peninsula just seaward of the entrance to San Diego Bay. It was established in 1913 as a one-acre monument to commemorate the landing of Juan Rodriguez Cabrillo on the west coast in 1542. The Monument consists of about 160 acres of land on the southern tip of the Point Loma Peninsula, and administers an additional 128 acres of submerged land extending 900 feet from shore on the ocean side of the peninsula under agreements with the U.S. Navy and the Army Corps of Engineers. Just outside of this marine boundary, occupying water between 6-30 m deep, is the Point Loma kelp bed, which continues northward for about 7 km along the coast. A subset of the waters within the administrative boundary of CABR, extending outward from shore 150 feet, constitutes the Mia Tegner State Marine Conservation Area. The Point Loma headland rises steeply to approximately 420 feet above sea level (maximum elevation in the Monument is 422 feet), and consists of brush covered, eroded slopes and coastal cliffs. With the exception of a few unmapped seeps, there are no freshwater features within the Monument. Most of the coastline is rocky intertidal habitat, with a few small sand 'pocket' beaches. Purposes of the Monument now include preservation of an historic 1854 lighthouse, structures and facilities from WWI and WWII, viewscapes, whale-watching, and habitat preservation. Average annual public visitation is about one million persons, about 10% of whom visit the tide pools each year.

This report is a cooperative effort between the Marine Science Institute, University of California, Santa Barbara; the Department of Environmental Science & Policy, University of California, Davis; and the National Park Service. It provides a summary of the current status of aquatic resources at CABR. The purpose of this report was to examine existing information pertaining to water quality, the condition of the marine habitat and its biota, sources of point and non-point pollution in the region, avenues of transport of pollutants to monument waters, and consumptive and non-consumptive uses of monument habitat. In addition, the report identifies current information gaps and makes recommendations for addressing them.

Although the Point Loma peninsula was not intensively used by early indigenous groups, maritime resources along San Diego Bay and the open coast supported a population of prehistoric hunters and gatherers. A shell midden at Ballast Point, near the entrance to the bay, dates as early as 7830 years ago. Sharks were exploited by the early residents, as well as rocky reef and kelp bed fish. Marine mammals and sea birds were also hunted. Stands of oaks, toyon, manzanita and lemonadeberry existed on the peninsula until the mid-1800s, but were later reduced significantly by local leather tanning operations, firewood collection, construction, and terrain fires. Some families that tended the original lighthouse in the 1800s maintained sheep, cattle, horses, and small garden plots, but by the 1870s, the vegetation along the ridge crest was sparse, consisting of low, scrubby sagebrush. Cattle grazing on the open peninsula also altered ground cover and created animal trails. Currently, sensitive habitat within the federal reservation on Point Loma Peninsula receives protection via a voluntary, non-regulatory collaboration among the U.S. Navy, the U.S. Coast Guard, the National Park Service, the Department of Veterans Affairs, the City of San Diego and the U.S. Fish & Wildlife Service. The collaboration resulted in the designation of 668 acres (including 129 acres within the Monument) as the Point Loma Ecological Conservation Area, or PLECA. Land owners within PLECA restore native habitat by removing invasive species, avoiding construction, using erosion control, and planting native seedlings.

CABR was one of the first units in the National Park System to be established in proximity to an urban area. Immediately adjacent to the Monument on the peninsula are the City of San Diego's Point Loma Wastewater Treatment Plant, a U.S. Coast Guard facility with the modern-day Point Loma Lighthouse and Coast Guard housing, and the U.S. Naval Base Point Loma Complex. To the east of Point Loma lies the entrance to San Diego Bay and North Island, where the U.S. Naval Air Station is located. San Diego Bay extends approximately 14 miles along a curved axis from its entrance at Point Loma to its innermost reaches at the mouth of the Otay River in the south. A central navigation channel is maintained in the bay by dredging to accommodate relatively deep drafted vessels such as container ships, cruise liners, and Navy vessels including submarines and aircraft carriers. Several public marinas in the bay house yachts, sailboats, charter boats, and a commercial fishing fleet. A commercial port and a shipyard are located in the interior of the bay. San Diego Bay hosts four major U.S. Navy bases with approximately 80 surface ships and submarines. The cities of San Diego, National City, Chula Vista, Coronado, and Imperial Beach surround San Diego Bay.

Two rivers with large watersheds enter the Pacific Ocean in the general vicinity of Point Loma: the San Diego and Tijuana Rivers. Historically, the mouth of the San Diego River shifted back and forth from San Diego Bay to Mission Bay. In 1852, the U.S. Army constructed a dike along the south side of the river to prevent it from shifting back to San Diego Bay. Now, the San Diego River enters the Pacific Ocean through a man made channel between Mission Bay and the northern part of the Point Loma Peninsula. The Tijuana River enters the Pacific Ocean south of Imperial Beach, and drains a large watershed that is shared between the U.S. and Mexico.

The intertidal habitat administered by CABR encompasses about 1.5 km of shoreline consisting mostly of flat, gently-sloping benches with scattered, hard, metavolcanic boulders at the base of soft, eroding sandstone cliffs. The Monument provides the only public access to the shoreline at the end of the peninsula, and the tide pools are well visited. For management and monitoring purposes, the intertidal area of CABR has been divided into three zones (Zones I-III) each approximately 330 m in length. Zone I is easily accessed using a public trail from a parking lot on the coastal bluff, and experiences the highest visitation. Visitors to Zone II must hike through the rocky intertidal zone to reach Zone II, thus it receives fewer visitors than Zone I. Zone III has always received the lowest number of visitors, but was closed to visitors in late 1996 after results of the first five years of intertidal monitoring revealed serious declines, near disappearance, or disappearance of key taxa throughout the rocky intertidal area. The goal of the closure of Zone III was to allow the area to recover from the impacts of visitors.

The intertidal community at CABR has been well investigated, starting in the 1970s. Recently, diver surveys and gill net deployments (for fish) were carried out in the subtidal habitat within the administrative boundary of the Monument. Otherwise, the subtidal habitat between the low tide line at the Monument and the Point Loma kelp bed is undescribed. One hundred species of macroalgae, 247 species of marine invertebrates, and 48 species of fish (the latter includes subtidal species) are reported from CABR. The fish assemblage of CABR is a typical rocky-shore fish assemblage for the southern California mainland coast, and overall richness is comparable with other similar habitats in the San Diego region. Several fish and invertebrate species that utilize CABR habitat are targets of recreational or commercial fishing at Point Loma or in the San Diego area.

An intertidal monitoring program began at CABR in 1990. Intertidal surveys are conducted twice per year, near the spring and fall extreme low tides. Thirteen key taxa are monitored using four methodologies, which are carried out in a consistent fashion in all three zones:

1) Circular plots: size frequency of owl limpets (*Lottia gigantea*)
2) Rectangular photoplots: percent cover of thatched and acorn barnacles (*Tetraclita rubescens*, *Balanus glandula*/*Chthamalus* spp.), mussels (*Mytilus californianus*), rockweed (*Silvetia compressa*, formerly *Pelvetia fastigiata*), and goose barnacles (*Pollicipes polymerus*).
3) Point-intercept transects ("kelp transects"): percent cover of red algal turf, surfgrass (*Phyllospadix* spp.), boa kelp (*Egregia menziesii*), Sargassum weed (*Sargassum muticum*), and anemones (*Anthopleura elegantissima*/*sola*).
4) Timed searches: presence or absence of rare species (black abalone, *Haliotis cracherodii* and ochre sea stars, *Pisaster ochraceus*)

Additionally, birds and visitors are counted during a number of daytime low tides throughout the fall, winter and spring.

A prohibition on collection or harvest of intertidal organisms has been enforced at CABR since at least the 1970s. Nonetheless, the first five years of monitoring revealed that 7 of the 13 key intertidal taxa had either declined or disappeared entirely from the area. Nonconsumptive impacts of high visitation (trampling, rock overturning, poking) were believed to be responsible in part for the trend. In response, CABR management implemented the Tidepool Protection, Education and Restoration Program (TPERP) in 1996. TPERP consists of three parts: (1) education and enforcement[1], (2) monitoring and research, and (3) restoration through area closure (thus far, Zone III).

Notable trends revealed by the first fifteen years of intertidal monitoring include:

Owl limpets: Although owl limpet average size is declining in CABR, individuals of this species are particularly large in the Monument compared to other areas in southern California. Owl limpets have not been successfully recruiting into Zone III for unknown reasons.

[1]Trained volunteers and park rangers educate visitors and enforce park regulations (such as no collecting or placement of animals in containers - the "no buckets" policy).

Mussels: Mussels declined dramatically in Zones II and III between 1990 and 1995, and remain at very low levels in those areas.

Surfgrass: A dramatic expansion of surfgrass, which continued throughout much of the study period, is now slowing or reversing.

Red algal turf: Red algal turf communities are particularly impacted by human visitation of tidepools, and the closure of Zone III has resulted in higher biomass and diversity in red algal turfs in that area.

Black abalone: Black abalone are absent at CABR, although external studies indicate that this disappearance is occurring on a large scale throughout southern California.

Ochre sea stars: Ochre sea stars are absent at CABR, although they are present at points north and south of the Monument.

Seabirds and shorebirds: There is a strong negative relationship between the presence of birds and visitors in the intertidal zone.

The only shoreline water quality monitoring that takes place within the administrative boundary of CABR is for bacterial abundances (which occurs as part of the City of San Diego's Point Loma Ocean Outfall (PLOO) Ocean Monitoring Program), and water temperature (via temperature loggers located in intertidal Zones I, II, and III). Shoreline bacterial exceedances at CABR are rare, and are usually associated with extremely wet weather (for example during the exceptional rains of the 2004/2005 winter season, when rainfall events with 25- to 50-year recurrence intervals occurred in southern California). Even when a brief raw sewage overflow occurred in 2004 near the border of CABR, bacterial exceedances were observed for only three days at the site of the spill. Directly offshore from CABR, the City of San Diego also measures bacterial abundances and depth profiles of chlorophyll-a, salinity, transmissivity, pH, dissolved oxygen, and temperature five times per month at two stations along the 30-ft depth contour, and at three stations along the 60-ft depth contour.

Direct measurements of pollutants in water or sediment at CABR are lacking. Sentinel mussel programs provide indirect evidence that a suite of trace metals and synthetic organics contaminates the nearshore water column at Point Loma. In an ongoing effort, the National Oceanic and Atmospheric Administration (NOAA) sampled mussels at, or near, the end of the Point Loma peninsula (NOAA site PLLH) 13 times between 1986-2005, providing a time series for tissue levels of fifteen trace metals (Al, As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Sb, Sn, Zn); 23 different polyaromatic hydrocarbons (PAHs); PCBs; DDT and its metabolites; other biocides such as aldrin, dieldrin, endosulfan, chlordane, mirex, chlorpyrifos, and organotin; and other chlorinated hydrocarbons such as tetrachlorobenzene. The State conducted sporadic tissue analyses on mussels from several sites at or near CABR from 1981 to 1993, however organic constituents were rarely measured, and only one site was sampled more than three times. In a one year experiment at CABR, bay mussels were transplanted from an unpolluted coastal location to sites surrounding the end of the Point Loma peninsula representing a gradient of exposure to San Diego Bay water. After 2-3 month exposures, mussels were evaluated for a suite of trace elements and organics similar to those listed above.

Early results of the transplantation study (for Cu, Al, PCB101, PCB118 and fluoranthene) suggest that mussels on the *bay* side of Point Loma are not necessarily exposed to more polluted water than those on the *ocean* side of Point Loma, but that as a group, Point Loma mussels accumulate more PCBs and copper than those further north on the open coast. The NOAA time series from Point Loma suggests the following temporal trends in seawater contamination near the boundaries of the Monument.

<u>strong declines since 1986</u>:	silver, PCBs, organotin, total DDT, lindane
<u>slight decline since 1986</u>:	arsenic, copper
<u>declines since peaks in mid-1990s</u>:	aluminum, selenium
<u>slow decline after peak in 1991</u>:	total PAH, mercury
<u>no large change since 1986</u>:	zinc, cadmium, tin, lead
<u>increasing (?)</u>:	chromium and nickel

Potential sources of marine water pollution in the region are diverse. Fourteen highly urbanized watersheds in the San Diego area contribute pollutants to San Diego Bay, Mission Bay, and the coastal ocean in the general vicinity of CABR. Numerous stream and river segments, estuaries, and shoreline segments from these fourteen watersheds are on the state 303d list for impairments which include bacteria, lead, cadmium, zinc, mercury, nickel, PCBs, PAH, chlordane, diazinon, lindane, sediment toxicity, and eutrophy. There are six main routes through which pollutants may enter the coastal ocean in the general vicinity of CABR:

1) ocean outfalls for two sewage treatment plants (South Bay International Wastewater Treatment Plant, Point Loma Wastewater Treatment Plant)
2) wet weather outflow from two rivers with large watersheds (San Diego River and Tijuana River)
3) tidal flushing of San Diego Bay
4) storm drain or other runoff to the ocean along the western shore of the Point Loma Peninsula
5) illegal discharges or accidental spills from marine vessels (commercial, private, military), primarily during transit between the ocean and San Diego Bay (includes groundings and wrecks)
6) desorption from dredged material disposed at, and near, ocean disposal site LA-5 offshore from Point Loma.

In this report, background information is presented for each of these potential sources of marine pollution, selected data from monitoring or other research programs are evaluated, evidence of harmful consequences for marine biota is discussed, and the processes are examined by which pollutants from these external sources may reach the Monument's boundaries.

There is some disagreement among stakeholders as to whether the federal government or the State of California has jurisdiction over fishing in the marine habitat administered by CABR. A subset of these waters within 150 feet of shore constitutes a State Marine Protected Area - the Mia Tegner State Marine Conservation Area - within which recreational take of finfish is allowed, commercial take of finfish and marine plants is allowed, but *any* take of invertebrates is prohibited by state law. The National Park Service recognises the *existence* of the Mia Tegner SMCA and agrees that all take (commercial or recreational) of *invertebrates* is disallowed there, but contends that other (federal) law (1) extends this prohibition to the entire marine area administered by CABR, and includes finfish and marine plants as prohibited targets of commercial take. Conflicting definitions of jurisdiction notwithstanding, the Point Loma kelp beds offshore from CABR are a popular destination for recreational fishermen and dive boats. Commercial trapping for lobster and crab reportedly takes place to some degree within the administrative boundary of CABR, and some fraction of the region's commercial nearshore finfish, red sea urchin, spiny lobster, and crab catch takes place in and near the kelp offshore of CABR. For this report, state fishing regulations pertaining to particular species, and groups of species, as contained in the California Code of Regulations, and the California Fish & Game Code, were assembled into tabular tools provided as appendices. A recent review (Dayton et al. 1998) indicates that broomtail groupers, black sea bass, California sheephead, white seabass, yellowtail, elasmobranchs (rays, sharks), lobsters, abalone, and red sea urchins, in particular, show signs of overexploitation in the Point Loma kelp beds.

CABR staff do not conduct counts or interviews of recreational, shore-based anglers within the Monument, nor are counts made of fishing boats that use waters within the administrative boundary of CABR. In its database of commercial fishing effort, the California Dept. of Fish and Game assigns the waters off of CABR to one of two 10 x 10 minute blocks (referred to as "Fish & Game blocks") that together include the coastal ocean from La Jolla to south of the U.S./Mexico border. Consequently, it is difficult to discover how much of the commercial take of fish or invertebrates in the San Diego region derives from the locality of Point Loma. However, combined commercial landings for San Diego Bay and Mission Bay show that red sea urchin, California spiny lobster, swordfish, albacore tuna, and rock crab (in that order) are the most important commercial species harvested in the area, with red sea urchin far ahead of the other species. Only 8 out of the top 20 commercially important species for the San Diego area are on species lists for CABR: red sea urchin, California spiny lobster, rock crab, California sheephead, yellowtail, white seabass, and warty sea cucumber.

A somewhat different picture emerges from the recreational fishery in the San Diego area. Annual landings for the San Diego and Mission Bay harbors' Commercial Passenger Fishing Vessel (CPFV) fleet reveal that 15 of the top 23 species caught by recreational fishermen on charter boats in 2004 are on species lists for CABR. However, several of the most sought after species by the CPFV fleet, such as albacore tuna, dolphinfish, and striped marlin, are offshore species not reported from Monument waters. Finally, a sample of survey data from recreational fishermen on private boats and CPFVs (conducted by the California Recreational Fisheries Survey) that fished between 1999-2005 in waters up to 120 feet deep from the tip of Point Loma to the northern boundary of the Monument, revealed that two of the top five species caught from *CPFVs* (ocean whitefish and lingcod) are not on the CABR species list, and are normally deeper water fish. However, all of the top five species caught on *private* boats (kelp bass, barred sandbass, California halibut, California scorpionfish, and vermillion rockfish) are on the CABR species list. The difference may indicate that a high proportion of charter boats in the San Diego area target pelagic fish found offshore (such as tuna, marlin, dolphinfish, yellowtail), and thus are not utilizing nearshore habitat, such as the Point Loma kelp bed, as much as the private boats do.

Known and hypothesized stressors pertaining to aquatic resources at the Monument are summarized in Table i. Recommendations for addressing information gaps are as follows:

1. Evaluate the extent to which the San Diego Bay ebb tide jet affects water quality at CABR.

    i. Monitor the influence of tidal outflow from San Diego Bay at stations around the end of Point Loma using moored ultraviolet fluoresence sensors.

    ii. Conduct toxicity tests and larval settlement tests *using water collected specifically from the ebb tide jet.*

    iii. Evaluate the feasibility of employing drogues to identify the sources of water in the ebb tide jet from San Diego Bay, and the physical fate of the ebb tide jet at sea.

2. Measure priority pollutants in seawater within Monument boundaries using passive in-situ exposure samplers, or best available techniques.

3. Continue to work with researchers to understand larval settlement of mussels and owl limpets in Zones I, II, and III.

4. Review recent stormwater monitoring reports, and related products, for industrial stormwater permittees proximate to CABR.

5. Review the results of SCCWRP's San Diego and Tijuana River plume toxicity studies when they become public later in 2006.

6. Better utilize CODAR and OI data to understand the behavior of San Diego and Tijuana River plumes.

7. Collaborate with SDCOOS to establish a CODAR station that would reveal surface currents in areas along the outer coast of the Point Loma peninsula which are currently in the shadow of the existing CODAR array.

8. Conduct interviews with shore-based anglers to determine fish species caught from shore. Count fishing boats that use waters within the administrative boundary of CABR.

9. Determine the numbers of red sea urchins and California spiny lobsters caught within the administrative boundary of CABR to aid in the assessment of the impact of the commercial fisheries on CABR resources.

10. Survey available information about the condition of the groundwater on the Point Loma Peninsula, its extent, and whether it could influence the rocky intertidal areas.

11. Survey resources available to reconstruct past changes in the extent of sand coverage at CABR, and to monitor future changes in sand coverage.

12. Investigate the feasibility of using mineral fingerprints to identify the sources of sand that appear at CABR.

Table i. Existing and hypothesized stressors for the aquatic resources at Cabrillo National Monument. 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 level of threat; blank - not applicable.

Stressors and Contributors	Ground-water	Rocky intertidal	Subtidal habitat
Fecal bacteria			
PLOO - operating normally		OK	OK
Sewage Spills/Outfall Pipe Break		EP	EP
San Diego and Tijuana Rivers		OK	OK
San Diego Bay outflow		PP	PP
SBOO		OK	OK
Infiltration or Runoff from Peninsula	?	EP	EP
Dredging		OK	OK
Marine Vessels		OK	OK
Chronic exposure to metals and organics			
PLOO - operating normally		PP	PP
Sewage Spills/Outfall Pipe Break*			
San Diego and Tijuana Rivers		PP	PP
San Diego Bay outflow		EP	EP
SBOO		PP	PP
Infiltration or Runoff from Peninsula	PP	?	?
Dredging		?	?
Marine Vessels		PP	PP
Acutely toxic exposures to metals and organics			
PLOO - operating normally		OK	OK
Sewage Spills/Outfall Pipe Break		PP	PP
San Diego and Tijuana Rivers		OK	OK
San Diego Bay outflow		OK	OK
SBOO		OK	OK
Infiltration or Runoff from Peninsula	?	?	?
Dredging		?	?
Marine Vessels		PP**	PP**
Other stressors			
Fishing***		OK	PP
Visitation		EP	OK
Disease		PP	PP

*considers sewage spills and pipe breaks as temporally restricted events, thus not potential sources of chronic exposure

**considers cargo or fuel spills

***includes invertebrates, plants, fish

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ABLM……………. Ambient Bay and Lagoon Monitoring Program
CABR……………. Cabrillo National Monument
Cal EPA………….. California Environmental Protection Agency
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
City………………. City of San Diego
CODAR…………... Coastal Ocean Dynamics Applications Radar
Commission……… California Fish and Game Commission
CPFV…………….. Commercial Passenger Fishing Vehicle
CRFS…………….. California Recreational Fishing Survey
CRIMP……………. Cabrillo Rocky Intertidal Monitoring Program
CSD………………. City of San Diego
CSDM ……………. Coastal Storm Drain Outfall Monitoring Program
CTD………………. Conductivity/Temperature/Density instrument
DBT………………. Dibutyltin
DDD……………… Dichloro-diphenyl-dichloroethane
DDE………………. Dichloro-diphenyl-dichloroethylene
DDT……………… Dichloro-diphenyl-trichloroethane
DEH………………. San Diego County Department of Environmental Health
DFME…………….. Diesel Fuel Marine Equivalent
EEZ……………….. United States Exclusive Economic Zone
ERL………………. Effects Range Low
ERM……………… Effects Range Medium
FGC……………… Fish & Game Code
HA………………... Hydrologic Area
HCH………………. Hexachlorocyclohexane
HSA………………. Hydrologic Subarea
HU……………….. Hydrologic Unit

IWTP…………….. South Bay International Wastewater Treatment Plant
MBT……………… Monobutyltin
MEP……………… Maximum Extent Practicable
MGD……………… Million Gallons per Day
MHHW…………… mean higher high water
Mia Tegner SMCA.. Mia Tegner State Marine Conservation Area
MLLW……………. mean lower low water
MLPA…………….. Marine Life Protection Act
MLS………………. Mass Loading Station
MODIS…………… Moderate Resolution Imaging Spectroradiometer
MOU……………… Memorandum of Understanding
MRPA……………. Marine Resources Protection Act
MS4………………. Municipal Separate Storm Sewer System
Navy……………… U.S. Navy
NMFS…………….. 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
NS&T…………….. National Status and Trends
OI………………… Ocean Imaging Corporation
PAH………………. Polycyclic aromatic hydrocarbons
PCB………………. polychlorinated biphenyl compounds
PFMC…………….. Pacific Fishery Management Council
PLECA…………… Point Loma Ecological Conservation Area
PLOO ……………. Point Loma Ocean Outfall
PLWTP…………… Point Loma Wastewater Treatment Plant
Port………………. San Diego Unified Port District
POTW……………. Publically Owned Treatment Plant
ppb………………... parts per billion
ppt………………… parts per thousand
PSMFC…………… Pacific States Marine Fisheries Commission
RCG………………. Rockfish/Cabezon/Greenling
Region 9………….. San Diego Regional Water Quality Control Board
RHMP……………. Regional Harbor Monitoring Program
RWQCB………….. Regional Water Quality Control Board
SANDAG………… San Diego Association of Governments
SBOO…………….. South Bay Ocean Outfall

SCB………………. Southern California Bight
SCCOOS…………. Southern California Coastal Ocean Observing System
SCCWRP…………. Southern California Coastal Water Research Project
SDCOOS…………. San Diego Coastal Ocean Observing System
SDMWD………….. City of San Diego Metropolitan Wastewater Department
SDRWQCB………. San Diego Regional Water Quality Control Board
SIYB……………… Shelter Island Yacht Basin
SLC ………………. California State Lands Commission
State Board……….. California SWRCB
SWMP……………. Storm Water Management Plan
SWRCB…………... State Water Resources Control Board
TBT………………. Tributyltin
TAMT…………….. Tenth Avenue Marine Terminal
TMDL……………. Total Maximum Daily Load
TPERP……………. Tidepool Pretection, Education, and Restoration Program
TSS……………….. Total Suspended Solids
USCG…………….. U.S. Coast Guard
USEPA…………… U.S. Environmental Protection Agency
USFWS…………… U.S. Fish & Wildlife Service
USGS…………….. U.S. Geological Survey
UVF………………. Ultraviolet fluorescence
VIP……………….. Volunteers in Parks
WMA……………... Watershed Management Area

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I. PARK DESCRIPTION

A. Background

A.1. Location and Key Features

Cabrillo National Monument (CABR, or Monument) is located at the end of the Point Loma Peninsula directly seaward of the entrance to San Diego Bay. CABR was established on October 14, 1913, by Presidential authorities in the 1906 'Antiquities Act' as a one-acre monument within military lands. It was originally established to commemorate the first presence of Europeans on the West Coast: Juan Rodriguez Cabrillo and his landing in 1542. Following a War Department reorganization, the parcel was transferred to the Department of the Interior in 1933 and subsequently enlarged by Presidential proclamations and transfers from the U.S. Navy (Kelly and May 2001).

Purposes of the Monument now include preservation of an historic 1854 lighthouse, structures and facilities from WWI and WWII, viewscapes, whale-watching and habitat preservation. Average annual public visitation is about one million persons, about 10% of whom visit the tide pools each year within monument boundaries. The lighthouse was the first of eight constructed for America's west coast and is a National Historic Landmark. Other historic military structures and facilities within the monument are included within a listed National Register Historic District.

The Monument contains 160 acres of land, and administers approximately 1.5 km of rocky intertidal habitat and an additional 128 acres of submerged land wrapping around the tip of the peninsula (Figure 1). Elevation within the Monument ranges from tidal zones to about 430 feet above sea level. The upland consists of brush-covered, eroded slopes. The coastline is irregular with only a few small sand 'pocket' beaches along the western tidepool zone and bedrock seacliffs around the remaining shoreline. The Point Loma Peninsula is classified as a Mediterranean semi-arid steppe moderated by ocean influences such as fog and winds. Rainfall occurs primarily from December to April, and averages 10.6 inches per year. Typical native plants are lemonadeberry, madrone, toyon, cacti species, Shaw's agave, and sages. Exotic plants include iceplant, non-native grasses, bottlebrush, and ivy. Predominant vegetation categories within CABR are Maritime Succulent Scrub, Diegan Coastal Sage Scrub, and Southern Coastal Bluff Scrub. Predominant vegetation types on the Point Loma Peninsula are Maritime Succulent Scrub, Southern Maritime Chaparral and Diegan Coastal Sage Scrub (Figure 2).

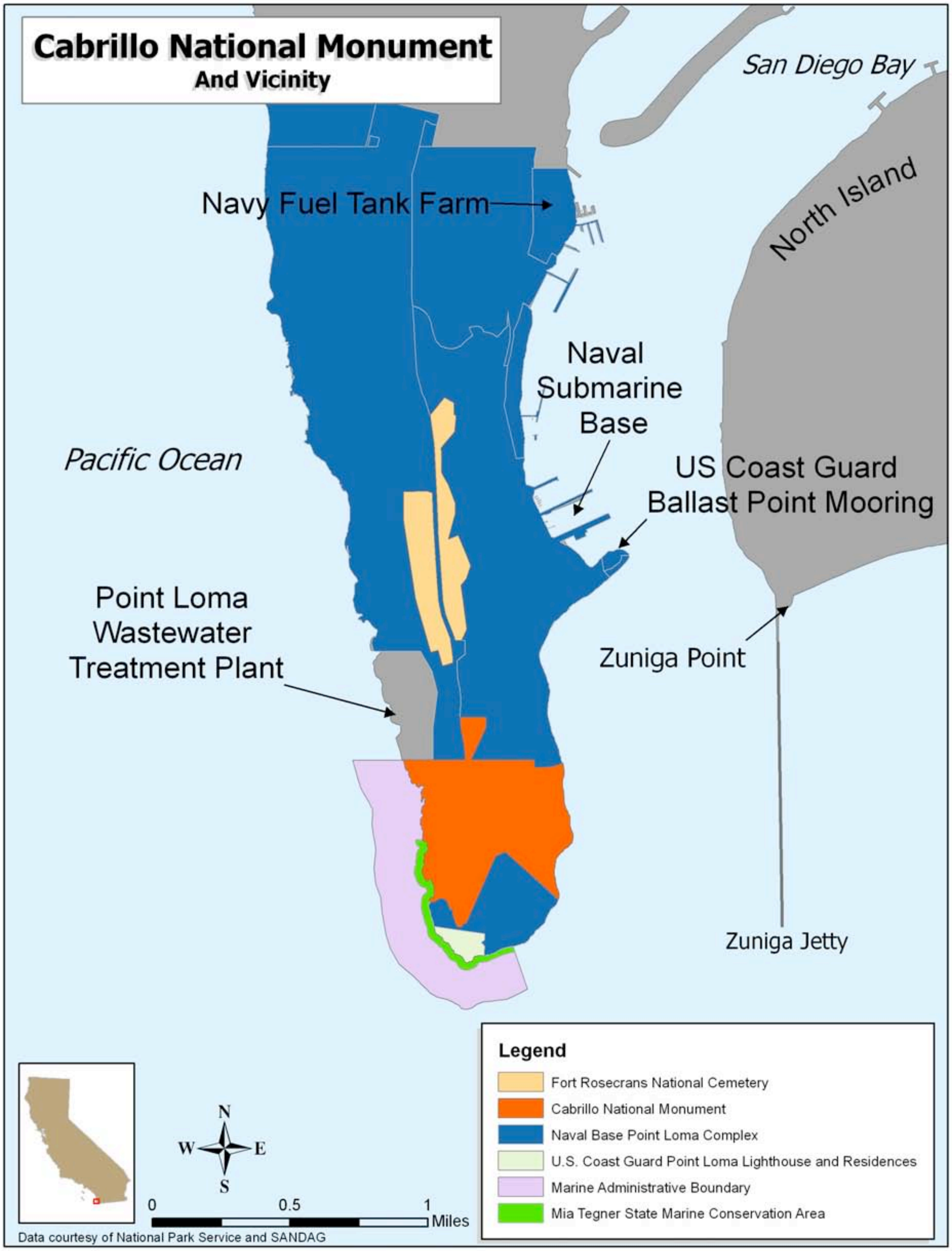

Figure 1. Location of Cabrillo National Monument on the Point Loma Peninsula.

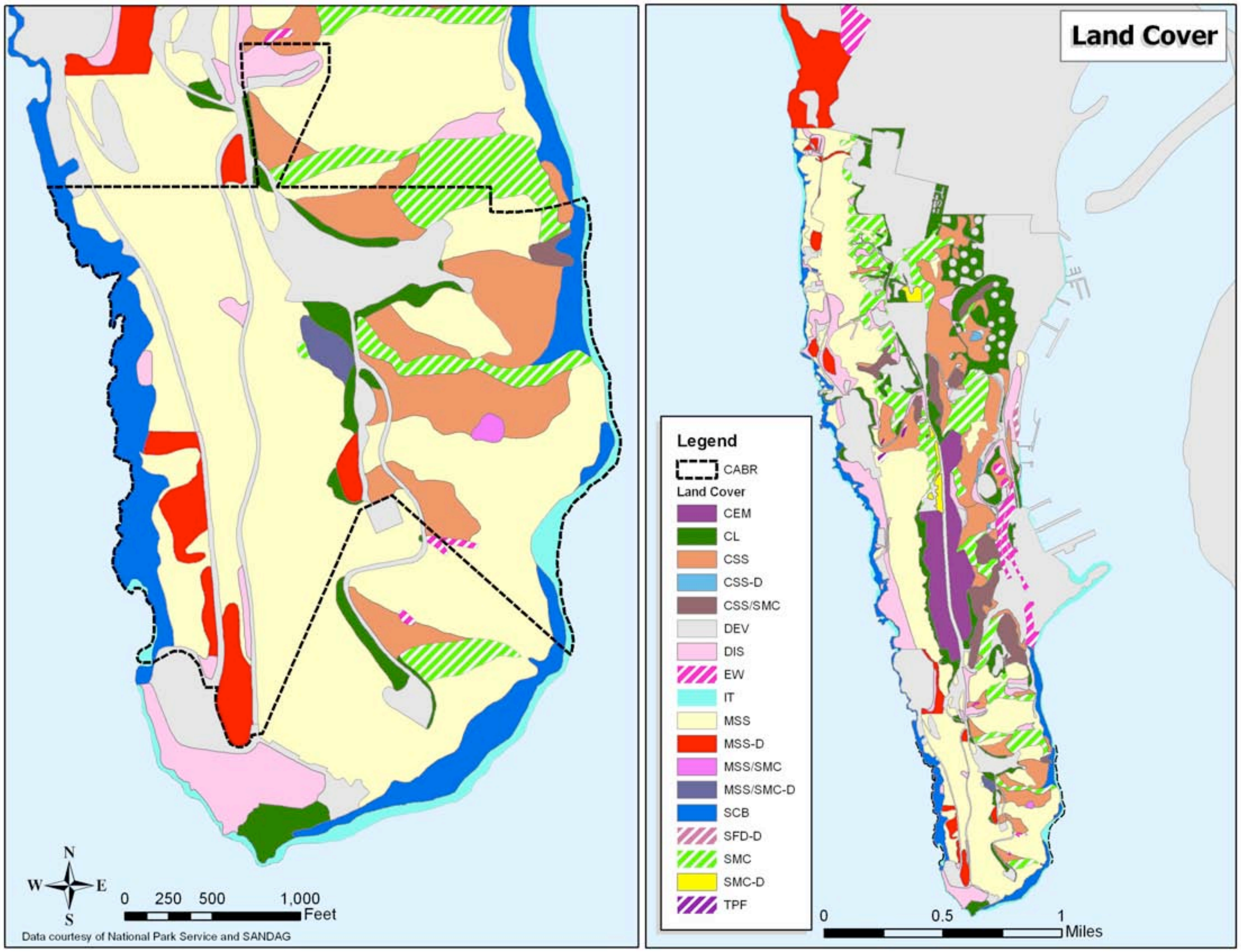

Figure 2. Land cover at Cabrillo National Monument and the Point Loma Peninsula. Categories are as follows: CEM=cemetery, CL=Cultivated/Landscape, dCSS=Diegan Coastal Sage Scrub, CSS-D=Disturbed Diegan Coastal Sage Scrub, CSS/SMC=Diegan Coastal Sage Scrub/Southern Maritime Chaparral, CSS/SMC-D=Disturbed Diegan Coastal Sage Scrub/Southern Maritime Chaparral, DEV=Developed, DIS=Disturbed, EW=Eucalyptus Woodland, IT=Intertidal, MSS=Maritime Succulent Scrub, MSS-D=Disturbed Maritime Succulent Scrub, SCB=Southern Coastal Bluff Scrub, SFD-D=Disturbed Southern Foredune, SMC=Southern Maritime Chaparral, SMC-D=Disturbed Southern Maritime Chaparral, TPF=Torrey Pine Forest-Cultivated

CABR was one of the first units in the National Park System to be established in proximity to an urban area. The following facilities are immediate neighbors of CABR on the Point Loma Peninsula: (1) City of San Diego's Point Loma Wastewater Treatment Plant (PLWTP), (2) the Point Loma Lighthouse and U.S. Coast Guard residences, (3) U.S. Coast Guard Ballast Point Mooring, and (4) the Naval Base Point Loma (NBPL) Complex. The NBPL Complex is located along the eastern and western shores of the Point Loma Peninsula from Ballast Point to Taylor Street. It includes the following facilities:

(1) Naval Submarine Base, San Diego,

(2) Magnetic Silencing Facility,

(3) Fleet Anti-Submarine Warfare Training Center, Pacific,

(4) Space and Naval Warfare Systems Center, San Diego, Point Loma Campus,

(5) Fleet Combat Training Center, Pacific,

(6) Fleet and Industrial Supply Center and Navy Fuel Tank Farm, Pt. Loma.

San Diego Bay is a natural, crescent-shaped embayment extending approximately 14 miles along a curved axis from its entrance at Point Loma in the north to its innermost reaches at the mouth of the Otay River in the south (Figure 3). The bay has been extensively modified by dredging and filling. The surface area of the bay is now approximately 19 square miles. The width of the bay currently ranges from 0.25 to 2.5 miles. Depths average less than 40 feet, but range from more than 60 feet in some northern areas to only a few feet in much of the southern portion. A central navigation channel is maintained by dredging to accommodate relatively deep drafted vessels such as container ships, cruise liners and Navy vessels, including submarines and aircraft carriers. Several public marinas house yachts, sailboats, whale watching boats, and fishing boats. A commercial port and a shipyard are located in the interior of the bay. San Diego Bay hosts four major U.S. Navy bases with approximately 80 surface ships and submarines (SDRWQCB 1997). The cities of San Diego, National City, Chula Vista, Coronado, and Imperial Beach surround San Diego Bay (Figure 4).

Two rivers with large watersheds enter the Pacific Ocean in the general region of Point Loma: the San Diego and Tijuana Rivers. Historically, the mouth of the San Diego River shifted back and forth from San Diego Bay to Mission Bay. In 1852, the U.S. Army constructed a dike along the south side of the river to prevent it from shifting back to San Diego Bay. Now, the San Diego River enters the Pacific Ocean through a man made channel that runs between the southern shore of Mission Bay and the northern part of the Point Loma Peninsula. The Tijuana River enters the Pacific Ocean south of Imperial Beach, and drains a large watershed that is shared between the U.S. and Mexico.

The promontory of Point Loma was formed from 300-foot uplift motion along a major fault line. A basal Point Loma Formation is superimposed by the Cabrillo Formation of sandstones and conglomerates, and the visible, younger Bay Point Formation that forms marine terraces and uplands. The Point Loma Formation was formed 70 to 80 million years ago from Cretaceous Period deep ocean deposits and extends from northern Baja California to about Carlsbad, California. The Cabrillo Formation is also of deep marine origin (66 to 70 million years old) and has two characteristic beds: a thick layer of cobbles, gravels and boulder conglomerate and a sandstone layer. The Cabrillo Formation is eroded into undercut seacliff caves and ledges.

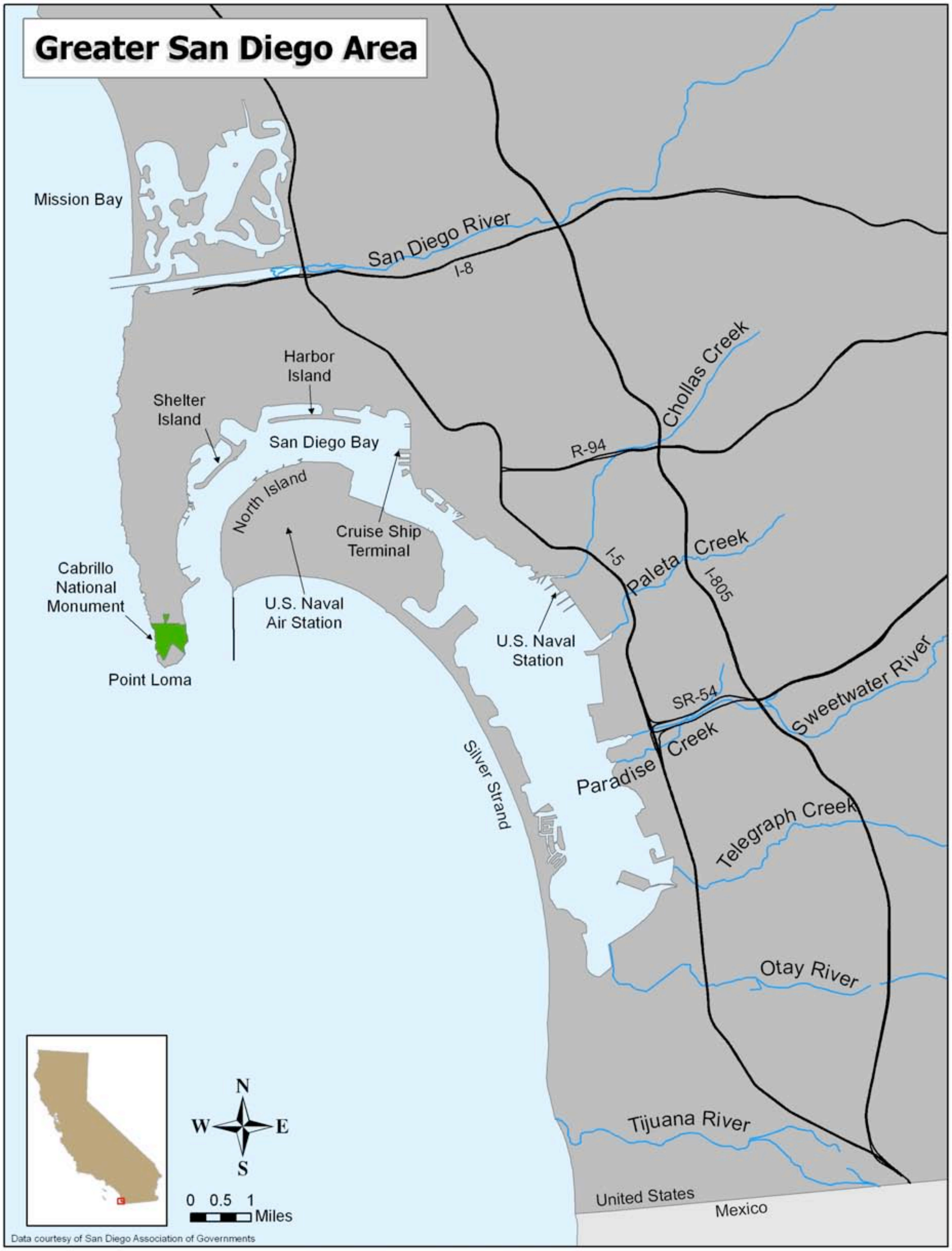

Figure 3. The greater San Diego area.

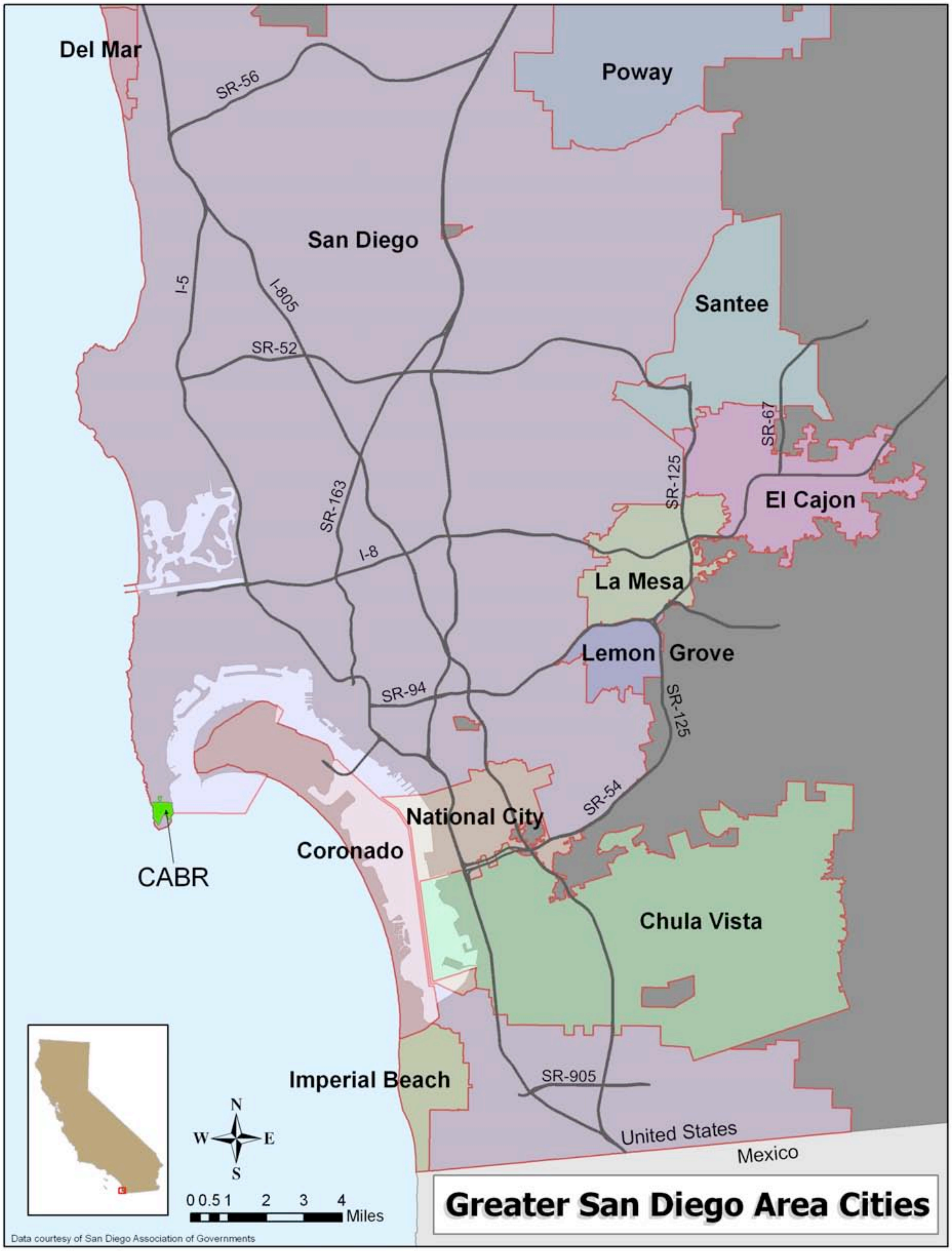

Figure 4. Municipalities in the San Diego area.

Forming coastal terraces on both sides of the peninsula, the Bay Point Formation supports coastal sage scrub, cacti and marine succulents, chaparral, oak, Torrey pines, and introduced vegetation. This formation is composed of marine and non-marine sandstone beds, but is not very old (120,000 to 400,000 years old).

The peninsula was an island during an interglacial period about 120,000 to 140,000 years ago but became connected to the mainland by westward growth of a delta created by the San Diego River less than 11,000 years ago. At that time, San Diego Bay was a valley with marshy wetlands and Point Loma was an inland mountain. Sea level rose five meters to flood the Point Loma River Valley, creating San Diego Bay. Between 4,500 and 3,500 years ago, coastal erosion caused shoreline retreat. Coastal bluffs formed around Point Loma with avalanches and scouring of former river cobbles.

A.2. Jurisdictions, Regulatory Bodies and Management Entities

On February 26, 1852, an Executive Order was signed which withdrew Point Loma from California state lands and transferred it to the federal government. California ceded its authority over Point Loma and its offshore lands (to 900 feet seaward of the mean lower low tide line) to the U.S. government for use as a military reservation. Using this basis, Point Loma and the offshore lands are under federal jurisdiction. Although the monument boundary ends at the mean high tide line, the National Park Service (NPS) has a Memorandum of Agreement (MOA) in place with the U.S. Navy (which claims waters to the west of the Monument), and a similar agreement is currently being renewed with the U.S. Army Corps of Engineers (which claims waters to the south of the Monument) (Figure 5), for the NPS to have administrative jurisdiction over federally claimed waters at Point Loma. The authority for these agreements is granted through 16 USC 17j-2 (b), which allows the National Park Service to expend its funds for "administration, protection, improvement, and maintenance of areas under the jurisdiction of other Agencies of the Government, devoted to recreational use pursuant to cooperative agreements" (Andrea Compton, Chief of Natural Resource Science, CABR, pers. comm.). For the purposes of this report, the seaward boundary of these federally-claimed waters is referred to as the "administrative boundary", or the "marine boundary" of CABR (Figure 1). Owing to the federal Submerged Lands Act of 1953 (CFR Title 43, Chapter 29, Subchapter II), which granted to coastal states control of the submerged lands and waters within 3 nautical miles of the U.S. coastline, there is a lack of consensus among stakeholders about whether the State or the federal government has authority over the submerged lands and waters from shore to 900 feet at Point Loma. In Section III.B., the regulation of fishing at Point Loma is discussed using both the state and the federal perspectives.

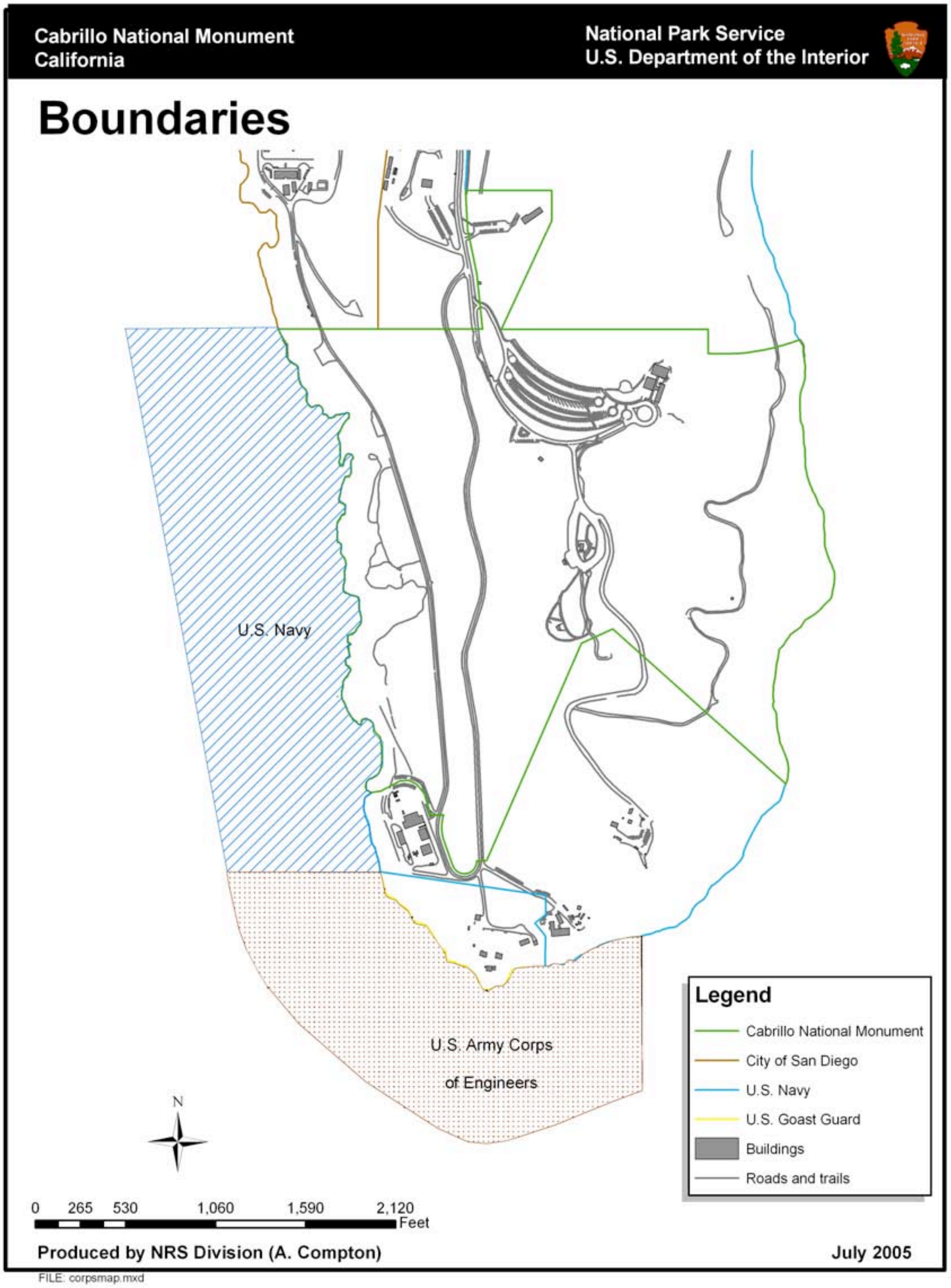

Figure 5. Roads, buildings, and property boundaries at Point Loma (figure is courtesy of Cabrillo National Monument).

CABR is located in San Diego County, and is within the boundaries of the City of San Diego (CSD, or the City). Listed below are other federal, state and local entities which exercise authority over the Point Loma Peninsula and the marine resources in or near CABR. Because the marine boundary of CABR is well within state waters, entities that manage the living and non-living resources only *outside* of state waters (such as the National Marine Fisheries Service[2]) are not listed below.

California State Lands Commission (SLC)

The SLC has jurisdiction over all of California's tide lands and submerged lands up to three nautical miles from the California shore (state waters), and the beds of naturally navigable rivers and lakes (the latter are not pertinent to CABR).

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.

US Fish & Wildlife Service (USFWS)

The USFWS is responsible for protecting and conserving freshwater and estuarine fisheries, certain marine mammals (southern sea otter, walrus, manatees, and polar bears), migratory birds, seabirds, sea turtles on shore, and 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 Endangered 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 Commisson 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.

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[2]The National Marine Fisheries Service (NMFS) is required by several acts of Congress to provide scientific and technical services and products to support the marine fisheries management and conservation operations of the United States. The NMFS carries out federal fishery acts by coordinating and approving fishery management plans, implementing regulations, and promoting other activities that conserve and protect the marine resources within the 200-mile United States Exclusive Economic Zone (EEZ).

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

The CF&G 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 Pacific Fisheries Management Council[3]. CF&G enforces the regulations created by the Commission, which apply to state waters (within 3 nautical miles from land). CF&G establishes seasons, methods, and limits for harvest in state waters. Ocean sportfishing regulations are provided in Fish & 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. *California fishing regulations (such as the State's Nearshore Fishery Management Plan) must be consistent with federal law for species managed by the Pacific Fishery Management Council.* There is some disagreement about whether the State or the federal government has jurisdiction over recreational and commercial fishing within the administrative boundary of CABR. This is discussed in Section III.B.1.

Mia Tegner State Marine Conservation Area

The Mia Tegner State Marine Conservation Area (Mia Tegner SMCA) was created in 2004 by a state regulatory act that redesignated dozens of previously existing state marine reserves to conform with the Marine Life Protection Act (MLPA)[4]. The regulatory action (among other things) repealed the previous Point Loma Reserve (which was established in 1978), and created the Mia Tegner SMCA in its place[5]. The Mia Tegner SMCA extends seaward 150 feet from the mean high tide line along the Point Loma coastline within the administrative boundary of CABR (Figure 1). Depth range is ~0-6 feet, and total area is 0.01 square nautical miles. The primary objective of the Mia Tegner SMCA is to protect intertidal and shallow subtidal marine populations at CABR. Within this conservation area, state law

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[3] **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 purpose of the acts are to provide conservation and management of fishery resources, develop domestic fisheries, and phase out foreign fishing activity within the EEZ consisting of ocean waters from the edge of state waters (3 miles) to 200 miles offshore. Eight Regional Fishery Management Councils implement the goals of the Act in coordination with the National Marine Fisheries Service. 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 (4/2006) 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. For more, see http://www.pcouncil.org/.

[4] The MLPA is found 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.

[5] The Point Loma Reserve was originally described in CCR Title 14, Division 1, Subdivision 1, Chapter 14, Article 1, Section 27.50, but is now repealed.

prohibits (1) the recreational take of marine plants and invertebrates, and (2) the commercial take of marine invertebrates.

Pacific States Marine Fisheries Commission (PSMFC)

The PSMFC was authorized by an act of Congress and includes representatives from the Pacific coastal states from Alaska to California. Membership in the PSMFC is set by law to include government and industry leaders and a host of fishing industry advisors from each state. The PSMFC has no management authority. It coordinates data collection, research, funding and addresses issues of concern regarding fisheries amongst its member states. The PSMFC provides project coordination for catch monitoring for both sport and commercial fisheries. In conjunction with CF&G, the PSFMC developed the California Recreational Fishing Survey (CRFS), which conducts dockside, shoreline, and on-boat surveys to characterize recreational fishing effort from shore, man-made structures, private boats, and charter boats.

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 the nine Regional Water Quality Control Boards (RWQCBs), CalEPA regulates offshore drilling activities, discharges from cruise lines, ocean dumping, point- and nonpoint-source pollution, stormwater and wastewater discharge programs. CABR, and its environs, are under the jurisdiction of the San Diego RWQCB, or *Region 9*.

U.S. Navy (Navy)

The U.S. Navy owns much of the Point Loma Peninsula, some of the submerged land adjacent to CABR, and much of North Island, on the other side of San Diego Bay, where the U.S. Naval Air Station is located.

U.S. Coast Guard (USCG)

The USCG operates two facilities adjacent to CABR: (1) the Point Loma Lighthouse on the end of the peninsula (maintained by the Coast Guard Aids to Navigation Team, San Diego) and private residences, and (2) the Ballast Point Mooring, just seaward of the U.S. Naval Submarine Base inside San Diego Bay. In addition, the USCG is the principal entity that enforces regulations concerning marine vessel discharges.

U.S. Environmental Protection Agency (USEPA)

The USEPA 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.

San Diego Association of Governments (SANDAG)

Regional planning in the San Diego area is conducted by SANDAG, which is governed by a Board of Directors composed of mayors, council members, and a county supervisor from each of the region's 19 local governments. Supplementing these voting members are advisory representatives from Imperial County, the U.S. Department of Defense, Caltrans, San Diego Unified Port District, Metropolitan Transit System, North County Transit District, San Diego County Water Authority, and Mexico.

San Diego Unified Port District (Port of San Diego, or Port)

The Port of San Diego is a special government entity, created in 1962 by an act of the California legislature, that administers approximately 5500 acres, or 37%, of the tidelands in San Diego Bay (Figure 6). The Port of San Diego has the authority to protect, preserve, and enhance physical access to the bay, the natural resources of the bay, and the quality of water in the bay. The Port's jurisdiction includes both historic tidelands, existant tidelands, and submerged lands. The Port of San Diego periodically conducts dredging operations to maintain the depth of the central navigation channel of San Diego Bay.

Point Loma Ecological Conservation Area (PLECA)

PLECA is a voluntary, non-regulatory collaboration among the Commander, Navy Region Southwest, the Coast Guard, the NPS, Department of Veterans Affairs, the City of San Diego and the USFWS to cooperatively oversee conservation and enhancement of sensitive habitats on 668 acres on the southern portion of the Point Loma Peninsula (Figure 1). Of these, 129 acres are within CABR. The area was initially set up in 1993 as the Point Loma Ecological Reserve. When a Memorandum of Understanding was renewed in 2005, it was renamed the Point Loma Ecological Conservation Area (MOU 2005). PLECA is intended to protect sensitive biological communities on Point Loma and ensure their long-term viability and perpetuation, avoid incremental habitat loss, and provide for long-term habitat conservation. PLECA is also intended to serve as long-term, in-place, mitigation that allows the signatories to accomplish their diverse missions while complying with pertinent environmental laws, in particular the National Environmental Policy Act and the California Environmental Quality Act. The current agreement is valid through 2015.

The members of PLECA restore native habitat by removing invasive species, using erosion control, planting native seedlings, and monitoring for re-emerging exotic species. Most new construction and projects are designed to avoid impacting the conservation area. New road construction is discouraged to prevent further fragmentation of the reserve. Existing security measures continue to allow only limited public access. If any impacts are proposed, the impacts are mitigated by adding land to the conservation area or improving lower quality habitats within PLECA. To date (2006), there has been only one instance where habitat was impacted within PLECA, and additional land was subsequently transferred into the PLECA to mitigate that loss.

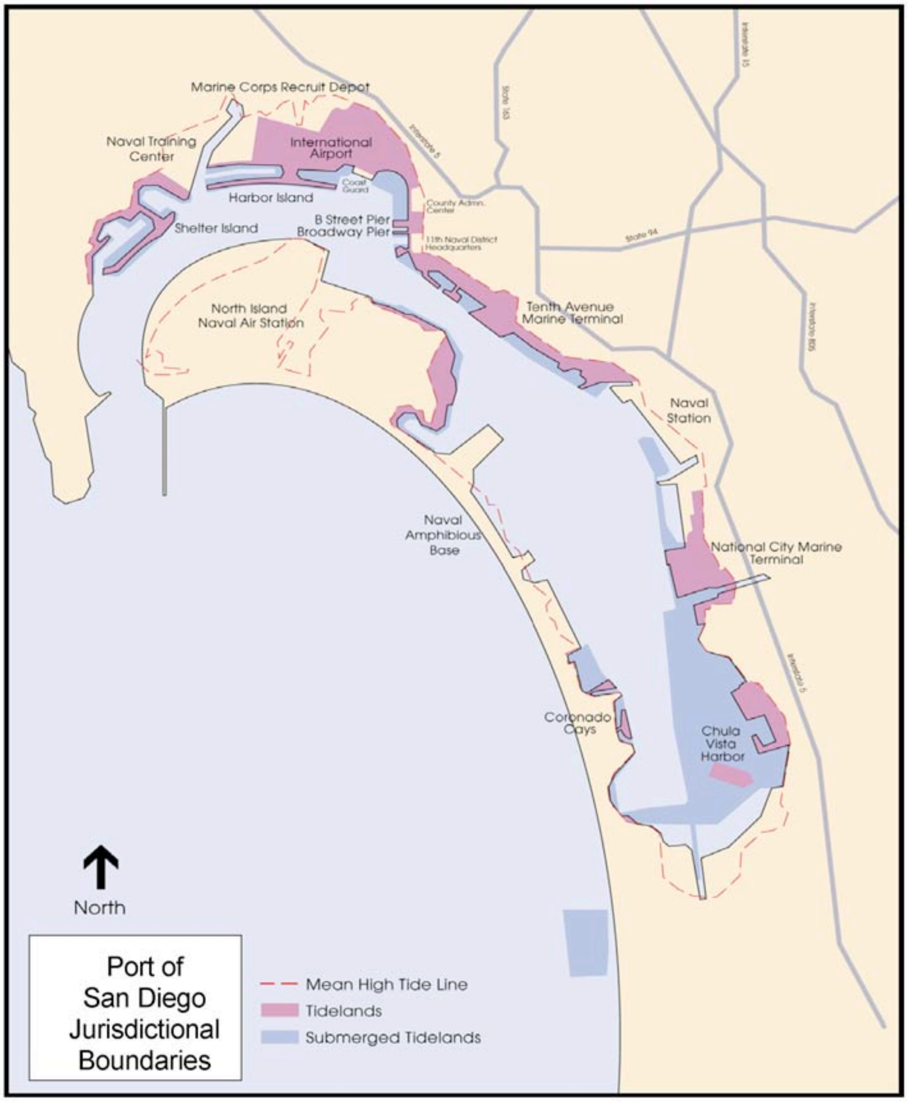

Figure 6. Port of San Diego jurisdictional boundaries (from PSD 2005). Mean high tide line is the historic mean high tide line, before filling and dredging operations created the current configuration of the bay.

A.3. Human Utilization

[drawn from Kelly & May (2001)] Shell middens in the San Diego area began to develop at least 9,000 years ago, when the weather cycles and moisture regimes were quite different from today. Clearly defined settlement systems developed in San Diego County and along the Baja California coast after 8500 years ago. The large shell middens that formed along the bluffs and shorelines are rich in marine shells, splintered food bones, charred seeds and plant remains, crudely flaked cutting and chopping tools, and milling equipment.

The earliest prehistoric culture to set foot on Point Loma appears to have come from the Great Basin and Lake Mohave area of the Colorado Desert between 7,000 and 12,000 years ago. A shell midden at Ballast Point dates as early as 7830 years ago, fourteen other radiocarbon dates indicate that the site was occupied primarily between 3510±90 and 1550±80 years ago. Exploitation at Ballast Point developed a diverse shark fishing industry quite distinct from other coastal sites in San Diego and Orange County to the north. Other fish remains from Ballast Point are rocky reef and kelp bed species. Although land mammals were present on Point Loma and North Island, hunting emphasized adult sea mammals and sea birds.

From ancient times, maritime resources from the bay and coast supported a reasonable population, perhaps 5 to 7 persons per square mile. These people were hunters and gatherers residing in villages, and interacted with their mountain and desert-dwelling relatives through trade, marriage and kin connections. Small, sparse and eroded scatters of shell middens, a discovery of one human burial within Fort Rosecrans in the 1960s, and an occasional isolated stone artifact indicate that the southern area of the Point Loma Peninsula was not intensively used by early indigenous groups. Stands of oaks, toyon, manzanita and lemonadeberry existed on the peninsula until the mid-19th century, but were later reduced significantly for local leather tanning operations, firewood collection, construction, and terrain fires. Cattle grazing on the open peninsula lands in the 1800s also altered ground cover and created animal trails.

In the 1850s, the promontory was recognized for strategic values by the United States. The southern portion was made a military reservation by Presidential Executive Order in February 1852, followed by a smaller land reservation established for a lighthouse in September 1852. From the 1850s, the magnificent views from the lighthouse area were attractive to local people. For a short period, whale spotters used the vantage point to identify whale pods, alerting hunters at the Ballast Point whaling station. In 1855, four Utah men were granted a 15 year lease by the San Diego Board of Supervisors "to open and work a coal mine" on Point Loma. During 1856-57, the 'San Diego Coal Company' attempted to develop the coal veins without success, and the company leaders returned to Salt Lake City in November 1857. Although included within federal lands, the shaft of the "Mormon Coal Mine" remained open until 1960 when the location was developed for Atlas missile testing facilities. This land is now used by the San Diego City Point Loma Wastewater Treatment Plant.

Excursions and visits to the lighthouse were made by San Diego citizens who drove buggies or wagons up the 1857 road. Some lighthouse families kept sheep, cattle, horses, and small garden plots near the buildings, but by the 1870s the vegetation along the ridge crest was sparse, consisting of low, scrubby sagebrush, probably because of impacts from livestock. The original lighthouse was abandoned in 1854, and replaced by a facility (commissioned in 1891) at lower elevation on the tip of the peninsula, which is still operated by the U.S. Coast Guard.

In 1913, President Wilson signed a proclamation designating one-half acre as the Cabrillo National Monument, but military use of the old lighthouse structure and its locality continued. Along the western ocean terraces of the peninsula, a road leading to the lower Point Loma lighthouse was in place and shown on a 1904 USGS map. This road, later known as Gatchell Road, was improved during World War I when Army coastal searchlights and a powerhouse were built. The western portion of the monument became more intensively utilized and altered for coastal defense and for lighthouse operation. By the 1920s, the old lighthouse was a military radio station and later, a tourist destination. In 1931, the lighthouse was renovated, and informal visitor use continued into the 1930s.

In 1933, a National Park Service official visited the location for the first time and recommended restoration of grounds and the structure, which took place between 1935 and 1937. Following WWII, the monument was increased in size, and public programs expanded. Custodian Donald Robinson was appointed Superintendent in 1956 and the unit began to develop its own management directions. By the 1960s, the Monument's neighbors included various Navy program facilities and the City of San Diego's sewage treatment plant. A one-story visitor center with administrative offices, auditorium, enclosed viewing and sales area and restrooms was dedicated in August 1966. By the 1980s, Park Service management plans, environmental analyses, an administrative history, an historic structure report on the lighthouse, a resources management plan, and specific cultural resources studies had been completed.

Currently, almost a million persons visit CABR annually, making it the third most visited National Monument in the country (Andrea Compton, Chief of Natural Resource Science, CABR, pers. comm.). Current facilities include: the visitor center (View Building) with an information desk and store, exhibit area on Cabrillo and the Age of Exploration, a 135 seat auditorium and accessible restrooms; the Bayside Trail with interpretive wayside exhibits; the refurnished 19th century Old Point Loma Lighthouse, remodeled Assistant Lighthouse Keeper's Quarters with an exhibit on Pacific Coast lighthouses, and adjacent comfort station; a 20th century U.S. Army Radio Station with exhibits on Fort Rosecrans coast defense system; a Whale Overlook with wayside exhibits; two maintenance facilities; administrative offices in the visitor center complex and in Battery Ashburn (South) owned by the Space and Naval Warfare Systems Center, San Diego; the new entrance station, north of the intersection of Cabrillo Memorial Drive and Cabrillo Road; and a trail that leads from a lower parking lot down the coastal bluff to the Monument's intertidal zone. Becker (2006) estimated that annual visitation to the Monument's tide pools is approximately 60,000 (in Zone I), 12,500 (Zone II), and 1000 (Zone III)[6].

B. Hydrologic Setting

B.1. Coastal Ocean

(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 7). 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 Santa Barbara Channel, which runs east to west. Circulation in the Bight is complex owing to its composite bottom topography. Any water flow entering the 12 basins making up the Southern California 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).

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[6] Zones I-III are administrative zones established by CABR to manage and monitor the intertidal habitat (see Section I.C.3).

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 advecting 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).

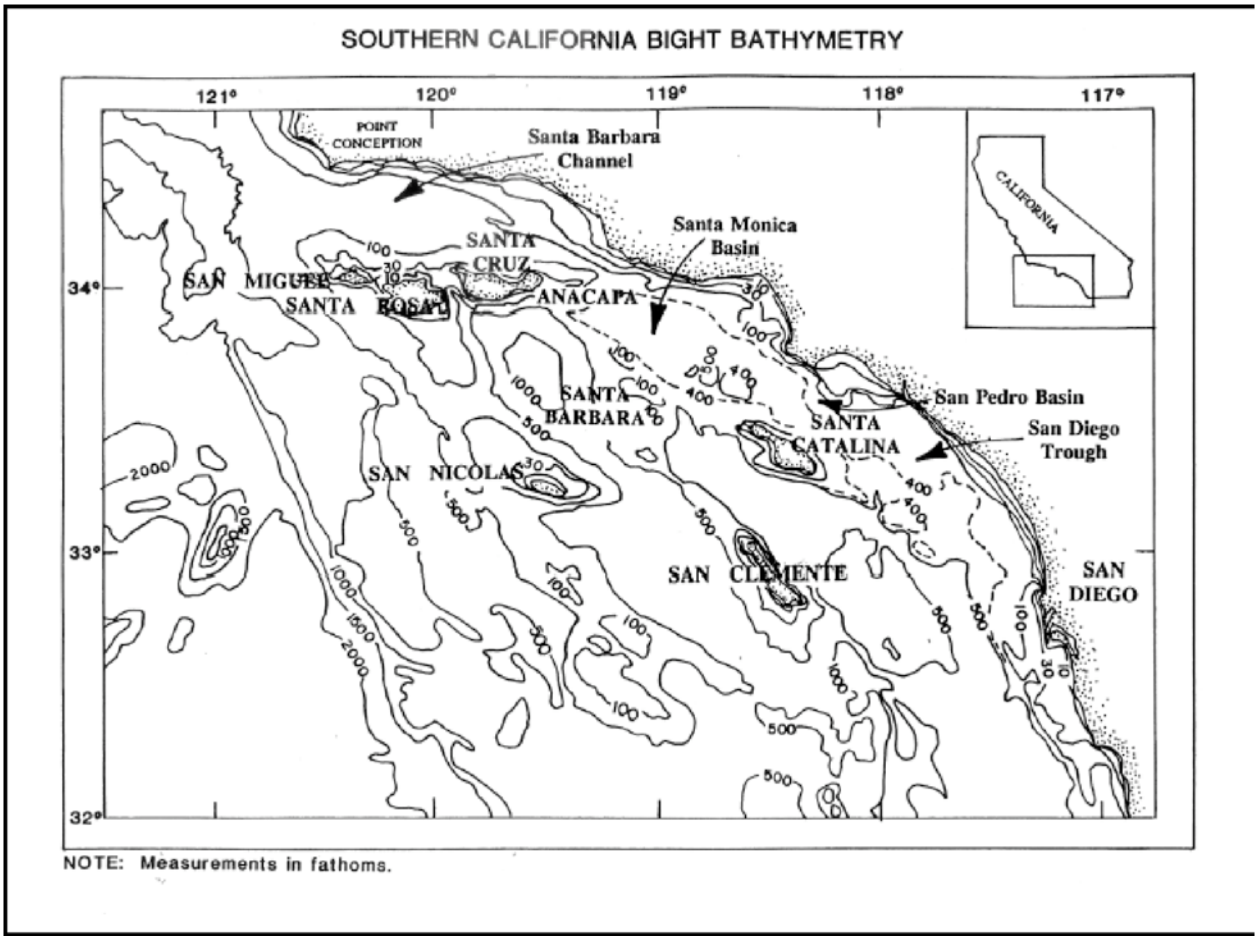


Figure 7. Landmasses and bathymetry of the Southern California Bight (from MMS 2001).

(b) The Local Setting

Local Bathymetry. The ocean shelf offshore from San Diego County is complex, mostly composed of soft sediments, and extends to the 125–150 m contours (Figure 8). The slope offshore from the shelf is steepest near La Jolla where the La Jolla Submarine Canyon is located. The shelf is much broader south of Point Loma and extends to Punta Descanso ~32 km south of the Mexican border. The "9-Mile Bank" is an extension of the shelf but separated from it by the Loma Sea Valley to the northeast and the Coronado Submarine Canyon to the south. There are also areas of rocky bottom, mainly limited to waters off La Jolla and Point Loma where two of the largest giant kelp forests in the Bight are located. Additionally, there are smaller kelp forests and an associated rocky bottom located in northern San Diego County and near the Tijuana River Estuary located near the Mexican border

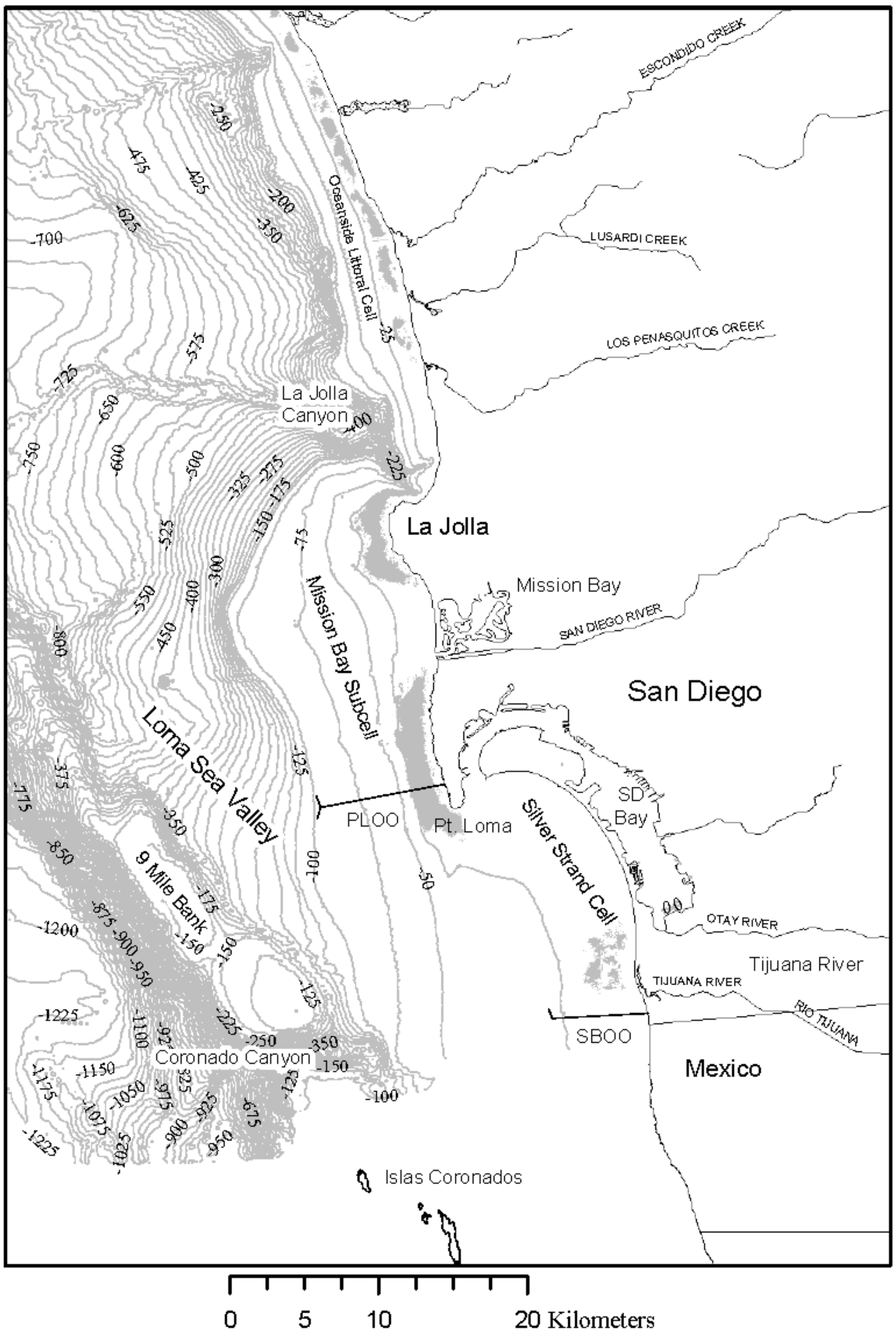


Figure 8. Bottom features in the coastal ocean off San Diego County (from SIO 2004).

The shelf contains two littoral cells, the Oceanside Cell and the Silver Strand Cell (Figure 9), and one subcell, the Mission Bay Subcell, between Point Loma and La Jolla. Littoral cells are coastal segments in which a complete cycle of sediment supply, transport, and loss occurs. There is little or no mixing of sediments among littoral cells. Consequently, sediments with pollutants discharged into one cell are likely to remain in the receiving cell (SIO 2004, and references therein).

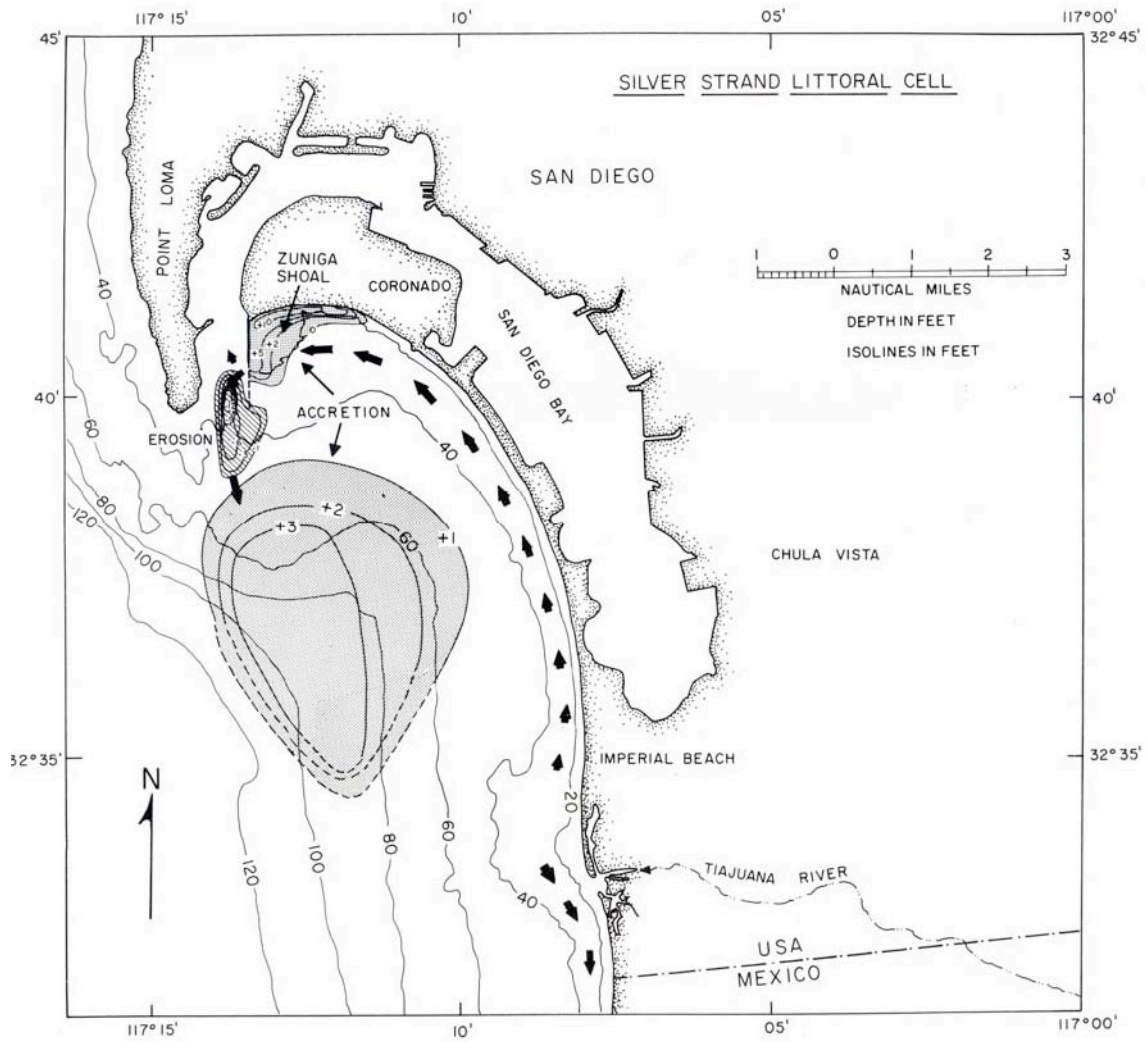


Figure 9. The Silver Strand littoral cell (from SIO 2004).

Principal phenomena influencing coastal currents. Several coastal phenomena combine with the prevailing southward California Current to influence circulation in the coastal ocean near Point Loma. Principal phenomena are summarized below.

***Internal waves**:*

Linear (small amplitude) and nonlinear (amplitude being a large fraction of the water depth) internal waves are prevalent features of the coastal circulation along the coast of the Southern

California Bight. Lerczak et al. (2003) concluded that on the slope and shelfbreak offshore from Mission Bay the semidiurnal variability is dominated by northward-propagating, topographically-trapped internal waves. Internal waves need a stratified water column to propagate (SIO 2004). The waves form as the tide moves over submerged banks offshore, and they propagate with speeds of about 20 cm s^{-1} and amplitudes of up to 15 m. With horizontal wavelengths of 100 m to 1 km, internal waves and the internal tide can generate significant vertical shear of the horizontal currents through the water column. In shallow water the waves lose energy and may break, causing vertical mixing.

Tidal currents:
The dominant tidal components in the Point Loma region are the semidiurnal tide and the fortnightly spring-neap cycle. The tidal currents can be up to 20 cm s^{-1}, and the dominant period is 12.42 hours, resulting in significant changes in speed and direction over time scales of several hours. As the tidal flows move onshore into shallow waters, the current directions change to predominantly alongshore (SIO 2004).

Wind-driven flows:
Wind forcing can cause local upwelling and downwelling, as well as alongshore currents of tens of cm s^{-1}. Upwelling takes some time (at least one intertial period - about one day) to spin up, and requires a reasonably steady wind over more than one day (SIO 2004). The daily sea breeze blows onshore in the afternoon, with initial surface water motions in the direction of the wind. Generally, local winds in San Diego are light and variable and wind-driven upwelling is not the dominant forcing in the region (Roughan et al. 2005). However, at times the local wind field may interact with the complex topography of the Point Loma headland in a way that leads to offshore Ekman transport of surface waters.

Topographically forced flows:
Horizontal currents tend to follow bathymetric contours; if these contours have strong curvature, the currents may overshoot, leading to local upwelling or downwelling. Localized upwelling occurs just south of Point Loma. This upwelling is not primarily due to local or remote wind forcing, but rather the divergence of the prevailing southerly flow as it passes the Point Loma headland (Roughan et al. 2005). The mixed layer can be as shallow as 4 m (inshore) or up to 10 m deep (offshore) in the vicinity of Point Loma. In this area, the thermocline only has to be uplifted on the order of a few meters to have a significant effect on the temperature in the surface waters. Time series of surface vorticity calculated from high frequency (HF) radar measurements of sea surface velocity show that as the flow separates from the headland relative vorticity increases offshore of Point Loma. The time series of divergence/convergence shows a tendency towards divergence at the surface, which favors upwelling. The observed divergence in the surface flow field, although small, is sufficient (over a 24 to 48 h period) to raise sub-thermocline, nutrient-rich water to the surface in 2 to 3 days, where phytoplankton blooms can develop (Roughan et al. 2005). Local chlorophyll maxima are observed that correspond to these upwelling events (Figure 10), although the blooms are are advected away from the headland and offshore by the prevailing surface currents. Flows past headlands (such as Point Loma) can also generate eddies that may persist (retaining water locally) or propagate away. Such eddies are known to form at the mouth of San Diego Bay at each tidal cycle. Analysis by Hendriks &

Christensen (1987) using current measurements southeast of Point Loma suggests that an eddy mode of circulation explains about 24% of the variance in non-tidal flow.

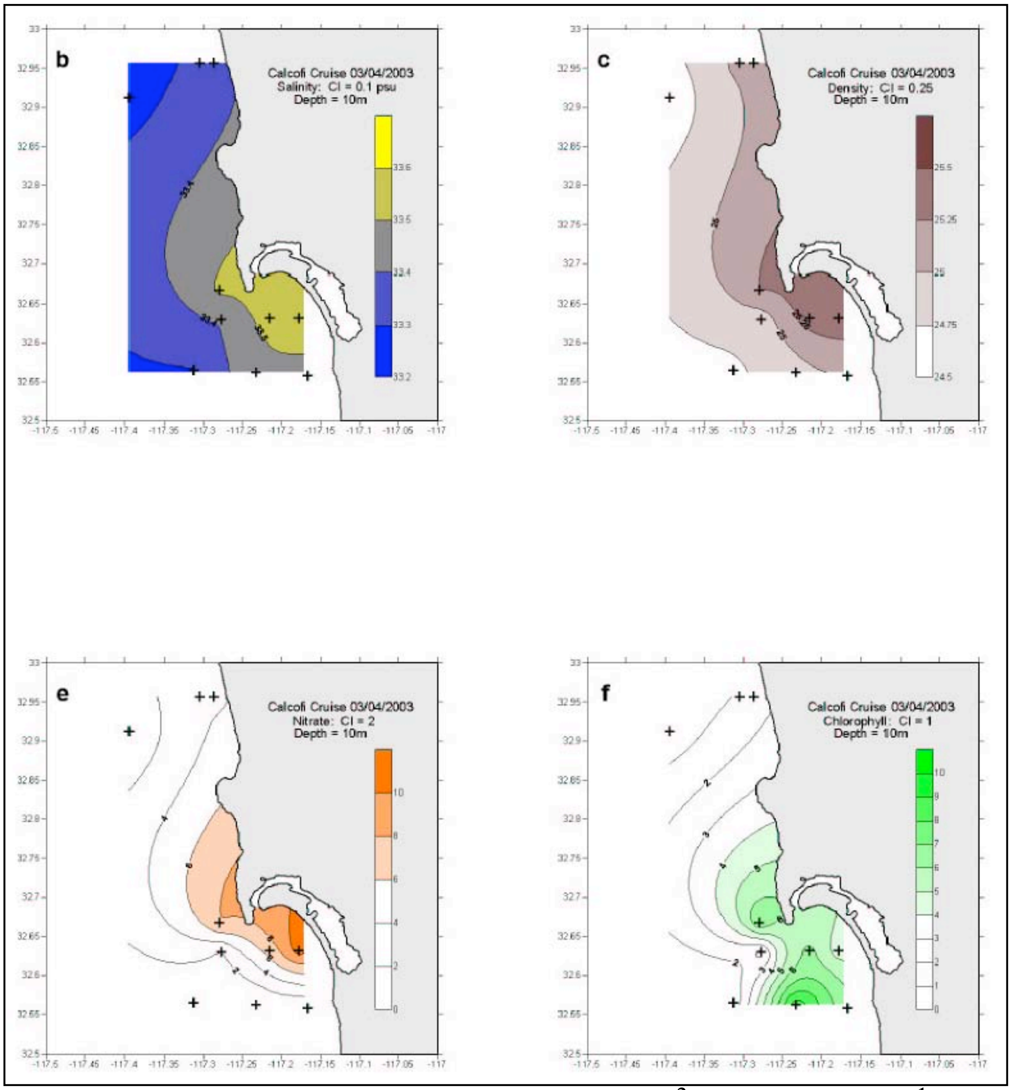


Figure 10. Contour maps of (b) salinity (psu), (c) density (kg m^{-3}), (e) nitrate (µmol L^{-1}), and (f) chlorophyll-a (mg m^{-3}), at 10 m depth (adapted from Roughan et al. 2005).

Remotely forced flows:

Winds off Baja California can generate coastally trapped waves that propagate up the coast at speed of 2-3 m s^{-1} (Pringle & Riser 2003). These waves can create sudden elevations of the pycnocline, with the upwelling of bottom waters inshore. Other large-scale forcings determine the speed and direction of the ambient coastal currents in the region over time scales of days to years.

Point Loma Kelp Bed:

Physically, kelp beds are regions of enhanced hydrodynamic drag. The Point Loma kelp bed, which extends from Point Loma north toward the mouth of the San Diego River, is one of the largest along the California coast, with a width of 1-1.5 km that is comparable to an internal Rossby radius (~1.5 km in this shallow water) and a length of 7 km that is comparable to wavelengths of suprainertial frequency Kelvin waves (Jackson 1998, and references therein). Drag from kelp plants affects internal waves propagating across the bed, damping the high frequency waves and slowing the low frequency waves (Jackson 1998). Upon encountering a kelp stand, most of an energetic alongshore current will flow around it, moving to the outside (Jackson & Winant 1983). This has implications for the behavior of storm plumes emanating from the mouth of the San Diego River, when southerly flow is occurring (see Section II.B.2.e).

Currents measured in the Point Loma kelp bed are low. Average alongshore currents are on the order of 1 cm s^{-1} inside the kelp. Water flowing in the alongshore direction through the 7 km long kelp bed at Point Loma will spend more than a week before exiting (Jackson & Winant 1983). Crossshore velocity fluctuations are more important than alongshore fluctuations for the movement of material between offshore waters and the kelp bed interior. Internal waves, with frequencies of 3 d^{-1} and velocities of 1 cm s^{-1} will move water inward for half a cycle (1/6 of a day) a distance of 150 m (Jackson & Winant 1983). Barotropic waves assist water exchange near the outside of the kelp bed. Results suggest that, over 24 h, crossshore penetration of water from the edge of the Point Loma kelp bed to 400 m inside the kelp is common (Jackson 1998). Excursions 600 m or greater through kelp are episodic, at best.

Monthly mean surface flow fields

Monthly mean surface flow fields, created using data from the San Diego Coastal Ocean Observing System (SDCOOS) high frequency (HF) radar array (http://www.sdcoos.ucsd.edu), were obtained for the period April 2003 to March 2004 (Sung Yong Kim, Scripps Institute of Oceanography, pers. comm.). The array consists of four Coastal Ocean Dynamics Applications Radar (CODAR) instruments: (1) on the Point Loma headland, (2) near Imperial Beach, (3) on Coronado Island just south of the Mexico border, and (4) and at the PEMEX facility in Rosarito Beach, Mexico. The CODAR data is used to produce real time maps of surface currents in the San Diego region (hourly and 24 hr means), which may be viewed at (http://www.sccoos.org/data/surfacecurrents/sd.ph). Monthly mean flow fields reveal that surface currents are predominantly southward in the region (e.g., April, 2003, in Figure 11; annual cycle shown in Appendix A). Brief episodes (0-3 days) of predominantly northward flow also occur in the region, usually at least once per month (Jan Svejkovsky, Ocean Imaging Corporation, pers. comm.), but are too infrequent to be captured by the monthly averages (Eric Terrill, Scripps Institute of Oceanography, pers. comm.). Analysis of ~15 months of current measurements from a site 10 km SSW of Point Loma indicated that alongshore flow was northward ~31% of the time and southward ~68% of the time (Hendriks & Christensen 1987). Northward flow is discussed further in Section II.B.2.d.

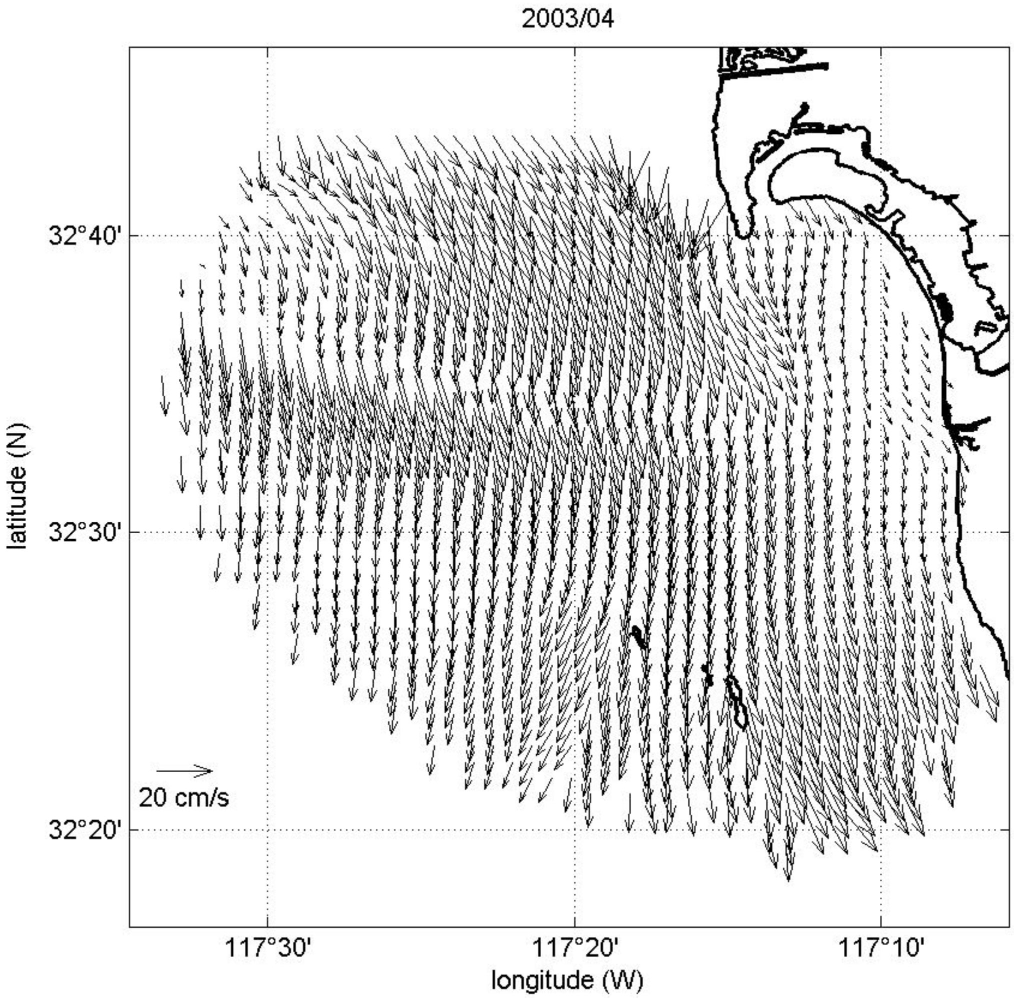


Figure 11. Monthly mean surface flow field in the San Diego region for April 2003 mapped by HF radar (courtesy of the San Diego Coastal Ocean Observing System).

B.2. San Diego Bay

(a) Freshwater input to San Diego Bay

San Diego Bay is comprised of 10,532 acres of submerged land and 4,419 acres of tidelands. Only seventeen to eighteen percent (17 to 18%) of the original bay floor remains undisturbed by dredge or fill (USN 1999) (Figure 12). The majority of freshwater input to San Diego Bay is from surface runoff from urban areas and intermittent flow from rivers and creeks during rain events (PSD 2003). Until the 1870s, the San Diego River alternately drained into San Diego Bay or Mission Bay. However, to combat siltation of San Diego Bay, in 1878 the U.S. Army Corps of Engineers constructed a dike along the south side of the river to prevent it from draining into San Diego Bay (USN 1999). Since then, the San Diego River has drained into the ocean through a man made channel running between Mission Bay and the Point Loma Peninsula (Figure 3).

More recently, the Sweetwater and Otay Rivers contributed substantial seasonal flow to San Diego Bay. Dams on these rivers, and extensive use of groundwater in the Sweetwater and Otay River basins, have reduced input from these rivers by seventy-six percent, so that they are now minor contributors of water to the bay (PSD 2003). There are over 200 storm drain outfalls in San Diego Bay (SDRWQCB 2005). In addition, several creeks that collect urban runoff are tributary to the bay - notably Chollas, Switzer, Paleta, Paradise, and Telegraph Creeks.

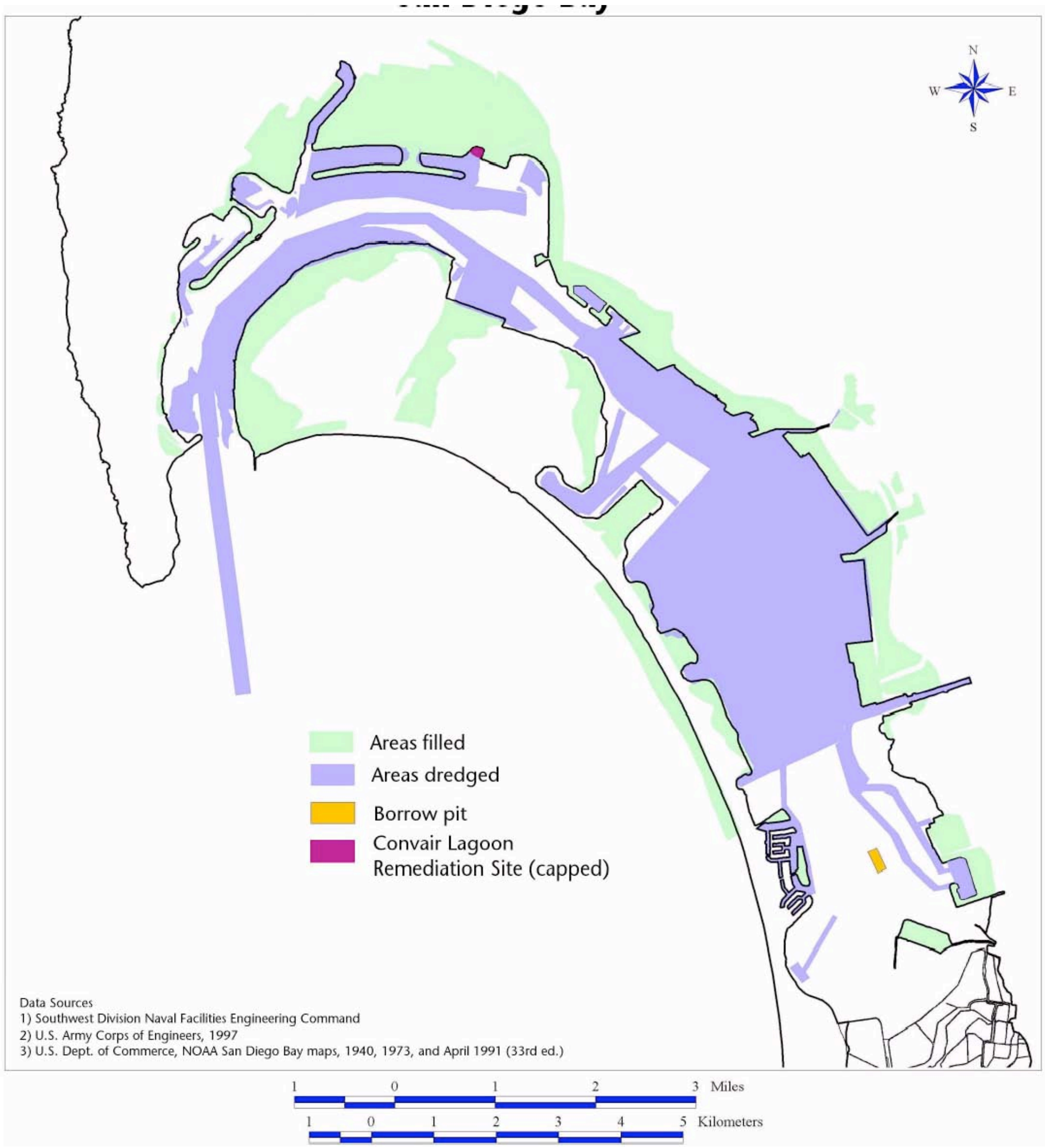


Figure 12. Cumulative history of dredging and filling in San Diego Bay (from USN 1999).

(b) Tidal exchange between San Diego Bay and the ocean

Tidal exchange in San Diego Bay exerts control over the flushing of contaminants, transport of aquatic larvae, salt and heat balance, and residence time of water (Chadwick 1997). Tidal patterns off San Diego are mixed, with two unequal highs and lows each day. The diurnal difference in the mean higher high water (MHHW) and mean lower low water (MLLW) tides is 5.6 ft (1.7 m), with extremes of 9.8 ft (3 m). The tidal prism, or the volume of water contained between the tides, is about 73 x 10^6 m^3 (USN 1999). Highest tides are in January and June.

The exchange of water between San Diego Bay and the ocean during ebb flow and flood flow is asymmetrical (Chadwick & Largier 1999). During the flood tide, water is drawn uniformly from the offshore region into the narrow entrance of the bay in a sink-like fashion (Figure 13). During the ebb tide, water is expelled from the bay as a jet. Bottom friction, and the longitudinal and vertical thermal gradients, lead to different vertical velocity profiles in the region of exchange during ebb tide, compared to flood tide. During ebb flow, the near-bottom flow is damped, leading to strong vertical shear in the outflow (for an example, see Figure 50, at -1 km on x-axis). Starting just inside the entrance of the bay and extending seaward for ~2 km, much of the ebb flow takes the form of warmer bay water riding above cold water (Chadwick & Largier 1999). Centerline velocities in the ebb flow jet reach 60-70 cm s^{-1} near the entrance to the bay. During neap tides, the vertical density gradient is enhanced by lower flow and less vertical mixing. Consequently, "liftoff" of the ebb flow from the bottom of the channel is more pronounced during neap tides than during spring tides (Chadwick et al. 1996). During flood tide, near-bottom flow into the bay is equal in magnitude to the surface flow. The efficiency of tidal pumping increases when the offshore length scale of the ebb jet exceeds the radial scale of the withdrawal zone for return flow during the flood (Chadwick & Largier 1999).

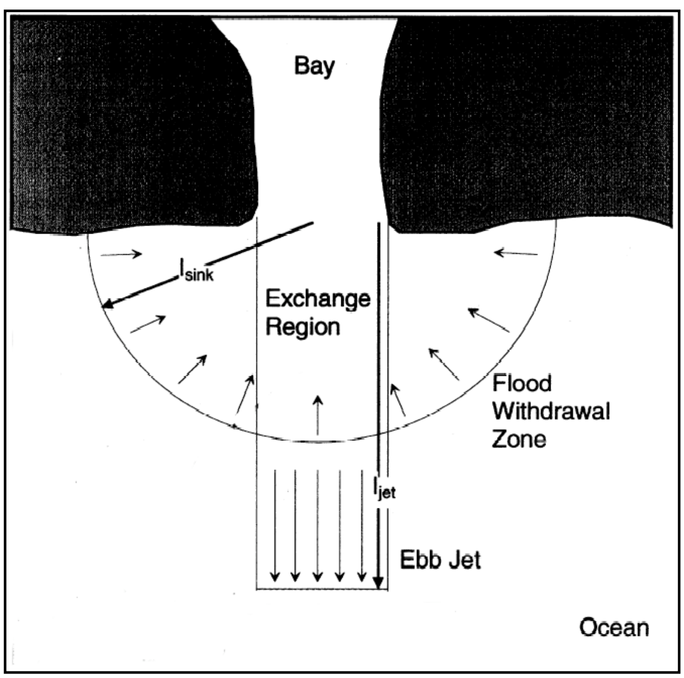


Figure 13. Tidal pumping model as described by Chadwick & Largier (1999) Depicting are the ebb flow jet, the flood flow sink, and the exchange region determined by the overlap of the jet and sink (adapted from Chadwick & Largier 1999).

Cross-channel asymmetry is observed during the transition between slack high tide and ebb flow such that inward flow along the western shore of San Diego Bay (peninsula side) continues for a period after outward flow has already begun along the eastern boundary of the channel (near North Island). Later, when flow reverses from ebb to flood, residual momentum of the outflowing jet, especially in the surface layer, continues to carry bay water offshore in the middle of the channel for about 2 hrs at velocities of 5-15 cm s^{-1}, even after return flow has begun along the eastern and western shorelines of the bay (Chadwick et al. 1996). When flood tide is underway, the ebb jet is pinched off offshore by the lateral convergence of water masses moving toward the bay entrance from within the "sink" region.

B.3. Freshwater in the Monument

The only freshwater resources at CABR are a few unmapped, possibly seasonal seeps. Little is known about groundwater at CABR, including how much communication there might be between groundwater within the Monument and the rest of the Point Loma Peninsula (Andrea Compton, Chief of Natural Resource Science, CABR, pers. comm.). CABR itself is not underlain by a regional aquifer, although an aquifer extends under North Island (SDRWQCB 1994), and another aquifer reportedly lies under the northern portion of the Point Loma peninsula. In February 2006, the Navy announced that a fuel plume (up to 1.5 million gallons) from leaking fuel tanks, was detected and was floating on the groundwater in the northern portion of the peninsula. The extent of the groundwater aquifer underlying the peninsula is unknown. It is also unknown whether this aquifer is brackish due its proximity to the bay, and whether its depth varies from sea level (Congressional Research Service 2006). A search of the USGS groundwater site inventory yielded no data from test bores, wells, or other groundwater samples from within an area bounded by (south to north) 32.6653-32.6789°N, and (east to west) 117.11-117.16°W.

C. BIOLOGICAL RESOURCES

C.1. Overview

The intertidal habitat administered by CABR encompasses about 1.5 km of shoreline, consisting mostly of flat, gently-sloping benches with scattered, hard, metavolcanic boulders at the base of soft, eroding sandstone cliffs (Becker 2005). For management and monitoring purposes, the area has been divided into three zones (Zones I-III), each approximately 330 m in length (Figure 14). Zone I is approximately 40-65 m wide on a fairly low tide. It consists of a flat bench in the north, with numerous large boulders and narrow channels, and fewer boulders to the south. A short stretch (<100 m) of permanent sandy beach, referred to as Grunion Beach, occurs there (Figure 15). Zone I is easily accessed using a public trail from a parking lot on the coastal bluff, and experiences the highest visitation. Zone II resembles the northern section of Zone I, although it is a bit wider (40-90 m) (Figure 16). Visitors to Zone II must hike through the rocky intertidal zone to reach Zone II, thus it receives fewer visitors than Zone I. Zone III is much wider (90-120 m) and flatter than the other zones, with few large boulders and many small, flat rocks (Figure 17). There is a single line of large boulders at the southern end of the area. This area is close to the mouth of San Diego Bay. The base of the cliffs in this area is artificially reinforced with granite riprap. Zone III has always received the lowest number of visitors, but was closed to visitors in late 1996 after results of the first five years of monitoring revealed serious declines, near disappearance, or disappearance of key taxa in this zone (see below).

The Point Loma kelp bed, which extends for approximately 7 km along the outer coast of the Point Loma Peninsula, northward from Point Loma, occupies water between 6-30 m deep (Jackson 1998). Over the last century, the Point Loma kelp canopy has undergone frequent fluctuations, ranging from being essentially absent at least three times to covering almost 10 km^2. The inshore edge of the kelp forest is located outside the administrative boundary of CABR; we do not describe the kelp bed in detail here. The ecology of the Point Loma kelp forest is well described elsewhere (Dayton & Tegner 1984; Dayton et al. 1998, 1999; Graham 2003; Tegner & Dayton 1991; Tegner et al. 1995, 1996, 1997). Historic impacts of fishing on selected kelp forest species are described in Section III.B.5.

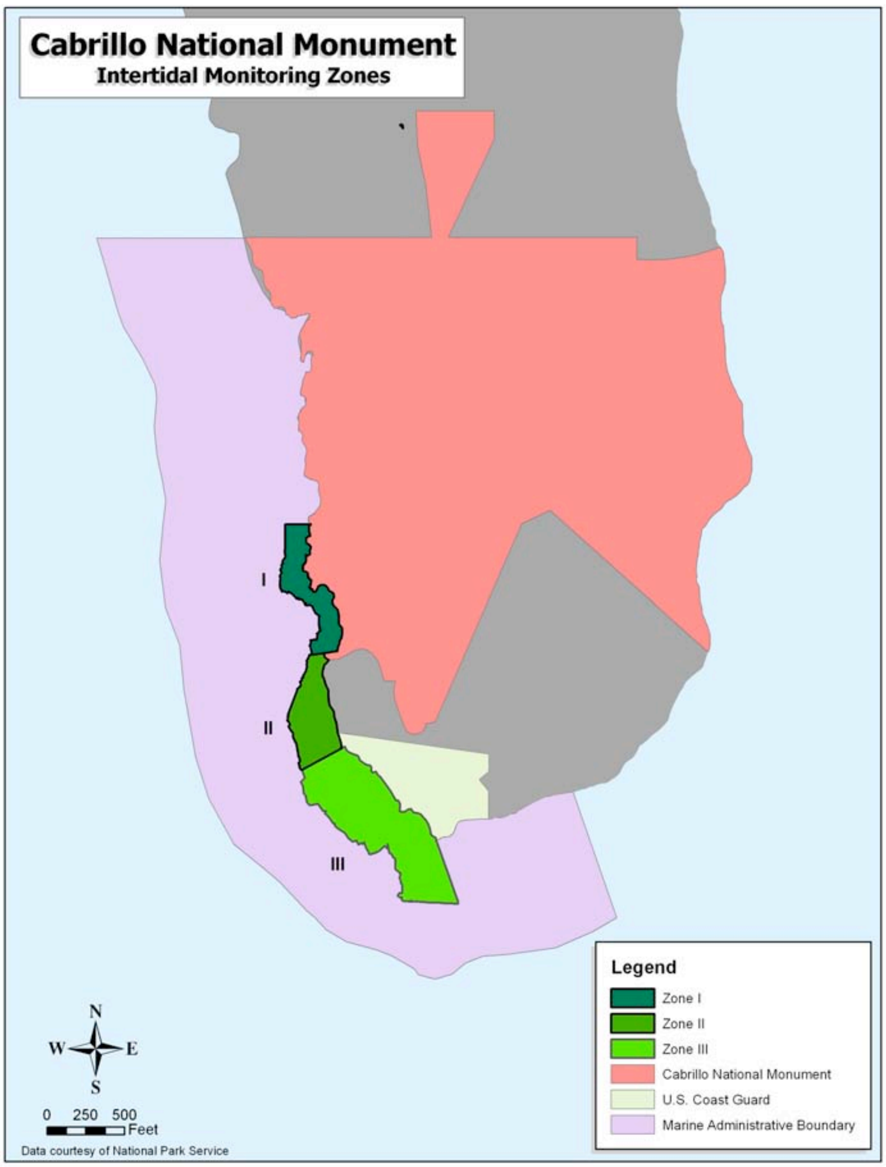


Figure 14. Intertidal management zones within the administrative boundary of Cabrillo National Monument.

C.2. Inventories of Marine Biota

The earliest known comprehensive surveys of the CABR tidepools were conducted in the late 1970's. Two reports (Zedler 1976, 1978) documented the effects of high visitation in the Monument. Throughout the 1980s, studies were conducted of surfgrass beds (Stewart & Myers 1980), red algal turf communities (Stewart 1982), and the interactions between them (Stewart 1989), in the tidepools of Point Loma. Craig & Pondella (2005) censused fish at CABR using gill nets, minnow traps, 50 m diver transects, and visual tide pool surveys. Results from these studies, and other efforts, have resulted in inventories of fish, marine macroalgae, marine macroinvertebrates, and seabirds for CABR.

<u>Macroalgae</u>. Miller (2005) created an annotated species list of marine macroalgae encountered during three surveys at CABR in 2005 (conducted jointly with Dr. Stephen N. Murray), and compared results to earlier information about seaweeds from Zedler (1976, 1978). A species list extracted from Miller (2005) is presented in Appendix B.

<u>Marine macroinvertebrates</u>. NPS staff at CABR maintain a database of confirmed and unconfirmed reports of fish, plants and marine macroinvertebrates from past surveys, monitoring efforts and other observations at CABR (Bonnie Becker, Marine Biologist, CABR, pers. comm.). A list of marine macroinvertebrate species extracted from this database is presented in Appendix C.

<u>Fish.</u> Craig & Pondella's (2005) fish census, and a query of the NPS Monitoring and Inventory Program's NPSpecies database, were combined to produce a fish list for CABR (known and probable species), which is presented in Appendix D.

<u>Seabirds</u>. Table 1 categorizes birds observed during fifteen years of the CABR intertidal monitoring program (see below).

C.3. Cabrillo Intertidal Monitoring Program (CRIMP)

An intertidal monitoring program began at CABR in 1990 (Engle & Davis 2000a,b). Intertidal surveys are conducted twice per year, near the spring and fall extreme low tides. Thirteen key taxa (Table 2) are monitored using four methodologies, which are carried out in a consistent fashion in all three zones:

1) Circular plots: size frequency of owl limpets (*Lottia gigantea*)
2) Rectangular photoplots: percent cover of thatched and acorn barnacles (*Tetraclita rubescens*, *Balanus glandula*/*Chthamalus* spp.), mussels (*Mytilus californianus*), rockweed (*Silvetia compressa*, formerly *Pelvetia fastigiata*), and goose barnacles (*Pollicipes polymerus*).
3) Point-intercept transects ("kelp transects"): percent cover of red algal turf, surfgrass (*Phyllospadix* spp.), boa kelp (*Egregia menziesii*), Sargassum weed (*Sargassum muticum*), and anemones (*Anthopleura elegantissima*/*sola*).

4) Timed searches: presence or absence of rare species (black abalone, *Haliotis cracherodii* and ochre sea stars, *Pisaster ochraceus*)

Additionally, birds and visitors are counted during a number of daytime low tides throughout the fall, winter and spring.

Table 1. Birds observed over time during the rocky intertidal monitoring efforts at CABR. Inventory and categories are from Becker (2006).

Category	Common Name
Shore Birds	Black Turnstone
	Black-Bellied Plover
	Least Sandpiper
	Marbled Godwit
	Ruddy Turnstone
	Sanderling
	Spotted Sandpiper
	Surf Bird
	Wandering Tattler
	Western Sandpiper
	Whimbrel
	Willet
Other	Black Phoebe
	Common Merganser
	European Starling
	Grebe
	Kingfisher
	Mallard
	Merganser
	Mocking Bird
	Osprey
	Red-breasted Merganser
	Say's Phoebe
	Sparrow
	Western Grebe

Category	Common Name
Sea Birds	Bonaparte's Gull
	California Gull
	Double Crested Cormorant
	Forster's Tern
	Heerman's Gull
	Herring Gull
	Mew Gull
	Oyster Catcher
	Pelican
	Ring-Billed Gull
	Royal Tern
	Tern
	Western Gull
Wading Birds	Great Blue Heron
	Great Egret
	Green-backed Heron
	Snowy Egret

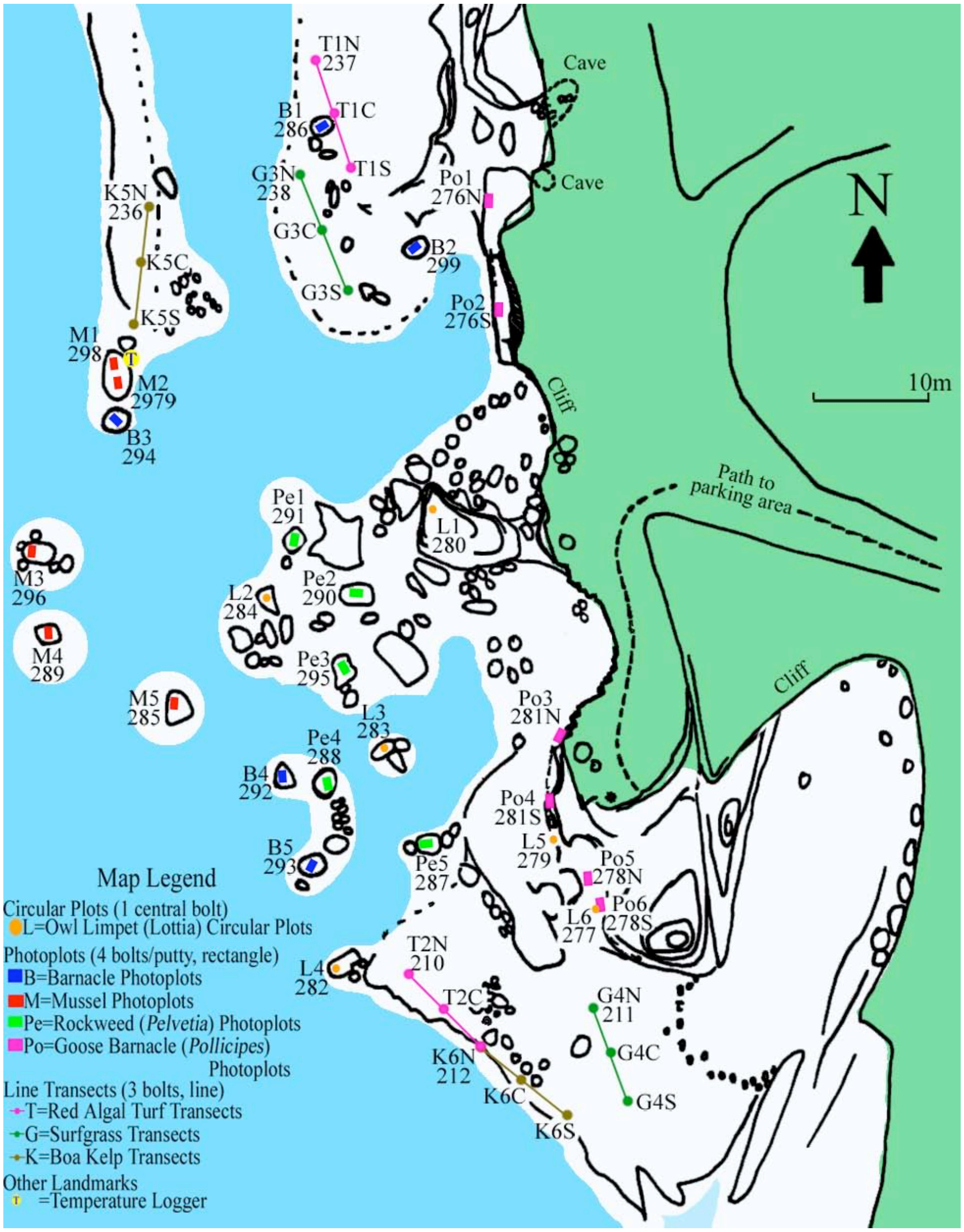


Figure 15. Cabrillo Rocky Intertidal Monitoring Program (CRIMP) sampling locations in Zone I of Cabrillo National Monument (from Becker 2006).

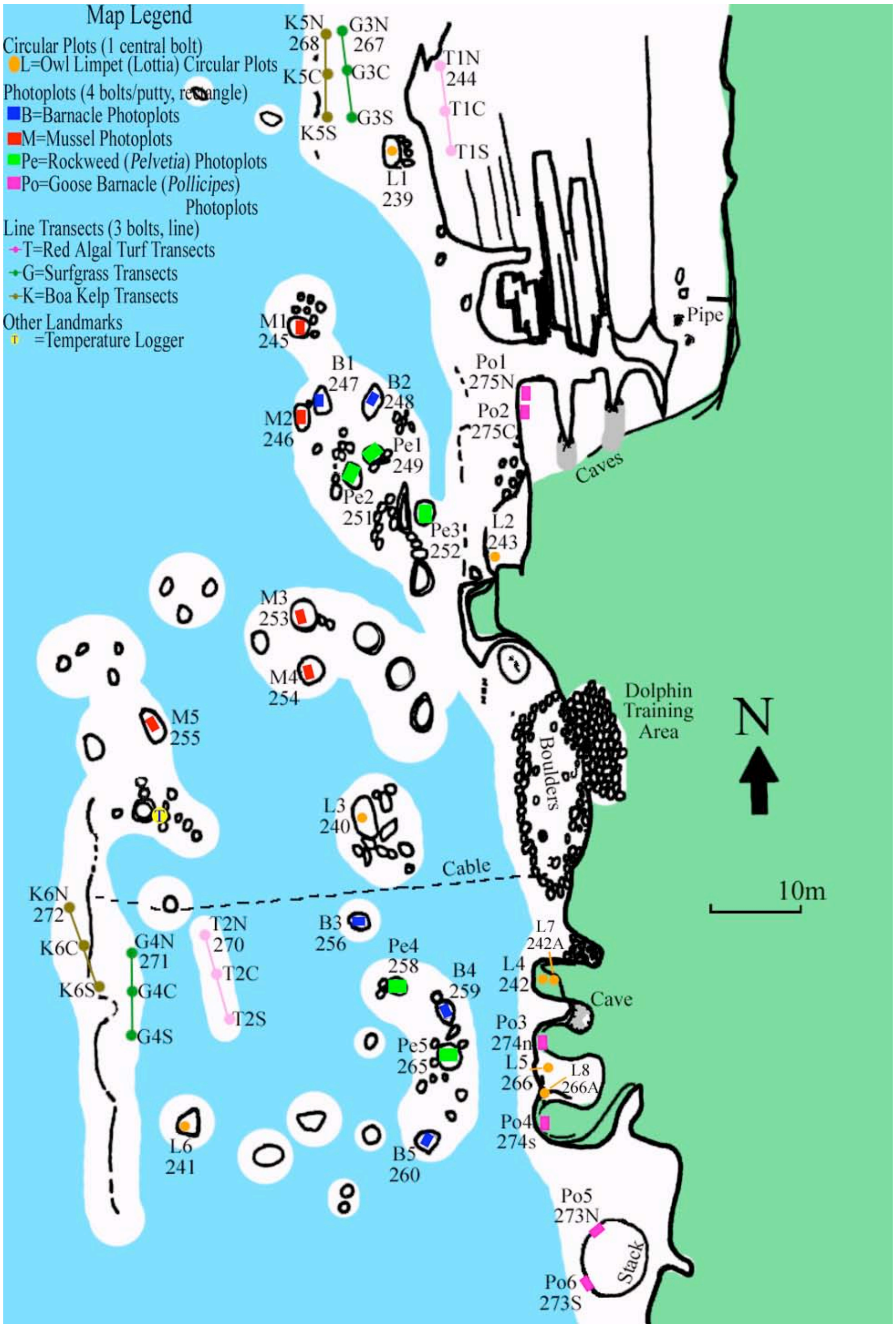


Figure 16. Cabrillo Rocky Intertidal Monitoring Program sampling locations in Zone II of Cabrillo National Monument (from Becker 2006).

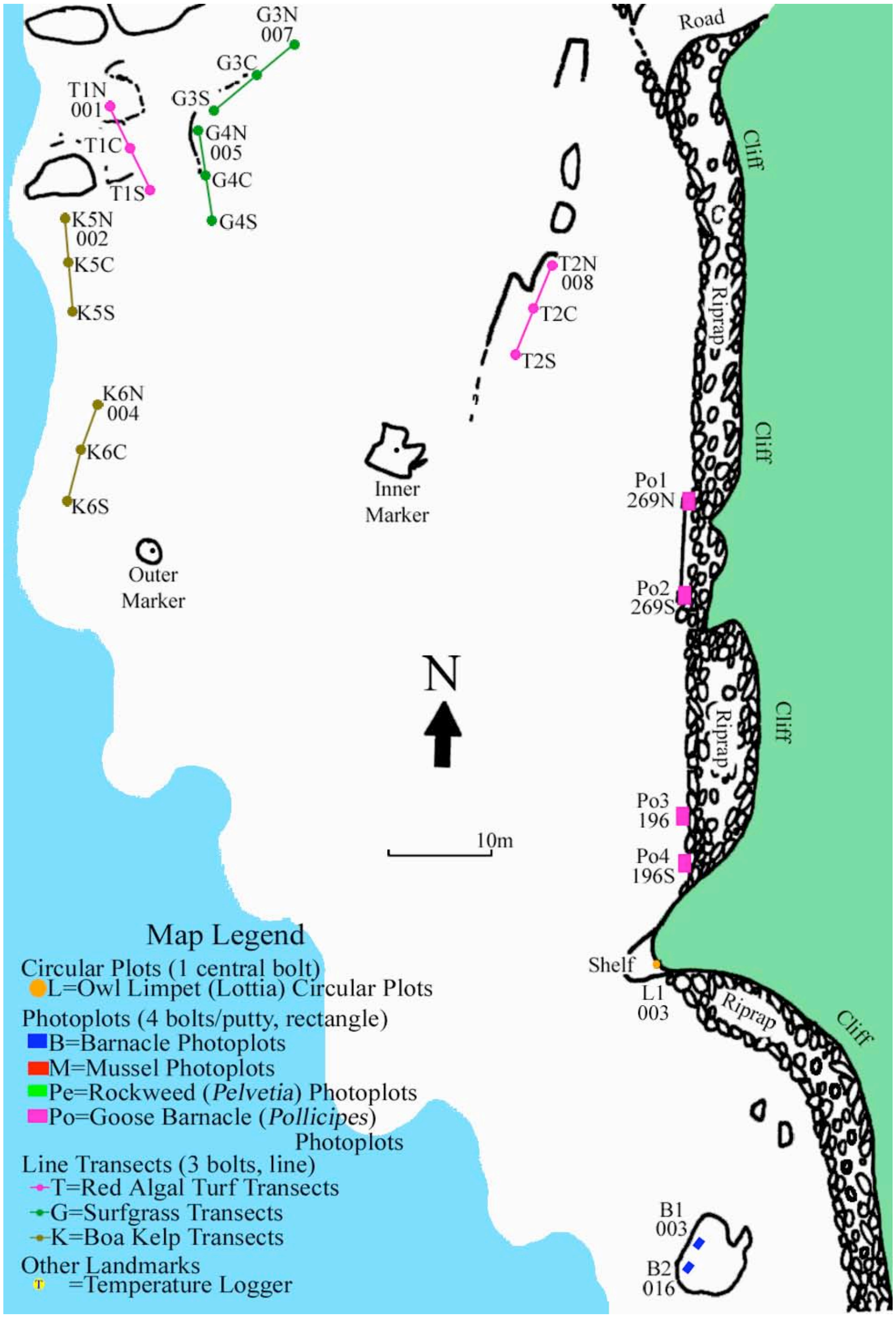


Figure 17. Cabrillo Rocky Intertidal Monitoring Program (CRIMP) sampling locations in Zone III of Cabrillo National Monument (from Becker 2006).

Table 2. Key taxa in CRIMP. Taxa are monitored twice per year using one, or several, of four methodologies (see text). Table is from Becker (2006).

Taxa/Category	Species included
Acorn Barnacles	*Chthamalus dalli*, *C. fissus*, *Balanus glandula*, no effort made to determine species.
Aggregating Anenome Anthopleura elegantissima/sola	Mostly *A. elegantissima* but could be some *A. sola*
Articulated corallines	Many species, could include *Corallina* spp., *Bosiella* spp., *Lithothrix* spp., etc.; no effort made to determine species
Chitons	Including *Nuttalina fluxa*
Chondracanthus canaliculatus	
Cladophora columbiana	
Colpomenia spp.	Probably either *C. tuberculata* or *C. sinuosa*
Crustose corallines	Unidentified species
Egregia menziesii	
Eisenia arborea	
Endarachne binghamiae/ Petalonia fascia	Probably *E. binghamiae*, but no effort made to determine species.
Endocladia muricata	
Fucus gardneri	
Halidrys dioica/Cystoseira spp.	Probably *H. dioica*, but no effort to determine species.
Hesperophycus californicus	
Limpets	Many species, could include *Lottia digitalis*, *L. paradigitalis*, *L. pelta*, etc.
Lottia gigantea	
Mastocarpus papillatus	
Mazzaella affinis	
Mazzaella spp. (=*Iridaea* spp.)	
Mexacanthina lugubris	
Mytilus californianus	Recorded as *M. californianus*, but could also include *M. galloprovincialis*
Non-coralline crusts	Unidentified species
Other barnacles	
Phragmatopoma californica	
Phyllospadix scouleri/torreyi	Probably only *P. torreyi* found in park, but no effort made to determine species during monitoring
Pisaster ochraceus[6]	
Pollicipes polymerus	
Porphyra spp.[6]	
Sargassum muticum[3]	
Scytosiphon spp.[3]	
Septifer bifurcatus[5]	Mostly *S. bifurcatus*, but could be some *Brachidontes adamsianus* mixed in.
Silvetia compressa[10]	
Tetraclita rubescens	
Turf-forming red algae (non-coralline)	Many species, including *Centroceras clavulatum*, *Laurencia* spp., etc.
Ulva spp./*Enteromorpha* spp.	Unidentified species

The first five years of CRIMP revealed that 7 of the 13 key taxa had either declined or disappeared entirely from the area (Engle & Davis 2000c). After the release of these results in 1996, CABR management implemented the Tidepool Protection, Education, and Restoration Program (TPERP) to try to reverse this trend. The purpose of TPERP is to accommodate visitation of the CABR tidepools while restoring the intertidal area under the administration of CABR. TPERP consists of three parts: (1) education and enforcement, (2) monitoring and research, and (3) restoration through area closure. Beginning in the fall of 1996, the NPS has been recruiting and training a cadre of Volunteers-In-Parks (VIPs) and increased the number of park rangers in the intertidal area during low tides. VIPs and park rangers provide education about the tidepools while simultaneously explaining and enforcing park regulations (such as no collecting or placement of animals in containers - the "no buckets" policy). To date, part three of TPERP has consisted of the closure of Zone III to visitors. The closure is intended to allow Zone III to recover from the pressures of high visitation (mostly trampling, rock overturning, and poking; restriction of collection and hunting has been very strict since the 1970s). A thorough description of the results of the first fifteen years of CRIMP is available in Becker (2006).

As of 2005, monitoring had occurred consistently in fall and spring of every year starting in fall 1990, except for a missing season in spring 1996 and an extra season in summer 1992, for a total of 31 sampling events. A total of 1754 photoplots were scored, 576 transects were read, and 20,621 owl limpets were measured in 565 circular plots. A total of 49,095 visitors and 54,762 birds were counted by more than 85 volunteers and staff during 833 bird and visitor censuses. Table 3 summarizes the key findings of CRIMP as of 2005. Specific trends of interest are as follows:

Owl limpets: Although owl limpet average size is declining in CABR, a number of additional studies have demonstrated that individuals of this species are particularly large in the Monument compared to other areas in southern California; this has been attributed to the well-enforced limitation of harvesting at CABR. Additionally, CRIMP data have documented recruitment pulses of owl limpets that occur irregularly in the fall season; particularly large pulses occurred in fall 1998-2001 and fall 2004 in Zone I. Owl limpets have not been successfully recruiting into Zone III for unknown reasons.

Mussels: Mussels experienced a dramatic decline in Zones II and III from 1990 through 1995, and remain at very low levels in those areas. Based on regional comparisons, the cause of the mussel decline appears to be local (Becker 2006). In a mussel transplantation study conducted at CABR (discussed in Section II.A.4), the growth and health of some mussels transplanted to Point Loma were lower than the growth and health of mussels transplanted to a more polluted site inside San Diego Bay, indicating that water quality and mussel health are not well correlated at CABR. Starvation and larval recruitment failure are remain as alternative hypotheses for the mussel decline at Cabrillo (Becker 2005).

Surfgrass: A dramatic expansion of surfgrass, mostly into formerly kelp- and turf-dominated habitats, continued throughout much of the study period and appears to be stabilizing or reversing.

Red algal turf: Red algal turf communities, in particular, have been highly impacted by the large amount of human visitation to the tidepools, and the closure of Zone III has led to a richer and more diverse turf habitat in that area. Ten months of comparative study of red algal turf in Zones I and III in 2002 revealed that algal biomass was almost twice as high, and invertebrate densities were almost four times as high, in Zone III compared to Zone I (T. Huff, unpub. data).

Black abalone: Black abalone continue to be absent from CABR. This disappearance is occurring on a large scale throughout southern California, and is primarily explained by overharvesting and a bacterial disease, referred to as "withering syndrome", that began to affect regional populations in the mid 1980s.

Ochre sea stars: Ochre sea stars have been absent at CABR since 1990. They continue to be found elsewhere in San Diego County, such as to the north at La Jolla and Cardiff (Becker 2006). Their absence at CABR remains unexplained. Although they are near the southern end of their natural range at CABR, they are found at points south of CABR. Decline in mussels, which are a preferred food of ochre sea stars, has been proposed as an explanation for their absence at CABR (Becker 2006)[7].

Visitor effects on birds: Over the past twelve years the number of visitors to the tidepools has remained fairly stable. Sea birds and shore birds declined throughout the monument from 1990-1995, but abundances remained fairly stable thereafter; the exception to this pattern is in Zone III, where shore birds have increased since 2000. The spatial patterns of visitor and bird use have remained fairly consistent: dramatically more people are found in Zone I than in the other zones, while birds tend to be found in Zone III. Even with the zone effect removed, there appears to be a strong negative relationship between birds and people: few birds are found where there are many people, while large numbers of birds are only found when large crowds are absent.

C.4. Fish Fauna

Information about the fish fauna of CABR is provided by Craig & Pondella (2005). Overall, 48 species from 22 families are confirmed from CABR (Appendix D). The fish assemblage of CABR is a typical rocky-shore fish assemblage for southern California mainland habitats, and overall richness is comparable with other similar habitats in the San Diego region (Craig & Pondella 2005, and references therein). Tide pool fishes are represented by 12 mostly cryptic species, including members of the Blenniidae, Clinidae, Cottidae, Gobiesocidae, and Kyphosidae. Subtidal fishes account for the remaining 36 species and represent several common marine families. The most abundant intertidal fish species is the wooly sculpin, *Clinocottus analis* (Cottidae), followed by the spotted kelpfish, *Gibbonsia elegans* (Clinidae), and the opaleye, *Girella nigricans* (Kyphosidae). The most common species taken by gill net in Craig & Pondella's (2005) census was the salema, *Xenistius californiensis* (Haemulidae), followed by the

[7] Near disappearance of ochre sea stars, and declines in other sea stars, at the Channel Islands (mostly during recent El Niños) has been caused by bacterial diseases (Eckert et al. 2000).

queenfish, *Seriphus politus* (Sciaenidae), and the leopard shark, *Triakis semifasciata* (Triakidae). The most common species observed in diver surveys were the señorita wrasse, *Oxyjulis californicus* (Labridae), the opaleye, *Girella nigricans* (Kyphosidae), and the garibaldi, *Hypsypops rubicundis* (Pomacentridae). While 11 of the 12 species found in the tide pools may be considered resident, the remaining species collected by the gill nets and observed by the diver surveys are most likely utilizing the tidal flat habitat as foraging area during high tides. Several fish species that utilize CABR habitat are targets of recreational or commercial fishing at Point Loma or in the San Diego Area (see Section III.B.).

Table 3. Selected findings of the first fifteen years of the Cabrillo Rocky Intertidal Monitoring Program (from Becker 2006).

	Trend 1990-1995 (Engle and Davis 2000c)	**General Trend**	**Comments/Major Findings**
Circular Plots			
Owl limpet abundance	Moderate decline	Continued decline II and III, highly variable increase in I	Large recent recruitment events, especially in Zone I
Owl limpet average size	Slight decline	Moderate decline	CABR owl limpets much larger than unprotected areas
Number of owl limpets in smallest size class	Not determined	Highly variable increase	Notable recruitment events
Average size of 10 largest owl limpets	Not determined	Slight decline	Cause remains unknown
Photoplots			
Acorn barnacles	Little change	Little change	Too variable to draw conclusions, more abundant in Zone III
Thatched barnacles	Sharp decline	Decline with possible recovery	Cause remains unknown
Mussels	Sharp decline	Sharp decline in II and III, Increase in I	Cause remains unknown
Goose barnacles	Moderate decline	Large cycles	Appears to be larger cyclical pattern
Rockweed	Little change	Little change	Expanding into other plot types
Transects			
Red algal turf	Little change	Slight decline	Being outcompeted by surfgrass; Trampling studies stress importance of turf thickness and microscopic community
Surfgrass	Sharp increase	Increase with stabilitzation/decrease	Expanded throughout lower intertidal, stabilizing
Boa kelp	Sharp increase	Decline with stabilization/decrease	Replaced by surfgrass, stabilizing
Anemones	Little change	Little change	Too rare to draw conclusions.
Sargassum weed	Little change	Little change	Too variable to draw conclusions

II. ASSESSMENT OF WATER QUALITY

A. Water Quality at the Monument

A.1. State designated beneficial uses or classifications of CABR waters

No beneficial uses are designated by the State specifically for Point Loma or the marine habitat of CABR (SDRWQCB 1994). The state designated beneficial uses of coastal waters of the Pacific Ocean in the San Diego area are:

- Industrial Service Supply
- Contact & noncontact water recreation
- Navigation
- Marine habitat
- Shellfish harvesting
- Commercial and sport fishing
- Rare, threatened or endangered species habitat
- Wildlife habitat
- Aquaculture
- Migration of aquatic organisms
- Spawning, Reproduction and/or Early development

The groundwater on Point Loma (Point Loma HA, see Section B.1.a) is excepted by the State from use as a municipal water supply (SDRWQCB 1994), and has no other state designated beneficial uses.

A.2. Bacteriological sampling at CABR

The California Ocean Plan (CalEPA 2001) mandates that the same ocean-water-contact standards apply to three zones:

(1) between shoreline and 1000 feet from shoreline - or the 30-foot depth contour - whichever is further from shoreline

(2) areas outside this zone that are used for water contact sports, and

(3) kelp beds

California Health and Safety Code (Division 104, Environmental Health; Part 10, Recreational Safety; Article 2, Public Beaches) establishes the following indicator organism standards for ocean beaches and ocean water sport contact areas:

Single sample standards:

* Total coliforms: 10,000 per 100 ml
* Total coliforms: 1,000 per 100 ml, if the ratio of fecal/total coliforms is greater and 0.1. The fecal/total ratio is an indicator of health risk, and a ratio that increases from 0.1 towards 1.0 may indicate a greater risk of illness.
* Fecal coliforms: 400 per 100 ml
* Enterococcus: 104 per 100 ml

Thirty-Day Average Values

The log mean of at least 5 equally spaced samples in any 30-day period:

* Total coliforms: 1,000 per 100 ml
* Fecal coliforms: 200 per 100 ml
* Enterococcus: 35 per 100 ml

The only shoreline water quality monitoring that takes place within the administrative boundary of CABR is for bacterial abundance[8], which occurs as part of the City of San Diego's Point Loma Ocean Outfall (PLOO) Ocean Monitoring Program (which is described in detail in Section II.B.2.a), and water temperature (which occurs via temperature loggers located in intertidal Zones I, II, and III). Grab samples of seawater from the beach are taken five times per month at the tip of the Point Loma Peninsula below the lighthouse (station D4, Figure 18), and below the PLWTP, near the northern border of CABR (station D5). The data collected at these stations by the City is used and reported by various agencies and web sites including the City of San Diego County Department of Environmental Health, Surfrider, and Heal the Bay.

Inspection of several years of recent data (Figures 19, 20) reveals that bacterial exceedances are rare at CABR, and are usually associated with wet weather (for example during the exceptional rains of the 2004/2005 winter season, when rainfall events with 25- to 50-year recurrence intervals occurred in southern California). When a brief raw sewage overflow occurred on October 27, 2004, from the PLWTP onto the beach near the northern border of CABR, bacterial exceedances were observed for only three days at the site of the spill (station D5); at the tip of the peninsula (station D4), the only exceedances were for enterococcus, and lasted two days.

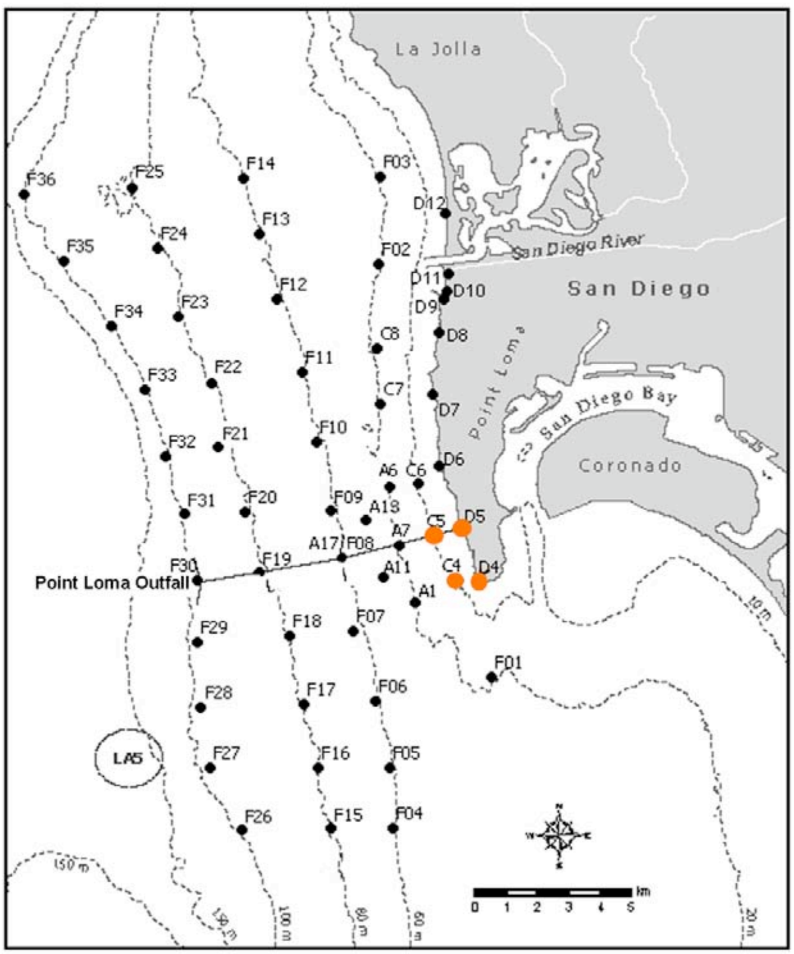


Figure 18. Locations where oceanographic parameters (F, A and C sites) and bacteria (F, A, C and D sites) are sampled in the PLOO Ocean Monitoring Program (CSD 2005a). Monitoring sites most pertinent to Cabrillo National Monument are shown in red. Active ocean dredge disposal site LA5 is also shown.

[8] There are temperature loggers in Zones I-III, but data from these instruments was not evaluated for this report.

A.3. Water quality in the Point Loma kelp bed near CABR

As part of the City's PLOO Ocean Monitoring Program, the following measurements are routinely taken at five stations (A1, A6, A7, C4, C5) in the Point Loma kelp bed directly offshore of CABR (Figure 18):

- bacterial abundance: total coliforms, fecal coliforms, enterococcus (five times per month)
- conductivity/temperature/density instrument (CTD) casts: depth profiles of chlorophyll a, salinity, transmissivity, pH, DO and temperature (five times per month)

The kelp bed sampling takes place to monitor compliance with water quality objectives for ocean water contact (explained above). Kelp bed stations C4 and C5 are located along the inshore edge of the kelp bed following the 30-ft depth contour. A1, A7 and A6 are located along the offshore edge of the kelp bed following the 60-ft depth contour. In recent years, water quality objectives for bacterial abundances within the Point Loma kelp bed have been exceeded only during wet weather (Table 4). Although raw data from CTD casts are publically available for download at http://sdcoos.ucsd.edu for PLOO monitoring sites further offshore (the "F" sites in Figure 18, in Section B.1.a), CTD data from the kelp bed stations is not currently available on the internet. During this project, data were obtained from the City for chlorophyll a, and salinity from all CTD casts that were conducted from 16-Jan-2003 to 27-Mar-2005 at stations C4, C5 and C6[9]. This time period was selected because it included a winter with below average rainfall (2003/2004) and an extraordinarily wet winter (2004/2005). Although not evaluated for this report, data from individual CTD casts at stations C4 and C5 from pertinent dates could presumably be examined for evidence of hypopycnal surface plumes related to terrestrial runoff events. Additionally, the nearshore chlorophyll record from the City's CTD casts (for more years than were obtained) could be used to address questions that have been raised (e.g., in Becker 2005) about whether food supply affects the growth and survival of mussels at CABR. A sample of 2004 CTD data from the nearshore kelp bed stations (monthly means for two depths) is shown in Table 5.

[9] The data is available in an Excel file on the CD-ROM that accompanies this report.

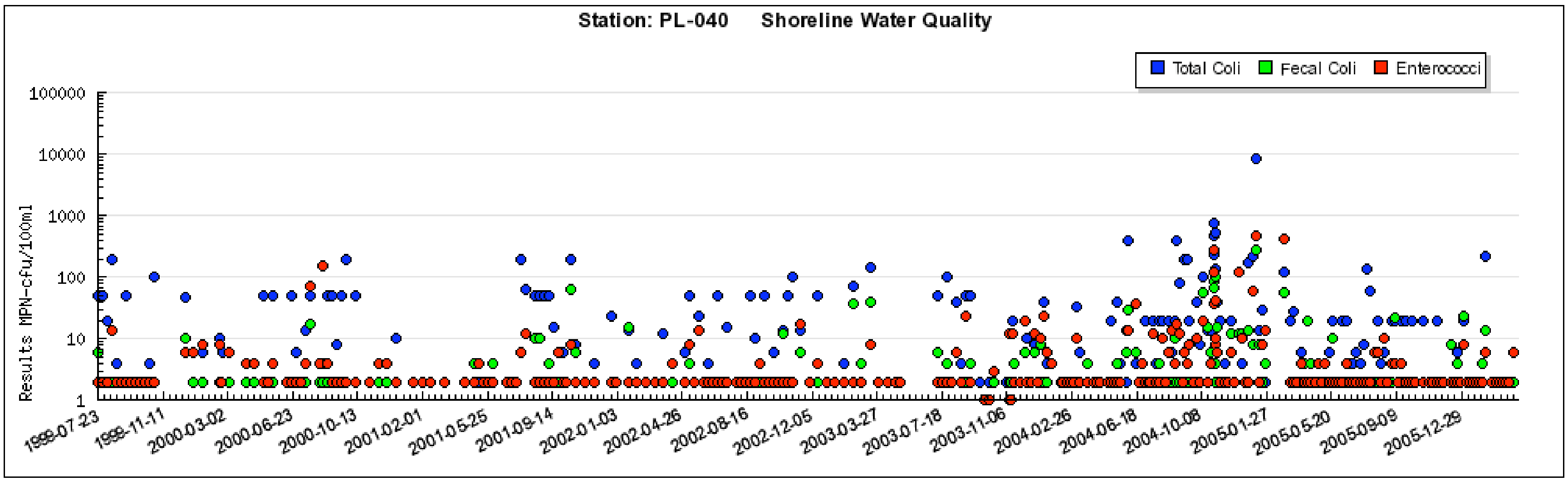


Figure 19. Shoreline bacterial abundances at the Point Loma Lighthouse from 7/1999 onward. Data are from Station D4 (Lat: 32° 39' 55.08"N, Lon: -117° 14' 35.52"W) in the City of San Diego's Point Loma Wastewater Treatment Plant Ocean Monitoring Program. Location of sampling station is shown in Figure 18. Raw data are archived as "shoreline water quality" data for station PL-040 at http://sdcoos.ucsd.edu.

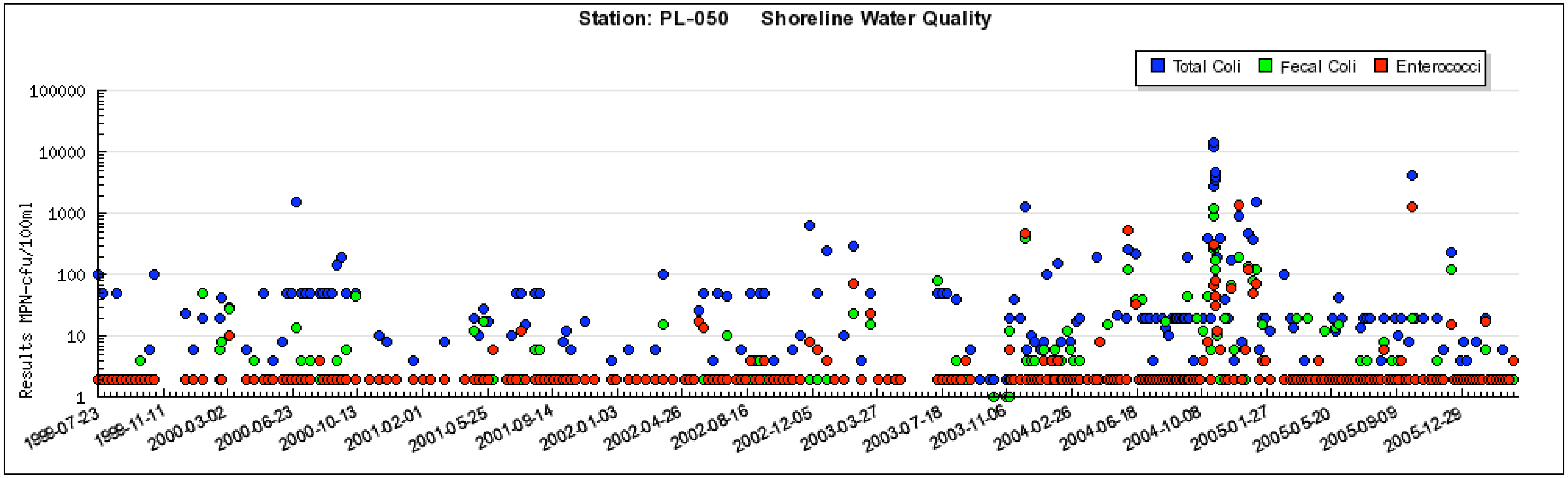


Figure 20. Shoreline bacterial abundances at the Point Loma Wastewater Treatment Plant from 7/1999 onward. Data are from Station D5 (Lat: 32° 40' 45.84"N, Lon: -117° 14' 53.16"W) in the City of San Diego's Point Loma Wastewater Treatment Plant Ocean Monitoring Program. Location of sampling station is shown in Figure 18. Raw data are archived as "shoreline water quality" data for station PL-050 at http://sdcoos.ucsd.edu.

Table 4. Summary of compliance with California Ocean Plan water contact standards for PLOO kelp bed stations during 2004. The values reflect the number of days that each station exceeded the 30-day total coliform standard. Kelp stations are listed left to right from south to north for the 9-m and 18-m depth contours. Location of the stations is shown in Figure 18. (from CSD 2005a).

30-Day Total Coliform Standard

		9-m stations			18-m stations				
Month	**# days**	**C4**	**C5**	**C6**	**A1**	**A7**	**A6**	**C7**	**C8**
January	31	0	0	0	0	0	0	0	0
February	29	0	0	0	0	0	0	0	0
March	31	0	0	0	0	0	0	0	0
April	30	0	0	0	0	0	0	0	0
May	31	0	0	0	0	0	0	0	0
June	30	0	0	0	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0
August	31	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0
October	31	0	0	0	0	0	0	0	0
November	30	1	0	0	1	12	0	0	0
December	31	1	1	1	1	1	0	0	1
Compliance (%)		99%	<100%	<100%	99%	96%	100%	100%	<100%

Table 5. Monthly average values for top (<2 m) and bottom waters at all PLOO nearshore kelp bed stations sampled during 2004. Parameters measured are: temperature (°C), salinity (ppt), density, DO=dissolved oxygen (mg/L), pH, XMS=transmissivity (%), and Chl a=chlorophyll a (µg/L) (from CSD 2005a).

		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Temp	Surface	14.3	14.1	15.3	16.0	18.2	19.2	20.1	20.8	20.6	18.6	16.7	15.5
	Bottom	13.7	13.4	13.2	12.5	14.6	15.1	13.6	15.1	15.0	15.9	15.3	15.0
Salinty	Surface	33.22	33.17	33.12	33.29	33.35	33.48	33.51	33.46	33.41	33.14	33.13	33.14
	Bottom	33.21	33.24	33.25	33.48	33.42	33.57	33.42	33.37	33.34	33.20	33.21	33.19
Density	Surface	24.74	24.74	24.46	24.43	23.97	23.82	23.58	23.36	23.39	23.70	24.15	24.44
	Bottom	24.87	24.95	24.98	25.29	24.82	24.81	25.04	24.68	24.65	24.36	24.52	24.58
DO	Surface	7.6	8.3	8.6	9.0	9.1	8.6	8.7	8.2	8.1	8.0	7.6	7.8
	Bottom	7.1	7.3	6.9	6.7	7.2	6.5	6.6	7.9	7.5	7.4	6.9	7.6
pH	Surface	8.1	8.1	8.1	8.1	8.2	8.2	8.2	8.1	8.2	8.1	8.1	8.1
	Bottom	8.0	8.0	7.9	7.9	8.1	8.0	8.0	8.1	8.1	8.1	8.1	8.1
XMS	Surface	81.5	78.2	79.0	75.3	77.9	75.8	79.6	84.4	80.9	77.5	76.7	76.2
	Bottom	83.2	82.3	84.0	79.9	79.9	79.9	85.0	85.0	83.9	84.6	81.3	77.4
Chl *a*	Surface	2.14	2.78	2.63	4.08	3.56	4.12	2.71	1.37	2.14	2.93	2.76	1.65
	Bottom	2.26	3.31	2.43	5.42	5.73	5.47	2.74	2.94	3.22	3.07	3.19	2.10

A.4. Inferences about Water Quality from Sentinel Mussels at CABR

(a) NOAA's Mussel Watch Project

NOAA created the National Status & Trends (NS&T) Program to assess the influence of human activities on the quality of coastal and estuarine areas. In 1986 the NS&T Mussel Watch Project (NOAA-MWP) began to monitor spatial and temporal trends of chemical contamination by chemically analyzing mussels and oysters collected at fixed sites throughout the coastal United States (Connor 2002). Owing to the fact that no single species of mollusc is common to all coasts, NOAA collects different species in different regions of the country: the blue mussel *Mytilus edulis* on the East Coast from Maine to Cape May, NJ; the American oyster *Crassostrea virginica* from Delaware Bay southward and throughout the Gulf of Mexico; the mussels *M. edulis and M. californianus* on the West Coast; the oyster *Ostrea sandvicensis* in Hawaii; the smooth-edged jewel box *Chama sinuosa* at the one site in the Florida Keys; the mangrove oyster *Crassostrea rhizophorae* in Puerto Rico; and the zebra mussel *Dreissena polymorpha* at sites in the Great Lakes. Sampling stations were selected by NOAA to represent large areas rather than the small-scale patches of contamination commonly referred to as ‘‘hot spots’’. *Toward this end, no sites were knowingly selected near waste discharge points.* NS&T sampling sites are not uniformly distributed along the coast. Within estuaries and embayments, they average about 20 km apart, while along open coastlines the average separation is 70 km. Almost half of the sites were selected in waters near urban areas, within 20 km of population centers in excess of 100,000 people.

Among the analytes measured in the NOAA-MWP are (1) chlorinated pesticides such as DDT (and its metabolites DDE and DDE), aldrin and dieldrin, chlordane (alpha-chlordane, trans-nonachlor, heptachlor, heptachlorepoxide), lindane (gamma-hexachlorocyclohexane, "HCH") and its metabolites, chlorpyrifos, and mirex; (2) many other pesticides (such as diazinon, ethion, endosulfan, parathion); (3) polychlorinated biphenyls (PCBs); (4) organotin (mono-, di-, and tri-butyltin); (5) trace elements; and (6) a suite of 23 polycyclic aromatic hydrocarbons (PAHs). NOAA maintains a sampling site near the boundary of CABR (NOAA site PLLH, for "Point Loma Lighthouse"). Between 1986 and 1989, site PLLH was located at the Point Loma Lighthouse. After 1989, the station was relocated to the PLWTP, near the northern boundary of CABR. In all, mussels were sampled at site PLLH thirteen times between 1986 and 2005 (Table 6).

Table 6. Analytes measured in mussels collected at site PLLH of the NOAA-MWP. Current station coordinates are 32.6805 °N, -117.249 °W.

Analyte	86	87	88	89	90	91	92	95	97	99	01	03	05
Aluminum	X	X	X	X	X	X	X	X	X	X	X	X	X
Antimony	X	X			X	X	X						
Arsenic	X	X	X	X	X	X	X	X	X	X	X	X	X
Cadmium	X	X	X	X	X	X	X	X	X	X	X	X	X
Chromium	X	X	X	X	X	X	X	X	X	X	X	X	X
Copper	X	X	X	X	X	X	X	X	X	X	X	X	X
Iron	X	X	X	X	X	X	X	X	X	X	X	X	X
Mercury	X	X	X	X	X	X	X	X	X	X	X	X	X

Analyte	86	87	88	89	90	91	92	95	97	99	01	03	05
Manganese	X	X			X	X	X	X	X	X	X	X	X
Nickel	X	X	X	X	X	X	X	X	X	X	X	X	X
Lead	X	X	X	X	X	X	X	X	X	X	X	X	X
Selenium	X	X	X	X	X	X	X	X	X	X	X	X	X
Silver					X	X	X	X	X	X	X	X	X
Tin	X	X	X	X	X	X	X	X	X	X	X	X	X
Zinc	X	X	X	X	X	X	X	X	X	X	X	X	X
PAHs			X	X	X	X	X	X	X	X	X	X	X
PCBs	X	X	X	X	X	X	X	X	X	X	X	X	X
DDT, DDE, DDD	X	X	X	X	X	X	X	X	X	X	X	X	X
Aldrin	X	X	X	X	X	X	X	X	X	X	X	X	X
Dieldrin	X	X	X	X	X	X	X	X	X	X	X	X	X
beta-HCH								X	X	X	X	X	X
delta-HCH								X	X	X	X	X	X
gamma-HCH (lindane)	X	X	X	X	X	X	X	X	X	X	X	X	X
Chlorpyrifos								X	X	X	X	X	X
Cis-nonachlor								X	X	X	X	X	X
Organotins (tri-, di-, monobutyltin)				X	X	X	X	X	X	X	X	X	X
Endosulfan I									X		X	X	X
Endosulfan II								X	X	X	X	X	X
Endrin						X	X	X	X	X	X	X	X
gamma Chlordane								X	X	X	X	X	X
Hexachlorobenzene	X	X	X	X	X	X	X	X	X	X	X	X	X
Mirex	X	X	X	X	X	X	X	X	X	X	X	X	X
Oxychlordane								X	X	X	X	X	X
Pentachloroanisole								X	X	X	X	X	X
Pentachlorobenzene								X	X	X	X	X	X
1,2,3,4 tetrachlorobenzene								X	X	X	X	X	X
1,2,4,5 tetrachlorobenzene								X	X	X	X	X	X

(b) California State Mussel Watch Program

For 26 years (1977-2003) the California State Mussel Watch Program (CA-SMWP) analyzed body burdens in transplanted and resident mussels and clams from the waters of California's bays, harbors and estuaries. Statewide, samples were analyzed for one of more of the following types of contaminants: trace elements, pesticides, PCBs, and a suite of PAHs. *In contrast with the NOAA-MWP, the CA-SMWP primarily targeted areas with known or suspected degradations in water quality*.

Over the life time of the program, mussels from 88 discrete sites in the San Diego area were intermittently sampled by the CA-SMWP from the U.S./Mexico border to the north jetty at the entrance to Mission Bay (see Appendix E for sampling history at these sites). A subset of these sites were located near CABR (Table 7). Unfortunately, none of the state sites near CABR were sampled very recently (most recent sample was from 1993), and none of the sites were as consistently sampled as NOAA-MWP site PLLH. Given that the NOAA-MWP yielded better time series data for mussels near CABR than the CA-SMWP, we did not evaluate state data for this report.

(c) Temporal Trends in NOAA-MWP data from Point Loma

We did not conduct statistical analyses on the time series data from NOAA-MWP. Time series plots for selected analytes, made using data from NOAA site PLLH for the period 1986-2003[10], are shown in Figures 21-24. Some trends are suggested by visual inspection of the data[11]. Among the trace elements found in mussel tissue, silver shows the strongest evidence of a decline since 1986 at site PLLH. Arsenic and copper concentrations show some signs of decline since 1986. Aluminum, selenium, and tin concentrations appear to be declining after peaking in 1995. Long term trends are not evident for zinc, cadmium, copper, and tin. Chromium and nickel levels may be increasing. Levels of organotins, total PCBs, and total DDTs have strongly decreased. Lindane was intermittently high in mussels up to the early 1990s, but levels have decreased since then. Temporal trends for lead, dieldrin, aldrin, and PAHs are less clear.

The apparent declines in lindane, DDT, PCBs, and organotins in mussels at site PLLH since 1987 are expected given patterns of chemical use in recent decades (Figures 21-24). Several of the substances measured in the NOAA-MWP are now banned for use in the U.S. or California. For example, although the pesticide lindane is still widely used in the U.S. (for treating head lice and scabies, and on pets, livestock, fruits and vegetables, cotton, wool, and tobacco), it is banned in California. All uses of DDT and dieldrin were banned in the U.S. in the 1970s. PCB use in the United States began being phased out in 1971, and a ban on new uses took effect in 1976. Tributlytin, and its byproducts mono- and dibutyltin, are found in molluscs because tributyltin has been used as an antifouling agent in the paint commonly used on boats and some underwater marine facilities. However, its use on vessels under 75 feet long was banned in 1988 by the U.S. Organotin Anti-Fouling Paint Act (O'Connor 2002), and water sampling has shown declines in organotins in seawater near Point Loma (Ken Richter, U.S. Navy, pers. comm.).

Although trace elements (Cd, etc.) occur naturally, they can also be indicators of industrial pollution. There was a substantial decrease in the use of silver by the U.S. in the late 1970s owing to a decrease of silver use in the photographic industry. This phenomenon may explain sharply decreasing levels of silver in mussels at site PLLH (Figure 21). Lead concentrations were expected to decline in aquatic organisms following the ban of lead in gasoline. Transportation emissions accounted for over 80% of total lead emissions in 1970, and lead emissions declined by more than 98% from 1970-1980 (USEPA 1990). A decline in lead was apparently still underway at site PLLH up to 1992, but further declines since then are not evident (Figure 22). Dissolved copper in San Diego Bay results hull coating leachate from civilian, commercial, and Navy vessels; civilian and Navy hull cleaning; other ship discharges (e.g., cooling water); point source discharges; stormwater runoff; and atmospheric deposition (Johnson et al. 1998). There is evidence that the mass balance of copper in San Diego Bay is dominated by chronic sources and that this balance probably approaches steady state (Chadwick et al. 2004). This view is supported

[10] Although NOAA sampled mussels at site PLLH in 2005 (sampling now takes place every two years), the data were not publically available when the analyses in this report were done.

[11] The relocation, in 1989, of site PLLH from the tip of the Point Loma peninsula, to a site near the northern boundary of CABR, may affect interpretation of some of the apparent trends in the data.

by studies over the last 25 years that have found similar levels of dissolved copper in San Diego Bay (Zirino et al. 1978; Flegal and Sañudo-Wilhelmy 1993; Esser and Volpe 2002). Copper in mussels at site PLLH has only slightly declined since 1987 (Figure 21).

PAHs occur in fossil fuels such as coal and oil, in creosote and asphalt, and are produced when organic matter burns. Almost all historical data concerning PAH concentrations in seawater from San Diego Bay comes from periodic surveys conducted by the Navy, starting in March 1990 (Katz 1998). In two San Diego Bay surveys conducted by the Navy in 1997, molecular fingerprinting showed that PAH in seawater outside the entrance to the bay was 80%-100% creosote derived, with the remainder diesel derived, and that PAH in water at the Naval Submarine Base at Ballast point was 86%-100% creosote derived, with the remainder diesel derived (Katz 1998). As recently as 1994, strong PAH gradients were observed near the Naval Station in the center of the bay, which implicated sources from within the quay wall of the Naval Station (Figure 25). As in other San Diego Bay locations, molecular fingerprinting identified creosote from pilings and weathered fuel products as the primary sources of PAH in this plume. Historically, bilge water from naval ships in San Diego Bay was discharged into gravity separators placed in the bay. In the mid-1990s the Navy altered operations so that bilge water is now collected and treated onshore. Additionally, the Navy began to replace creosote-impregnated pilings with plastic, concrete or untreated wooden pillings (Katz 1998). By 1997, the steep gradients in PAH originating at the Naval Station were no longer observed (Figure 26). PAH plumes have not been observed emanating from Naval facilities closest to Point Loma (the Naval Submarine Base and the northwest shore of NAS North Island), however, results from an August 1992 survey indicated slightly elevated concentrations in the vicinity of the Navy Fuel Tank Farm (Figure 25). Whether this was related to a source at the tank farm, or reduced tidal flushing there compared to the main channel, is not known. The NOAA-MWP data suggest that some phenomenon raised mussels' exposure to PAH at site PLLH between 1989 and 1991, and that a decline to earlier levels of exposure is still underway (Figure 22). Unfortunately, data are lacking for PAH levels in seawater from San Diego Bay prior to 1990 (Katz 1998).

Table 7. Sampling history (E: trace elements, O: organics) for California State Mussel Watch Project stations near Cabrillo National Monument from 1978 to 2000. Blanks indicate that sampling did not occur that year.

Station #	Station Name	Latitude °N	Longitude °W	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00
850.5	Point Loma	32.6641	117.2683						E																	
840.2	Point Loma/ Coast Guard Station	32.6653	117.2422									E														
902.0	Zuniga Jetty/ Buoy	32.6656	117.2267				O																			
840.0	Naval Ocean Sys Cntr/ Dolphin Tanks	32.6669	117.2436				E	E	EO		EO	E			E				E							
903.0	Zuniga Jetty	32.6672	117.2231							EO	E	EO														
839.2	Point Loma/ STP Outfall	32.6789	117.2481									E	E													

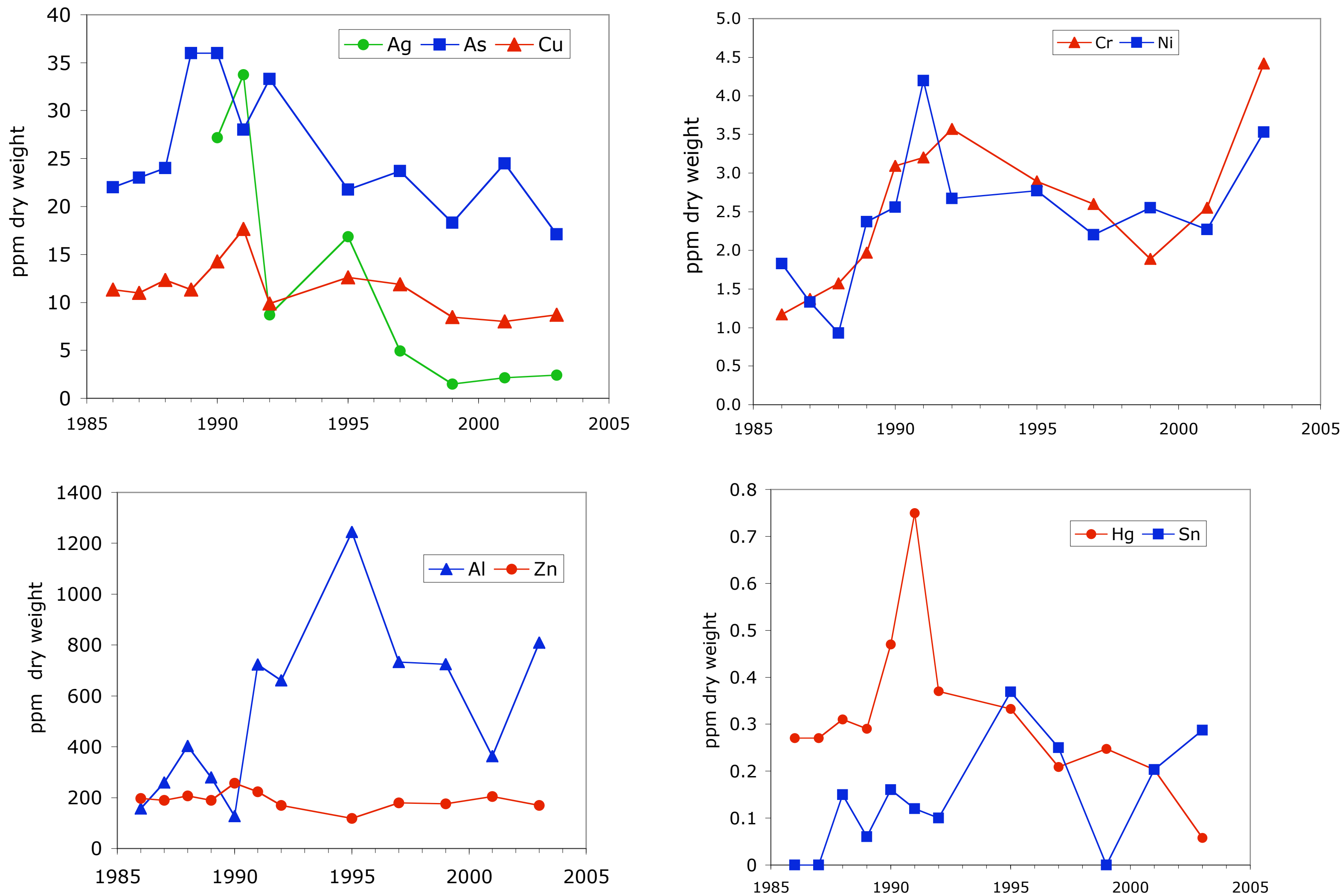
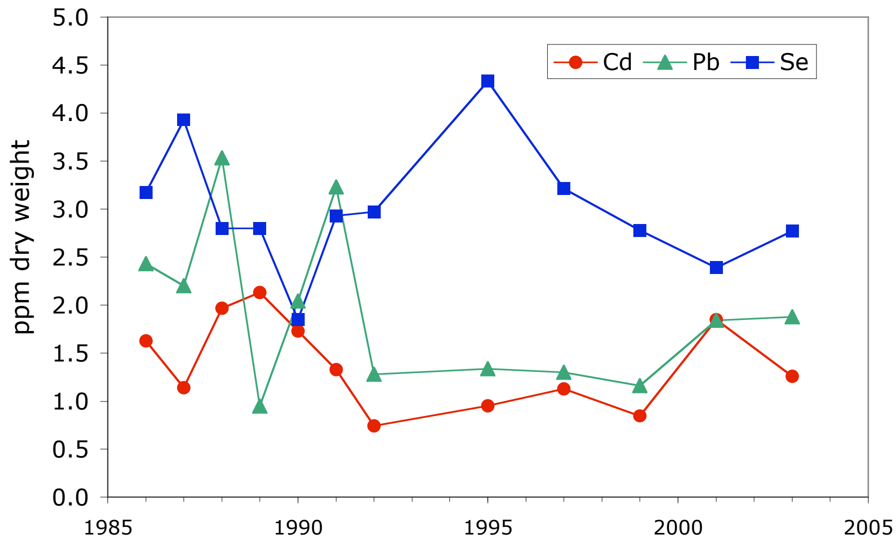


Figure 21. Levels of trace elements (Ag, As, Cu, Cr, Ni, Al, Zn, Hg, Sn) in mussel tissue (*Mytilus californianus*) measured at NOAA-MWP site PLLH from 1987 to 2003.



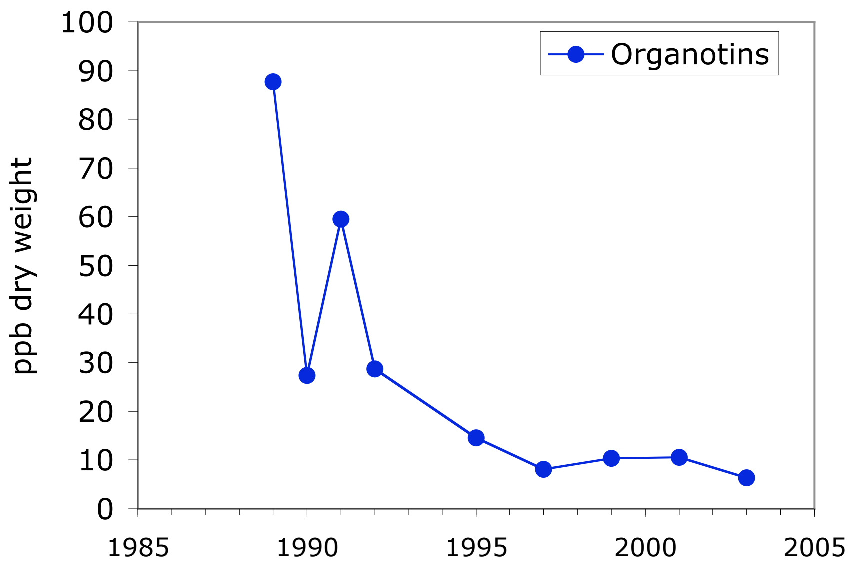


Figure 22. Levels of cadmium, lead, selenium, and organotin (tri-, di-, and monobutytin) in mussel tissue (*Mytilus californianus*) measured at NOAA-MWP site PLLH from 1987 to 2003.

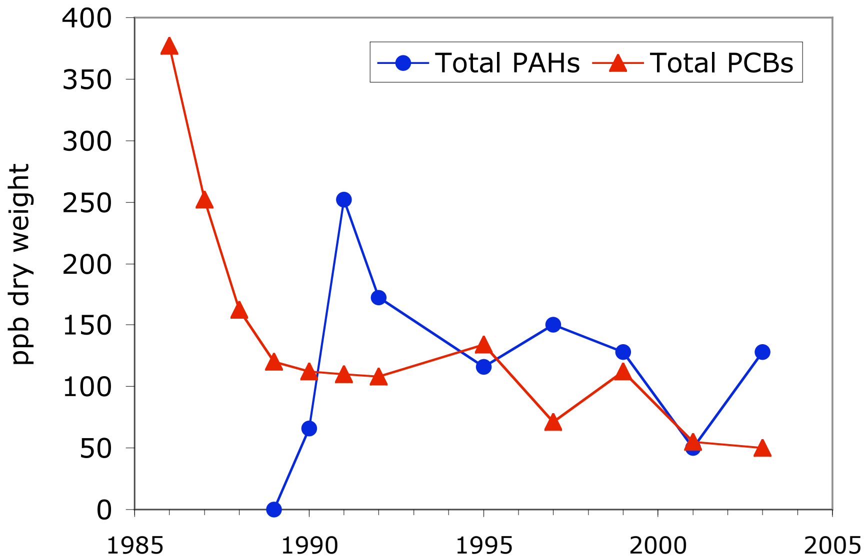


Figure 23. Levels of total PAH and total PCB in in mussel tissue (*Mytilus californianus*) measured at NOAA-MWP site PLLH from 1987 to 2003. In accordance with NOAA methods, total PAH was calculated as ∑[napthalene + 2-methylnaphthalene + 1-methylnapthalene + biphenyl + 2,6-dimethylnaphthalene + acenthe + acenaphthylene + 1,6,7-trimethylnaphthalene + fluorene + phenanthrene + anthracene + 1-methylphenanthrene + fluoranthene + pyrene + benz(a)anthracene + benzo(b)fluoranthene + benzo(k)fluoranthene + benzofluoranthene + benzo(e)pyrene + benzo(a)pyrene + dibenzo(a,h)anthracene + indeno(1,2,3-c,d)pyrene + benzo(g,h,i)perylene + chrysene + perylene]. Benzo(*b*)fluoranthene and benzo(*k*)fluoranthene were not reported when benzofluoranthene was; therefore benzofluoranthene is included in the sum. Total PCB was calculated for 1986-1987 as ∑[di + tri + tet + pen + hex + hep + oct + non], and after 1988 as 2 x ∑(pcb8 + pcb18 + pcb28 + pcb52 + pcb44 + pcb66 + pcb101 + pcb105 + pcb138 + pcb118 + pcb128 + pcb153 + pcb170 + pcb180 + pcb187 + pcb195 + pcb206 + pcb209). Compounds that were below detection levels were assigned values of zero.

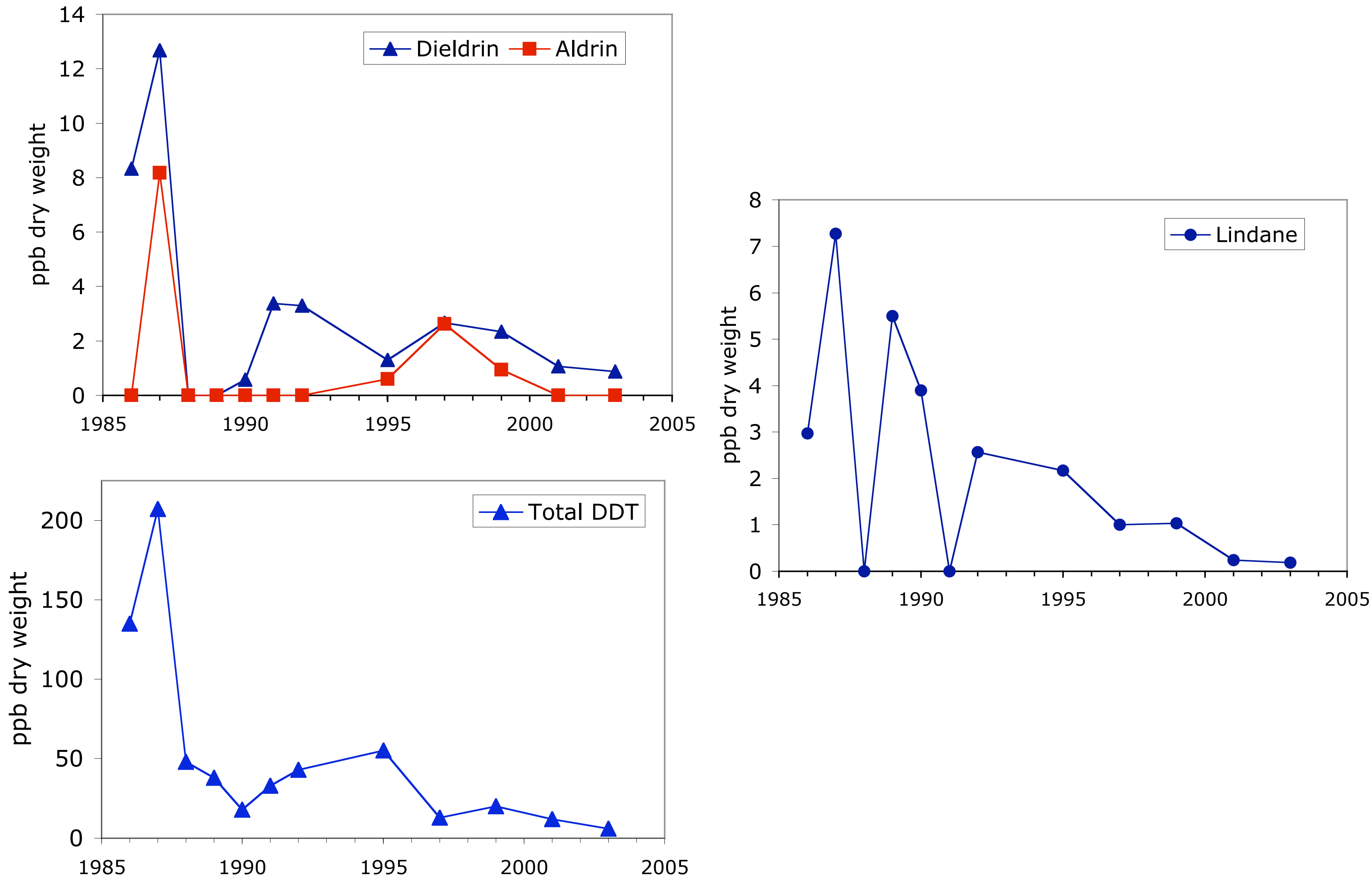


Figure 24. Levels of dieldrin, aldrin, lindane, and total DDTs in mussel tissue (*Mytilus californianus*) measured at NOAA-MWP site PLLH from 1987 to 2003.

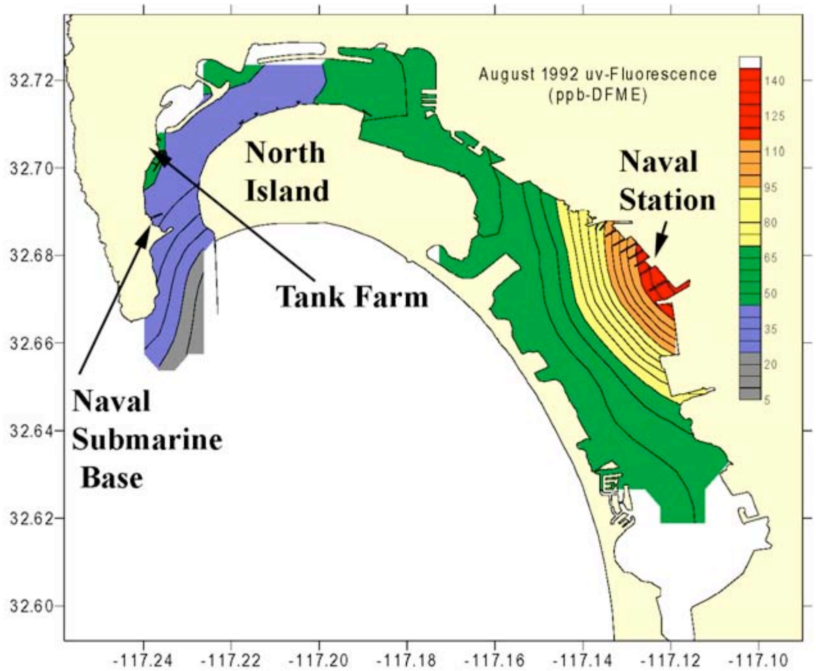


Figure 25. PAH gradients in surface water in San Diego Bay measured in a Navy survey on 20 August 1992. Data are for relative uv-fluorescence (ppb-DFME) (Katz 1998).

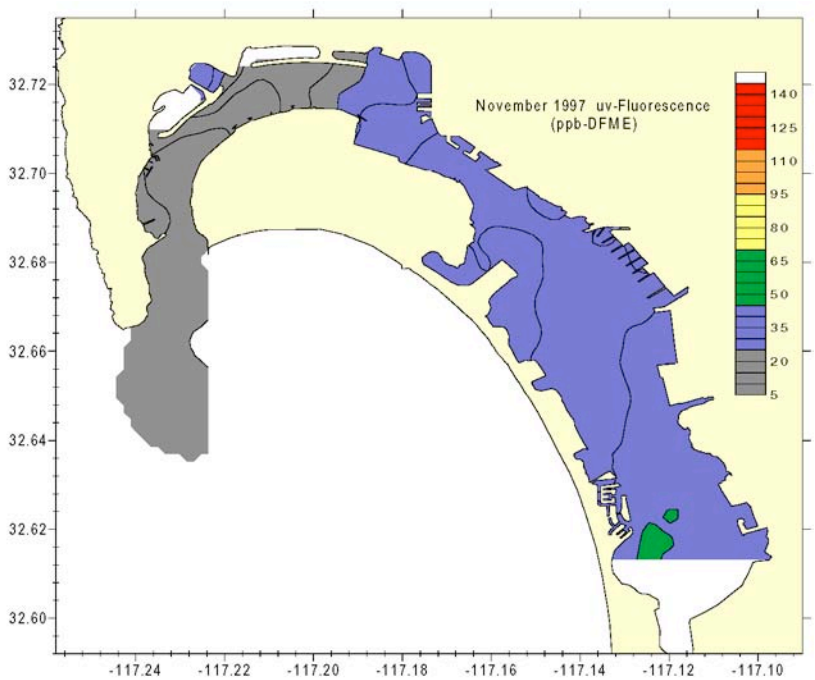


Figure 26. PAH gradients in surface water in San Diego Bay measured in a Navy survey on 4 November 1997. These data were obtained after operations were changed at Naval Facilities to reduce inputs of contamination from bilge water to the bay (see text). Data are for relative uv-fluorescence (ppb-DFME) (Katz 1998).

(d) Recent Spatial Trends in Mussel Body Burdens at Point Loma

For one year, beginning in August 2004, transplanted mussels were used by CABR to investigate spatial patterns of contaminant exposure around the end of the Point Loma Peninsula (Becker 2005). In the CABR study, bay mussels, *M. galloprovincialis,* were raised on set lines off of the Scripps Institution of Oceanography Pier in La Jolla for one year, outplanted at sites around Point Loma, allowed to grow for three months, and then collected for chemical analysis. Bay mussels were used because bay sites were included in the study, and in contrast to the California mussel, *M. californianus*, this species can thrive in both protected and exposed conditions. Three cages were outplanted at each of seven sites (Figure 27). One site ("Inner Bay") was located within San Diego Bay, at the Scripps Nimitz Marine Facility (MARFAC), on a pier used for large research vessels. The "Outer Bay" site was on the southeastern corner of Point Loma, on property administered by the U.S. Navy, on scattered boulders. The "CABR 1", "CABR 2", and "CABR 3" sites were located within the corresponding intertidal management zones of the park (see Section I.C.3), all on scattered boulders. The "Ocean Side" site was on the outer coast of Point Loma, on U.S. Navy Space and Naval Warfare System Center property. The last set of cages was suspended by rope on SIO Pier in La Jolla ("SIO" site), and was considered to be free of San Diego Bay influence due to its distance from the area. Four three-month deployments were conducted during each of four seasons from Fall 2004 to Summer 2005. Methodological details are found in Becker (2005). Table 8 shows the suite of analytes measured in the study.

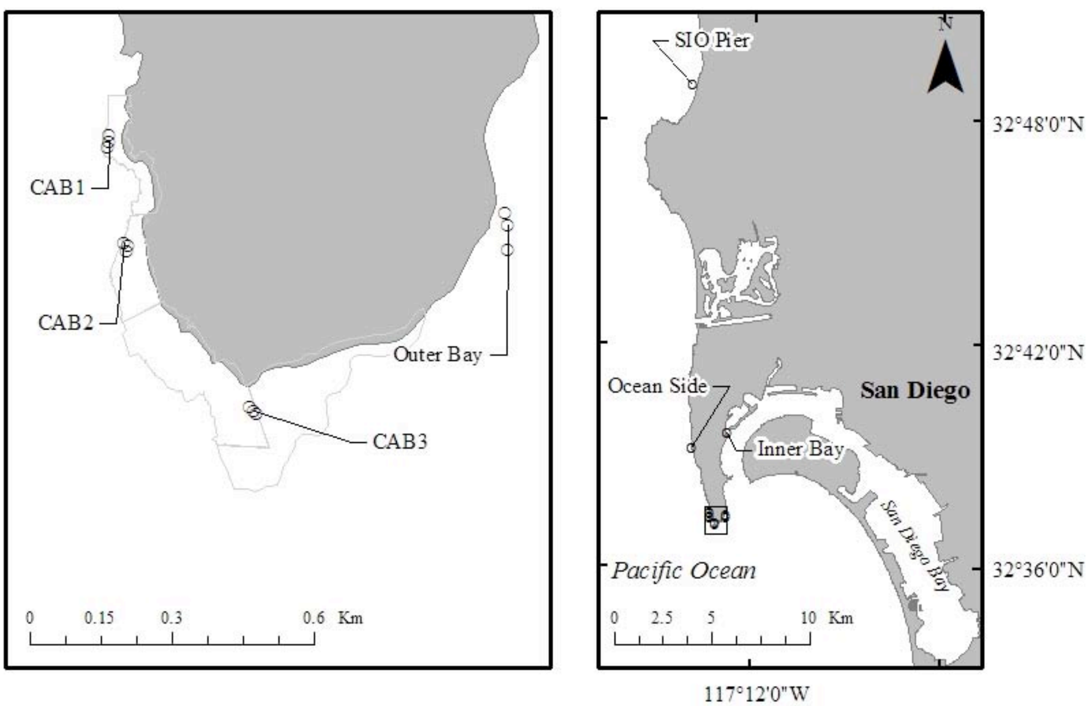


Figure 27. Maps showing the seven sites used in the sentinel mussel project conducted by Cabrillo National Monument in 2004-2005 (from Becker 2005).

As of this writing, results from this study were only available for only a few analytes (Al, Cu, PCB101, PCB118, and fluoranthene, see Appendix F for preliminary figures). Preliminary results provide no evidence that mussels at Point Loma ("CAB" sites) are exposed to more alumimum than mussels further north on the open ocean coast of the peninsula ("ocean side" site), and only during the fourth experiment ("fourth quarter") was aluminum higher in mussels caged on the bay side of Point Loma ("outer bay" site), versus the ocean side of the cape. Copper was significantly higher in mussels transplanted inside the bay (near the Shelter Island Yacht Basin and the Navy Fuel Tank Farm) versus those transplanted around the perimeter of Point Loma. However, position on the *bay side* ("outer bay") versus the *open ocean* side of Point Loma ("CAB1, 2") did not greatly influence copper levels in mussels at Point Loma, and, as a group, Point Loma mussels contained similar levels of copper as mussels caged further north on the open coast. Qualitative results for PCBs (arochlors 101 and 118) were similar to those for copper, except that in two experiments (first and second quarters) PCBs were higher in Point Loma mussels, as a group, than in those transplanted further north on the open ocean coast. Curiously, *growth* of mussels during the three-month cage deployments was lower on the bay-side of Point Loma (site 2, Appendix F) than it was *further* inside the bay or at the Point Loma sites exposed to the open ocean. This result has not yet been explained, although hypotheses are set forth in Becker (2005), and include food limitation, among other things.

Table 8. Analytes measured in the sentinel mussel project conducted by Cabrillo National Monument in 2005-2005. List was provided by B. Becker.

Analyte	Analyte	Analyte
1-methylnaphthalene	Gamma (trans) Chlordane	PCB 101
1-methylphenanthrene	Heptachlor	PCB 105
2,3,5-trimethylnaphthalene	Heptachlor epoxide	PCB 110
2,6-dimethylnaphthalene	Hexachlorobenzene	PCB 114
2-methylnaphthalene	Indeno(1,2,3-CD)pyrene	PCB 118
3,4-benzo(B)fluoranthene	Iron	PCB 119
Acenaphthene	Lead	PCB 123
Acenaphthylene	Lipids	PCB 126
Aldrin	Manganese	PCB 128
Alpha (cis) Chlordane	Mercury	PCB 138
Alpha Endosulfan	Mirex	PCB 149
Aluminum	Monobutyl Tin	PCB 151
Anthracene	Naphthalene	PCB 153/168
Antimony	Nickel	PCB 156
Arsenic	o,p-DDD	PCB 157
Barium	o,p-DDE	PCB 158
Benzo[A]anthracene	o,p-DDT	PCB 167
Benzo[A]pyrene	Oxychlordane	PCB 169
Benzo[e]pyrene	p,p-DDD	PCB 170
Benzo[G,H,I]perylene	p,p-DDE	PCB 177
Benzo[K]fluoranthene	p,-p-DDMU	PCB 18
Beryllium	p,p-DDT	PCB 180
BHC, Alpha isomer	Perylene	PCB 183

Analyte	Analyte	Analyte
BHC, Beta isomer	Phenanthrene	PCB 187
BHC, Delta isomer	Pyrene	PCB 189
BHC, Gamma isomer	Selenium	PCB 194
Biphenyl	Silver	PCB 201
Cadmium	Tetrabutyltin	PCB 206
Chromium	Thallium	PCB 28
Chrysene	Tin	PCB 37
Cis Nonachlor	Total Solids	PCB 44
Conductivity	Toxaphene	PCB 49
Copper	Trans Nonachlor	PCB 52
Dibenzo(A,H)anthracene	Tributyltin	PCB 66
Dieldrin	Turbidity	PCB 70
Endrin	Zinc	PCB 74
Fluoranthene		PCB 77
Fluorene		PCB 81
		PCB 87
		PCB 99

B. Sources of Water Pollution Outside the Monument

B.1. Regulatory Background Concerning Water Quality

(a) Pertinent coastal area defined

There are five main routes through which pollutants may enter the coastal ocean in the general vicinity of CABR:

1) ocean outfalls for two sewage treatment plants (South Bay Ocean Outfall, Point Loma Ocean Outfall, Figure 8)
2) wet weather outflow from two rivers with large watersheds (San Diego River and Tijuana River, Figure 3)
3) tidal flushing of San Diego Bay
4) storm drain or other runoff to the ocean from the western shore of Point Loma Peninsula
5) illegal discharges or accidental spills from marine vessels (commercial, pleasure, Naval), primarily during transit between the ocean and San Diego Bay (includes groundings and wrecks)
6) desorption from dredged material on the ocean floor at, and near, ocean disposal site LA-5 offshore from Point Loma (Figure 18).

Consequently, we define the coastline from the entrance to Mission Bay to the mouth of the Tijuana River as the region containing the point and non-point sources most pertinent to this report. Water quality in California is regulated by the California State Water Resources Control Board (SWRCB or *State Board*). The state is divided into the following nine Regions, each with a Regional Water Quality Control Board (RWQCB, or *Regional Board*):

Region 1: North Coast RWQCB
Region 2: San Fransisco Bay RWQCB
Region 3: Central Coast RWQCB
Region 4: Los Angeles RWQCB
Region 5: Central Valley RWQCB
Region 6: Lahontan RWQCB
Region 7: Colorado River Basin RWQCB
Region 8: Santa Ana RWQCB
Region 9: San Diego RWQCB

Region 9 is divided into eleven Hydrologic Units (HUs), and smaller units called Hydrologic Areas (HAs) and Hydrologic Sub-areas (HSAs). Water quality monitoring and pollution control in the following HAs and HSAs of Region 9 are pertinent to this report (Figure 28):

within Penasquitos HU (#906):
906.30 Scripps HA
906.40 Miramar HA
906.50 Tecolote HA

within San Diego River HU (#907):
907.11 Mission San Diego HSA (includes lowest reach of San Diego River)

within Pueblo San Diego HU (#908):
908.10 Point Loma HA
908.21 Lindbergh HSA
908.22 Chollas HSA
908.31 El Toyan HSA
908.32 Paradise HSA

within Sweetwater HU (#909):
909.11 Lower Sweetwater HAS
909.12 La Nacion HAS

within Otay HU (#910)
910.10 Coronado HA
910.20 Otay Valley HA

within Tijuana HH (#911)
911.11 San Ysidro HSA

The Pueblo San Diego, Sweetwater and Otay HUs are referred to collectively as the San Diego Bay Watershed Management Area.

(b) 303(d) listed water bodies and impairments

The State Board and the nine Regional Boards are responsible for monitoring, assessment, and reporting under Clean Water Act Sections 303(d) and 305(b) for the State of California. The

State Board and Regional Boards cooperate in developing Section 303(d) listing reports of water bodies which fail to meet water quality objectives for designated beneficial uses. Table 9 contains the currently listed water segments, and impairments, from the HAs and HSAs pertinent to this report.

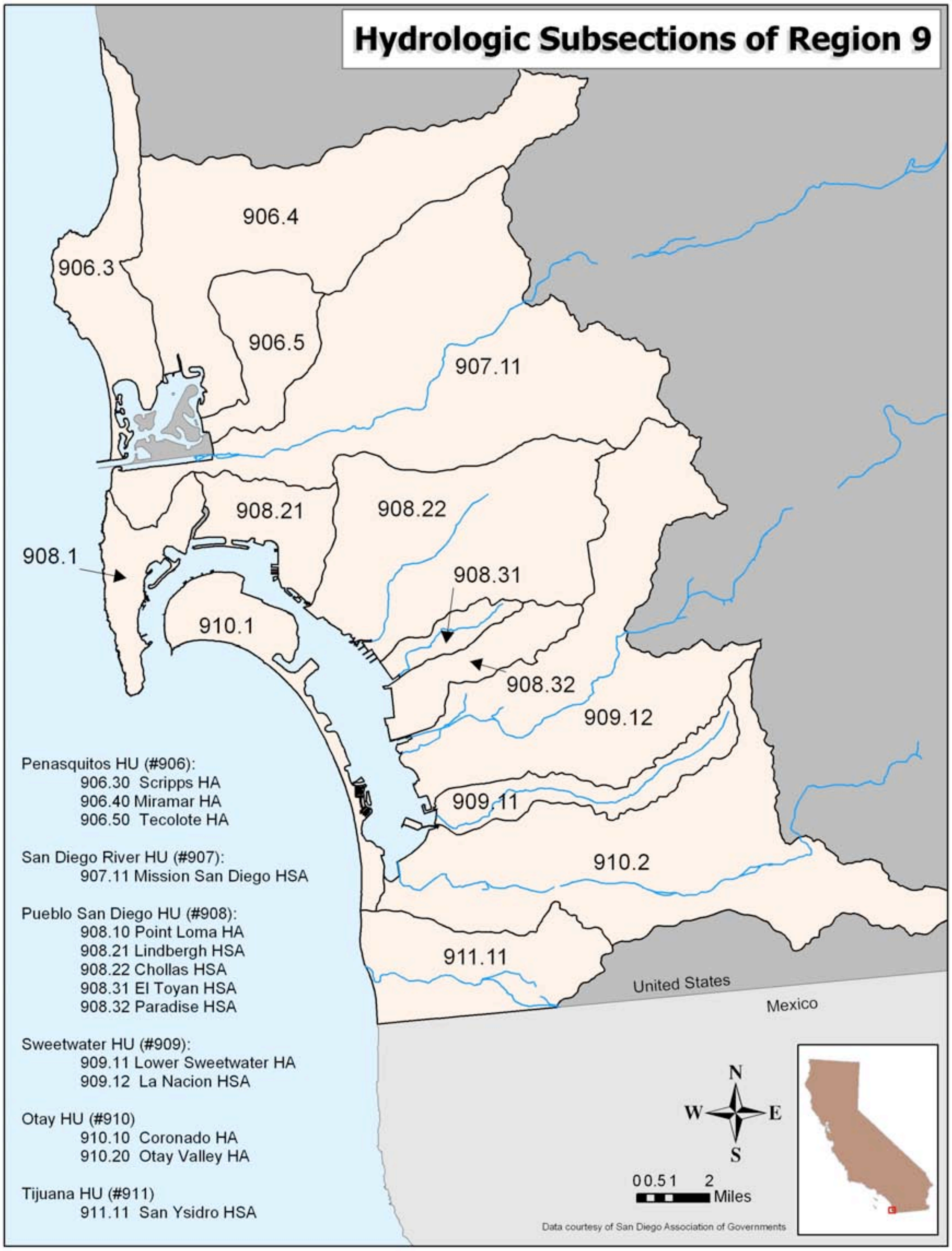


Figure 28. Hydrologic subsections of Region 9 that drain directly into Mission Bay, San Diego Bay, or the coastal ocean in the San Diego area.

Table 9. Water Quality Limited Segments from the State 303(d) list for selected HAs and HSAs of Region 9.

303(d) Listed River Segment, Beach, Harbor, Estuary	Impairment
PENASQUITOS HYDROLOGIC UNIT	
906.30 Scripps HA	
Pacific Ocean Shoreline	Bacteria • La Jolla Shores Beach (several locations) • Casa Beach • South Casa Beach • Whispering Sands Beach • Windansea Beach (four locations) • Tourmaline Surf Park • Pacific Beach
906.40 Miramar HA	
Mission Bay	Bacteria: entire bay shoreline Eutrophic: mouths of Rose Creek and Tecolote Creek Lead: mouths of Rose Creek and Tecolote Creek
906.50 Tecolote HA	
Tecolote Creek	Bacteria Cadmium Copper Lead Toxicity Zinc
SAN DIEGO HYDROLOGIC UNIT	
907.11 Mission San Diego HSA	
Famosa Slough and Channel	Eutrophic: 32 acres
Pacific Ocean Shoreline	Bacteria: mouth of San Diego River (aka Dog Beach)
lower San Diego River	Fecal Coliform: lower 6 miles Low Dissolved Oxygen Phosphorus Total Dissolved Solids
PUEBLO SAN DIEGO HYDROLOGIC UNIT	
908.10 Point Loma HA	
San Diego Bay Shoreline 16 acres near Naval Submarine Base	Benthic community effects Sediment toxicity
San Diego Bay Shoreline Shelter Island Shoreline Park	Bacteria
San Diego Bay Shelter Island Yacht Basin	Dissolved Copper
908.21 Lindbergh HSA	
San Diego Bay Shoreline Downtown Anchorage	Benthic community effects Sediment toxicity
San Diego Bay Shoreline G Street Pier	Bacteria
San Diego Bay Shoreline near Switzer Creek	chlordane lindane PAHs
San Diego Bay Shoreline Vicinity of B St. and Broadway Piers	Bacteria: 0.4 miles of bay shoreline Benthic community effects Sediment toxicity

303(d) Listed River Segment, Beach, Harbor, Estuary	Impairment
908.22 Chollas HSA	
Chollas Creek	Bacteria Cadmium Copper Diazinon Lead Zinc
San Diego Bay Shoreline 32nd St. San Diego Naval Station	Benthic Community Effects Sediment Toxicity
San Diego Bay Shoreline between Sampson and 28th Sts.	Copper Mercury PAHs PCBs Zinc
San Diego Bay Shoreline near Chollas Creek	Benthic community effects Sediment toxicity
San Diego Bay Shoreline near Coronado Bridge	Benthic community effects Sediment toxicity
908.31 El Toyan HSA	
San Diego Bay Shoreline 7th Street Channel	Benthic community effects Sediment toxicity
908.32 Paradise HSA	
San Diego Bay Shoreline north of 24th St. Marine Terminal	Benthic community effects Sediment toxicity
SWEETWATER HYDROLOGIC UNIT	
909.11 Telegraph HSA	
none	none
909.12 La Nacion HSA	
San Diego Bay Shoreline Chula Vista Marina	Bacteria
OTAY HYDROLOGIC UNIT	
910.10 Coronado HA	
TIJUANA HYDROLOGIC UNIT	
911.11 San Ysidro HSA	
3 miles of Pacific Ocean Shoreline from Mexico border northward	Bacteria
Tijuana River	Bacteria Eutrophic Low dissolved oxygen Pesticides Solids Synthetic Organics Trace Elements Trash
Tijuana River Estuary	Bacteria Eutrophic Lead Low dissolved oxygen Nickel Pesticides Thallium Trash

Two of the 303(d) listed water segments are located on the bay-side shoreline of the Point Loma Peninsula, and thus are in proximity to CABR: the Naval Submarine Base and Shelter Island Yacht Basin. More detail for these two listed segments is provided below.

Naval Submarine Base
In 2000, the SDRWQCB initiated efforts to develop Total Maximum Daily Loads (TMDLs) for the Naval Submarine Base to address benthic community degradation and sediment toxicity there. As of this writing (4/2006) , the TMDLs for this site were still under development. The Navy recently reviewed sediment chemistry and sediment toxicity data from the Naval Submarine Base compiled from six earlier studies spanning 1993-2002 (Figure 29) (USN 2003). Based on NOAA benchmarks (ERLs and ERMs), copper, zinc, total PCBs and total PAHs are present in sediment at the Submarine Base at concentrations that are potentially harmful to benthic biota (Figures 30-31).

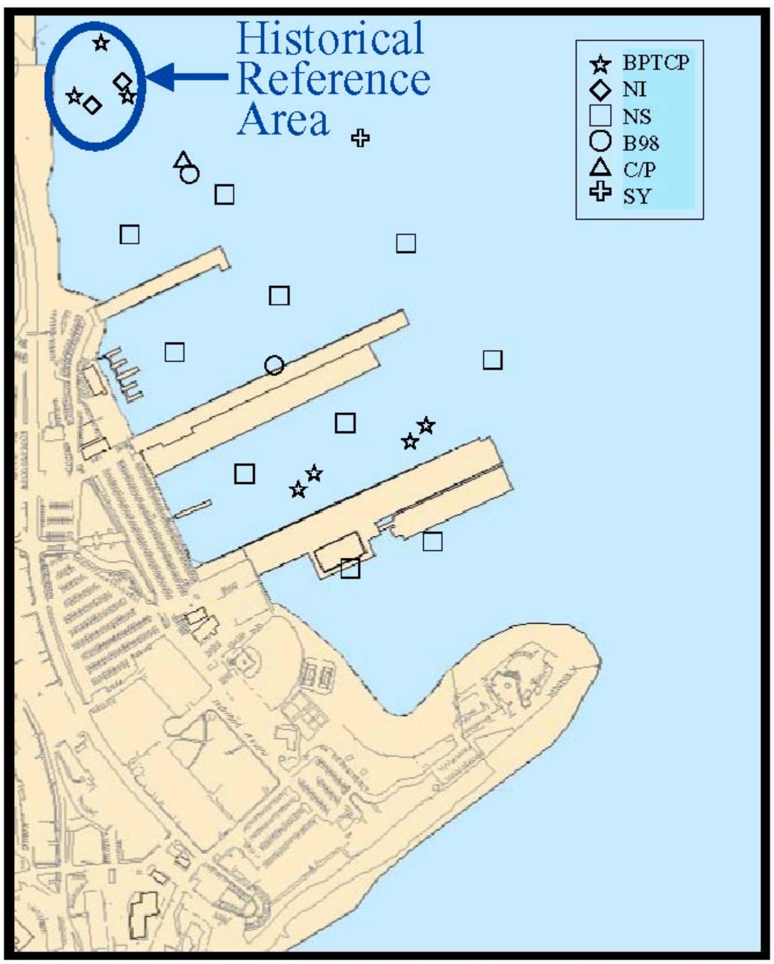


Figure 29. Sampling sites at the Naval Submarine Base from sampling programs that took place between 1993 and 2002. Data collected included sediment chemistry, sediment toxicity, benthic community effects, and bioaccumulation (clams). Codes for sampling programs are as follows: BPTCP (Bay Protection & Toxic Cleanup Program in 1993), NI (North Island Site 1 in 1996), NS (Navy Screening Study in 1997), B98 (Bight 98 in 1998), C/P (Chollas/Paleta TMDL study 2001), SY (NASSCO/SW Shipyard study in 2001-2002). (USN 2003)

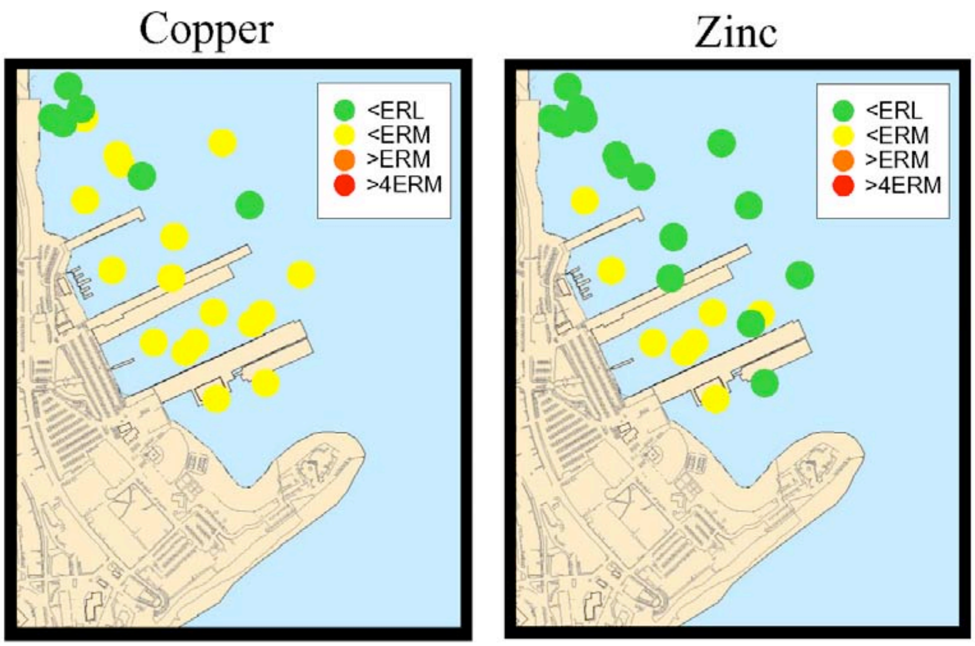


Figure 30. Exceedances for copper and zinc concentrations in sediments at the Naval Submarine Base measured in various sampling programs from 1993 to 2002. ERL and ERM are the "effects range low" and "effects range medium" benchmarks, as determined by NOAA. (USN 2003)

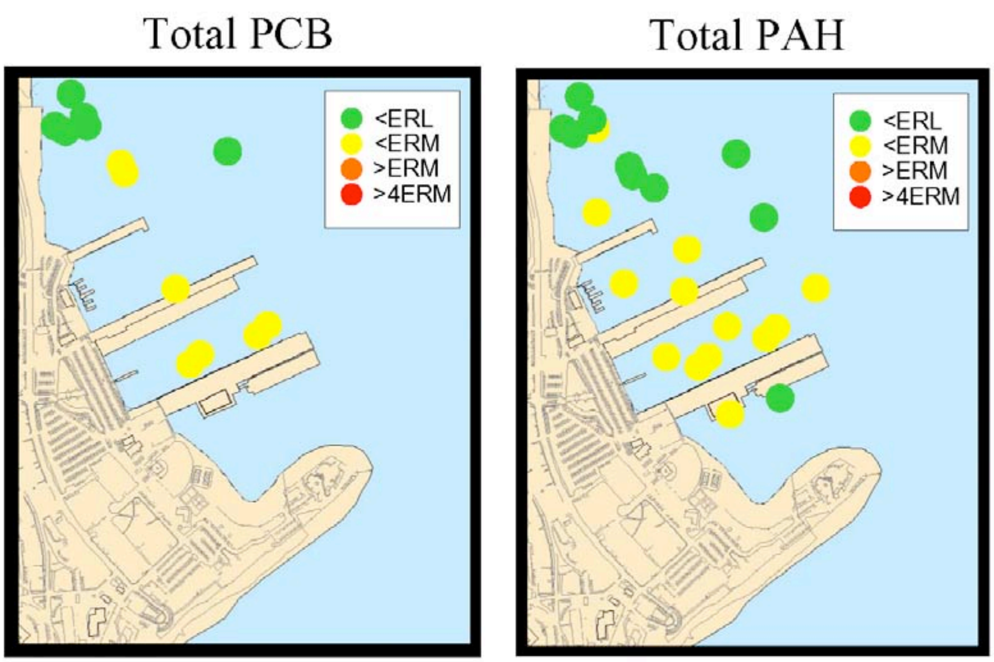


Figure 31. Exceedances for total PCB and total PAHs in sediments at the Naval Submarine Base measured in various sampling programs from 1993 to 2002. ERL and ERM are the "effects range low" and "effects range medium" benchmarks, as determined by NOAA. (USN 2003)

Shelter Island Yacht Basin

Shelter Island Yacht Basin (SIYB) is a popular recreational marina located in the north end of San Diego Bay (Figure 32). Recreational vessels are typically painted with copper-based antifouling paints. Passive leaching of copper from hulls and copper releases from underwater hull cleaning, combined with reduced tidal flushing, has resulted in elevated levels of dissolved copper in SIYB (Figure 32) that exceed numeric water quality objectives for dissolved copper (SDRWQCB 2005). In 1996, SDRWQCB placed SIYB on the state 303(d) list. In 2000, the SDRWQCB initiated efforts to develop a TMDL for dissolved copper at SIYB; a TMDL was adopted on February 9, 2005. More detail about water quality control at the SIYB can be found on-line at: http://www.waterboards.ca.gov/sandiego/tmdls/shelter%20island.html

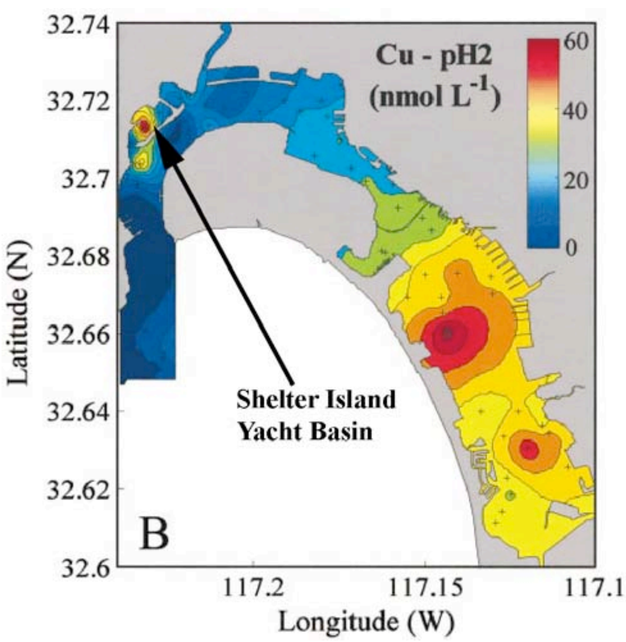


Figure 32. Distribution of dissolved copper in San Diego Bay. Survey data are from August 2000 (from Chadwick 2004).

(c) Regulation of Wastewater Discharges

Background

As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In California, the NPDES permit program is administered by the SWRCB. NPDES permits contain limits on what can be discharged, monitoring and reporting requirements, and other provisions. Pollutants include dredged soil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste. Point source means any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel, conduit, discrete fissure, or container. It also includes vessels or other floating craft from which pollutants are, or may be, discharged. By law, agricultural stormwater discharges and return flows from irrigated agriculture are not "point sources".

NPDES waste water permits are either *individual* or *general*. An individual permit is specifically tailored to an individual facility. These are developed based on the type of activity, nature of discharge, and receiving water quality. Individual permits are further categorized into *Major* or *Minor* dischargers. *Major* dischargers are either (1) Publically Owned Waste Water Treatment Works (POTWs) with a yearly average flow of over 0.5 million gallons per day (MGD), (2) industrial sources with a yearly average flow of over 0.1 MGD, or (3) those with lesser flows but with acute or potential adverse environmental impacts. *Minor* dischargers are all other discharges that are not categorized as Major. A *general permit* is an NPDES permit that covers several facilities that have the same type of discharge and are located in a specific geographic area (such as for oil platforms). A general permit applies the same or similar conditions to all dischargers covered under the general permit.

Pertinent Major Dischargers.
There are only three NPDES permittees in the pertinent area that are *major* dischargers:

1) POTW: Point Loma Wastewater Treatment Plant (PLWTP) (NPDES CA0107409)
2) POTW: South Bay International Wastewater Treatment Plant (IWTP) (NPDES CA0108928)
3) Amusement Park: Sea World Incorporated (NPDES CA0107336)

Discharges from the Sea World amusement park are into Mission Bay, and thus could only impact CABR indirectly through tidal flushing of Mission Bay and subsequent southward transport of pollutants. Both the PLWTP and IWTP discharge treated effluent directly into the coastal ocean through ocean outfalls in shelf waters. The ocean outfalls for these POTWs are discussed in Sections II.B.2.a and II.B.2.c.

Pertinent Minor Dischargers. A search of USEPA's Permit Compliance System (http://www.epa.gov/enviro/html/pcs/index.html) using zipcodes for the Point Loma Peninsula (92106, 92107), and North Island (92135, 92118) yielded the following NPDES *minor* discharge permittees in the vicinity of CABR:

NPDES ID	Facility
CAU000036	Eichenlaub Marine
CA0107891	Fish Sorting Slabs
CA0109061	Driscoll Custom Boats (Boat Building & Repairs)
CA0109070	Driscoll's West (Boat Building & Repairs)
CA0109096	Koehler Kraft Company (Boat Building & Repairs)
CA0109100	Nielsen Beaumont Marine (Boat Building & Repairs)
CA0109118	Shelter Island Yachtways Ltd. (Boat Building & Repairs)
CA0109363	US Naval Base Point Loma Complex (see below)
CA0109185	Naval Air Station North Island
CA0109169	US Naval Base, San Diego

US Naval Base Point Loma Complex. Several Navy facilities on the Point Loma Peninsula close to the Monument (referred to collectively as US Naval Base Point Loma Complex) are jointly covered by NPDES Wastewater Permit No. CA0109363[12]. The Navy facilities on the peninsula that are covered by this permit are:

- Naval Submarine Base, San Diego,
- Magnetic Silencing Facility,
- Fleet Anti-Submarine Warfare Training Center, Pacific,
- Space and Naval Warfare Systems Center, San Diego, Point Loma Campus,
- Fleet Combat Training Center, Pacific, and
- Fleet and Industrial Supply Center Pt. Loma.

Twelve general categories of potential point source discharges that are regulated by the permit are:

- Utility Vault and Manhole Dewatering;
- Steam Condensate;
- Cooling Water;
- ARCO Ballast Tanks;
- MSF Pier Cleaning;
- Dolphin Pools;
- Unused San Diego Bay Water;
- Abalone Tanks and Bioassay Trailer Discharges;
- Pier Boom Cleaning;
- Mammal Enclosure Cleaning;
- Small Boat Rinsing; and
- Miscellaneous Discharges (landscape watering runoff, potable water & fire system maintenance).

Prohibited waste water discharges from the Navy facilities are:

- paint chips;
- blasting materials;
- paint over spray;
- paint spills;
- water contaminated with abrasive blast materials, paint, oils, fuels, lubricants, solvents, or petroleum;
- hydroblast water;
- tank cleaning water from tank cleaning to remove sludge and/or dirt;
- clarified water from oil and water separator, except for storm water discharges treated by an oil and water separator and reported by the U.S. Navy to the Regional Board;
- steam cleaning water;
- demineralizer and reverse osmosis brine;
- water from the ARCO's wastewater holding tanks when the drydock is in use as a work area; and
- oily bilge water.

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[12] Several of these facilities also hold industrial stormwater permits, and are candidate Phase II small MS4 stormwater permittees.

(d) Regulation and Monitoring of Storm Water Discharges

Background

The 1987 Water Quality Act added section 402(p) to the Clean Water Act, requiring the EPA to issue NPDES permits for several categories of stormwater discharges. This is an effort to regulate non-point source pollution generated by runoff from land and impervious areas such as paved streets, parking lots, and building rooftops during precipitation. Through the Regional Boards, the SWRCB issues NPDES permits to government and private entities for storm water discharges. This process is distinct from the issuance of NPDES permits for *waste water* discharges. Three different types of storm water permits are issued: municipal, construction and industrial. Once permits are issued, the permittees are obligated to certain monitoring and reporting procedures and to carrying out best management practices to limit contamination of storm flow with sediment and other contaminants.

<u>Construction Permits</u>. Owing to Stormwater Phase II Final Rule of 1999, operators of small construction sites (1-5 acres of disturbed area) are required to obtain a NPDES permit and develop a Storm Water Management Program (SWMP). Dischargers whose projects disturb one or more acres of soil, or whose projects disturb less than one acre but are part of a larger common plan of development that in total disturbs one or more acres, are required to obtain coverage under the General Permit for Discharges of Storm Water Associated with Construction Activity (Construction General Permit, 99-08-DWQ). Construction activity subject to this permit includes clearing, grading and disturbances to the ground such as stockpiling, or excavation, but does not include regular maintenance activities performed to restore the original line, grade, or capacity of the facility. As of this writing (4/2006) there were 774 construction stormwater permittees in the San Diego, Pueblo San Diego, Sweetwater, Otay and Tijuana HUs combined (Dave Gibson, SDRWQCB, pers. comm.). Owing to their temporary nature of construction projects, the number of active construction stormwater permittees in any region routinely changes.

<u>Industrial Permits</u>. The federal storm water regulations, Code of Federal Regulations Section 122.26(b)(14), require the following facilities to obtain industrial stormwater permits.

1. Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards
2. Manufacturing facilities;
3. Mining/oil and gas facilities;
4. Hazardous waste treatment, storage, or disposal facilities;
5. Landfills, land application sites, and open dumps that receive industrial waste;
6. Recycling facilities such as metal scrap yards, battery reclaimers, salvage yards, automobile yards;
7. Steam electric generating facilities;
8. Transportation facilities that conduct any type of vehicle maintenance such as fueling, cleaning, repairing, etc.;
9. Sewage treatment plants; and
10. "Light industries" where industrial materials, equipment, or activities are exposed to storm water.

Industrial stormwater permittees are required to submit annual monitoring reports. As of this writing (4/2006) there were 356 industrial stormwater permitees in the San Diego, Pueblo San Diego, Sweetwater, Otay and Tijuana HUs combined (Dave Gibson, SDRWQCB, pers. comm.). Monitoring reports for individual facilities were not inspected for this report. The SDRWQCB does not archive electronic versions of industrial stormwater monitoring reports; hard copies of monitoring reports can be viewed at Region 9 offices in downtown San Diego.

Municipal Permits. The Municipal Storm Water Permitting Program regulates storm water discharges from municipal separate storm sewer systems (MS4s). Statewide, MS4 permits were issued in two phases. Under *Phase I*, which started in 1990, the Regional Boards have adopted NPDES storm water permits for medium (serving between 100,000 and 250,000 people) and large (serving 250,000 people) municipalities. Most of these permits are issued to a group of co-permittees encompassing an entire metropolitan area. These permits are reissued as they expire.

Under *Phase II*, which started in 1999, MS4s serving less than 100,000 people must obtain a NPDES permit, called a General Permit for the Discharge of Storm Water from Small MS4s (WQ Order No. 2003-0005-DWQ). Included as MS4s are smaller municipalities, including non-traditional small MS4s (governmental facilities such as military bases, public campuses, and prison and hospital complexes). The permit must describe how the regulated entity will identify and implement a range of Best Management Practices that reduce the discharge of pollutants to the maximum extent practicable (MEP). MEP is the performance standard specified in Section 402(p) of the Clean Water Act. SWMPs include public education and outreach; illicit discharge detection and elimination; construction and post-construction; and good housekeeping for municipal operations. In general, medium and large municipalities are required to conduct chemical monitoring of stormwater, although small municipalities are not.

Phase I San Diego County Joint Municipal Stormwater Permit

The County of San Diego, the City of San Diego, the San Diego Unified Port District, the San Diego Regional Airport Authority and 17 other cities (hereinafter, "Municipal Copermittees") are covered under a joint Phase I MS4 NPDES permit (Order No. 2001-01, NPDES No. CAS0108758, or "Municipal Stormwater Permit") for discharge of urban runoff to waters of the United States. The Municipal Copermittees include:

Cities: Carlsbad, Chula Vista, Coronado, Del Mar, El Cajon, Encinitas, Escondido, Imperial Beach, La Mesa, Lemon Grove, National City, Oceanside, Poway, San Diego, San Marcos, Santee, Solana Beach, Vista
County: Unincorporated areas of San Diego County within the Urban Limit Line
Other: San Diego Unified Port District, San Diego Regional Airport Authority

The Municipal Stormwater Permit requires the Municipal Copermittees to monitor the quality of urban runoff and stormflow in the San Diego Region. This is done using a watershed approach. Consequently, separate urban runoff management programs (and annual reports) exist for the following major drainages (termed Watershed Management Areas, or WMAs - *in most cases synonymous with HUs*) covered by the permit:

- Santa Margarita River WMA
- San Luis Rey River WMA
- Carlsbad WMA
- San Dieguito River WMA
- Los Penasquitos Creek WMA
- Mission Bay WMA
- San Diego River WMA
- San Diego Bay WMA
- Tijuana River WMA

Stormwater-program related information and documents for individual watersheds are found at: http://www.projectcleanwater.org/html/wg_wurmp.html. The boundaries of the WMAs appear in Figure 33.

Ten of the municipal Copermittees (the Cities of Chula Vista, Coronado, Imperial Beach, La Mesa, Lemon Grove, National City, and San Diego, the County of San Diego, the Port of San Diego, and the San Diego County Regional Airport Authority) collaborate to monitor stormwater quality entering the San Diego Bay (described in the San Diego Bay Watershed Urban Runoff Management Program: see (http://www.projectcleanwater.org/html/wurmp_san_diego_bay.html). As one of the Municipal Copermittees, the Port of San Diego has its own program, called the (Port) Jurisdictional Urban Runoff Management Program (JURMP), to manage the quality of urban runoff that affects the tidelands and submerged lands under its jurisdiction (Figure 6). Details about the activities, strategies, and program documents of the JURMP are available on-line at: http://www.portofsandiego.org/sandiego_environment/storm_water.asp

Only two environmental sampling programs overseen by the Municipal Copermittees measure contaminants in storm water that could directly influence water quality in San Diego Bay or the coastal ocean in the region of Pt. Loma:

(1) Copermittee Wet Weather Monitoring Program, in which stormwater volume and quality is measured a few times per year at a network of 11 mass loading stations just upstream of San Diego area receiving waters, and
(2) Coastal Storm Drain Outfall Monitoring Program, in which bacteria (only) are measured at Bay and open coastal sites near urban storm drains.

Mass Loading Stations (MLS). Twelve mass loading stations were initially selected to directly measure pollutant loads being discharged into San Diego County's receiving waters by the major watersheds within the San Diego region (Figure 33). Accordingly, the stations are located at the downstream ends of major watersheds, upstream of any tidal influences. Three storm events per year are captured at each MLS by grab sampling, channel flow rate is measured, and samples are analyzed for the following characteristics:

- Temperature
- pH
- Specific conductance
- Biological and chemical oxygen demand
- Wet chemistry: ammonia, phosphorus, dissolved organic carbon, nitrate, nitrite
- Turbidity, total dissolved solids, total suspended sediment (TSS)
- Surfactants
- Oil and grease
- Bacteria: total coliform, fecal coliform, enterococcus
- Total and dissolved metals (As, Cd, Cr, Cu, Pb, Ni, Se, Sb, Zn)
- Organophosphate pesticides (diazinon, chlorpyrifos, malathion)
- Toxicity (*Ceriodaphnia* 96-hr survival, 7-d survival, 7-d reproduction; *Hyalella* 96-hr survival; *Selanastrum* 96-hr survival)

Currently, only two of the MLS are tributary to San Diego Bay: the Chollas Creek and Sweetwater River MLSs. An Otay River MLS was established at the onset of the Wet Weather Monitoring Program, however, this site never experienced flow and was discontinued. Selected results from the San Diego River and Tijuana River MLSs are discussed in Section II.B.2.d.

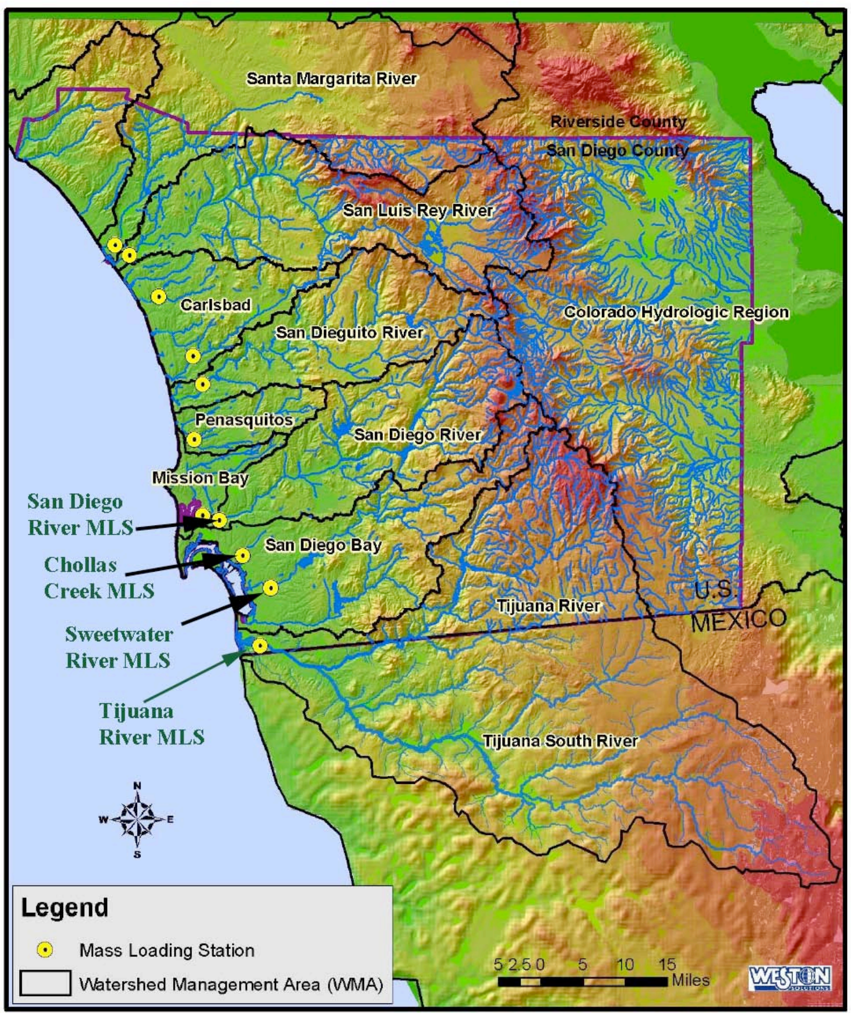


Figure 33. Locations of the Mass Loading Stations of the Copermittee Wet Weather Monitoring Program. Arrows indicate the four stations nearest Cabrillo National Monument (modified from Weston Solutions 2005).

Coastal Storm Drain Outfall Monitoring Program (CSDM). The objectives of the CSDM program are as follows: 1) evaluate the impacts of storm drains on the recreational beneficial uses in coastal receiving waters; 2) identify and eliminate sources of highly elevated bacteria from coastal storm drains; 3) develop a coastal water quality database. CSDM sites were selected in 2001 on the basis of storm drains having the greatest potential to adversely affect the bacterial water quality of coastal and lagoon receiving waters. Paired samples (simultaneous storm drain discharge and receiving water samples) are collected monthly during the wet season and every 2 weeks during the dry season at the coastal storm drains and lagoon sites (Weston Solutions 2005). Water samples are analyzed for total and fecal coliform and for enterococcus indicators. During the 2004/2005 stormwater season, the Copermittees monitored 59 storm drains discharging to coastal oceans or bays. Three of the storm drains monitored in the CSDM are located on the bay side of the Point Loma Peninsula: EH-210, EH-200, and EH-205 (Figure 34).

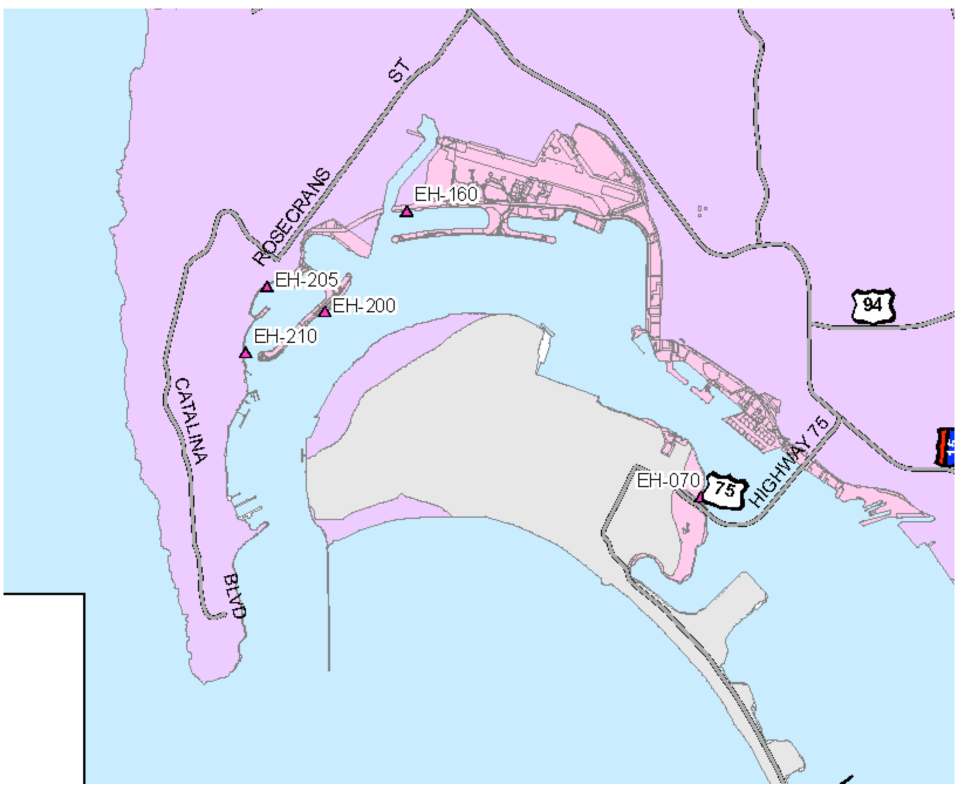


Figure 34. Storm drains near Point Loma that are monitored for total coliform, fecal coliform and enterrococcus in the Coastal Storm Drain Monitoring Program conducted by the Municipal Copermittees (Weston Solutions 2005).

Phase II MS4 Permit Program

Region 9's Phase II MS4 Permit program is still in early stages. As of this writing (4/2006) no Phase II MS4 permits have been issued, and no monitoring results are available. Listed below are facilities in close proximity to CABR that are anticipated to be designated as non-traditional small MS4s in the future (Christina Arias, SDRWQCB, pers. comm.). However, many of these facilities already hold industrial stormwater permits, and (presumably) monitoring results of storm drain water for some of these facilities are available at Region 9 offices.

Anticipated Phase II MS4 permittees
on the Point Loma Peninsula:
- Fleet & Industrial Supply Center
- Fleet Anti-Submarine Warfare Training Center, Pacific
- Fleet Combat Training Center, Pacific
- Magnetic Silencing Facility
- Naval Submarine Base, San Diego
- Space and Naval Warfare Systems Center, Point Loma

other:
- Naval Air Station, North Island
- Naval Amphibious Base, Coronado

B.2. Evaluation of Contaminants Potentially Advected to CABR

(a) Point Loma Wastewater Treatment Plant and Ocean Outfall

Background
Opened in 1963, the Point Loma Wastewater Treatment Plant (PLWTP) treats approximately 175 million gallons of wastewater per day (MGD) generated in a 450 square mile area by more than 2.2 million residents. Located immediately adjacent to CABR on a 40 acre site on the bluffs of Point Loma, the plant has a treatment capacity of 240 MGD. When first built, effluent was discharged approximately 3.9 km offshore of Point Loma at a depth of about 60 m (200 ft). From 1963 to 1985, the plant operated as a primary treatment facility (CSD 2002). The Point Loma Ocean Outfall (PLOO) was extended 3.3 km further offshore in the early 1990s in order to prevent intrusion of the wastewater plume into nearshore waters and to comply with California Ocean Plan recreational water contact standards for bacteria, which apply to area beaches *and* the Point Loma kelp bed. Construction of the new deepwater outfall pipe was completed in November 1993. The outfall operates via gravity feed and extends approximately 7.2 km offshore to a depth of 97 m (330 ft), where the pipeline splits into a Y-shaped multiport diffuser system. The two diffuser legs extend an additional 762 m to the north and south, each terminating at a depth of about 98 m (320 ft) near the edge of the continental shelf. The City is considering increasing the daily discharge from the PLWTP to the full 240 MGD permitted by the SDRWQCB.

Ocean Monitoring for the PLWTP
The PLOO "receiving waters" are considered to extend from the Mexico/U.S. border north to Point La Jolla and offshore to the 100 m isobath (SIO 2004). The effect of the effluent plume on demersal fish and megainvertebrates, benthic macroinvertebrates, sediment chemistry, bacterial abundances in sea water, and oceanographic variables are measured routinely (ca. weekly, monthly, or twice per year depending on the parameter) at a fixed grid of sampling sites in the vicinity of the PLOO by the City of San Diego Metropolitan Wastewater Department's (SDMWD) Ocean Monitoring Program. The sampling area off Point Loma presently extends from La Jolla southward to Point Loma, and from the shoreline seaward to a depth of about 116 m (380 ft) (Figures 18, 35). The monitoring program consists of the following major components:

(1) Oceanographic parameters (depth profiles of chlorophyll a, temp., salinity, DO, pH, transmissivity at 1 m intervals);

(2) Bacterial abundances in seawater (total coliforms, fecal coliforms, enterococcus)

(3) Benthic properties

- Sediment Characteristics (particle sizes, total organic carbon, total nitrogen, total sulfides, trace metals [Al, Sb, As, Ba, Be, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Sn, Zn], PAHs, and PCBs);
- Macroinvertebrate community;

(4) Otter trawls at 100-m contour for: (1) demersal fish and megabenthic invertebrate community analysis, and (2) contaminants in fish tissues.

Data tables, detailed methodologies, completed reports, and other pertinent information submitted to the USEPA and the SDRWQCB throughout the year are available online at the SDMWD website (http://www.sandiego.gov/mwwd).

Oceanographic parameters are measured at 49 stations (Figure 18). All 49 stations are sampled at least once each month by CTD, usually over a three-day period. The offshore stations (F01-F36) are sampled quarterly for bacteria, and are partitioned among the 18-m, 60-m, 80-m, and 98-m isobaths. Eight of the stations are located in the Point Loma kelp bed and are subject to the 2001 California Ocean Plan water contact standards: C4, C5, and C6 (located along the inshore edge of the kelp bed at 9-m depth); and A1, A6, A7, C7, and C8 (located along the offshore edge of the kelp bed at 18-m depth). To meet the sampling frequency requirements for water contact areas, bacterial sampling at the kelp bed stations is conducted five times per month.

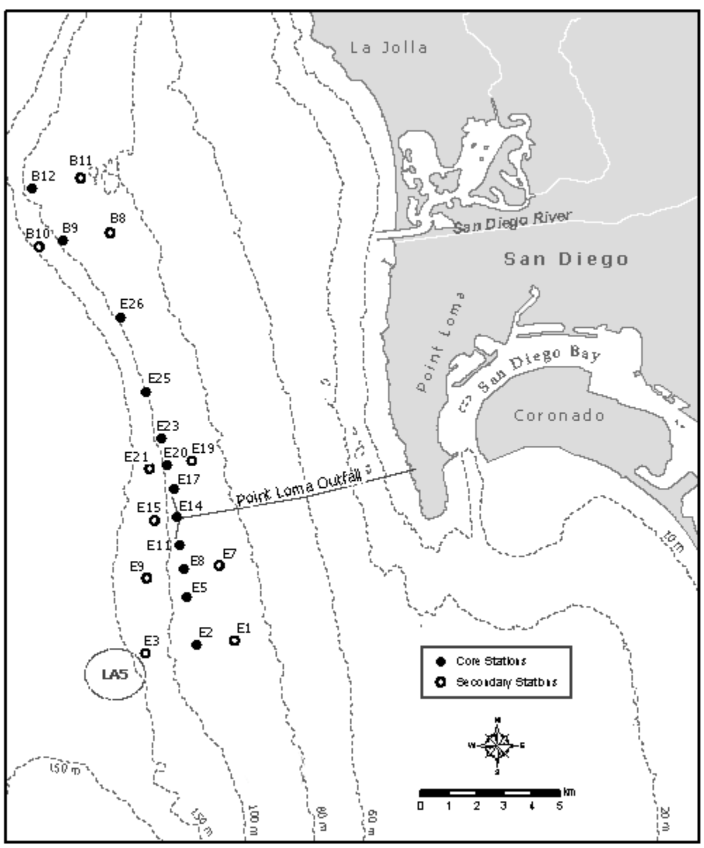


Figure 35. Locations where benthic properties are sampled in the PLOO Ocean Monitoring Program (CSD 2005a).

Selected Results from Recent Monitoring

Water quality. The oceanographic measurements (pH, DO, salinity, temp, etc.) do not directly provide information regarding potential threats to water quality at CABR arising from the PLOO. Raw data from the CTD casts at the "F" stations is publically available for download at http://www.sccoos.org/data/waterquality/; however, cast data for stations closer to shore must be obtained directly from the City. The CTD data from nearshore stations could potentially be compared to records of rainfall to evaluate how frequently terrestrial runoff results in surface lenses of freshened water in the vicinity of the Monument. Basic observations of water quality from kelp bed stations were discussed in Section II.A.3.

Sediment Chemistry. In 2004, none of the trace metals analyzed in sediment collected from the benthic stations ("B" and "E" stations in Figure 35) exceeded NOAA's ERL threshold for deleterious biological effects (CSD 2005a). Metals associated with industry and antifouling materials were found at sediment stations near dredge disposal site LA-5 and may be associated with the disposal of dredged sediments from San Diego Bay (see Section III.E.1). DDT was detected in sediment as its final metabolic degradation product (p,p'-DDE) at stations E2 and E26, and heptachlor epoxide occurred at station E25. The concentration of total-DDT at station E26 was 2750 parts per trillion (ppt), which was slightly above NOAA's ERL (1580 ppt).

In 2004, PAHs and PCBs were found together at two stations located near the LA-5 dredge materials disposal site (stations E2 and E9). Twenty-one PAH compounds were detected in low concentrations during 2004; all total-PAH concentrations from the sampling area were well below the NOAA's ERL of 4022 ppb. In recent years, concentrations of PAHs and PCBs have been higher in sediment at the southern "E" stations (E1, E2, E3, E9) than elsewhere off San Diego. There is speculation that this pattern results from misplaced deposits of dredged material that were originally destined for LA-5 (CSD 2005a). Previous studies have attributed elevated levels of various contaminants such as PAHs, PCBs, trace metals, and DDT in this area to the deposits from LA-5 (CSD 2002; Steinberger et al. 2003). However, over time, the average level of DDT in sediment at PLOO benthic sampling sites has not mirrored the pattern of disposal at LA-5 (see Section III.E.2).

Does the PLOO affect water quality at CABR?

As effluent is discharged at depth, it mixes with ambient seawater as it rises toward the surface under its own momentum and buoyancy. During this mixing, the effluent is diluted and becomes denser, losing momentum and buoyancy to the surrounding fluid. Eventually the diluted effluent will either reach the surface or stop rising at some depth below the surface where it is neutrally buoyant, forming a plume. The region of active mixing is known as the “near field” (SIO 2004). The region of plume spreading after the cessation of buoyancy-driven turbulence is known as the “far field.” The near field is established within minutes, and typically extends tens to hundreds of meters horizontally from the diffuser. The dynamics influencing the far field occur over spatial scales of hundreds of meters to tens of kilometers and time scales of tens of minutes to weeks.

The City uses bacterial abundances to determine the horizontal and vertical extent of the PLOO effluent plume. Recent (2004) bacteriological data from offshore stations suggested that the effluent plume was primarily restricted to depths greater than 60 m, and was detected at stations up to 13 km to the north, and 5.9 km to the south, of the PLOO (CSD 2005a). Cross-shore patterns of bacterial abundance indicate that the PLOO effluent plume does not penetrate the kelp bed offshore of CABR (Figure 36). Since the outfall pipe was extended in 1993, bacteriological water quality objectives for recreational water contact in the kelp bed have rarely been exceeded except during extremely wet weather (such as in the winter of 2004/2005) when terrestrial runoff was implicated as the source of bacteria (CSD 2005a). There is no evidence that the effluent field has affected bacterial abundances, pH, DO or other measured variables, at any of the shoreline sampling sites (CSD 2005a). Using these data alone, it seems reasonable to conclude that the effluent plume from the PLOO is not directly compromising water quality within the administrative boundary of CABR. Of course, alternative tracers for treated sewage are not utilized in the Ocean Monitoring Program, and according to SIO (2004), the shape, extent, and fate of the effuent plume from the PLOO has not been adequately characterized for the range of circulation patterns and temperature and density fields that are reasonably anticipated in the vicinity of the diffuser.

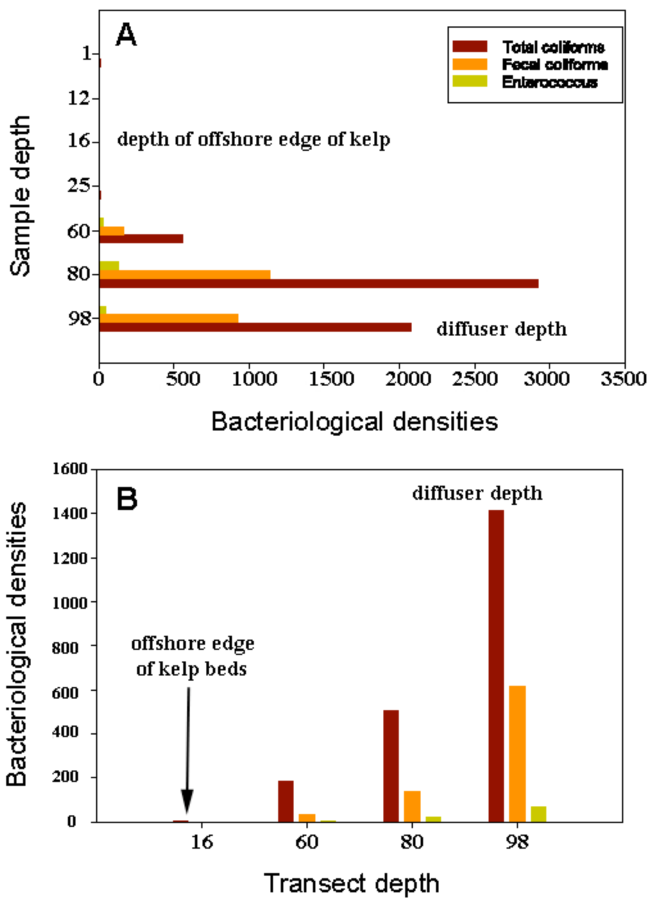


Figure 36. Cross shore patterns in bacterial abundance near the PLOO. A: Mean bacterial densities from quarterly samples for particular depths. B: vertical transects taken at stations of different depths (modified from CSD 2005a).

A very conservative approach to this problem is to consider whether marine organisms at CABR would be harmed by direct exposure to *undiluted* effluent leaving the PLOO. In Table 10, recent measurements of contaminants in PLWTP effluent (2004 annual averages) are compared to selected water quality criteria. Four analytes (copper, silver, cyanide and ammonia) were concentrated enough on average in effluent during 2004 to exceed national water quality criteria designed to protect aquatic marine life during brief exposures (daily maxima or acute exposure). Although the circumstances that could result in cross shore transport of the PLOO effluent plume all the way to CABR have not been described, it is possible that short-lived exposure to poorly diluted effluent could negatively influence some biota.

Raw Sewage Spills Several large sewage spills into waterways have occurred in recent years in the San Diego area (see text box). Of these, only the most recent spill (Oct. 27, 2004, down the bluff at PLWTP), produced detectable increases in bacterial abundance at CABR. Abundances of fecal coliforms, enterococcus and total coliforms sharply spiked at the beach below the treatment plant (PLOO monitoring site D5) after the Oct. 2004 spill (Figures 37, 39). However, single sample thresholds[13] were only exceeded for three days, and background levels of bacteria (and compliance) were reattained within one week. During this event, enterococcus sharply spiked for about three days at the beach below the Point Loma Lighthouse (PLOO monitoring site D4), but increases in fecal coliform and total coliforms were slight (Figures 38, 40), and did not result in exceedances of water quality objectives.

Raw Sewage Spills in the San Diego Area since 2000

February 2000: A clogged sewer line along Alvarado Creek goes undetected for a week, allowing 34 million gallons of sewage to flow into the San Diego River. (no sign at PL040 and 050)

February 2001: Mission Bay is contaminated by an estimated 1.5 million gallons of raw sewage caused by a clogged sewer line that overflowed into Tecolote Creek.

January 2002: Two sewage spills in the Tijuana River Valley send nearly 1 million gallons of waste into the Tijuana River.

Feb. 23, 2004: A clogged sewer line in Balboa Park causes 4.6 million gallons of raw waste to flow into San Diego Bay.

Oct. 27, 2004: Wastewater and debris clog the PLWTP sending 2.26 million gallons of untreated sewage down a hillside at the plant into the ocean.

[13] Bacteriological compliance standards for water contact areas, 2001 California Ocean Plan (CalEPA 2001). CFU = colony forming units.

(1) *30-day total coliform standard* — no more than 20% of the samples at a given station in any 30-day period may exceed a concentration of 1000 CFU per 100 mL.
(2) *10,000 total coliform standard* — no single sample, when verified by a repeat sample collected within 48 hrs, may exceed a concentration of 10,000 CFU per 100 mL.
(3) *60-day fecal coliform standard* — no more than 10% of the samples at a given station in any 60-day period may exceed a concentration of 400 CFU per 100 mL.
(4) *geometric mean* — the geometric mean of the fecal coliform concentration at any given station in any 30-day period may not exceed 200 CFU per 100 mL, based on no fewer than five samples.

Table 10. Average contaminant levels in PLWTP effluent for 2004. Values are means of quarterly samples (N=4). Water quality criteria for the protection of marine aquatic life (short term exposure) are shown in parentheses for analytes that were detected in effluent. Exceedances are in boxes. Data are from CSD (2005b).

Analyte	
Antimony*	4 µg/L
Arsenic (69 µg/L[a], 32 µg/L[b])	1.09 µg/L
Cadmium (43 µg/L[a], 4 µg/L[b])	0.1 µg/L
Chromium (8 µg/L[a,b])	2.0 µg/L
Copper (2.9 µg/L[a], 12 µg/L[b])	43 µg/L
Lead	0 µg/L
Mercury	0 µg/L
Nickel (75 µg/L[a], 20 µg/L[b])	5 µg/L
Selenium (60 µg/L[a,b])	1.1 µg/L
Silver (0.12 µg/L[a], 2.8 µg/L[b])	0.20 µg/L
Zinc (95 µg/L[a], 80 µg/L[b])	24 µg/L
Cyanide (1.0 µg/L[a], 4 µg/L[b])	1.7 µg/L
Ammonia as N (2.4 mg/L[a])	27.4 mg/L
Non-Chor. Phenols (120 µg/L[b])	11.3 µg/L
Chlorinated Phenols	0 µg/L
Endosulfan	0 ng/L
Endrin	0 ng/L
Lindane (gamma HCH)*	2 ng/L
Acrolein	0 µg/L
Bis(2-chloroethoxy) methane	0 µg/L
Bis(2-chloroisopropyl) ether	0 µg/L
Chlorobenzene	0 µg/L
di-n-butyl phthalate0 µg/L	0 µg/L
dichlorobenzenes	0 µg/L
1,1-dichloroethylene	0 µg/L
Diethyl phthalate*	0.6 µg/L
Dimethyl phthalate	0 µg/L
4,6-dinitro-2-methylphenol	0 µg/L
2,4-dinitrophenol	0 µg/L
Ethylbenzene	0 µg/L
Fluoranthene	0 µg/L
Hexachlorocyclopentadiene	0 µg/L
Nitrobenzene	0 µg/L
Thallium	0 µg/L
Toluene*	1.9 µg/L
1,1,2,2-tetrachloroethane	0 µg/L
Acrylonitrile	0 µg/L

Analyte	
Aldrin	0 ng/L
Benzene	0 µg/L
Benzidine	0 µg/L
Beryllium	0 µg/L
Bis(2-chloroethyl) ether	0 µg/L
Bis(2-ethylhexyl) phthalate*	1.2 µg/L
Carbon Tetrachloride	0 µg/L
Chlordane (90 ng/L[a])	3 ng/L
Chloroform*	6.4 µg/L
DDT	0 ng/L
1,4-dichlorobenzene*	1.3 µg/L
3,3-dichlorobenzidine	0 µg/L
1,2-dichloroethane	0 µg/L
Dichloromethane*	2.6 µg/L
1,3-dichloropropene	0 µg/L
Dieldrin	0 ng/L
2,4-dinitrotoluene	0 µg/L
1,2-diphenylhydrazine	0 µg/L
Halomethanes*	1.4 µg/L
Heptachlor	0 ng/L
Heptachlor epoxide	0 ng/L
Hexachlorobenzene	0 µg/L
Hexachlorobutadiene	0 µg/L
Hexachloroethane	0 µg/L
Isophorone	0 µg/L
N-nitrosodimethylamine	0 µg/L
N-nitrosodiphenylamine	0 µg/L
PAHs	0 µg/L
PCBs	0 ng/L
Tetrachloroethylene	0 µg/L
Toxaphene	0 ng/L
Trichloroethylene	0 µg/L
2,4,6-trichlorophenol	0 µg/L
Vinyl Chloride	0 µg/L
Tributyltin	0 µg/L
1,1,1-trichloroethane	0 µg/L
1,1,2-trichloroethane	0 µg/L

*State and Federal water quality criteria for protection of marine biota are not available

[a]National EPA Water Quality Criteria: Marine Acute

[b]California Ocean Plan, Water Quality Objective for Protection of Marine Aquatic Life: Daily Maximum

[c]National EPA Water Quality Criteria

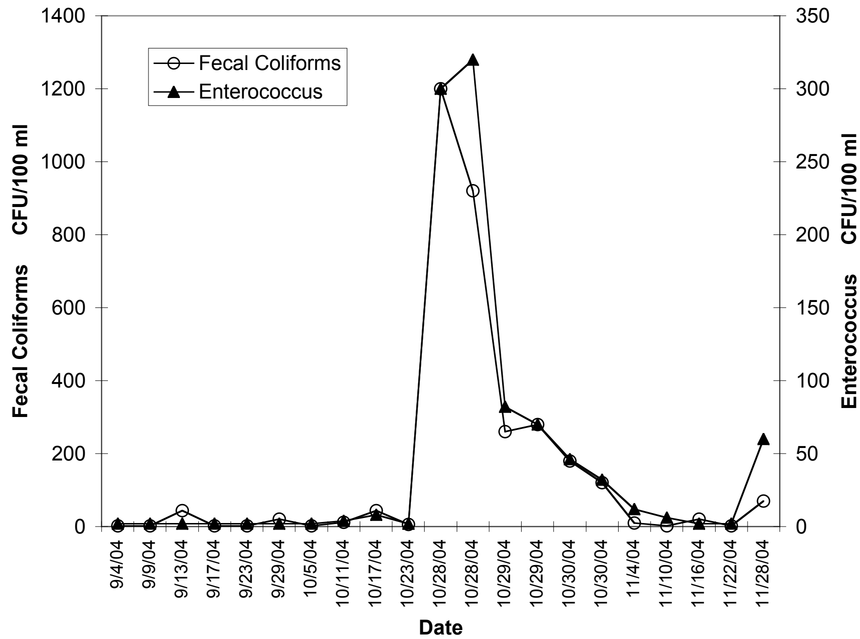


Figure 37. Abundances of fecal coliform and enterococcus in seawater from the beach from 9/4/2004 to 11/28/2004 at PLOO monitoring station PL-050 (or D5), located where the Point Loma Ocean Outfall pipe enters the ocean. A raw sewage spill onto the beach occurred on 10/28/2004 at this site. Data were downloaded at http://www.sccoos.org/data/waterquality/.

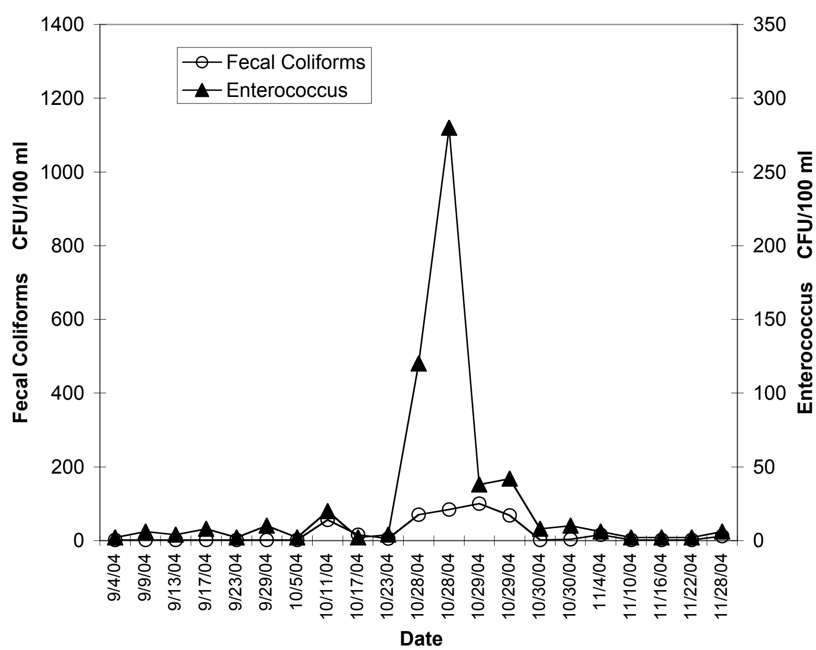


Figure 38. Abundances of fecal coliform and enterococcus in seawater from the beach from 9/4/2004 to 11/28/2004 at PLOO monitoring station PL-040 (or D4), located at the Point Loma Lighthouse. A raw sewage spill from shore occurred on 10/28/2004 less than 1 mile further north at the PLWTP. Data were downloaded at http://www.sccoos.org/data/waterquality/.

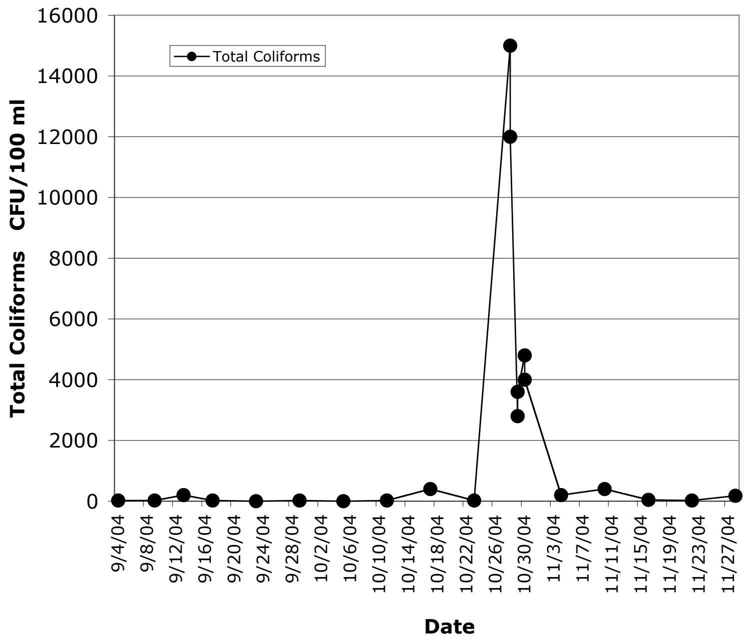


Figure 39. Abundances of total coliforms in seawater from the beach from 9/4/2004 to 11/28/2004 at PLOO monitoring station PL-050 (or D5), located where the Point Loma Ocean Outfall pipe enters the ocean. A raw sewage spill onto the beach occurred on 10/28/2004 at this site. Data were downloaded at http://www.sccoos.org/data/waterquality/.

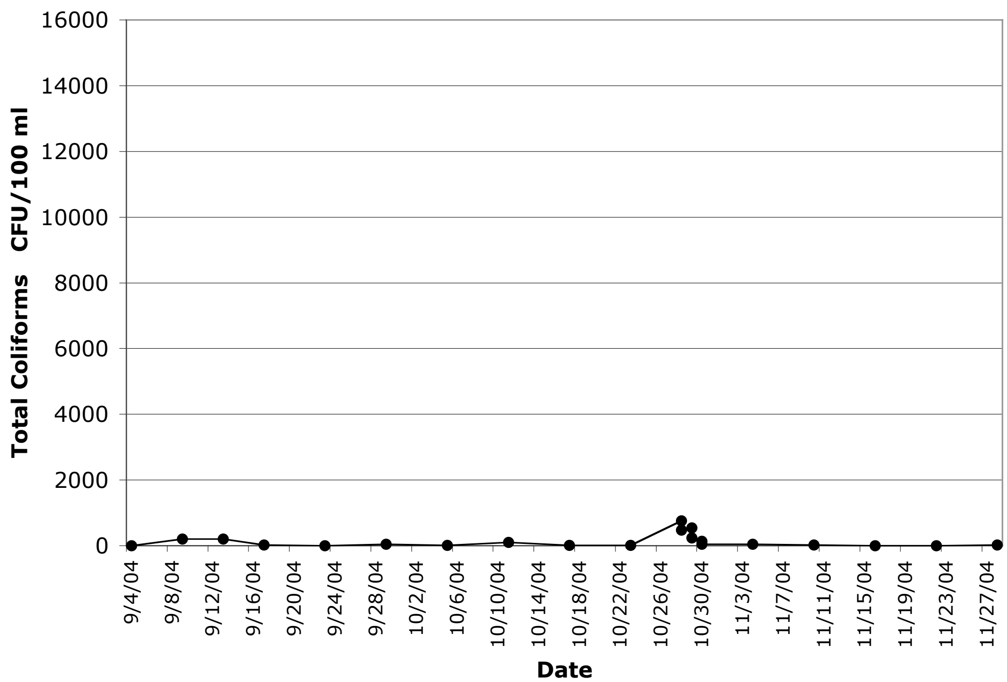


Figure 40. Abundance of total coliforms from 9/4/2004 to 11/28/2004 at PLOO monitoring station PL-040 (or D4), located at the beach below the Point Loma Lighthouse. A raw sewage spill from shore occurred on 10/28/2004 less than 1 mile further north at the PLWTP. Data were downloaded at http://www.sccoos.org/data/waterquality/.

1992 PLOO Pipe Rupture. In April 1992, the PLOO pipe ruptured, causing an effluent spill into nearshore water just north of CABR (Figure 41). Consequently, visitors were prohibited from visiting the CABR intertidal for two months. Presumably owing to the hiatus in visitor trampling, algae temporarily recolonized rocks that summer in popular pathways through the intertidal (Engle & Davis 2000c). The spill resulted in increased sedimentation in algal turf habitat and blooms of opportunistic algae in CABR (Engle & Davis 2000c). Between June and November 1992, rockweed, boa kelp and acorn barnacles decreased sharply in abundance, and surf grass and owl limpets increased in abundance.

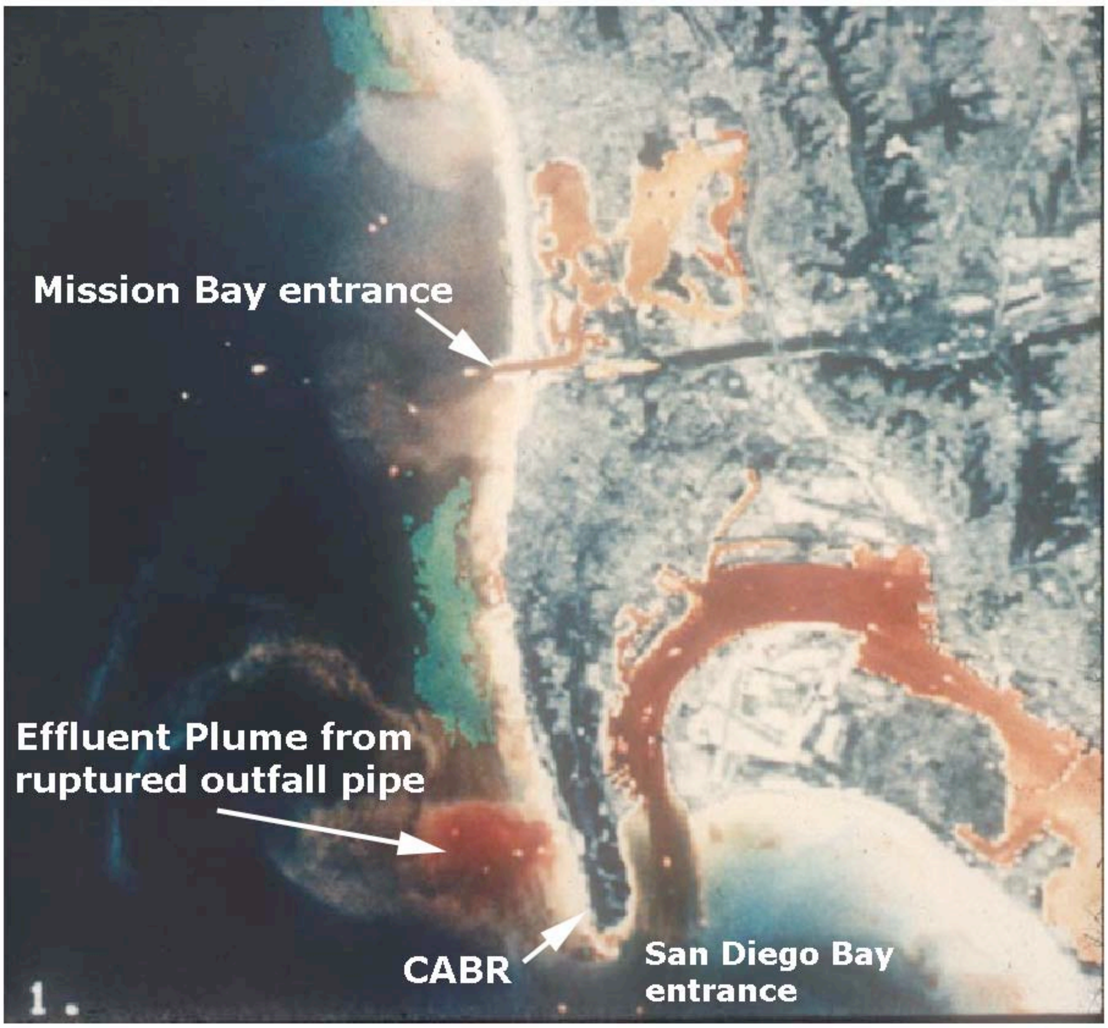


Figure 41. Satellite imagery of Pt. Loma during the period that the outfall pipe was ruptured in 1992. False color represents surface temperature, warmer temperatures indicated by red. (Modified from SIO 2004).

There is no proof that these changes resulted from the outfall pipe rupture, and they were similar in magnitude to interannual variability observed at other points in the longer record. Also, none of these short term changes substantially altered trajectories of change in abundance or habitat coverage that were already underway for some key taxa at CABR in 1992 (Engle & Davis

2000c, Becker 2006). For example, the pipe rupture occurred after the beginning of a long period of surf grass expansion, and after the beginning of a decade long decline in the relative abundance of boa kelp (Figure 42). No significant biological consequences of the 1992 pipe rupture were documented in the Point Loma kelp bed (Tegner et al. 1995).

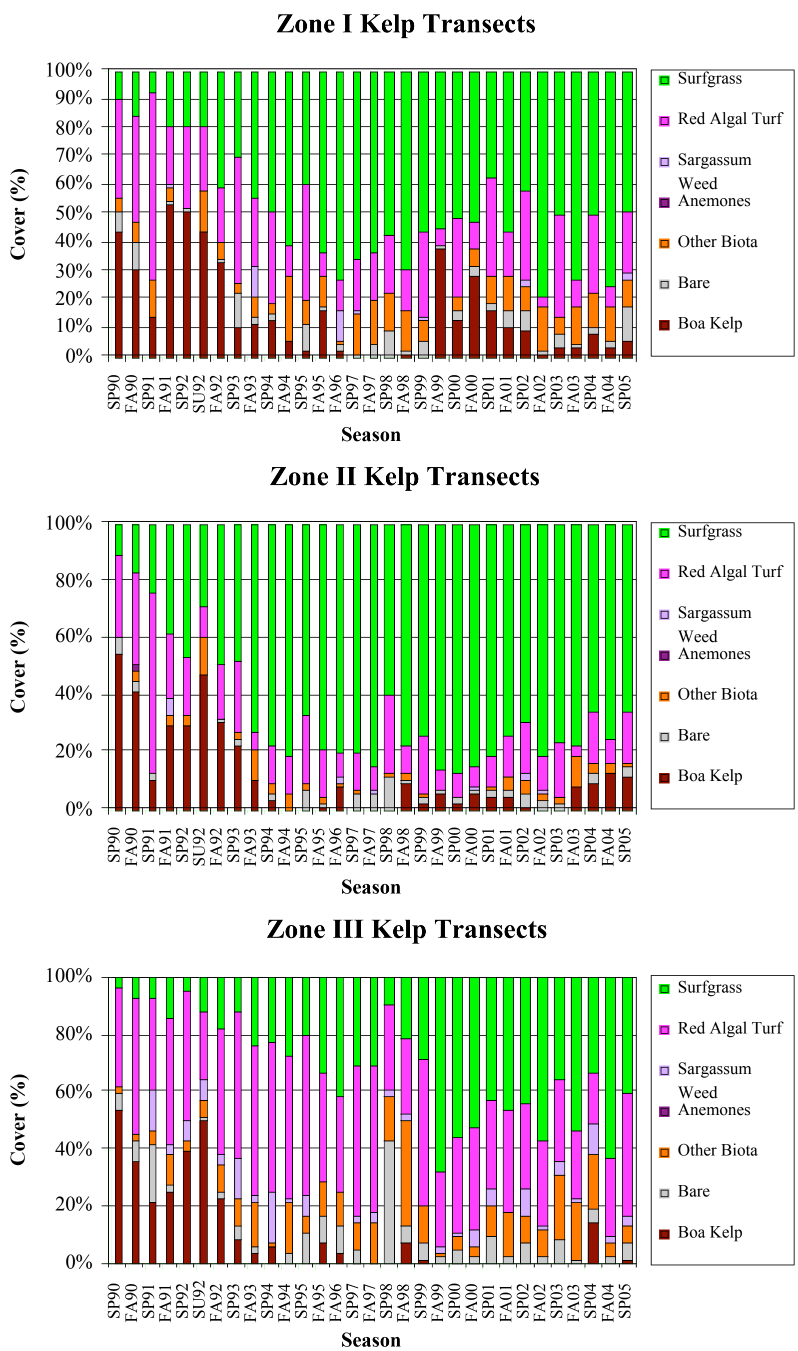


Figure 42. Proportion of each taxon in kelp transects from the three intertidal zones of the Cabrillo National Monument Rocky Intertidal Monitoring Program. Seasons are coded by SSYY, where SS is a code for season (SP=spring, SU=summer, FA=fall), and YY is year from 1990 (90) to 2005 (05). (Becker, 2006)

(b) Runoff to ocean from the Point Loma Peninsula

Data are lacking to indicate levels of pollution in runoff that directly enters the ocean along the length of the Point Loma Peninsula. No city storm drains that enter the ocean from the peninsula are monitored for bacteria, or any other parameters (JoAnn Weber, City of San Diego, pers. comm). Stormwater draining off of Naval facilities on the outer coast of the Point Loma Peninsula is not monitored (Chuck Katz, U.S. Navy, pers. comm.). The U.S. Coast Guard does not monitor the quality of runoff from the Point Loma Lighthouse station, nor at the Ballast Point Mooring (where they maintain offices and dock boats) (Roy Clark, U.S. Coast Guard, pers. comm.). Presumably, the PLWTP is an industrial stormwater permittee. If so, annual stormwater monitoring reports for the facility should be on file at the offices of Region 9 in San Diego.

(c) South Bay International Wastewater Treatment Plant and Ocean Outfall

Background

The SBOO is located offshore just north of the U.S./Mexico border. It terminates approximately 5.6 km from land shore at a depth of about 27 m (http://www.sandiego.gov/mwwd/facilities/sbayoutfall.shtml). The SBOO discharges treated wastewater from the South Bay International Wastewater Treatment Plant (IWTP) plus effluent from the South Bay Water Reclamation Plant. The IWTP is federally owned and operated, and provides primary treatment of 25 MGD of sewage from Mexico (http://www.sandiego.gov/mwwd/environment/binational.shtml). Unlike other southern California outfalls that are located on the surface of the seabed, the SBOO pipeline begins as a tunnel on land and then continues under the seabed to a distance of about 4.3 km offshore. From there it connects to a vertical riser assembly that conveys effluent to a pipeline buried just beneath the surface of the seabed. This pipeline then splits into a Y shaped multiport diffuser system, with the two diffuser legs extending an additional 0.6 km to the north and south. A tunnel boring machine was used to excavate the tunnel for this project. Barges were used as platforms to trench the ocean floor, install pipe, and then to cover the 1.5 miles of exposed pipeline with more than 400,000 tons of rock to protect the outfall from ocean waves and ship anchors.

The outfall was designed to discharge and disperse effluent via a total of 165 diffuser risers. In recent years, discharge has been generally limited to the distal end of the southern diffuser leg. Discharge from the IWTP began in 1999 and is performed under the terms and conditions set forth in Order No. 96–50, NPDES Permit No. CA0108928 and Cease and Desist Order No. 96–52. Discharge from the South Bay Water Reclamation Plant began in 2002 and is performed under NPDES Permit No. CA0109045, Order No. 2000–129.

Ocean Monitoring for the SBOO

The City conducts an ocean monitoring program in the vicinity of the SBOO that is similar to that for the PLOO. The same types of measurements described above for the PLOO program (oceanographic parameters, bacterial abundances, benthic properties, demersal fish and invertebrates) are made at a grid of stations above and below the US/Mexico border. The oceanographic measurements are made at 40 stations from 3.4 km to 14.6 km offshore situated along the 9-, 19-, 28-, 39- and 55-m depth contours ("I" stations, Figure 43). All 40 stations are sampled at least once each month by CTD, usually over a three-day period. Bacteriological samples are collected at five times per month at 11 shoreline stations ("S" stations, Figure 43) and monthly at 28 of the offshore "I" stations. Stations I25, I26, and I39 are considered kelp bed stations and are subject to the 2001 California Ocean Plan water contact standards, and are sampled for bacteria five times monthly.

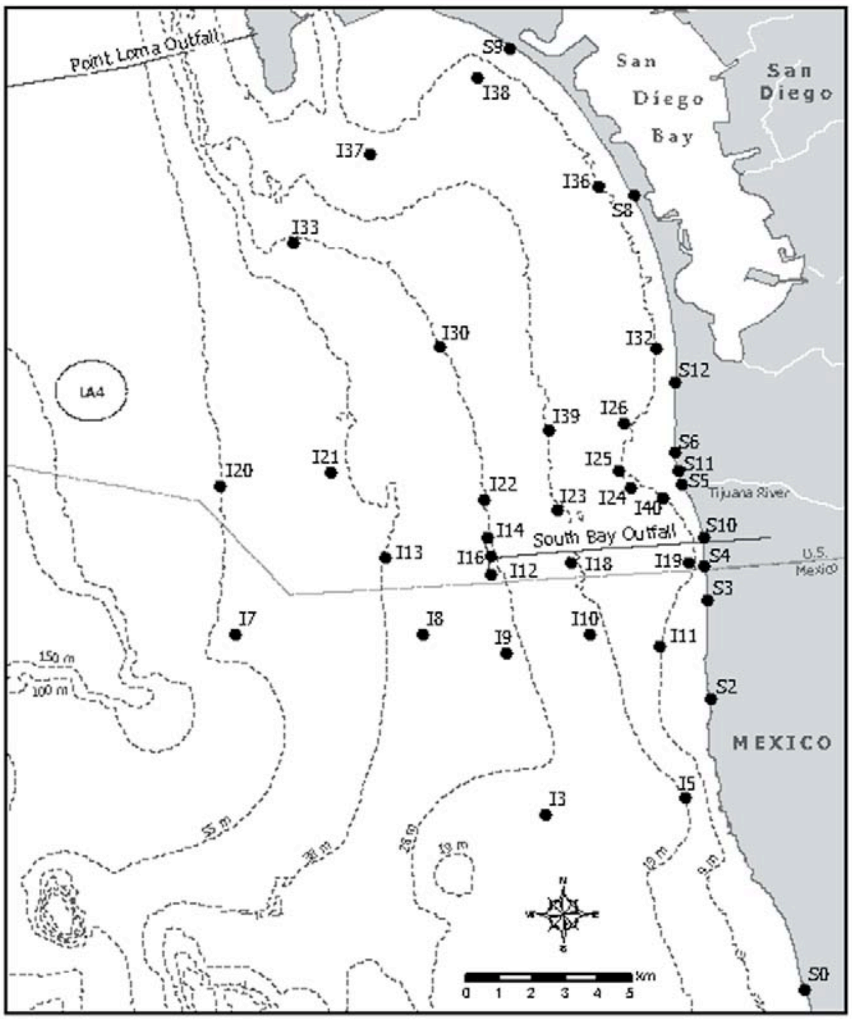


Figure 43. Offshore and shoreline water quality monitoring stations for the SBOO ocean monitoring program (CSD 2005c).

Results from the City's ocean monitoring program indicate that the effluent plume from the SBOO is confined below a stratified water column from April through November and disperses rapidly whenever transported laterally. Elevated bacterial counts from effluent are evident near the surface only during winter months when the water column is poorly stratified. Monthly monitoring of bacterial indicators detects the wastewater plume at depths of ≤18 m and predominantly near the discharge site during most of the year (CSD 2005c). Aerial imagery of surface slicks confirms that the SBOO plume surfaces at times in the vicinity of the diffusers. High bacterial densities along the shoreline and in shallow, nearshore waters in the SBOO monitoring area, have been attributed to sources other than the SBOO (see Tijuana River outflow, below). We did not inspect monitoring data for effluent from the ITWTP or the reclamation plant for this report for three reasons (1) the SBOO is twice as far from CABR (>15 km) than the PLOO, (2) although the SBOO is shallower than the PLOO, it is located along an isobath that runs well outside the administrative boundary of CABR (decreasing opportunities for lateral transport to CABR at depth), (3) the prevailing surface flows in the region are southward. We also do not present results from the SBOO monitoring program here. Raw data from the CTD casts at "I" stations, and bacterial abundances from shoreline ("S) stations, are publically available for download at http://www.sccoos.org/data/waterquality/. Interested readers are directed to the SDMWD website (http://www.sandiego.gov/mwwd) for data tables, detailed methodologies, completed reports, and other pertinent information concerning the IWTP and the SBOO.

(d) Outflow from the San Diego and Tijuana Rivers

Episodic storms, typically occurring late fall through early spring, contribute up to 95% of the annual runoff volume and pollutant load in the Southern California Bight (Schiff et al. 2000). Current estimates of mass emissions for the southern California region indicate stormwater discharges of many constituents rival, and often exceed, those from combined point sources (e.g. nitrate, phosphate, chromium, copper, lead, nickel and zinc [Table 11]). More than 60% of the southern California shoreline exceeds water contact standards for bacteria following wet weather events.

Direct measurements of chemical contaminants in offshore storm plumes are scarce. Except for an (as yet) unpublished study (involving two storms, 2/2003 and 2/2004; see below), the toxicity and chemical content of plumes from the San Diego and Tijuana Rivers has not been directly measured at sea. However, storm drain discharges in Southern California have been shown to be toxic to marine and freshwater organisms and this toxicity persists to some degree as discharge plumes spread through coastal receiving waters (Jirik et al. 1998). Toxicity tests, measuring the ability of sea urchin sperm to fertilize eggs, were conducted on stormwater collected from Ballona Creek and the surface water of storm plumes in the Santa Monica Bay (Bay et al. 2003). In this case, plume water was toxic when it contained at least 10% creek water. Toxicity was detected in Santa Monica Bay at a maximum of 4 km offshore after a 2-year storm in Feb. 1996. Dissolved zinc, and occasionally dissolved copper, were found to be at toxic levels in undiluted stormwater from Ballona Creek, and postulated to be responsible for much of the toxicity in tests conducted on plume water. Overall, dissolved constituents were responsible for more toxicity than particle-bound constituents in Ballona Creek water. However, particle-bound toxicity was relatively more important in plume water at sea than it was in creek water upstream of the mouth. Zinc was similarly implicated in toxicity tests of Chollas Creek stormwater in San Diego Bay (Schiff et al. 2003). Below, we examine indirect evidence concerning the potential threat posed to marine biota at CABR by wet weather outflow from the San Diego and Tijuana Rivers.

In conjunction with the City's PLOO and SBOO ocean monitoring programs, Ocean Imaging Corporation (OI) monitors the size and location of turbidity plumes in the region using (1) satellite imagery from both Moderate Resolution Imaging Spectroradiometer (MODIS) and Landsat Thematic Mapper instrumentation, and (2) aerial imaging done using OI's DMSC-MKII digital multispectral sensor. A subset of past reports created for the City by OI can be viewed on-line at http:/www.sdcoastview.oceani.com..

Table 11. Total mass emissions of selected pollutants from several sources to the coastal ocean in the Southern California Bight (adapted from Schiff et al. 2000).

		Percent of Total Load					
Constituent	**Total Load**	**Urban Runoff**	**Large POTWs**	**Small POTWs**	**Industrial Facilities**	**Power Plants**	**Oil Platforms**
Year of estimate		1994-1995	1997	1995	1995	1995	1990
Flow		21.36	11.19	1.44	0.17	65.81	0.04
Suspended solids (mt)	674 200	88.76	10.90	0.29	0.05	0.01	«0.01
BOD (mt)	140 541	-	98.19	1.68	0.13	«0.01	«0.01
Oil and grease (mt)	19 922	-	96.37	2.32	0.45	0.14	0.72
Nitrate-N (mt)	9224	95.41	2.87	1.65	-	0.07	-
Nitrite-N (mt)	151	-	84.11	15.89	-	-	-
Ammonia-N (mt)	45 898	1.96	90.06	7.84	0.12	0.01	-
Organic N (mt)	5880	-	99.00	1.00	-	-	-
Phosphate (mt)	4702	61.68	38.32	-	-	-	-
Total P (mt)	1841	-	100.0	-	-	-	-
Cyanide (kg)	8026	-	80.99	18.71	«0.01	«0.01	0.30
Arsenic (kg)	5723	-	87.37	6.67	4.11	1.00	0.86
Cadmium (kg)	2085	-	47.01	21.68	0.21	30.94	0.16
Chromium (kg)	38 396	76.05	18.23	3.65	0.25	1.05	0.78
Copper (kg)	149 464	58.61	35.46	4.53	0.03	1.31	0.06
Lead (kg)	51 349	76.53	4.67	4.64	0.03	2.29	11.83
Mercury (kg)	262	-	8.39	4.19	0.03	85.38	2.02
Nickel (kg)	91 572	63.67	32.53	2.96	0.15	0.01	0.69
Selenum (kg)	9212	-	84.67	8.48	6.85	«0.01	«0.01
Silver (kg)	6031	«0.01	89.54	10.38	0.01	_0.01	0.07
Zinc (kg)	443 437	71.35	19.39	3.57	0.24	4.17	1.27
Phenols (kg)	166 643	-	97.57	0.02	0.84	«0.01	1.57
Chlorinated	2900	-	96.55	3.45	«0.01	«0.01	-
Nonchlorinated	94 966	-	99.83	0.17	«0.01	«0.01	-
Total DDT (kg)	3	-	91.18	8.82	«0.01	«0.01	-
Total PCB (kg)	«0.1	-	-	-	-	-	-

San Diego River

Except for bacterial abundances measured at shoreline site D11 in the City's PLOO ocean monitoring program (Figure 18), water quality is not monitored at the mouth of the San Diego River. Although quarterly CTD casts and bacterial measurements are conducted offshore of the river mouth at sampling site F02 in the same program, these measurements are too infrequent to reveal the pattern of occurrence of storm plumes emanating from the mouth of the San Diego River and too limited in scope to reveal much about water quality during large terrestrial runoff events. Consequently, we have no data by which to directly guage the threat posed by San Diego River storm plumes to the marine organisms that are exposed to them.

The lower reach of the San Diego River is on the 303(d) list of impaired water segments owing to fecal coliform bacteria, low dissolved oxygen, phosphorus, and total dissolved solids. None of these impairments *per se* indicate that river outflow represents a threat to marine organisms exposed to storm plumes. Stormwater in the lower reach of the San Diego River is chemically evaluated by the City in the lower San Diego River during three storms per year at one of the Copermittee Wet Weather Monitoring Program's mass loading stations (Figure 33). These data provide a conservative avenue for evaluating whether San Diego River plumes have the potential to harm aquatic biota at CABR. Levels of contaminants in the lower reach of the San Diego River during stormflow reasonably estimate the upper end of contamination expected in a storm plume directly offshore of the river mouth. In Table 12, we compare the highest values of selected contaminants observed through Feb. 2005 in San Diego River stormwater to water quality objectives for the protection of marine aquatic life. This approach exaggerates the risk of San Diego River outflow for CABR biota, because it assumes no dilution of river water after it enters the ocean, nor during southward advection of a storm plume toward Point Loma.

Examination of Table 12 reveals that undiluted San Diego River stormwater potentially contains harmful levels of chlorpyrifos, copper, zinc, and suspended matter (turbidity). In the Municipal Copermittees Wet Weather Monitoring Program, MLS water is subjected to five toxicity tests:

- *Ceriodaphnia* 96 hour
- *Ceriodaphnia* 7-day survival
- *Ceriodaphnia* 7-day reproduction
- *Hyalella* 96 hr survival
- *Selanastrum* 96-hr survival

Out of the twelve storm events sampled through Feb. 2005, San Diego River MLS water was only shown to be toxic during one event (to *Selanastrum*, on 2/17/2002).

The predominance of equatorward flow in the region increases the likelihood that San Diego River plumes will be advected south (see Appendix A). Aerial imagery of turbidity plumes from the San Diego River suggest that after some storms the plume is diverted to the offshore side of the Point Loma kelp bed as it is transported southward (such as during an event on Jan. 3, 2000, captured in a Landsat 7 Thematic Mapper image, Svejkovsky 2004). This would be consistent with the predictions made by Jackon & Winant (1983) concerning the diversion of alongshore currents to the offshore side of kelp beds.

Table 12. Maximum levels of selected contaminants in San Diego River water observed at the Copermittee Wet Weather Monitoring Program's San Diego River mass loading station between November, 2001 and February, 2005. Values are the highest flow-weighted composite concentrations for single storms obtained from a set of 12 monitored storms (3 storms in each of four wet seasons from 2001/2002 to 2004/2005). Pertinent marine water quality objectives are provided. Values with asterisks (also with yellow highlighting) exceeded at least one water quality criterion. MLS data were obtained from the County of San Diego's Watershed Protection Program. Location of the mass loading station is shown in Figure 33.

			Water Quality Objectives for the Protection of Aquatic Life		
ANALYTE	UNITS	Maximum Value from all measured storms 2001-2004	2006 USEPA Saltwater Acute[a]	2006 USEPA Saltwater Chronic[a]	2001 Calif. Ocean Plan[b] daily maximum
Oil and Grease	mg/L	10.7	15		75
Enterococci	MPN/100 mL	**23,000***	------	------	104[c]
Fecal Coliform	MPN/100 mL	**110,000***	------	------	400[c]
Total Coliform	MPN/100 mL	**300,000***	------	------	10,000[c]
Ammonia As N	mg/L	**1.8**			2.4
Turbidity	NTU	**234***	------	------	225 (instant.max.)
Pesticides					
Chlorpyrifos	µg/L	**0.051***	0.011	0.0056	------
Diazinon	µg/L	0.21	0.82	0.82	------
Malathion	µg/L	0	NA	0.10	------
Metals: (T= Total, D=Dissolved;			**WQ criteria are for dissolved metals)**		
Antimony	mg/L	0.007 (T)			
		0.007 (D)	------	------	------
Arsenic	mg/L	0.008 (T)			
		0.004 (D)	0.069	0.036	0.032
Cadmium	mg/L	0 (T)			
		0 (D)	0.040	0.0088	0.004
Chromium	mg/L	0.02 (T)			
		0 (D)	1.100 (Cr VI)	0.050 (Cr VI)	0.008Cr VI
Copper	mg/L	0.028 (T)			
		0.015*(D)	0.0048	0.0031	0.012
Lead	mg/L	0.060 (T)			
		0.006 (D)	0.210	0.0081	0.008
Nickel	mg/L	0.007 (T)			
		0.006 (D)	0.074	0.0082	0.020
Selenium	mg/L	0.002 (T)			
		0 (D)	0.290	0.071	0.060
Zinc	mg/L	0.213 (T)			
		0.084*(D)	0.090	0.081	0.080

[a]Obtained at http://epa.gov/waterscience/criteria/wqcriteria.html

[b]California Ocean Plan, State Water Resources Control Board, California E.P.A., 2001.

[c]Microbiological criteria are for recreational water contact (not for protection of aquatic marine life)

Tijuana River

The watershed that drains into the Tijuana River and its estuary is ~4,483 km^2 in area; nearly three quarters of this watershed is in Mexico (see the Tijuana WMA in Figure 33). Historically, the City of Tijuana has had limited sewage treatment facilities, the result is that overflows have drained into the river and estuary. In fact, an average of 13-20 MGD of raw sewage consistently flowed into the river during the 1980s. Concentrations of metals (Cd, Cu, Ni, Pb, and Zn) in the sediments of the Tijuana estuary increased significantly from 1989 to 1997 (SIO 2004, and references therein). This increase coincided with the introduction and expansion of the maquiladora program in Mexico.

As is the case for the San Diego River, metals, pesticides and organic contaminants are not routinely measured in seawater at the mouth of the Tijuana River. As part of the SBOO ocean monitoring program, bacterial abundances are measured five times per month at several shoreline and nearshore sites (S5, S11, S6, I25, I26, I29), and monthly at several offshore sites (other "I" stations) proximal to the mouth of the Tijuana River (Figure 43). Patterns of bacterial abundance at these sites during wet weather indicate that outflow from the Tijuana River frequently contaminates the nearshore ocean surface between the river mouth and Imperial Beach (CSD 2005c). During the most recently reported monitoring year (2004) the highest densities of indicator bacteria at SBOO monitoring sites occurred from February to April and October to December during periods of heavy rainfall (3.6 and 9.3 inches, respectively), and at sites closest to the river mouth (S5, S11 and S6), as opposed to the site at Imperial Beach (S12), on the Silver Strand (S8), or at Coronado (S9) (Table 13). Normally, the northernmost reach of Tijuana River plumes is in the vicinity of Imperial Pier, far to the south of Point Loma (Jan Svejkovsky, Ocean Imaging Corporation, pers. comm.).

Table 13. Number of days per month during 2004 when the 30-day total coliform standard was exceeded at shoreline and nearshore SBOO monitoring stations (from CSD 2005c).

30-day Total Coliform Standard					**Shore stations**					**Kelp stations**		
Month	**# days**	**S9**	**S8**	**S12**	**S6**	**S11**	**S5**	**S10**	**S4**	**I25**	**I26**	**I39**
January	31	0	0	3	20	0	31	31	20	0	0	0
February	29	0	4	23	5	5	29	4	25	3	3	0
March	31	0	16	25	31	31	31	23	23	19	19	30
April	30	0	0	0	17	29	30	30	30	17	0	0
May	31	0	0	0	19	19	31	5	5	0	0	0
June	30	0	0	0	0	0	15	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0	0	0	0
August	31	26	0	0	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0	0	0	0
October	31	12	12	12	12	12	12	6	6	10	10	10
November	30	17	17	30	30	30	30	30	30	27	30	27
December	31	19	2	23	26	31	31	31	31	4	23	1
Percent Compliance		**80%**	**86%**	**68%**	**56%**	**57%**	**34%**	**56%**	**54%**	**78%**	**77%**	**81%**

Coastal surface currents in the San Diego region are predominantly equatorward year round (see Appendix A), and in recent years, aerial imagery of turbidity in the San Diego region indicated that water movement was primarily southward (CSD 2005c). However, episodes of northward flow, lasting between 1-3 days, occur intermittently throughout the year (Jan Svejkovsky, Ocean Imaging Corp., pers. comm.). An example of northward surface flow, mapped by HF radar, is shown in Figure 44. When these events coincide with winter storms, poleward advection of turbidity plumes from the Tijuana River is observed. This phenomenon was particularly evident during the exceptionally wet winter of 2004/2005. Between November 2004 and February 2005, northward flow in the region was unusually persistent. This unusual current regime, combined with rain events with 25- to 50-year return intervals, resulted in advection of turbidity plumes from the mouth of the Tijuana River all the way to Point Loma (J. Svejkovsky, Ocean Imaging Corp., pers. comm.). Researchers at the San Diego Coastal Ocean Observatory System (SDCOOS) have developed an experimental Tijuana River plume tracker (http://sdcoos.ucsd.edu/data/particles/IB/). On the website, a display shows the results of a lagrangrian particle tracking algorithm applied to the hourly surface currents calculated by HF radar. On an hourly basis, 100 particles are released at the rivermouth and tracked for a 3 day period. New positions within the region are updated hourly and the color of the particle represents the age of the particle since it was released. An example of this type of analysis, done on Feb. 10, 2003, during a period of northward flow, is shown in Figure 45.

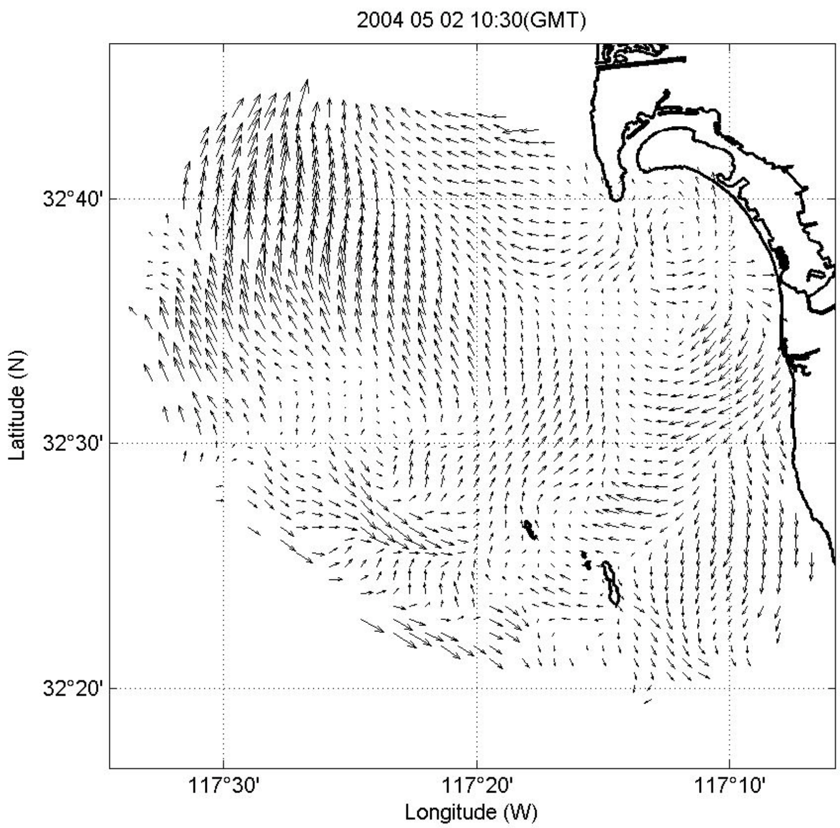


Figure 44. The surface flow field in the San Diego area on 2-May-2004, during an episode of northward flow. Surface currents were mapped using the Point Loma/Ensenada HF radar array (figure courtesy of Eric Terrill, Scripps Institution of Oceanography).

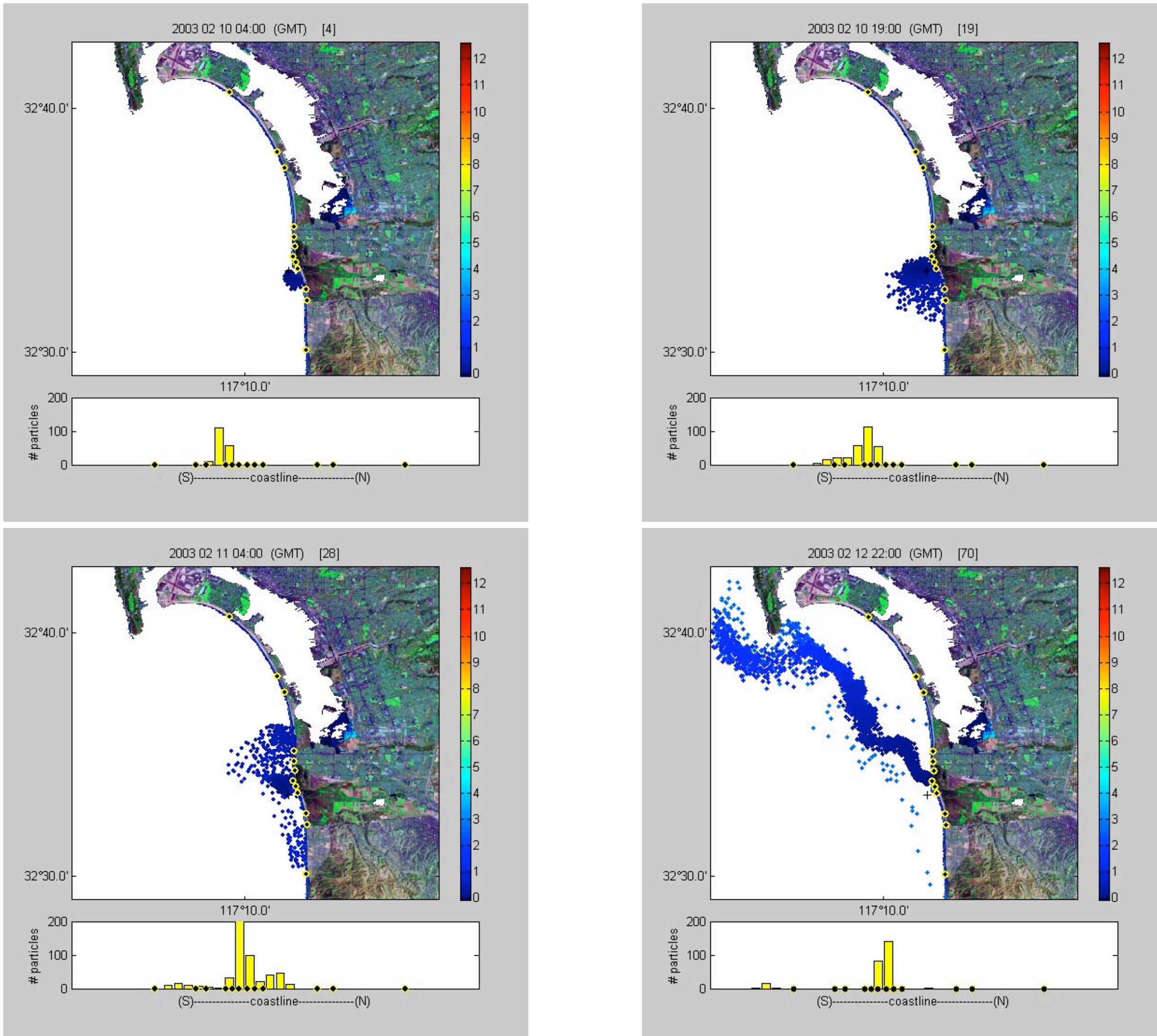


Figure 45. Modeled time series of particle transport from Tijuana River outflow over three days based on a discharge event beginning Feb. 10, 2003. Northward flow was occurring at the time. Particle transport was modeled as a random walk based on objectively mapped HF radar data fields. Color scale indicatees the age of the particles in days (figures provided by E. Terrill, San Diego Coast Ocean Obervatory System, Scripps Oceanographic Institute).

The lower reach of the Tijuana River and the Tijuana River estuary are on the state 303(d) list owing to bacteria, eutrophication, low dissolved oxygen, pesticides, solids, synthetic organics, trace elements (and specifically, lead, nickel and thallium), and trash (Table 9). Many of these impairments potentially pose a threat to marine organisms exposed to concentrated portions of storm plumes from the Tijuana River.

Water from the lower Tijuana River is chemically analyzed by the City during three storms per year at one of the Copermittee Wet Weather Monitoring Program's mass loading stations (Figure 33). As was true in the case of the San Diego River, these data provide an extremely conservative avenue for evaluating whether Tijuana River plumes have the potential to harm aquatic biota at CABR. In Table 14, we compare the highest levels of selected contaminants observed through Feb. 2005 in Tijuana River stormwater to water quality objectives for the protection of marine aquatic life. This approach greatly exaggerates the risk of Tijuana River outflow for CABR biota, because it assumes no dilution of river water after it enters the ocean, nor during northward transport of the plume toward Point Loma.

Examination of Table 14 reveals that undiluted Tijuana River storm flow potentially contains harmful levels of ammonia, chlorpyrifos, diazinon, malathion, copper, nickel, and zinc. In the toxicity tests routinely administered by the city using MLS water (see above), Tijuana River stormwater was always acutely toxic to *Ceriodaphnia*, toxic to *Hyalella* in 25% of storms tested (N=12), but was never toxic to *Selanastrum*. In related research, Gersberg et al. (2004) tested for acute toxicity to *Ceriodaphnia* in storm flow from the lower reach of the Tijuana River during five rain events in 2001. Water from the first storm studied (in January) caused 100% mortality at even the lowest concentration examined (20% river water) (Figure 46). Water from later storms was less toxic; receiving water needed to contain at least 60% river water to produce complete mortality. Overall, some mortality was observed when *Ceriodaphnia* were exposed to water containing as little as 20% Tijuana River water.

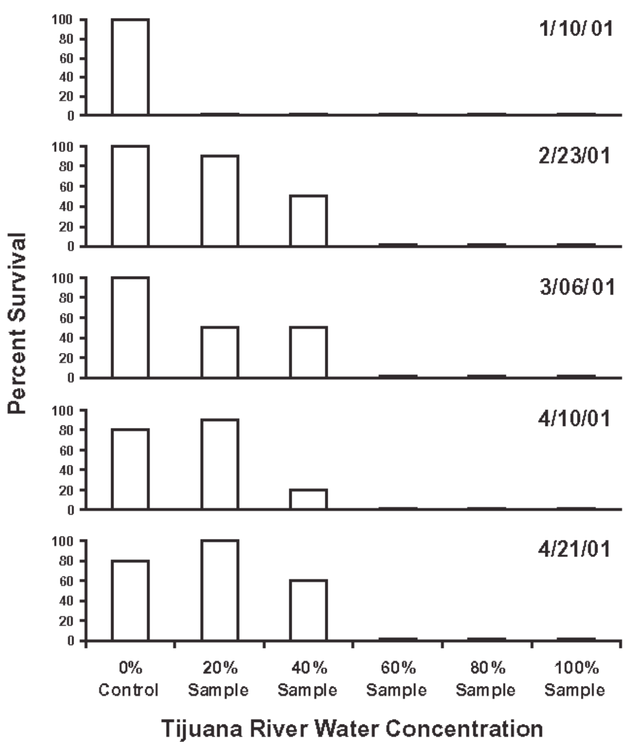


Figure 46. Percent survival of *Ceriodaphnia dubia* in acute toxicity testing (48 h) of wet weather runoff in the Tijuana River for 5 rain events (January 10, 2001; February 23, 2001; March 6, 2001; April 10, 2001 and April 21, 2001). Bars shown as only slightly above x-axis represent 0% survival. The control (0%) is dilution water tested for toxicity (from Gersberg et al. 2004).

Table 14. Maximum levels of selected contaminants in Tijuana River stormwater from the Copermittee Wet Weather Monitoring Program's Tijuana River mass loading station between November, 2001 and February, 2005. Values are the highest flow-weighted composite concentrations for single storms obtained from a set of 12 monitored storms (3 storms in each of four wet seasons from 2001/2002 to 2004/2005). Pertinent marine water quality objectives are provided. Values with asterisks (also with yellow highlighting) exceeded at least one water quality criterion. MLS data were obtained from the County of San Diego's Watershed Protection Program. Location of the mass loading station is shown in Figure 33.

			Water Quality Objectives for the Protection of Aquatic Life		
ANALYTE	**UNITS**	**Maximum Value from all measured storms 2001-2004**	**2006 USEPA Saltwater Acute[a]**	**2006 USEPA Saltwater Chronic[a]**	**Calif. Ocean Plan[b] daily maximum**
Oil and Grease	mg/L	9.1	15		75
Enterococci	MPN/100 mL	**5,000,000***	------	------	104[c]
Fecal Coliform	MPN/100 mL	**16,000,000***	------	------	400[c]
Total Coliform	MPN/100 mL	**16,000.000***	------	------	10,000[c]
Ammonia As N	mg/L	**10.4***	------	------	2.4
Turbidity	NTU	**4540***	------	------	225 (instant.max.)
Pesticides					
Chlorpyrifos	µg/L	**0.168***	0.011	0.0056	------
Diazinon	µg/L	**0.907***	0.82	0.82	------
Malathion	µg/L	**1.46***	NA	0.10	------
Metals: (T) = Total, (D) =Dissolved;			**WQ criteria are for dissolved metals**		
Antimony	mg/L	0.003 (T)			
		0.004 (D)	------	------	------
Arsenic	mg/L	0.055 (T)			
		0.010 (D)	0.069	0.036	0.032
Cadmium	mg/L	0.005 (T)			
		0 (D)	0.040	0.0088	0.004
Chromium	mg/L	0.189 (T)			
		0 (D)	1.100 (Cr VI)	0.050 (Cr VI)	0.008 (Cr VI)
Copper	mg/L	0.197 (T)			
		0.060* (D)	0.0048	0.0031	0.012
Lead	mg/L	0.278 (T)			
		0.003 (D)	0.210	0.0081	0.008
Nickel	mg/L	0.101 (T)			
		0.033* (D)	0.074	0.0082	0.020
Selenium	mg/L	0.008 (T)			
		0 (D)	0.290	0.071	0.060
Zinc	mg/L	1.530 (T)			
		0.130*(D)	0.090	0.081	0.080

[a]Obtained at http://epa.gov/waterscience/criteria/wqcriteria.html
[b]California Ocean Plan, State Water Resources Control Board, California E.P.A., 2001
[c]Criteria are for recreational water contact (not for protection of aquatic marine life)

Summary of threats from river outflow

Storm flow from both the Tijuana and San Diego Rivers contains levels of several constituents that exceed thresholds for acute and/or chronic toxicity established by the USEPA or the State for marine organisms. Exposure to storm plumes from these rivers over the course of many hours or several days of runoff is probably toxic to some marine organisms at least very near the mouth of these rivers. Recently, the Southern California Coastal Water Research Project (SCCWRP) coordinated sampling of plumes generated by the San Diego and Tijuana Rivers during two winter storms (in Feb. 2004 and in Feb. 2005, Paul DiGiacomo, Jet Propulsion Laboratory, pers. comm.). Standard oceanographic measurements (such as CTD casts, chlorophyll a, dissolved nutrients, TSS) were conducted at a grid of stations offshore of the mouth of the river. In addition, bacteria (total and fecal coliforms, enterococcus) were measured and toxicity tests (sea urchin egg fertilization) were conducted on surface water from multiple stations (Paul DiGiacomo, Jet Propulsion Laboratory, pers. comm.). Unfortunately, results of this synoptic study will not become available until Fall 2006, and until then there is no comparable information by which to directly evaluate the toxicity of outflow from the San Diego or Tijuana Rivers once it has entered the ocean.

Aerial imaging and modeling results indicate that storm plumes from both rivers are occasionally transported as far as Point Loma. However, as of this writing, there is no direct evidence that toxic water reaches CABR during these events. Inside San Diego Bay, where dilution rates of storm plumes are likely to be lower than in the coastal ocean, toxicity persisted for 3 days in a storm plume emanating from Chollas Creek (purple sea urchin fertilization tests, Schiff et al. 2003). The toxicity of Chollas Creek water is comparable to that of Tijuana River water; seawater was toxic (albeit to different test organisms) when it contained ≥10% Chollas Creek water, versus ≥20% Tijuana River water. Nevertheless, the toxic portion of the Chollas Creek plume was restricted to an area within 1 km of the mouth of the creek (Schiff et al. 2003).

(e) San Diego Bay Ebb Tide Jet

Unpublished results from a two-month mussel transplantation experiment (unrelated to the CABR transplantation experiment described in Section II.A.4.d) show that mussels placed in the pathway of tidal outflow from San Diego Bay accumulate trace metals and PCBs. In 2004, researchers at Scripps Institution of Oceanography transplanted juvenile mussels (25–50 cm in shell length) in cages near the surface and near the bottom at four sites in the vicinity of Point Loma and at a reference site near the Scripps Pier in La Jolla for two months (SIO 2004). Unfortunately, the mooring inside the mouth San Diego Bay was lost. The sample from Scripps Pier had low concentrations of most constituents. According to SIO (2004), mussels near the mouth of the bay ~1 km south of Pt. Loma (distance estimated from figure) had "highly elevated" concentrations of aluminum, zinc, iron, lead, and some PCBs, as well as "moderately elevated" concentrations of nickel, manganese, and other PCBs. A puzzling result from this study was that mussels placed about 2 km south of Pt. Loma (site B in Figure 47), which should also have been exposed to the tidal outflow, were less contaminated than those closer to the peninsula (site "A" in Figure 47) (SIO 2004).

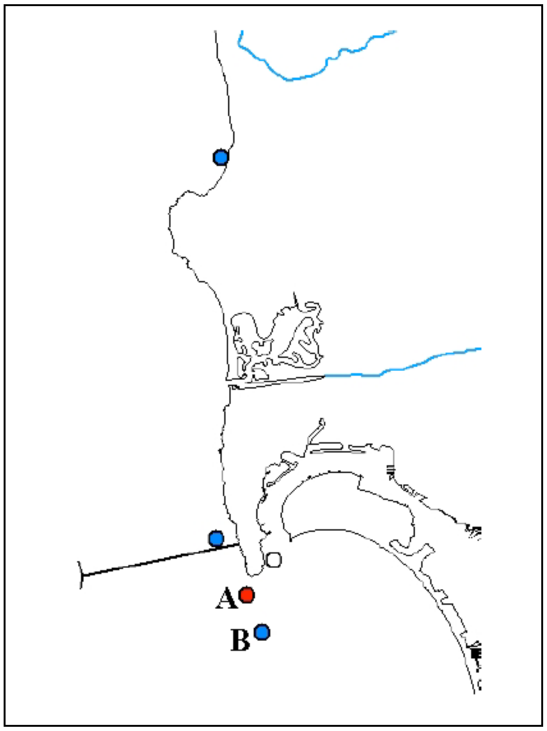
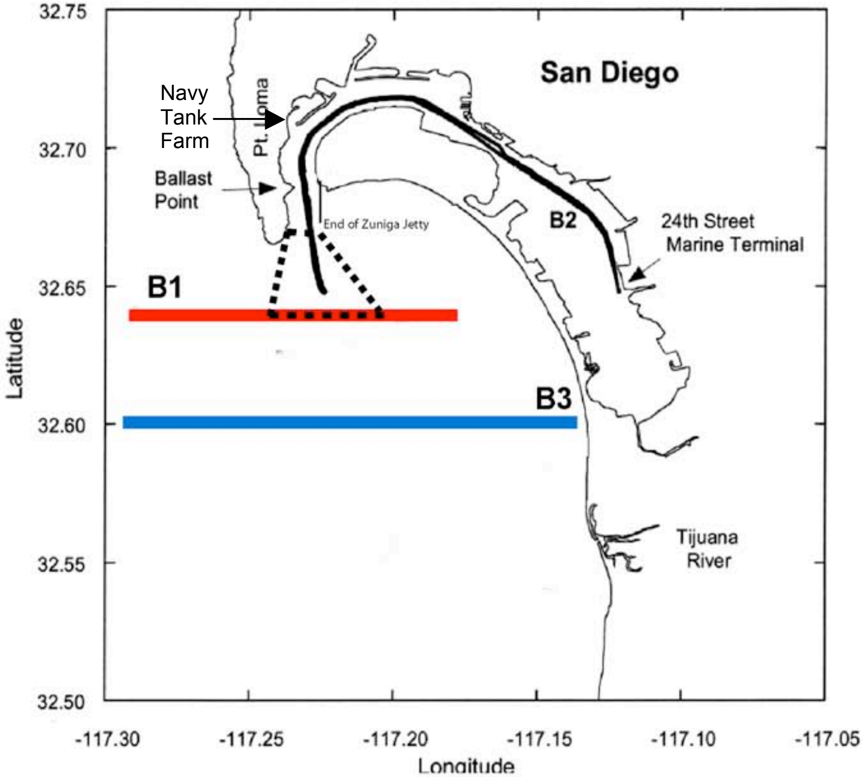


Figure 47. Locations near Point Loma where mussels were outplanted for two months in 2004 in cages on moorings near the surface and bottom. The open circle indicates the site within the mouth of San Diego Bay where a mooring was lost. The red circle indicates the location of the 'hot spot' where concentrations of some contaminants were elevated (modified from SIO 2004).

Although the hydrodynamic behavior of the ebb flow from San Diego Bay has been described in several studies (Chadwick et al. 1996, Chadwick & Largier 1999), very few investigators have measured concentrations of contaminants at sea in the ebb tide jet expelled from San Diego Bay. In Sept., 1999, Esser & Volpe (2002) mapped the San Diego ebb tide jet at sea using continuous real-time measurements of Cd, Cu, Mn, Ni, and Zn (Figure 48). In addition, they mapped gradients in the same trace elements along the axis of San Diego Bay during single ebb and flood tides (Figure 49). The axial transects indicated that, during ebb tide, surface water streaming seaward past Point Loma ("0" on x-axis in Figure 49) has similar trace metal concentrations as water in the main navigation channel at Ballast Point, but is more dilute than water further into the bay. This implies that water quality near Ballast Point at slack high tide is a reasonable proxy for the quality of water that enters the coastal ocean between Point Loma and the end of Zuniga Jetty during ebb tide. Unfortunately, water chemistry data are scarce from this portion of the bay, and tidal phase is not identified in most historic data sets. Based on tracer studies using UVF as a proxy for PAH, Chadwick & Largier (1999) showed that the longitudinal excursion of surface water during ebb tide along the axis of the bay (near the mouth) is up to 3 km (Figure 50). This suggests that surface water from points in the bay ≤ 3 km from the end of Zuniga Jetty is probably entrained into the semidiurnal ebb tide jet. The Navy Fuel Tank Farm is located on the shore of Point Loma Peninsula about this far from the end of Zuniga Jetty.



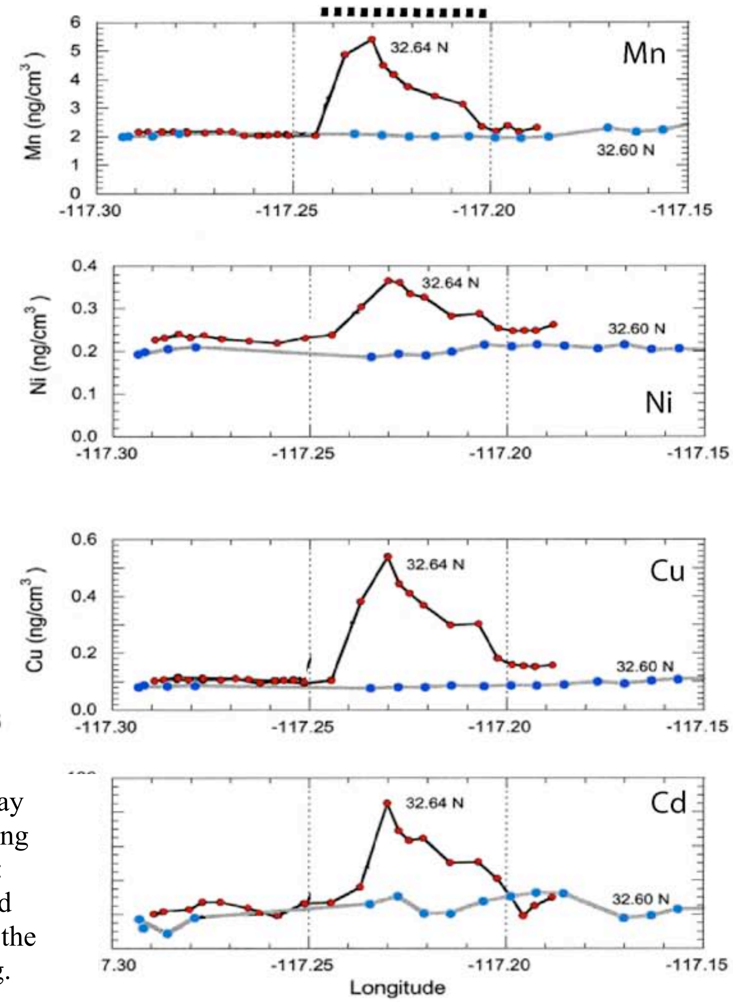


Figure 48. Trace elements measured 9/13- 9/17/1999 outside San Diego Bay from a depth of 1.4-2.3 m during ebb tide (B1: red line, red circles - sampling centered during one slack low tide, 0.8 to 0.3 to 0.6 m), and rising tide (B3: blue line, blue circles - centered on high tide, 0.9 to 1.45 to 0.6 m). Elevated concentrations of trace elements between -117.25°W and -117.20°W mark the location of the San Diego Bay plume at 32.64°N produced by tidal flushing. The thick dashed lines on the map indicate the area through which contaminants were advected after leaving the mouth of the bay in order to reach the first transect line. The thick dashed line at the top of the line graphs shows the part of transect B1 that intersects this area. (Adapted from Figures 1 & 5 in Esser & Volpe (2002).

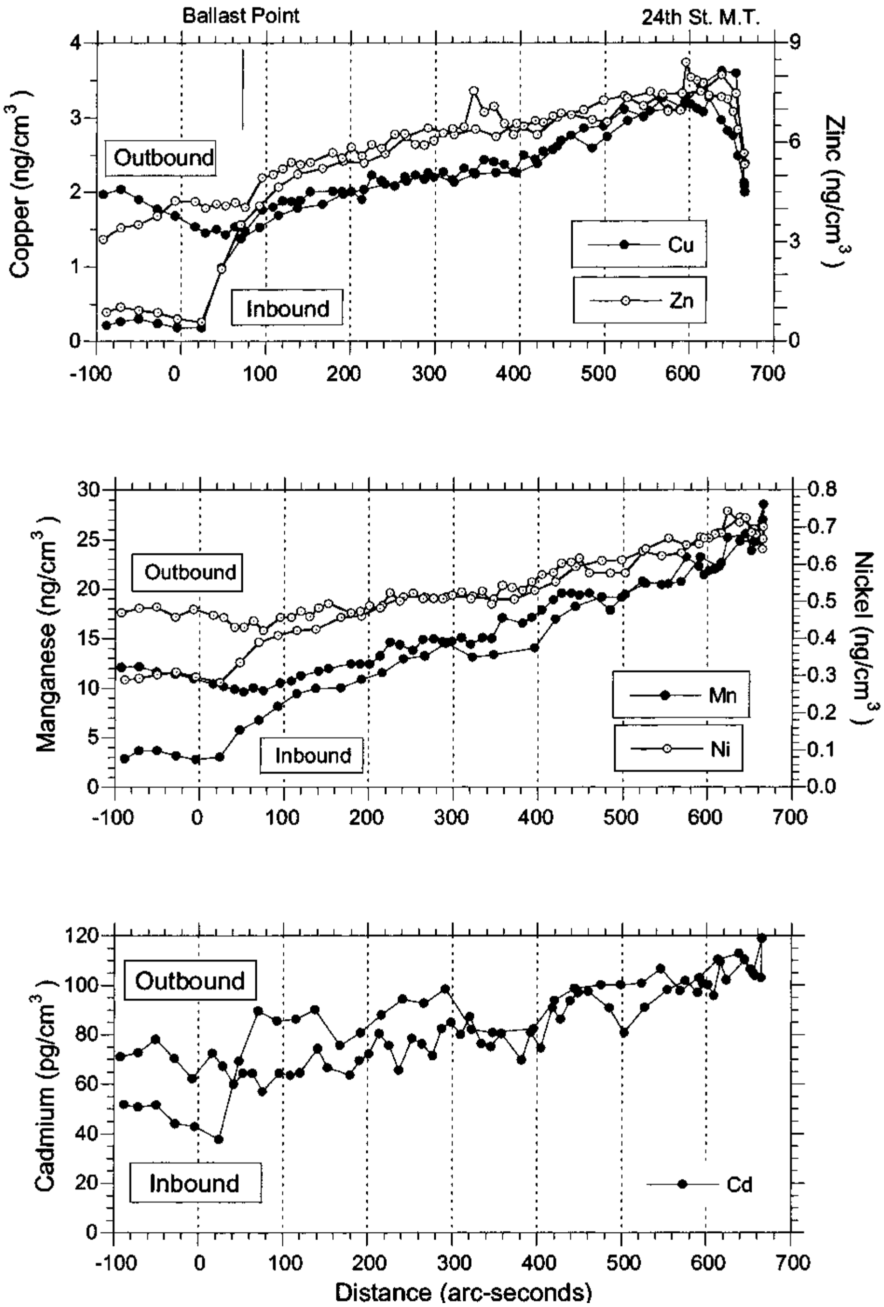


Figure 49. Trace element concentrations from an axial survey of San Diego Bay (path B2 in Figure 48) versus distance into the bay (arc seconds). Trace element data were collected every 4 min, and each data point corresponds to water collected for 90 seconds. Distance is calculated from the center of the shipping channel due west from the tip of Point Loma, with positive distance being into the bay. Both inbound (on a flood tide) and outbound (on an ebb tide) legs are shown. The turn (at slack high water) was at the 24th Marine Terminal in National City (from Esser & Volpe 2002)

In Table 15 comparisons are made between selected trace metal data from Esser & Volpe's (2002) ebb tide transects and values from a Navy database measured near the Navy Fuel Tank

Farm close to the same time (May and June, 1999) (the latter data provided by Ken Richter, U.S. Navy).

Table 15. Concentrations of trace metals measured in 1999 in the ebb tide jet and at three locations inside San Diego Bay. All values are in µg/L.

	Data from 13-17 September 1999 during ebb tides (estimated from figures in Esser & Volpe, 2002)				Data from 25-May-1999 and 18-June-1999 from Navy database (tidal phase unknown)
	maximum value in San Diego Bay plume ~4 km from mouth of bay (transect B1)	axial transect in Bay (transect B2)			
		~ 2 km into ocean	Pt Loma	Ballast Point	Navy Fuel Tank Farm*
Cu	0.56	2.0	1.6	1.5	1.37 (6/99) 1.54 (5/99)
Zn	NA	3.5	4	4	3.90 (5/99) 2.25 (6/99)
Mn	5.4	12	11	10	3.95 (6/99) 4.32 (5/99)
Ni	0.38	0.48	0.48	0.46	0.53 (5/99) 0.46 (6/99)
Cd	0.084	0.070	0.065	0.065	0.091 (6/99) 0.077 (5/99)

*Location of Navy Fuel Tank Farm indicated in Figure 48.

With the exception of Mn, levels of trace metals measured at the Navy Fuel Tank Farm (albeit about three months earlier) were very similar to those measured in water (1) flowing past Ballast Point, (2) flowing past Point Loma, and (3) present 2 km into the ocean, during ebb tide in Sept. 1999. From these data we conclude that maximum pollutant levels between the Navy Fuel Tank Farm and the end of Zuniga Jetty reasonably constitute the upper end of contamination expected in the ebb tide jet at sea within a 2 km distance from the mouth of the bay. This conclusion is supported by other synoptic surveys of the bay, which consistently reveal weak gradients in water quality parameters from just south of Shelter Island to the mouth of the bay (e.g., see horizontal gradients of salinity and dissolved copper in Figure 51, and PAH in Figure 52). For the remainder of this report, this portion of the bay (between the Navy Fuel Farm and the end of Juniga Jetty) is referred to as the *Front Bay*.

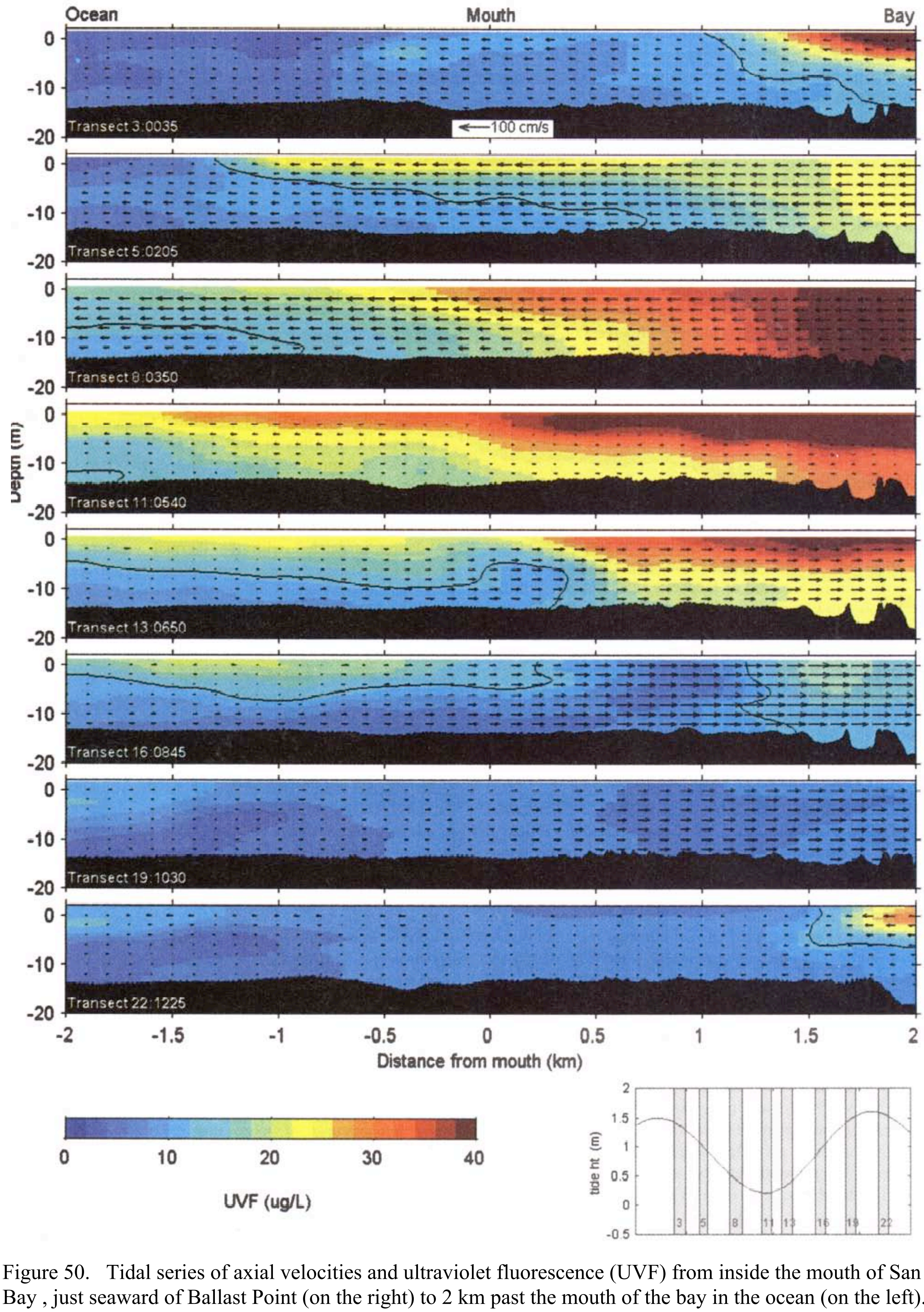


Figure 50. Tidal series of axial velocities and ultraviolet fluorescence (UVF) from inside the mouth of San Diego Bay , just seaward of Ballast Point (on the right) to 2 km past the mouth of the bay in the ocean (on the left). UVF serves as a proxy measurement for PAH, and a tracer of bay water. Tide conditions for each transect are shown at bottom right (from Chadwick & Largier 1999).

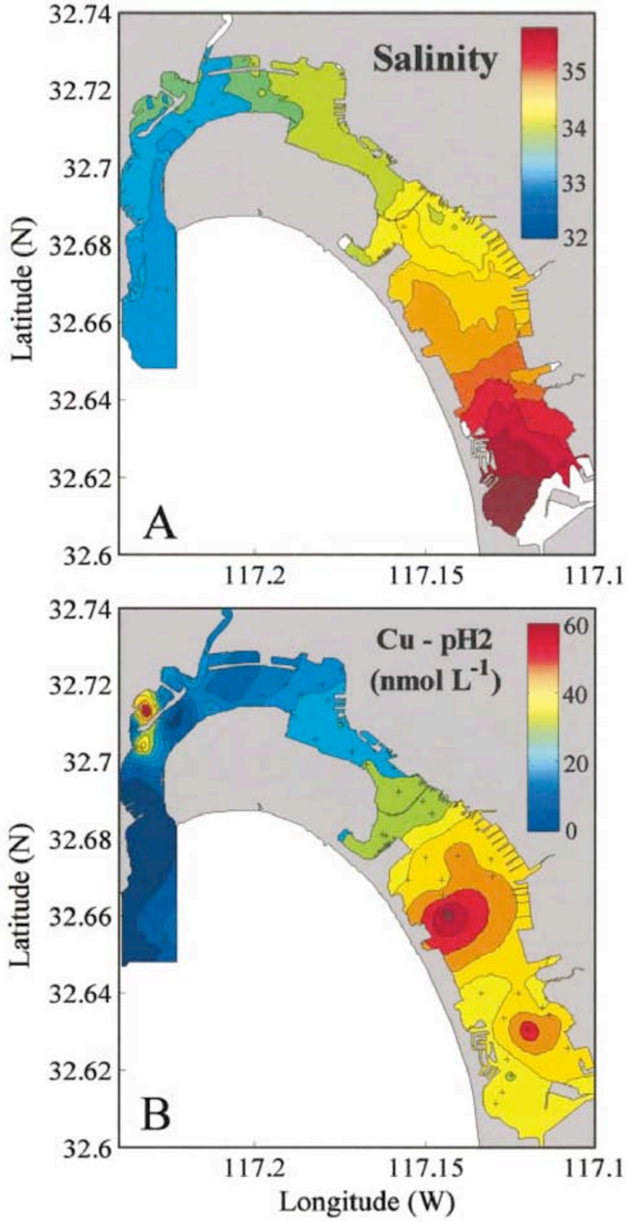


Figure 51. Horizontal gradients of salinity and dissolved copper in San Diego Bay measured in a Navy survey in August 2000 (from Chadwick et al. 2004).

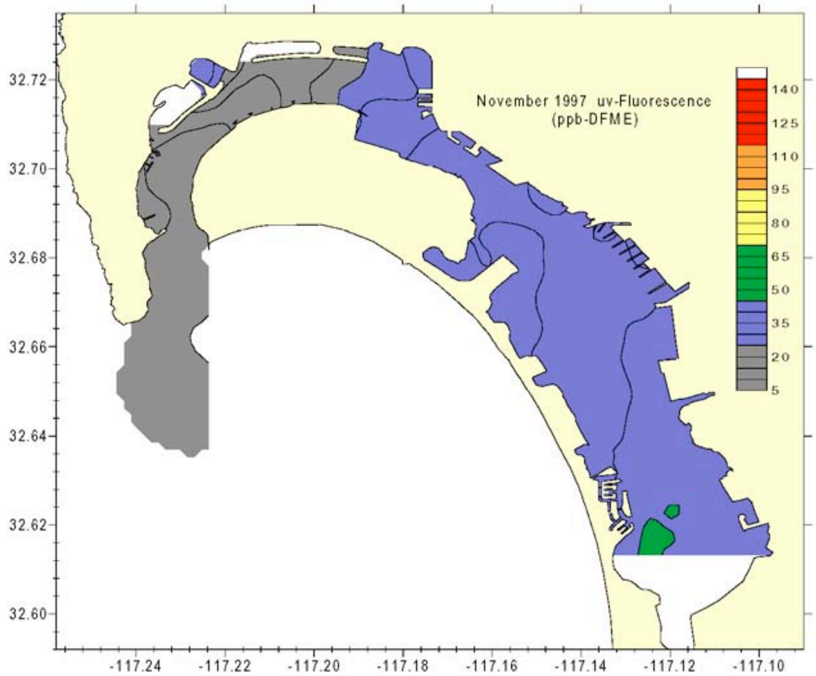


Figure 52. Horizontal gradients of PAH in San Diego Bay measured in a Navy survey on 4 November 1997. These data were obtained after operations were changed at Naval Facilities to reduce inputs of contamination from bilge water to the bay (see text). Data are for relative uv-fluorescence (proxy for ppb-DFME) (from Katz 1998).

Sources of water chemistry data for the Front Bay

Chronic (or Dry Weather) Levels of Contamination

Contaminants in San Diego Bay *water* (as opposed to sediments, or storm drain water) are not routinely measured in any program mandated by Region 9 or carried out by the Municipal Copermittees. In July, 2003, the SDRWQCB, under §13225 of the California Water Code, requested the development of a coordinated and comprehensive harbor water quality monitoring program called the Regional Harbor Monitoring Program (RHMP). The intent of the RHMP was to coordinate monitoring effort of harbors in the San Diego Region, provide water quality status and trends information, and assess the surface water's abilities to support designated beneficial uses. The largest single component of the RHMP is the Ambient Bay and Lagoon Monitoring Program (ABLM). The ABLM is intended to compile information on the status of physical, chemical, and biological indicators in each harbor. However, as of 4/2006, RHMP had not produced any new measurements or database on water quality within the bay (Christina Arias, SDRWQCB, pers. comm.); instead, it had resulted in various sediment chemistry, sediment toxicity and benthos work in the estuaries and lagoons in the greater San Diego region (SDRWQCB 2005). The San Diego County Department of Environmental Health (DEH) monitors bacterial abundances (only) at bay and ocean beaches in the region. The only DEH site located in the Front Bay is at Shelter Island. However, because bacterial abundances are routinely measured at two locations right at CABR (see Section II.A.2) we did not examine bacterial abundances from bay sites for this analysis. SIYB is the only site within the Front Bay that has been placed on the 303(d) list for impaired water quality (for dissolved copper), as opposed to impaired sediment quality. Consequently, dissolved copper data in and near SIYB (and in the Commercial Basin adjacent to it) are available from several studies (SDRWQCB 2005a, Schiff et al. 2006, Katz 1998). In addition, water from SIYB has been shown to be toxic to mussel larvae (Schiff et al. 2006). However, owing to limited circulation between SIYB and the main channel of the Bay (see Section I.B.2.c), the elevated dissolved copper levels observed *within* SIYB are usually confined to the basin (i.e., are not observed in the main navigation channel), even during wet weather (Blake et al. 2004). Therefore, ambient concentrations of dissolved copper inside SIYB and the Commercial Basin are not representative of concentrations expected in the ebb tide jet leaving the mouth of the Bay. A database compiled from miscellaneous Naval studies in the 1980s and 1990s contains limited data for organotin (1986-1996) and PAHs in seawater (1994-1998) from the vicinity of the Ballast Point out past the end of Zuniga Jetty (sample sites shown in Figure 53) (Ken Richter, U.S. Navy, pers. comm.). The same database contains data for a wider suite of contaminants (PAHs, trace elements, DDT, PCBs, organotins, several pesticides) in seawater from the vicinity of the Navy Fuel Tank Farm for one year only (1999) (Ken Richter, U.S. Navy, pers. comm.). Selected values from this Navy database (from sites shown in Figure 57) are provided in Table 17. Several synoptic studies of water chemistry that included the Front Bay have been conducted by the US Navy to address the status of priority contaminants (such as copper, zinc, PAH); pertinent values are available in the following articles or reports:

- Blake et al. (2004): Survey of Cu speciation throughout the bay in four seasons in 2000-2001;
- Chadwick et al. (2004): Mass modeling of Cu for the bay based on the surveys in Blake et al. (2004) (see Figure 51);
- Katz (1998): Cu and PAHs throughout the bay in 1997 (see Figure 52).

Tracer studies using ultraviolet fluorescence as a surrogate measurement for PAH provide estimates of PAH concentrations from 1995 in part of the Front Bay (Chadwick et al. 1996, Chadwick & Largier 1999; see Figure 50). However, owing to changes in the mid 1990s in the handling of bilge water at Naval facilities, which has substantially reduced PAH baywide (Katz 1998), PAH levels in the Front Bay have declined by at least 50% since 1995. Researchers from SCCWRP measured PCBs in seawater twice (1999 and 2000) along the axis of the bay following the main shipping channel (Zeng et al. 2002). One of their stations (Station 1) was in the Front Bay, near Ballast Point (data are in Table 16). Esser & Volpe (2002) contrasted spatial patterns of chlorophyll a, Cu, Ni, Mn, Zn, and Cd along the axis of the Bay, and offshore of the mouth of the Bay, during ebb tide and flood tide (selected data appear in Figure 49, Table 15). From November 2000 to February 2002 the Port of San Diego measured temperature, salinity, conductivity, turbidity, and dissolved oxygen every half-hour in five locations inside the Bay; only one of the stations was located in the Front Bay - off the southern end of Shelter Island. Because organic contaminants and trace elements were not measured in the Port's program, we did not include the Port's data in this report.

Table 16. PCBs measured at Station 1 (near Ballast Point) by Zeng and others in 1999 and 2000. Data are from Zeng et al. (2002). All concentrations are in ng/L.

	1999			2000		
depth	dissolved	particulate	total	dissolved	particulate	total
1.5 m	0.024	<0.0095	0.24	0.065	0.014	0.079
5.0 m	<0.011	<0.011	<0.011	0.054	<0.037	0.054

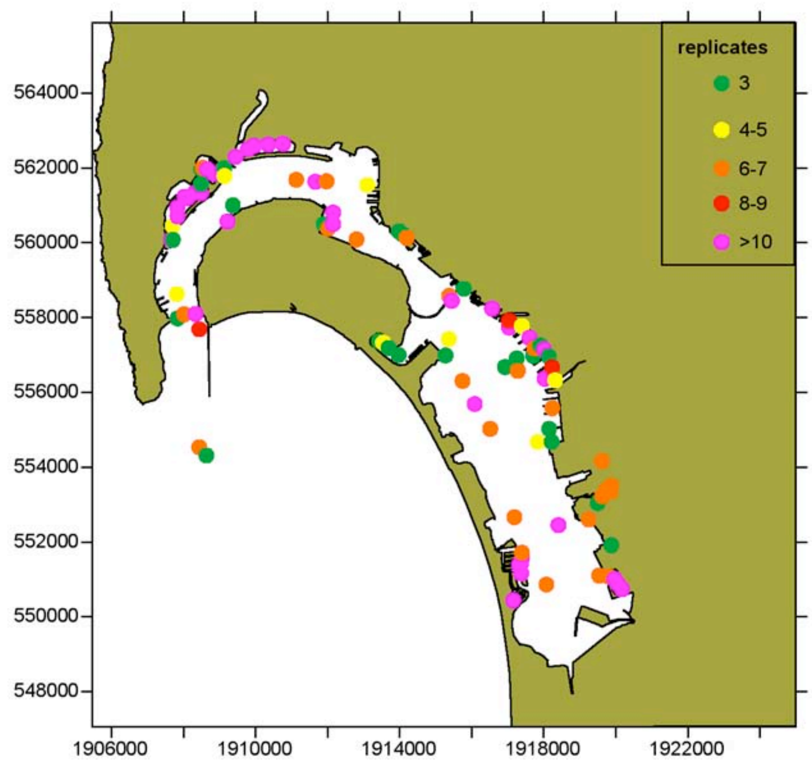


Figure 53. Location and frequency of water samples contained in a U.S. Navy database evaluated by K. Richter (Ken Richter, U.S. Navy, pers. comm.). Sample dates range from 1986 to 1999.

Among the suite of analytes for which we have concentration data from the Front Bay (Tables 15-17), the EPA has established threshold values for the protection of marine aquatic life for the following analytes:

Analyte	**Acute**	**Chronic**
Pesticides (all values in ng/L)		
4,4'-DDT	130	1
chlordane	90	4
heptachlor	53	36
heptachlor epoxide	53	36
aldrin	1300	NA
dieldrin	710	1.9
alpha endosulfan	34	8.7
beta endosulfan	34	8.7
endrin	370	2.3
gamma HCH (lindane)	160	NA
PCBs (ng/L)	NA	30
Trace Metals (all values in µg/L)		
arsenic	69	36
cadmium	40	8.8
chromium	1100	50
copper	4.8	8.1
lead	210	8.1
nickel	74	8.2
silver	1.9	NA
zinc	90	81

Although none of the trace metal values in Table 17 exceed EPA water quality criteria for marine life, many of the organic constituents exceeded applicable thresholds. For example, 4,4'-DDT exceeded the EPA's threshold for chronic exposure. PCBs, PAH and tributyltin exceeded Region 9's ocean water quality criteria (0.019, 8.8 and 1.4 ng/L respectively, from the Region 9 Basin Plan[14]). Inspection of Table 17 reveals that water sampled at the Navy Fuel Tank Farm pier in 1999 was more contaminated with PAH (up to two orders of magnitude for some analytes) than water sampled in 1998 both near Ballast Point and outside the entrance to the bay. Also, PCBs were more concentrated in water at the tank farm pier in 1999 than they were at Ballast Point in the same year. Unfortunately, pesticide/herbicide data from the 1990s are lacking for sites seaward of the Fuel Tank Farm in the Navy database we used for this report. The most recent organotin measurements in the Navy database were from 1996. Mussel data from NOAA-MWP site PLLH suggest that most of the decline in exposure to organotins near CABR occurred before 1997 (Figure 22).

[14] Not every organic analyte in Table 17 was compared to Basin Plan ocean water WQ criteria.

Wet Weather Levels of Contamination

Owing to the presence of a Copermittee Wet Weather Monitoring Program MLS station near the end of Chollas Creek (Figure 33), flow-weighted concentrations for a suite of contaminants (listed in Section II.B.1[d] ii) from Chollas Creek stormwater are available for three storms per year starting in the wet season of 2001/2002. Although Chollas Creek is tributary to San Diego Bay, contaminants are higher in the creek than they are in receiving water (bay water) during wet weather, owing to longitudinal mixing and tidal flushing (except very close to the creek mouth after large storms, Schiff et al. 2001). Schiff et al. (2001, 2003) mapped runoff plumes in central San Diego Bay produced by Chollas Creek outflow during two storms in 2000. They also mapped the areal extent of toxicity in the plume, measured trace elements inside and outside of the plume, and conducted toxicity identification evaluations (Figures 54-55). Trace metals, and zinc in particular, were implicated as the source of toxicity in Chollas Creek plumes. Three of the storm drains included in the Copermittees Coastal Storm Drain Monitoring Program are located in the Front Bay: EH-210, EH-200, and EH-205 (Figure 34). However, the only parameters measured in this program are bacterial (total coliforms, fecal coliforms and enterococcus). Owing to the fact that routine bacterial abundance data are available from sites within, and bordering, CABR (see Section II.A.2), data from the Coastal Storm Drain Monitoring Program were not examined for this report. Navy facilities that occupy the shoreline of San Diego Bay all monitor storm drain water quality to some extent in order to comply with industrial stormwater permits (Chuck Katz, US Navy, pers. comm.). The type of monitoring is outfall- and drainage area-specific. All drains get a visual inspection. Storm drains that are sampled are analyzed for oil and grease, specific conductance, suspended solids, and pH. Measurements at many Navy storm drains include analyses for total copper and zinc; at a few storm drains total organic carbon, aluminum, titanium, iron and magnesium are also measured. All samples are first-flush grabs (first hour of flow) from the end-of-pipe. They are monitored two events per year.

In support of TMDL development for toxicity at the Naval Submarine Base, a full suite of total and dissolved metals, PAHs, PCBs, and chlorinated pesticides, were measured recently at four sites at the base during two storms (Chuck Katz, U.S. Navy, pers. comm.). These were first-flush and composite samples. In addition, the Navy also took samples of bay water at the base before, during, and after the storms for metals and PAH (other organics are below detection limits at this site). As of June 1, 2006, a toxicity study report (SSC-SD TR1938) had just been completed, but was not yet publically available. A draft TMDL report for toxicity at the Naval Submarine Base should become publically available during summer 2006 (Chuck Katz, U.S. Navy, pers. comm.).

The largest of the Chollas Creek storm plumes studied by Schiff et al. (2001, 2003), which resulted from 1.6 cm of rainfall (5 March 2000), did not extend into the Front Bay, and although some toxicity persisted for 3 days in the plume, it was limited to a small area near the creek mouth (Figure 55). To our knowledge, data are lacking to indicate how far Chollas Creek plumes extended into San Diego Bay during the extraordinary wet weather of winter 2004/2005. It seems doubtful that acute toxicity from Chollas Creek runoff would ever reach the Front Bay (as we define it), much less Point Loma. Higher concentrations of dissolved copper in inner San Diego Bay in January, 2001, compared to drier months (Figure 56), were interpreted by Blake et al. (2004) as evidence of increased copper loading from stormwater input to the bay. However, inspection of Figure 56 shows that wet weather had little impact on dissolved copper concentrations at Point Loma, presumably due to increased tidal flushing closer to the entrance of the bay. From the information above, we hypothesize that measurements of water chemistry from the Front Bay during wet weather are adequate to predict pollutant levels in the ebb tide jet during wet weather, even when storm plumes from Chollas Creek, or other tributaries to the bay further south (such as Paleta Creek, and the Sweetwater and Otay Rivers) are present.

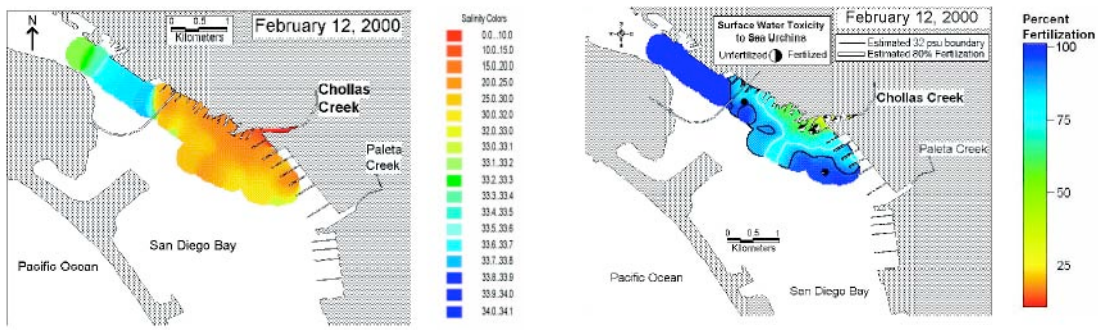


Figure 54. Characteristics of a Chollas Creek storm plume in San Diego Bay produced on Feb. 12, 2000, following 1.0 cm of rain. Left: areal extent of the plume, based on salinity. Right: area extent of toxicity in the plume, as percent fertilization of sea urchin eggs (modified from Schiff et al. 2003).

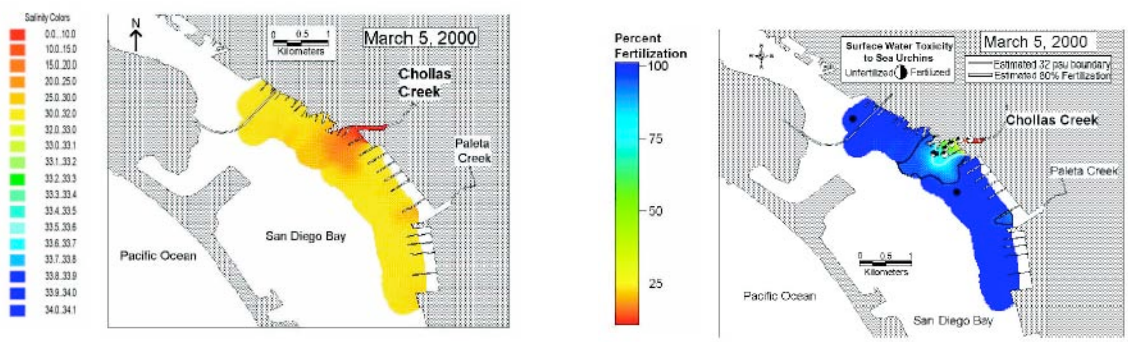


Figure 55. Characteristics of a Chollas Creek stormwater plume in San Diego Bay produced on Mar. 5, 2000, following 1.6 cm of rain. Left: areal extent of the plume, based on salinity. Right: Area extent of toxicity in the plume, as percent fertilization of sea urchin eggs (modified from Schiff et al. 2003).

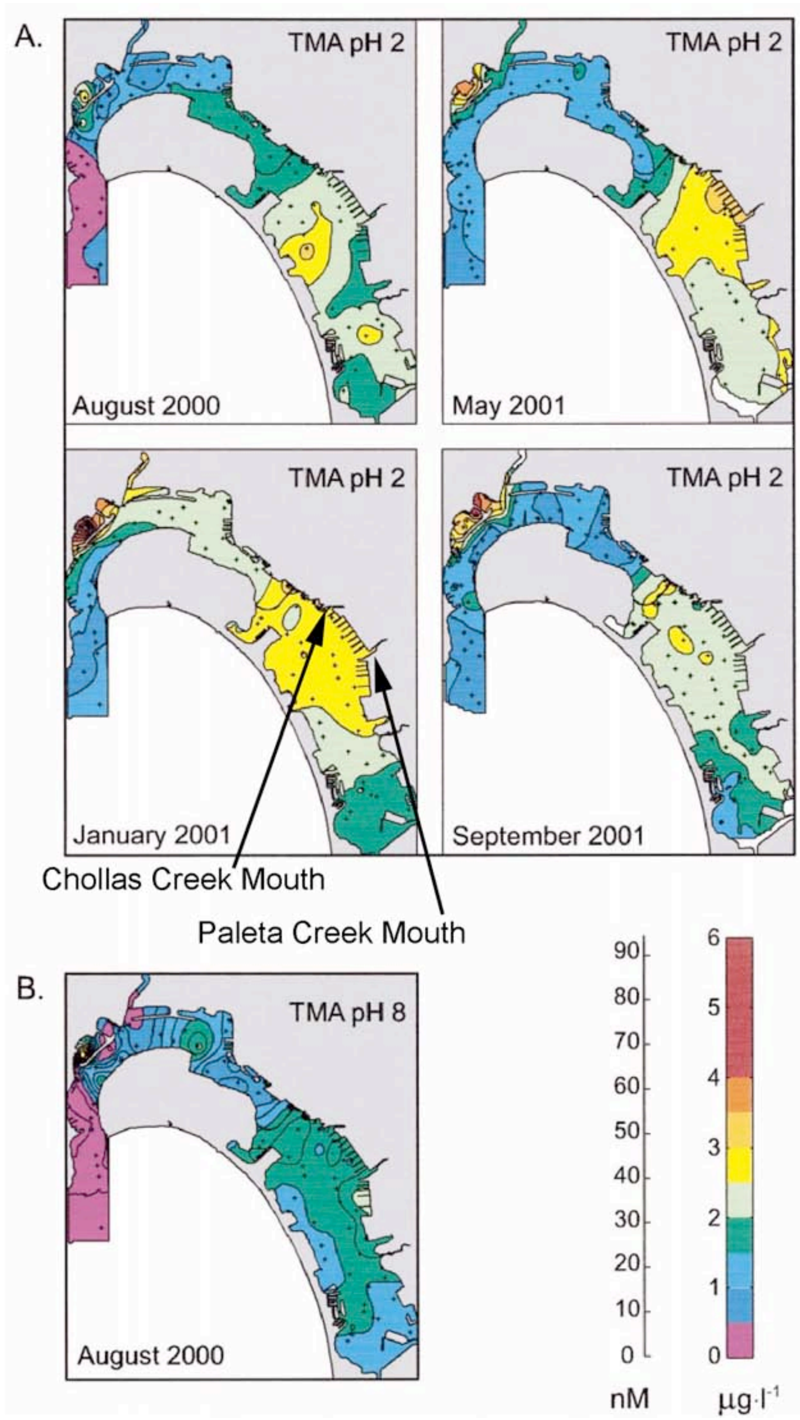


Figure 56. Seasonal distribution of total dissolved copper in San Diego Bay. TMA pH 2 and TMA pH 8 refer to different methodologies for measuring total dissolved copper. The mouths of Chollas and Paleta Creeks are shown (modified from Blake et al. 2004).

Table 17. Selected surface water chemistry data for the Front Bay from a compilation of U.S. Navy data from the 1980s and 1990s (see text). Navy sampling stations are shown in Figure 57. 1999 was the most recent year in the database with data from the pier at the Navy Fuel Tank Farm (station NSBBLN). For stations close to Ballast Point, only the most recent value from the database is shown for each available analyte. Analytes which were also measured by NOAA in mussels from Point Loma (site PLLH) are flagged in the second column.

			Navy Fuel Tank Farm Pier		Vicinity of Ballast Point							Outside Bay
Compound	NOAA MWP data avail?	units	25-May 1999 NSBBLN	18-June 1999 NSBBLN	15-Apr 1996 SD-02C	15-Apr 1996 SD-02E	15-Apr 1996 SD-02B	18-May 1998 SDB02	11-Sep 1997 SDB02	23-Aug 1995 SDB02	21-Aug. 1996 SDB02	18-May 1998 SDB01
DDTs												
2,4'-DDD	yes	ng/L	4.17	4.51								
2,4'-DDE	yes	ng/L	1.02	1.105								
2,4'-DDT	yes	ng/L	1.93	2.085								
4,4'-DDD	yes	ng/L	1.99	2.15								
4,4'-DDE	yes	ng/L	1.23	1.325								
4,4'-DDT	yes	ng/L	1.79	1.93								
PAHs												
Benzo[a]anthracene	yes	ng/L	91.8	99.37				1.11				0.99
Benzo[a]pyrene	yes	ng/L	27.2	30.625				0.33				0.39
Benzo[b]fluoranthene	yes	ng/L	40.03	43.24				1.08				0.87
Benzo[e]pyrene	yes	ng/L	18.28	19.375								
Benzo[g,h,i]perylene	yes	ng/L	81.13	87.77				0.33				0.33
Benzo[k]fluoranthene	yes	ng/L	33.13	35.865				0.30				0.31
C1-Chrysenes	yes	ng/L							3.12			
C4-Chrysenes	yes	ng/L	229.7	167.83								
Chrysene	yes	ng/L	25.13	27.18				0.65				1.30
C1-Fluoranthenes/ pyrenes	yes	ng/L	52.84	57.175				3.06				2.29
Fluoranthene	yes	ng/L	52.84	57.175				18.20				12.42
Indeno[1,2,3-cd]pyrene	yes	ng/L	40.79	44.13				0.27				0.36
Perylene	yes	ng/L	19.5	21.105								
Pyrene	yes	ng/L	72.71	78.675				5.94				4.14
Dibenz[a,h]anthracene	yes	ng/L	16.13	17.435								0.24[b]

Compound	NOAA MWP data avail?	units	Navy Fuel Tank Farm Pier		Vicinity of Ballast Point							Outside Bay
			25-May 1999 NSBBLN	18-June 1999 NSBBLN	15-Apr 1996 SD-02C	15-Apr 1996 SD-02E	15-Apr 1996 SD-02B	18-May 1998 SDB02	11-Sep 1997 SDB02	23-Aug 1995 SDB02	21-Aug. 1996 SDB02	18-May 1998 SDB01
Acenaphthene	yes	ng/L	32.13	34.755				1.95				4.13
Acenaphthylene	yes	ng/L	34.46	37.295				0.83				0.39
Anthracene	yes	ng/L	51.21	55.395				1.60				1.12
Dibenzothiophene	yes	ng/L	41.67	45.075					4.81			0.29
C1-Dibenzothiophenes	yes	ng/L							2.66			0.42[c]
C2-Dibenzothiophenes	yes	ng/L							5.06			0.85
C3-Dibenzothiophenes	yes	ng/L							4.26			13.59[a]
C1-Fluorenes	yes	ng/L	89.13	96.51				0.99				0.92
C2-Fluorenes	yes	ng/L	101						6.95			2.17
C3-Fluorenes	yes	ng/L	109.9							12.07		27.98[a]
Fluorene	yes	ng/L						0.92				1.95
C1-Naphthalenes	yes	ng/L	80.8	87.42				3.24				3.44
C2-Naphthalenes	yes	ng/L	1730	1590				2.31				1.85
C3-Naphthalenes	yes	ng/L	81.6	219.5					6.96			2.74[c]
C4-Naphthalenes	yes	ng/L	756	92.75							7.27	1.78[c]
Naphthalene	yes	ng/L	109.48	143.775				5.67				5.30
C1-Phenanthrenes /anthracenes	yes	ng/L	18.88	30.895				1.43				1.70
C2-Phenanthrenes/ anthracenes	yes	ng/L	135.4	178.75					15.08			1.27[c]
C3-Phenanthrenes/ anthracenes	yes	ng/L	19.3						7.15			16.66[a]
C4-Phenanthrenes/ anthracenes	yes	ng/L	251	255.2								
Phenanthrene	yes	ng/L	28.9	35.975				1.21				2.11
PAH, total	yes	ng/L						51.41				46.73
Organotin												
Tributlytin	yes				2.50	2.20	2.80					
Dibutlytin	yes				3.80	2.90	2.20					
Monobutyltin	yes				2.00	2.10	1.20					

			Navy Fuel Tank Farm Pier		Vicinity of Ballast Point							Outside Bay
Compound	NOAA MWP data avail?	units	25-May 1999 NSBBLN	18-June 1999 NSBBLN	15-Apr 1996 SD-02C	15-Apr 1996 SD-02E	15-Apr 1996 SD-02B	18-May 1998 SDB02	11-Sep 1997 SDB02	23-Aug 1995 SDB02	21-Aug. 1996 SDB02	18-May 1998 SDB01
Pesticides and residues												
alpha-Chlordane	yes	ng/L	3.66	3.96								
Heptachlor	yes	ng/L	2.08	2.255								
Heptachlor epoxide	yes	ng/L	0.49	0.53								
trans-Nonachlor	yes	ng/L	4.93	5.325								
gamma-Chlordane	yes	ng/L	2.05	2.22								
1,4-Dichlorobenzene		ng/L	41.67	45.075								
Aldrin	yes	ng/L	1.72	1.86								
alpha-benzene hexachloride		ng/L	2.05	2.22								
beta-benzene hexachloride		ng/L	2.05	2.22								
Delta-benzene hexachloride		ng/L	2.05	2.22								
Dieldrin	yes	ng/L	0.55	0.595								
Endosulfan I	yes	ng/L	2.05	2.22								
Endosulfan II	yes	ng/L	2.05	2.22								
Endosulfan sulfate	yes	ng/L	2.05	2.22								
Endrin	yes	ng/L	2.05	2.22								
Endrin ketone		ng/L	2.05	2.22								
Hexachlorobenzene	yes	ng/L	1.5	1.62								
gamma-HCH	yes	ng/L	1.86	2.01								
Methoxychlor		ng/L	2.05	2.22								
Mirex	yes	ng/L	1.88	2.03								
Trace Metals												
Arsenic (As)	yes	ug/L	1.22	1.10								
Cadmium (Cd)	yes	ug/L	0.08	0.09								
Chromium (Cr)	yes	ug/L	0.24	0.30								
Copper (Cu)	yes	ug/L	1.54	1.37								0.2 [d]
Iron (Fe)	yes	ug/L	5.22	5.81								
Lead (Pb)	yes	ug/L	0.18	0.17								

Compound	NOAA MWP data avail?	units	Navy Fuel Tank Farm Pier: 25-May 1999 NSBBLN	Navy Fuel Tank Farm Pier: 18-June 1999 NSBBLN	Vicinity of Ballast Point: 15-Apr 1996 SD-02C	Vicinity of Ballast Point: 15-Apr 1996 SD-02E	Vicinity of Ballast Point: 15-Apr 1996 SD-02B	Vicinity of Ballast Point: 18-May 1998 SDB02	Vicinity of Ballast Point: 11-Sep 1997 SDB02	Vicinity of Ballast Point: 23-Aug 1995 SDB02	Vicinity of Ballast Point: 21-Aug. 1996 SDB02	Outside Bay: 18-May 1998 SDB01
Manganese (Mn)	yes	ug/L	4.32	3.95								
Nickel (Ni)	yes	ug/L	0.53	0.46								
Silver (Ag)	yes	ug/L	0.01	0.03								
Zinc (Zn)	yes	ug/L	3.9	2.25								
PCBs												
PCB-101	yes	ng/L	0.86	0.93								
PCB-104		ng/L	0.59	0.64								
PCB-105	yes	ng/L	0.53	0.57								
PCB-118	yes	ng/L	0.83	0.9								
PCB-126		ng/L	1.06	1.15								
PCB-128	yes	ng/L	0.43	0.47								
PCB-138	yes	ng/L	0.61	0.66								
PCB-153	yes	ng/L	0.69	0.75								
PCB-154		ng/L	0.98	1.06								
PCB-170	yes	ng/L	0.35	0.38								
PCB-18	yes	ng/L	1.87	2.02								
PCB-180	yes	ng/L	0.49	0.53								
PCB-183		ng/L	0.95	1.03								
PCB-184		ng/L	0.95	1.03								
PCB-187	yes	ng/L	0.68	0.74								
PCB-188		ng/L	0.39	0.43								
PCB-195	yes	ng/L	0.48	0.52								
PCB-200		ng/L	2.52	2.73								
PCB-206	yes	ng/L	0.69	0.75								
PCB-209	yes	ng/L	0.49	0.53								
PCB-28	yes	ng/L	1.25	1.36								
PCB-29		ng/L	0.98	1.06								
PCB-44	yes	ng/L	0.54	0.59								
PCB-49		ng/L	0.95	1.03								

Compound	NOAA MWP data avail?	units	Navy Fuel Tank Farm Pier 25-May 1999 NSBBLN	18-June 1999 NSBBLN	Vicinity of Ballast Point 15-Apr 1996 SD-02C	15-Apr 1996 SD-02E	15-Apr 1996 SD-02B	18-May 1998 SDB02	11-Sep 1997 SDB02	23-Aug 1995 SDB02	21-Aug. 1996 SDB02	Outside Bay 18-May 1998 SDB01
PCB-50		ng/L	1.66	1.8								
PCB-52	yes	ng/L	0.63	0.68								
PCB-66	yes	ng/L	0.68	0.73								
PCB-8	yes	ng/L	1.77	1.91								
PCB-87		ng/L	0.63	0.68								
PCB-101	yes	ng/L	0.86	0.93								
PCB-104		ng/L	0.59	0.64								
PCB-105	yes	ng/L	0.53	0.57								
PCB-118	yes	ng/L	0.83	0.9								
PCB-126		ng/L	1.06	1.15								
PCB-128	yes	ng/L	0.43	0.47								
PCB-138	yes	ng/L	0.61	0.66								
PCB-153	yes	ng/L	0.69	0.75								
PCB-154		ng/L	0.98	1.06								
PCB-170	yes	ng/L	0.35	0.38								
PCB-18	yes	ng/L	1.87	2.02								
PCB-180	yes	ng/L	0.49	0.53								
PCB-183		ng/L	0.95	1.03								
PCB-184		ng/L	0.95	1.03								
PCB-187	yes	ng/L	0.68	0.74								
PCB-188		ng/L	0.39	0.43								
PCB-195	yes	ng/L	0.48	0.52								
PCB-200		ng/L	2.52	2.73								
PCB-206	yes	ng/L	0.69	0.75								
PCB-209	yes	ng/L	0.49	0.53								
PCB-28	yes	ng/L	1.25	1.36								
PCB-29		ng/L	0.98	1.06								
PCB-44	yes	ng/L	0.54	0.59								
PCB-49		ng/L	0.95	1.03								

Compound	NOAA MWP data avail?	units	Navy Fuel Tank Farm Pier: 25-May 1999 NSBBLN	Navy Fuel Tank Farm Pier: 18-June 1999 NSBBLN	Vicinity of Ballast Point: 15-Apr 1996 SD-02C	Vicinity of Ballast Point: 15-Apr 1996 SD-02E	Vicinity of Ballast Point: 15-Apr 1996 SD-02B	Vicinity of Ballast Point: 18-May 1998 SDB02	Vicinity of Ballast Point: 11-Sep 1997 SDB02	Vicinity of Ballast Point: 23-Aug 1995 SDB02	Vicinity of Ballast Point: 21-Aug. 1996 SDB02	Outside Bay: 18-May 1998 SDB01
PCB-50		ng/L	1.66	1.8								
PCB-52	yes	ng/L	0.63	0.68								
PCB-66	yes	ng/L	0.68	0.73								
PCB-8	yes	ng/L	1.77	1.91								
PCB-87		ng/L	0.63	0.68								

[a]Sample date: 23-Aug-1995

[b]Sample date: 21-Aug-1996

[c]Sample date: 24-Mar-1997

[d]Measured on 28-Apr-1997 at "Station 1" (-117.223889 W, 32.6525 N), which is almost the same location as SDB01.

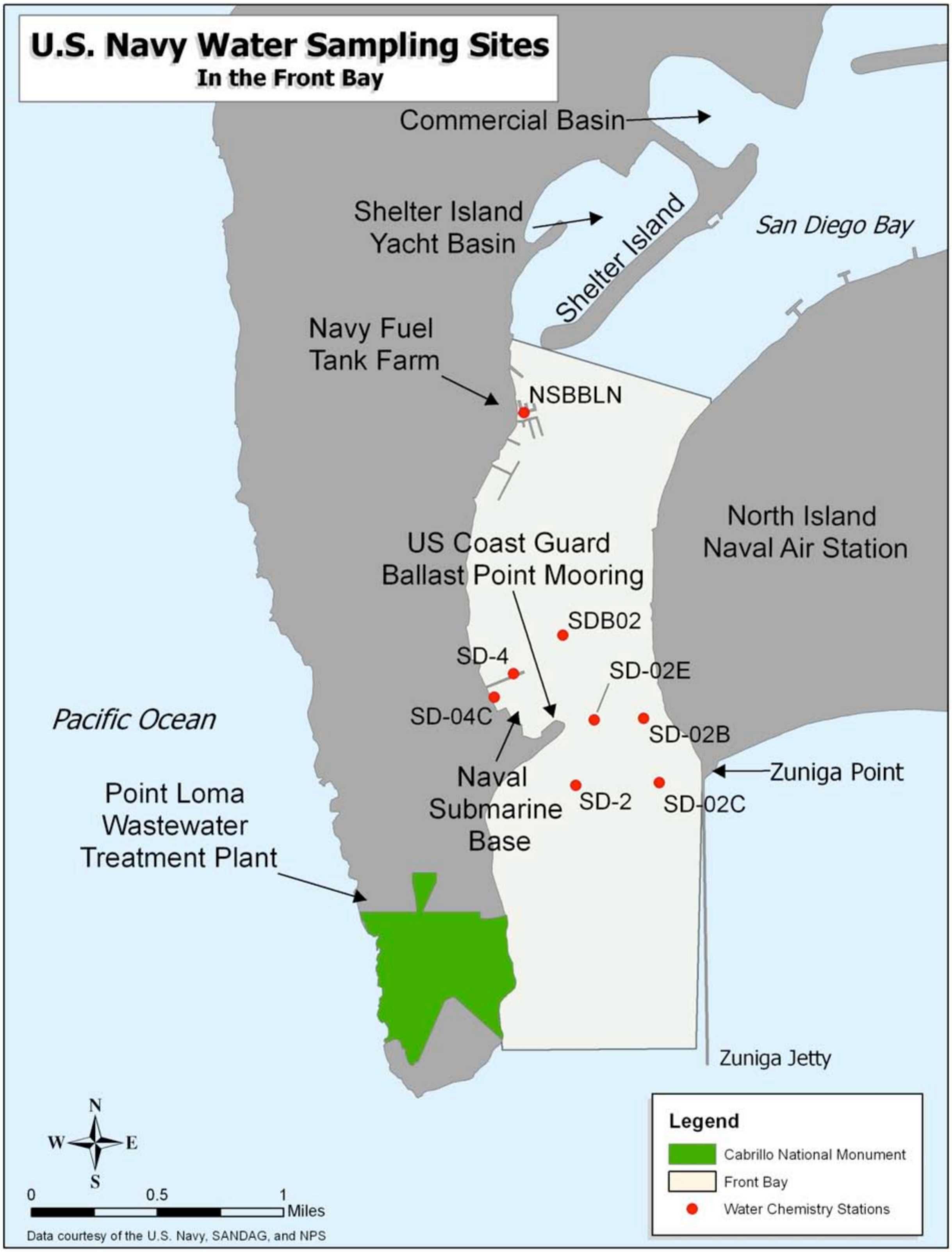


Figure 57. U.S. Navy water sampling sites in the Front Bay for which data are presented in Table 17.

III. OTHER CONCERNS for AQUATIC RESOURCES

A. Exotic Marine Species

Only three non-native algal species have been reported from the CABR intertidal (Bonnie Becker, Marine Biologist, CABR, pers. comm.):

Sargassum muticum
Caulacanthus ustulatus
Lomentaria hakodatensis

Of these, the first two are more common than the third. *Sargassum muticum* has also been reported from San Diego Bay. It is conspicuous in shallow water where large plants grow near docks and piers, spreads rapidly, and interferes with boating. It was probably introduced on Japanese oysters in Puget Sound in 1930s (USN 1999). The highly invasive seaweed, *Caulerpa taxifolia*, has not yet been found in San Diego Bay.

A non-native animal that has been tentatively reported from CABR is the common mussel, *Mytilus galloprovincialis*. It originates from the Mediterranean and appears to have displaced a native mussel in the San Diego Bay. Many exotic marine animals have been found in San Diego Bay that are not yet reported from CABR; the difference in habitat types (bay/estuarine vs open coast) is a probable explanation. Among the exotic fauna in San Diego Bay are 2 anemones (*Bunodeopsis* sp., *Diadumene lineatu*), 5 polychaetes (*Capitella* sp., *Marphysa sanguinea*, *Neanthes acuminata*, *Polydora ligni*, *Seudopolydora paucibranchiata*), 1 sponge (*Haliclona* sp.), 2 hydroids (*Obelia* sp., *Tubularia crocea*), 1 barnacle (*Balanus amphitrite*), the oriental shrimp (*Palaemon macrodactylus*), 2 other mussel spp. (Japanese mussel [*Musculista senhousia*], Atlantic ribbed mussel [*Geukensia demissum*], 1 clam (Japanese littleneck [*Tapes semidecussata*]), 11 tunicates (*Ascidia zara*, *Ascidia* sp., *Botrylloides diegensis*, *Botryllus schlosseria*, *Ciona intestinalis*, *Ciona savignyi*, *Microcosmus squamiger*, *Polyandrocarpa zorritensis*, *Styela canopus*, *Styela plicata*, *Symplegma brakenhielmi*), and 5 fish (yellowfin goby (*Acanthogobius flavimanus*), chameleon goby (*Tridentiger trigonocephalus*), sailfin molly (*Poecilia latipinna*), striped sea bass (*Morone saxatilis*), and threadfin shad (*Dorosoma petenense*) (USN 1999).

B. Commercial Harvest and Recreational Fishing

B.1. Regulatory Background

The Federal Perspective. The State of California and the federal government, in particular the National Park Service, disagree over who has sole jurisdiction over the submerged lands and living marine organisms within 300 yards of mean low water at CABR. The California Department of Fish & Game (CF&G) believes that owing to the Submerged Lands Act of 1953, the State has sole jurisdiction within three miles of the mainland shore. The National Park Service believes otherwise based on the following. On February 26, 1852, President Fillmore issued an Executive Order that established the Federal reservation on Point Loma for military purposes. Prior to that, the United States had acquired California from Mexico under the terms of the Treaty of Guadalupe-Hidalgo. On March 9, 1897, the State of California ceded to the United States of America (Statutes of California 1897, Chapter 81, approved March 9, 1897), “the parcels of land extending from high-water mark out to three hundred yards beyond low-water mark, lying adjacent and contiguous to such lands of the United States in this State as lie upon tidal waters and are held, occupied, or reserved for military purposes or defense,… only so long as the as the United States shall continue to hold and own the adjacent lands now belonging to the United States;….” This cession included the Federal reservation on Point Loma. The NPS believes that Section 1313 of the Submerged Lands Act excepted “…all tracts or parcels of land..., resources therein, …title to which has been lawfully and expressly acquired by the United States from any State…, and all lands which the United States lawfully holds under the law of the State; all lands expressly retained by or ceded to the United States when the State entered the Union (otherwise than by a general retention or cession of lands underlying the marginal sea); all lands acquired by the United States by eminent domain, proceedings, purchase, cession, gift or otherwise in a proprietary capacity;…and any rights the United States has in lands presently and actually occupied by the United States under claim of right;..,” which includes the federal reservation on Point Loma.

The NPS believes that, owing to the agreements it has with the Army Corps of Engineers and the Navy pursuant to the authority in 16 U.S. Code §17j-2(b), it has jurisdiction within the federal offshore ocean waters (within 300 yards of mean low water) adjacent to Cabrillo NM that had been excepted from the Submerged Lands Act. The Code of Federal Regulations (CFR) Title 36, Parks, Forests, and Public Property, Chapter 1 – National Park Service, Department of the Interior, Part 1, §1.2 Applicability and scope, states that the regulations in the chapter “apply to all persons entering, using, visiting or otherwise within: …(2) The boundaries of lands and waters administered by the National Park Service for public-use purposes pursuant to the terms of a written instrument; (3) Waters subject to the jurisdiction of the United States located within the boundaries of the National Park System, including navigable waters and *areas within their ordinary reach (up to the mean high water line in places subject to the ebb and flow of the tide and up to the ordinary high water mark in other places) without regard to the ownership of submerged lands, tidelands, or lowlands;* [emphasis added]….As a result, the NPS has the authority to implement the regulations in Part 2 – Resource Protection, Public Use and Recreation, which includes §2.2 Wildlife protection and §2.3 Fishing. Owing to the definition of *wildlife* contained in §1.4 Definitions, the NPS believes that marine invertebrates are considered wildlife protected by federal law. Consequently, the removal of marine invertebrates of potential interest to fishermen (e.g., crab, lobster, urchins, sea cucumbers, molluscs) from within the administrative boundary of CABR is prohibited. The NPS also holds that CFR Title 36, Part 2, Section 2.3 ("Fishing") contains the fishing regulations that apply within the administrative boundary of CABR. The text of CFR Title 36, Part 2, Section 2.3, is as follows (code pertinent to CABR is in bold type):

> “**(a) Except in designated areas or as provided in this section, fishing shall be in accordance with the laws and regulations of the State within whose exterior boundaries a park area or portion thereof is located. Nonconflicting State laws are adopted as a part of these regulations.**
>
> (b) State fishing licenses are not required in Big Bend, Crater Lake, Denali, Glacier, Isle Royale (inland waters only), Mammoth Cave, Mount Rainer, Olympic and Yellowstone National Parks.

(c) Except in emergencies or in areas under the exclusive jurisdiction of the United States, the superintendent shall consult with appropriate State agencies before invoking the authority of §1.5 for the purpose of restricting or closing park areas to the taking of fish.

(d) The following are prohibited:

(1) Fishing in fresh waters in any manner other than by hook and line, with the rod or line being closely attended.

(2) Possessing or using as bait for fishing in fresh waters, live or dead minnows or other bait fish, amphibians, nonpreserved fish eggs or fish roe, except in designated waters. Waters which may be so designated shall be limited to those where non-native species are already established, scientific data indicate that the introduction of additional numbers or types of non-native species would not impact populations of native species adversely, and park management plans do not call for elimination of non-native species.

(3) Chumming or placing preserved or fresh fish eggs, fish roe, food, fish parts, chemicals, or other foreign substances in fresh waters for the purpose of feeding or attracting fish in order that they may be taken.

(4) Commercial fishing, except where specifically authorized by Federal statutory law.

(5) Fishing by the use of drugs, poisons, explosives, or electricity.

(6) Digging for bait, except in privately owned lands.

(7) Failing to return carefully and immediately to the water from which it was taken a fish that does not meet size or species restrictions or that the person chooses not to keep. Fish so released shall not be included in the catch or possession limit: Provided, That at the time of catching the person did not possess the legal limit of fish.

(8) Fishing from motor road bridges, from or within 200 feet of a public raft or float designated for water sports, or within the limits of locations designated as swimming beaches, surfing areas, or public boat docks, except in designated areas.

(e) Except as otherwise designated, fishing with a net, spear, or weapon in the salt waters of park areas shall be in accordance with State law.

(f) Authorized persons may check fishing licenses and permits; inspect creels, tackle and fishing gear for compliance with equipment restrictions; and inspect fish that have been taken for compliance with species, size and other taking restrictions.

(g) The regulations contained in this section apply, regardless of land ownership, on all lands and waters within a park area that are under the legislative jurisdiction of the United States.

[48 FR 30282, June 30, 1983, as amended at 52 FR 35240, Sept. 18, 1987] ”

NPS staff have expressed the opinion that CFR Title 36 §2.3 provides that recreational fishing is only allowed by hook and line within the administrative boundary of CABR (Terry DiMattio, Superintendent, CABR, pers. comm.). However, the code above stipulates this gear restriction for *freshwater*, with no mention of salt water (see above), and thus it appears as if the restriction appears not to apply to recreational fishing at CABR. However, Section 1.2 indicates the implementation of the fishing regulations applies to all water (fresh and salt) under the jurisdiction of the NPS.

The State perspective. CF&G holds that owing to the Submerged Lands Act of 1953[15], the State of California has sole jurisdiction over the living marine resources within 3 nautical miles of the mainland shore (John Ugoretz, CF&G, pers. comm.). With the exception of the area included within the Mia Tegner SMCA (which extends 150 feet seaward of mean high tide line, Figure 1), CF&G holds that state law permits both recreational and commercial fishing at CABR, in accordance with pertinent state fishing regulations. State law regarding the Mia Tegner SMCA is as follows:

> "CCR Title 14, Division 1, Subdivision 2, Chapter 11, Section 632 (84): (A) Take of all living marine resources is prohibited except the recreational take of finfish and the commercial take of finfish and marine aquatic plants."

Consequently, from the state perspective, recreational and commercial finfish harvest is permitted within the entire administrative boundary of CABR (shore to 300 yards), and commercial take of invertebrates[16] is permitted within the administrative boundary of CABR in areas outside of the Mia Tegner SMCA. Below, we discuss state fishing regulations that would apply *if one assumes state jurisdiction*. If one assumes federal jurisdiction, then the state regulations below concerning commercial fishing are moot, all take of invertebrates is prohibited from shore to 300 yards, and recreational fishing for finfish is allowed in all areas, subject to non-conflicting state law. In the latter case, the portions of Fish & Game Code (FGC) Sections 7100-7400 and the California Code of Regulations (CCR), Title 14, Division 1, Subdivision 1, Chapter 4, that pertain to *recreational take of finfish* would apply throughout the administrative boundary of CABR. The conflicting federal and state interpretations of jurisdiction over commercial fishing at CABR have not yet been resolved by the courts. However, from a practical perspective, the physical attributes of this area (very shallow tidal flats) would make commercial harvest of finfish very difficult and labor intensive (Andrea Compton, Chief of Natural Resource Science, CABR, pers. comm.). Kelp is present in only very small quantities in shallow waters within the administrative boundary of CABR, so commercial harvest of kelp is not likely to occur there in any case (Andrea Compton, Chief of Natural Resource Science, CABR, pers. comm.).

CABR staff do not conduct counts or interviews of shore-based anglers, nor are counts made of fishing boats that use waters within the administrative boundary of CABR. The Point Loma kelp forest is a popular destination for recreational fishermen and dive boats. Commercial trapping for lobster and crab apparently takes place to some degree within the administrative boundary of CABR (Andrea Compton, Chief of Natural Resource Science, CABR, pers. comm.). Although

[15] CFR Title 43, Chapter 29, Subchapter II ("Lands beneath navigable water within state boundaries"), §1312 ("Seaward boundaries of States").

[16] Harvest of eelgrass and surfgrass is prohibited by the State everywhere in California.

we are unable to quantify it here, some fraction of the region's commercial nearshore finfish, red sea urchin, spiny lobster, and crab catch takes place in and near the kelp bed offshore of CABR.

State Fishing Regulations. The marine habitat of CABR is located within the State's Commercial Fishing District 19, and the Southern Management Area for recreational fishing. The State restricts the sizes, numbers, depths, gear types, and seasons for commercial and recreational take of many species which are reported from CABR[17]. Appendix D indicates which finfish species reported from CABR are included in landings from commercial fishing boats or commerical passenger fishing vessels (CPFV) at San Diego area harbors. Appendix G provides more detail about state fishing regulations for pertinent finfish species, and links to on-line sources of information about biology and fishery conditions for many species. Appendix H lists state regulations pertaining to invertebrates present at CABR that are possibly taken by commercial or sport fishermen outside of the Mia Tegner SMCA. Although many CABR species are, generally speaking, targets of fishing in the San Diego area, it is not necessarily true that the marine habitat in proximity to CABR provides appropriate or popular fishing ground for all of these species.

Live fish trapping for rockfish (*Sebastes* spp.), California sheephead, California scorpionfish and other shallow water fish has expanded recently owing to demand for live fish in the Asian market (see more below). Limited entry Nearshore Fishery Permits, and Deeper Nearshore Species Permits, are now required by the State for commercial fishing of nearshore finfish, and a limited number of live-fish trap permits (Nearshore Finfish Trap Endorsements) are issued. Without a live-fish trap permit, the 19 species regulated as Nearshore Finfish (see Appendix G for a list, most are rockfish) may only be taken by line. It is unlawful to use more than 150 hooks on a vessel, or to use more than 15 hooks per line, to take nearshore fish stocks for commercial purposes in ocean waters within one mile of shore in District 19. Recreational fishing for all species of rockfish, together with cabezon and greenling spp., is subject to rules for the Rockfish/Cabezon/Greenling, or "RCG" complex (see Appendix G). Traps are also used in the waters off southern California to take shrimp and prawns, California spiny lobster, and three types of rock crab (red, brown and yellow). However, south of Pt. Conception, the use of traps to catch shrimp is prohibited in waters <50 fathoms (150 feet) deep, which rules out shrimp trapping within the administrative boundary of CABR. Use of gill nets (set- and drift gill nets) and trammel nets to catch *any* species is prohibited in ocean waters 3 nm from the California mainland, and consequently within the administrative boundary of CABR. Bottom trawling for any species is prohibited within 3 nautical miles of the mainland shore in District 19, except for halibut within specially designated grounds (none exist in the San Diego area). Abalone was closed to commercial harvest south of San Fransisco Bay by the state legislature in 1997. The commercial take of California corbin, yellowfin croaker, giant sea bass, kelp bass, barred sand bass, spotted sand bass, garibaldi, and wolf eel is currently prohibited. Recreational take of giant seabass and garibaldi is also prohibited. There is a small but increasing fishery for turban snails and whelks in California, which is not currently regulated (203 lbs of Kellet's whelk, and 39 lbs of "sea snails" were taken commercially in the San Diego area in 2004, CF&G 2005a). We are aware of no state regulations that would prohibit commercial diving for sea cucumbers, or purse

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[17] Commercial Ocean Fishing Regulations are found in CCR Title 14, Division 1, Subdivision 1, Chapter 6, and F&G Code, Division 6, Part 3, Sections 7600-9055.

seining for market squid, in nearshore waters near Point Loma, although we have no information that suggests these activities are important there.

B.2. Commercial Fishing

Species were ranked according to the 2004 combined commercial catch (lbs) landed at harbors in San Diego Bay and Mission Bay (2004 is the most recent year available, top 20 species shown in Figure 58). Although these data are not specific to effort at Point Loma, they provide an indication of the species most-sought by the commercial fleet currently operating out of San Diego Bay area harbors. In the San Diego area, the commercial red sea urchin catch greatly exceeds the catch of other commercially important invertebrate and finfish species (Figure 58). California spiny lobster, swordfish, albacore tuna, and rock crab (in that order) are the next most important commercial species in the area. Only 8 out of the top 20 commercially important species for the San Diego area are on species lists for CABR (red sea urchin, California spiny lobster, rock crab, California sheephead, yellowtail, white seabass, and warty sea cucumber).

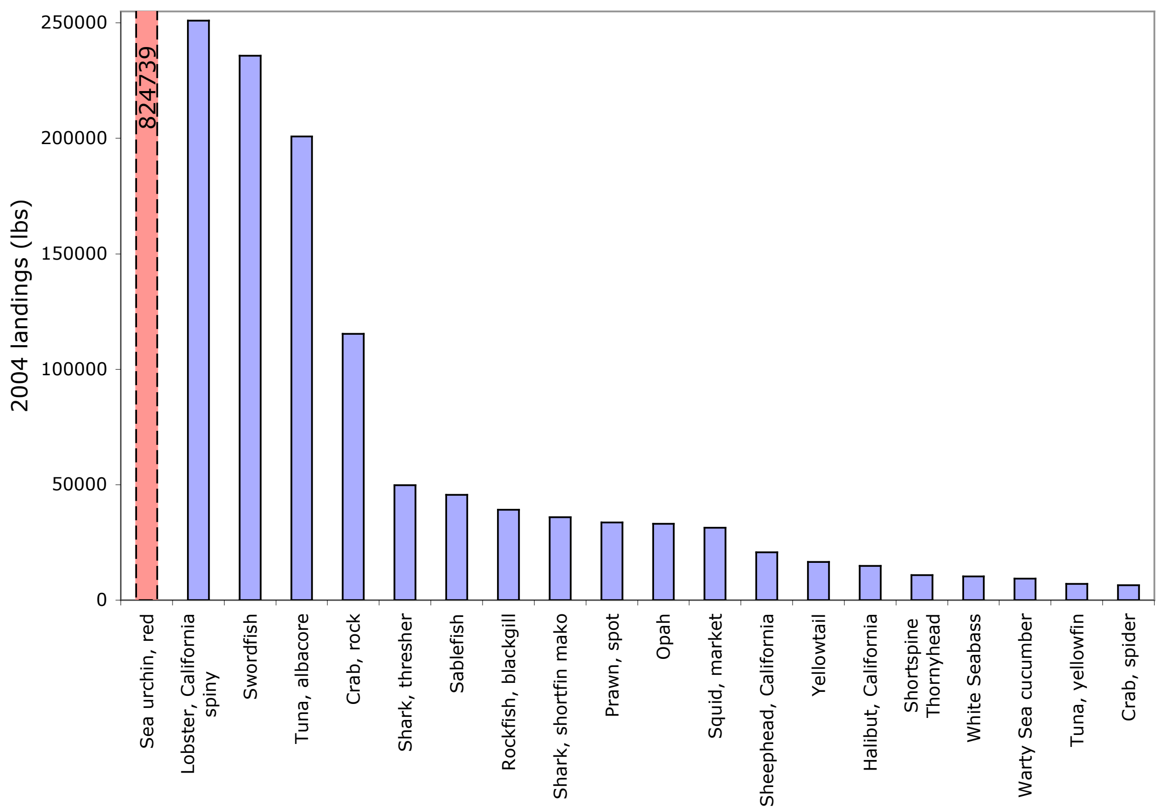


Figure 58. 2004 commercial landings for San Diego and Mission Bay harbors combined. Data are from CF&G (2005a).

CF&G data on commercial fishing effort is assigned to 10 x 10 minute blocks. The CF&G blocks that include the marine habitat of CABR are 860 and 878 (Figure 59). Unfortunately, because CABR habitat comprises such a small portion of these two blocks, block data could not be well used to answer questions concerning commercial fishing effort just offshore of CABR, and extraction of information about commercial effort on a finer geographic scale from boat logs was not practical. Some information from a 1998 review (Dayton et al. 1998) about population trends for Point Loma kelp forest species, and their relationship to commercial and sport fishing, is presented below in Section III.B.5.

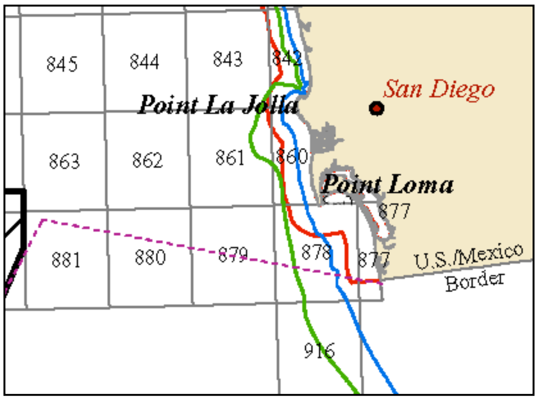


Figure 59. California Department of Fish & Game Fishing commerical catch blocks near Point Loma. The 10 x 10 minute blocks are the smallest units for which statistics (species, time period, gear type, vessel size, etc.) are calculated for commercial landings. Nearshore waters off Cabrillo National Monument are in blocks 860 and 878. Figure is modified from the Map of California Cowcod Conservation Areas at http://www.dfg.ca.gov/mrd/cowcod.html

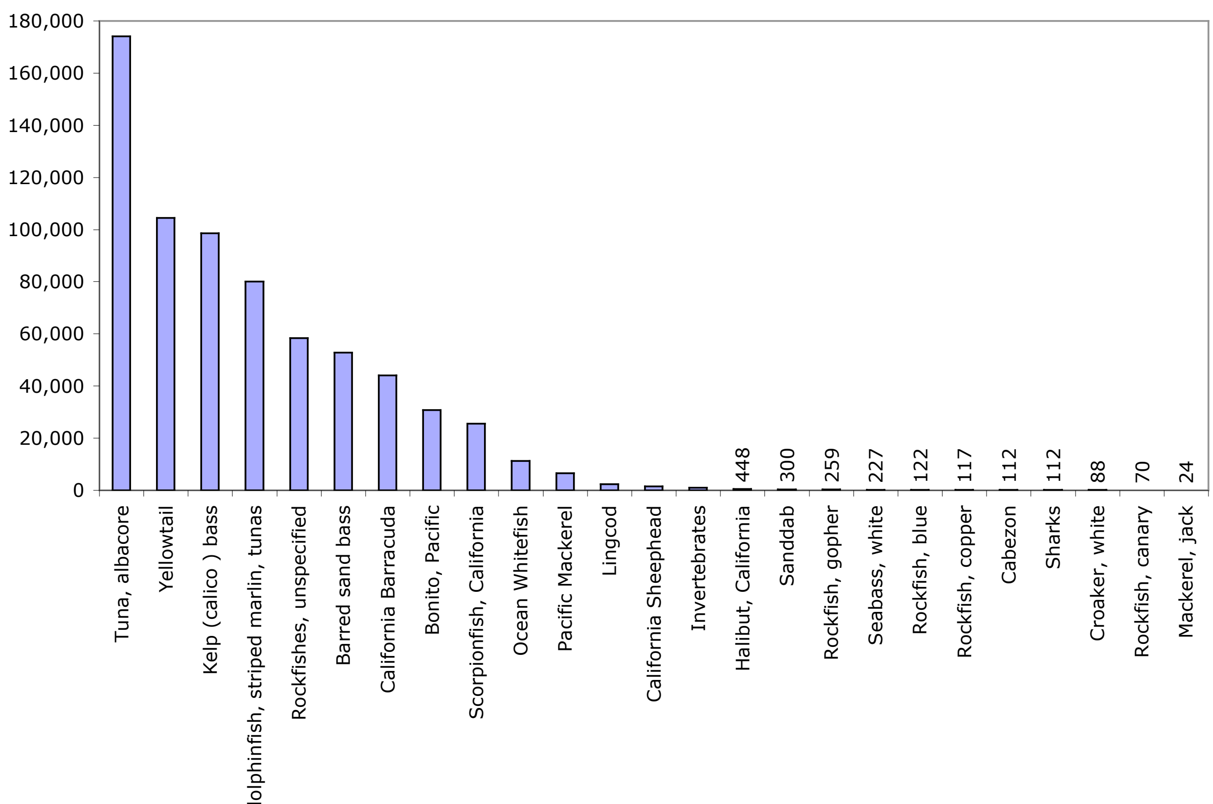


Figure 60. Combined 2004 CPFV landings (numbers) for the San Diego Bay and Mission Bay fleets. Data are from CF&G (2005b).

B.3. Recreational Fishing

In Figure 60, we rank recreationally caught species of fish and invertebrates according to the combined 2004 CPFV landings from San Diego Bay and Mission Bay harbors. Of the top 23 species caught on CPFVs in the area, fifteen are on species lists for CABR.

The California Recreational Fisheries Survey (CRFS) is a coordinated state-wide sampling survey designed to gather catch and effort data from anglers in all modes of marine recreational finfish fishing (http://www.dfg.ca.gov/mrd/crfs.html). CRFS began officially in January 2004, but its database includes older survey data from 1999 forward. CRFS incorporates and updates the comprehensive sampling methodologies of the former Marine Recreational Fisheries Statistics Survey (MRFSS) and the CF&G's Ocean Salmon Project. Elements of CRFS include:

- A single, integrated statewide marine recreational finfish sampling program
- Increased sampling for private, rental, and Commercial Passenger Fishing Vessels ("party" boats, or CPFVs)
- Estimation of beach/bank and private access angler effort using an angler license database
- Effort and catch estimation on man-made structures using instantaneous angler counts, roving effort surveys, and angler interviews
- Monthly effort and catch estimates for all modes at a fine geographical resolution
- Sufficient sampling of private/rental vessels to meet ocean management data requirements including collection of coded wire tags in salmon heads

CRFS data is assigned to much smaller geographical blocks than the CF&G commercial blocks (each CF&G block is broken into 100 smaller blocks, Connie Ryan, CRFS, pers. comm.). Howatt King, formerly of CF&G, conducted a pilot study ("hot spot analysis") using CRFS data from 1999-2003 to investigate methods of data analysis. However, his study does not provide detailed data pertinent to CABR (Wade Buskirk, CRFS, pers. comm.). CRFS does not conduct shoreline angler interviews at CABR, nor at any point south of the gate for Fort Rosecrans Military Reservation on the Point Loma Peninsula. The CRFS shoreline survey site nearest to CABR is #73206 at Sunset Cliffs Parks, approximately halfway between Point Loma and the mouth of the San Diego River. The next nearest shoreline survey site is the Ocean Beach Pier (site #73302), just south of the mouth of San Diego River.

At our request, Wade Buskirk, of CRFS, queried the CRFS database for results from boats that reported catch from a geographical area extending (south to north) from the tip of Point Loma Peninsula to the PLOO (32.6653 N to 32.6789 N), from shore to a depth of 120 feet. The database contained on-board surveys of anglers from only one CPFV per year in 1999, 2000, 2001, and 2003; and from only two CPFVs per year in 2004 and 2005 (Table 18). Additionally, 548 anglers from private boats that reported catch from the target area were surveyed (at landing sites) by CRFS (or earlier incarnations of the survey) from 1999-2005 (Table 19). Although this data does not estimate the total recreational take (which requires a sophisticated analysis not done here), it reveals which fish are known to be taken by recreational fishermen just offshore of CABR. A greater variety of fish were reported caught by anglers from private fishing boats than from CPFVs. Two of the top five species caught from this small sample of CPFVs (ocean whitefish and lingcod) are not on the CABR species list, and are normally deeper water fish. All of the top five species caught on private boats are on the CABR species list. The Point Loma CPFV sample data from CRFS contrasts in several ways with the species rankings for the combined CPFV fleet landings from San Diego area harbors (Figure 60). For example, ocean whitefish and lingcod figure more prominently in the CPFV data for Point Loma than they do in the CPFV data from the greater San Diego area. The top finfish species landed by the San Diego area CPFV fleet in 2004 (tuna) was not reported as caught off CABR by any recreational fishermen interviewed by CRFS, and does not appear on the species list for CABR. The second ranked finfish species landed by the area CPFV fleet (yellowtail) was ranked very low in CRFS Point Loma catch data from private boat fishermen. The difference may indicate that a high proportion of charter boats in the San Diego area target pelagic fish found offshore (such as tuna, marlin, dolphinfish, yellowtail), and thus are not utilizing nearshore habitat, such as the Point Loma kelp bed, as much as the private boats do.

Table 18. Total numbers of fish caught on 8 CPFVs surveyed by CRFS from 1999-2005 that were in water just offshore of CABR (see text for description of target area). Shading indicates species that are reported as present, or probably present, at CABR. Data were provided by W. Buskirk at CRFS.

CHARTER BOATS (CPFVs)	**depth**	**number kept**	**number thrown back**
ocean whitefish	86	82	.
lingcod	83	38	2
treefish	91	32	.
California barracuda	75	17	3
California halibut	81	16	.
kelp bass	75	9	3
gopher rockfish	82	6	.
barred sandbass	82	5	4
sharpnose seaperch	90	5	5
chub (Pacific) mackerel	80	4	4
starry rockfish	88	3	.
kelp rockfish	88	2	1
olive rockfish	86	2	2
California scorpionfish	86	1	1
cabezon	79	1	2
copper rockfish	80	1	1
rockfish genus	101	1	2
unidentified fish	65	1	.
vermilion rockfish	90	1	.
California lizardfish	89	0	4
greenspotted rockfish	83	0	4
longnose skate	66	0	1

Table 19. Total numbers of fish caught in water just offshore from CABR by a sample of 548 anglers using private boats that were surveyed by CRFS from 1999-2005 (see text for description of target area). Beige highlighting indicates species that are reported as present, or probably present, at CABR. Data were provided by W. Buskirk at CRFS.

PRIVATE BOATS	Kept	Reported dead	Released alive
kelp bass	94	6	375
barred sandbass	74	9	202
California halibut	60	4	363
California scorpionfish	29	11	73
vermilion rockfish	27	3	39
chub (Pacific) mackerel	9	3	69
spotted sandbass	8	1	113
kelp rockfish	7	.	10
silverside family	7	.	4
California barracuda	5	.	53
gopher rockfish	5	.	2
lingcod	5	.	15
orangemouth corvina	5	.	20
sandbass genus	5	3	26
Pacific bonito	4	.	4
brown rockfish	4	.	7
white seabass	4	.	16
white croaker	3	.	12
yellowtail	3	.	.
grass rockfish	2	.	2
gray smoothhound	2	.	.
olive rockfish	1	.	5
rockfish genus	1	7	4
specklefin midshipman	1	.	4
treefish	1	.	1
yellowfin croaker	1	.	2
California butterflyray	.	.	1
California lizardfish	.	.	8
California sheephead	.	18	1
horn shark	.	.	1
shovelnose guitarfish	.	.	4
skate and ray order	.	.	1
smoothhound genus	.	.	3
spiny dogfish shark	.	.	1
unidentified (sharks)	.	.	4

B.4. Commercial Kelp Harvesting

Macrocystis has been harvested in the Point Loma kelp bed since the early 1900s, but the regulated method of harvest is to cut only the upper 1.2 m of the surface canopy, and this appears to have little impact at Point Loma (Barilotti et al. 1985). Indeed, although there is considerable interannual variability in kelp yield related to storms and temperature (Tegner et al. 1996), the long-term stability of the kelp harvest suggests that it may be the best managed harvest of coastal populations in California (Dayton et al. 1998). The company ISP Alginates, previously known as Kelco, harvested kelp in the Point Loma kelp bed for over 70 years (Andrea Compton, Chief of Natural Resource Science, CABR, pers. comm.). In 2005, the company decided to close down their operations and move operations to Scotland. It is unknown if CF&G will issue a new permit for harvesting in the Point Loma kelp bed, who would purchase the lease, when operations would start, and which type of harvest (manual versus mechanical harvest methods) would be employed. In the past, ISP Alginates efforts included transplanting new plants when winter storms removed large portions of the stand.

B.5. Recent impacts of fishing on selected Point Loma species

As occupants of the rocky intertidal habitat at CABR, mussels and owl limpets have been well monitored at Point Loma in recent years. Because the prohibition on collection of intertidal organisms at CABR is well enforced, sessile invertebrates from the CABR intertidal zone are not directly threatened by harvesting near Point Loma. Indeed, regional patterns in the size distribution of at least one sessile species, owl limpet, indicates the importance of CABR as a refuge from harvest (Becker 2006). A review of recent impacts of commercial and sport harvest on several taxa from the Point Loma kelp forest community is provided in Dayton et al. (1998). Excerpts from this review are provided below. Many of the finfish species that visit the subtidal zone of CABR are strongly associated with kelp forest. No data are available to indicate how much the harvest of fish and invertebrates from within the Point Loma kelp bed affects the abundance of fish and invertebrates that use the subtidal habitat of CABR.

> [from Dayton et al. (1998); see original article for figures and references cited therein]
>
> "**Spear fishing**
>
> Although southern California is in the northern part of their range (Rosenblatt and Zahuranec 1967), broomtail groupers, Mycteroperca xenarcha, and other species of grouper were once common in certain areas (J. Stewart, personal communication), and black sea bass (Stereolepis gigas) were once plentiful in local kelp forests. These were very large fish weighing hundreds of kilograms. We have no measure of their densities, but old movies, photos, and interviews tell us that it was typical for divers to see several of these fish on one dive. We guess that they may have had home ranges of 2–3 ha, suggesting a surprisingly high productivity to feed these large fish. Broomtail groupers are territorial, and we believe that black sea bass tend to remain in home ranges during the spring to fall seasons. Thus, especially for the broomtail groupers, mortality caused by a few spearfishermen may easily explain their loss from the system; black sea bass were also taken by anglers and nets. Equally difficult to quantify is the change in size distributions of hunted species that are still present; historical comparisons of spearfishing contest results with present populations suggest major changes in abundance and size distributions of species such as

California sheephead, Semicossyphus pulcher. Two decades after the mid 1970s' regime shift, and after gill nets were moved offshore in 1994, a few black sea bass and grouper are reappearing."

"**Other sport and commercial fisheries**

White seabass (Atractoscion noblis) and yellowtail (Seriola lalandi) are two fishes once common along the outer edge of San Diego kelp forests during warm summer months, especially in El Niño years. Divers in the early 1950s observed schools of hundreds of these fishes (J. Stewart, personal communication). In extensive diving since 1970, we have never seen more than a half-dozen of either of these species at one time. In the absence of independent stock assessments, the only information available on population size is fishery statistics, and these data are affected by changes in fishing gear, fishing effort, Mexican stocks, markets, and other confounding variables. Yellowtail commercial landings crashed in the mid 1950s and have remained at a few percent of previous landings for the last four decades (Leet et al. 1992). Interpretation of sport and commercial landings of white seabass (Fig. 4) was further complicated by exclusion of U.S. fishermen from Mexican waters in 1982 and the banning of nearshore gill nets in 1994, but landings exhibit a pattern similar to that of yellowtail. An interesting example of reduced expectations can be found in the opinion of some fishery experts that the persistence of this relatively low population during recent years is evidence that the stocks are doing fine, such that they advocate no changes in fishing regulations."

"In 1988, a market, primarily the Asian community, was identified for live fishes (California Department of Fish and Game 1996). This fishery focuses on animals that are the size of a single entree (1 kg), visually attractive, and hardy enough to survive the rigors of capture and transportation. It began with hook and line gear; after 1989, the use of traps grew rapidly. Target species include California sheephead (Semicossyphus pulcher), California halibut (Paralichthys californianus), cabezon (Scorpaenichthys marmoratus), lingcod (Ophiodon elongatus), scorpion fish (Scorpaena guttata), and several species of rockfish (Sebastes spp.). Statewide, the landings (1 metric ton = 1 Mg) for this fishery jumped over the period 1989 to 1995 from 16203 to 194942 Mg for sheephead, 1473 to 115879 Mg for California halibut, and 163 to 179785 Mg for cabezon. Some insight into the effects on sheephead populations is offered by Department of Fish and Game logbook data from commercial passenger sport fishing vessels. From 1981 to 1986, an average of 1809 sheephead was taken per year from Point Loma; by 1994–1995, the average number was 145 sheephead/yr. The live-fish fishery has grown as an alternate use of lobster traps in the off-season, and with the prohibition of commercial gill nets within three U.S. nautical miles (5.6 km) of shore in 1994. Essentially, all fishes that respond to bait in a trap are being taken by this fishery, and many of these are now rarely seen. These fisheries are minimally regulated, require inexpensive gear and low effort, and have the potential for virtual elimination of the community roles of these species[18]. The pressure of this fishery on sheephead stocks is especially problematic; these fishes are sequential hermaphrodites and the fishery takes only small females, which may be prereproductive (Leet et al. 1992). We have evidence that many of these fishes were once important predators on benthic prey, such as cabezon on abalones (Tegner and Butler 1989), scorpion fish on octopuses (Quast 1968), and sheephead on sea urchins (Tegner and Dayton 1981,

[18] Dayton et. al. (1998) predates the creation of the State's Nearshore Fishery Management Plan, the adoption of limited entry Nearshore Fishery Permits, Deeper Nearshore Species Permits, and limited numbers of Live Finfish Trap Endorsements (see Appendix G for detail).

Cowen 1983). The changes in sheephead populations suggest that outbreaks of destructive grazing by the minimally exploited purple sea urchin, Strongylocentrotus purpuratus, will become more frequent. Natural densities, population size structures, and ecological relationships are unknown for a host of fishes that have functionally disappeared from Point Loma and other coastal kelp forest communities. ”

“Populations of elasmobranchs such as several species of rays and sharks, including gray smoothhounds (Mustelus californicus), leopard sharks (Triakis semifasciata), and several smaller species, once much more common, were heavily impacted by gill net fishing, whether as target species or as bycatch. Some species have not been seen by our programs since the early 1970s, and all elasmobranchs are now rare. Other species once observed on a regular basis include bat rays (Myliobatis californica), torpedo rays (Torpedo californica), horn sharks (Heterodontus francisci), California halibut, other flat fish, and moray eels (Gymnothorax mordax). The elasmobranchs were largely swept from the seas by the gill nets; the halibut and flat fish presumably have been taken by sport and commercial fisheries, including the live-fish fishery. Moray eels, also taken in the live-fish fishery, do not reproduce in California, and their recruitment may be tied to strong El Niño events (McCleneghan 1973); it is not clear whether their absence results from recruitment failure or other ecological factors. Elasmobranchs have very low reproductive rates; although the gill nets have been moved offshore, it is too early to evaluate their recovery. Probably too late to study is the reported relationship between gray smoothhound and leopard sharks that formed large, mixed schools in the early 1950s (Limbaugh 1955; J. Stewart, personal communication). ”

“**Abalones and spiny lobsters**

Both abalones (Haliotis spp.) and spiny lobsters (Panulirus interruptus) were extremely abundant before diving and effective trap fisheries. Again, there are no data on former abundance, but Chinese immigrants in the San Diego region, working intertidally and in the shallow subtidal with poles and gaffs, landed 1.86 _ 106 kg (4.1 million pounds) in 1879 alone (Cox 1962). Divers of the 1950s reported green abalones stacked on top of each other in shallow water and describe the Point Loma kelp forest as “paved with red abalones” (J. Stewart, personal communication). Abalones are now so scarce that all five species fished in southern California have been closed to both sport and commercial harvest, and there is good reason to believe that one, H. sorenseni, will become the first marine invertebrate known to become biologically extinct as a result of human fishing (Tegner et al. 1996b).

“Probably because the spiny lobster source population has yet to be rendered ecologically extinct in Mexico, the lobster fishery has persisted, but abundance and size distributions are clearly different from historical patterns. The commercial fishery began in 1872, and in 1887 the average lobster taken was 150 mm in carapace length (CL). By 1955, the average lobster from the commercial fishery was 119 mm CL. Average harvest in San Diego from 1976 to 1980 varied from 86 mm to 90 mm CL. In 1888, 260 traps yielded 104807 kg (231060 pounds) of lobsters. By 1975, 19000 traps were required to harvest almost the same mass, 105768 kg (233179 pounds; see references in Tegner and Levin 1983). Lobster landings, although well below the peaks of the 1950s, have continued through the mid-1990s at relatively high levels in comparison with other fisheries. Nevertheless, because larger lobsters have higher feeding rates and consume larger sea urchin prey (Tegner and Levin 1983), their functional role in the kelp forest today is very different from that apparent at the turn of the century. ”

“**Sea urchins and other invertebrates**

Before the fishery for red sea urchins, Strongylocentrotus franciscanus, grew to full strength in the mid-1970s at Point Loma, the target species was common throughout the forest (Tegner and Dayton 1981). By the late 1980s, this urchin remained abundant along the outer edge of the forest, but was functionally absent from much of the interior (Tegner and Dayton 1991). Besides their well-known potential for overgrazing kelps, red urchins have positive impacts on the community. The spine canopy association of species that shelter under adult sea urchins is an important recruitment habitat for abalones and urchins (Tegner and Dayton 1977, Tegner and Butler 1989), and its competitive interactions with its congener, S. purpuratus, may be important for controlling the distribution of the smaller echinoid (Schroeter 1978). Recruitment is maintaining red sea urchin populations along the outer edge of the forest, but recruitment decreases with distance into the forest and is virtually zero along the inner margin (Tegner and Dayton 1991). ”

“Unregulated commercial fisheries have recently targeted invertebrates such as holothurians (10454 kg were landed in San Diego in 1995) and snails. Some snails are not identified in the records, but presumably include Lithopoma: 1590 kg were landed in San Diego in 1995. Others such as Kellettia reproduce in large aggregations (Rosenthal 1971) and are particularly vulnerable to unregulated take; >900 kg were identified as landed in San Diego in 1995. Only a few samples of their densities before the fishery commenced exist, and these animals may now be joining the sequential depletion of fishable stocks. ”

C. NONCONSUMPTIVE USE OF AQUATIC RESOURCES

C.1. Tide pool visitation

Past concerns about visitor impacts on tidepool biota, and the process leading to the formation of TPERP and management zones I-III in the CABR intertidal, were discussed in Section I.C.3. It has now been ten years since visitors have been excluded from Zone III. Visitation remains highest in Zone I, and very low in Zone II (Figure 61). Very few of the changes in intertidal plant and animal populations that have occurred since the imposition of TPERP (see Table 3 for a summary) can be attributed to patterns in visitor use. For example, owl limpets and mussels are not successfully recruiting into Zone III, despite the exclusion of visitors. Surfgrass expansion during much of the last fifteen years has occurred in all three zones, regardless of levels of visitor use. However, red algal turf is reportedly now more diverse and more robust in Zone III than in the other two zones, and this difference has been attributed to lower trampling rates in Zone III (Becker 2006). In addition, birds clearly avoid visitors in the CABR intertidal, and are most abundant in Zone III. Interestingly, shore birds - and subsequently wading birds - began to comprise larger proportions of total bird sightings in Zone III starting in 2000 (Figure 62). This change began four years after visitors were prohibited in Zone III, thus it is not clear that it is related to patterns of human use.

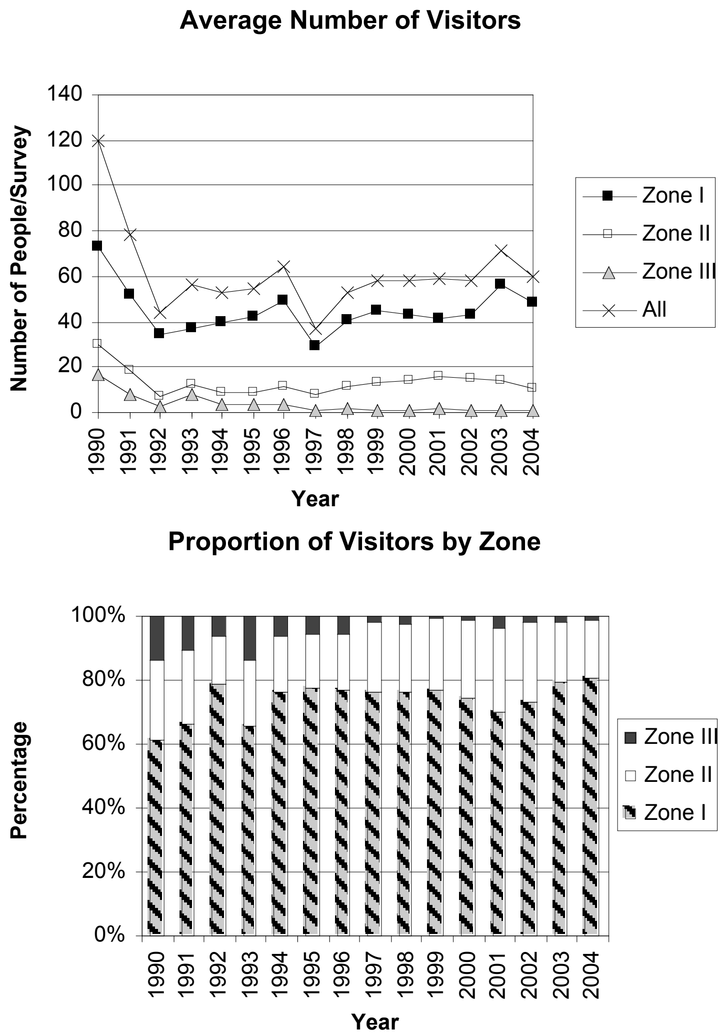
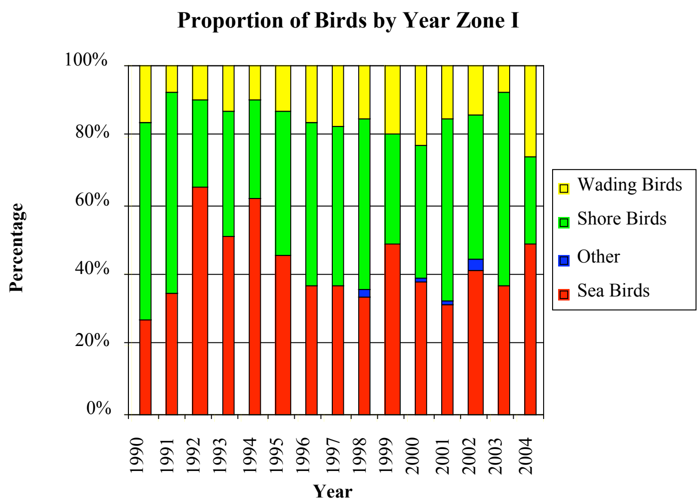
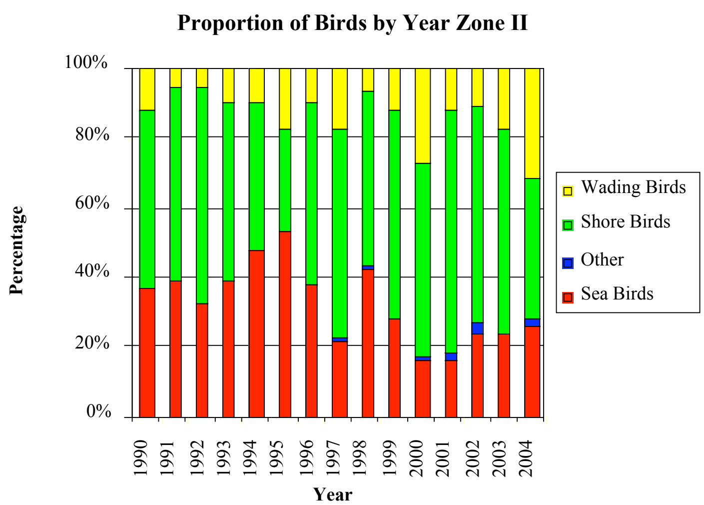


Figure 61. Average number of visitors (upper), and proportion of total number of visitors (lower), counted in each zone of Cabrillo National Monument during 1-hour censuses 1990-2004 during the Cabrillo National Monument Rocky Intertidal Monitoring Program (from Becker 2006).





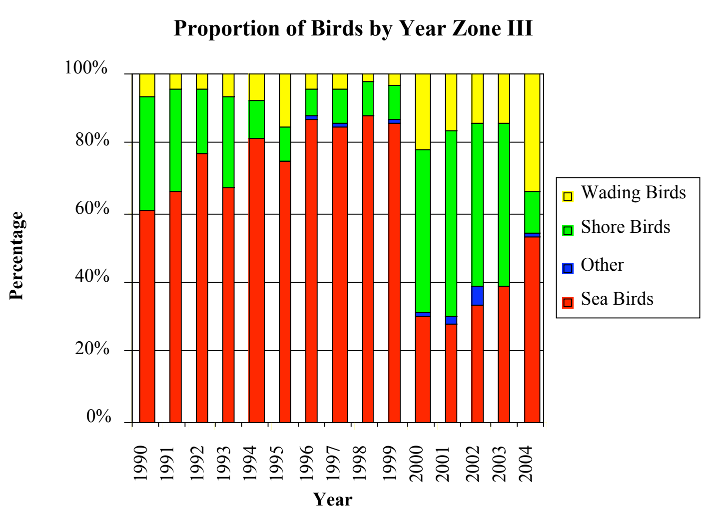


Figure 62. Proportion of each category of birds found in each zone during 1-hour censuses associated with the Cabrillo Rocky Intertidal Monitoring Program from 1990 to 2004, listed by category (from Becker 2006).

C.2. Surfers and personal watercraft

Surfing takes place regularly within the administrative boundary of CABR. The surfers do not launch from shore (which is illegal); however they do boat into the area, and then surf from the boats. Occasionally someone will stand on the rocky intertidal zone if they come too close to shore before pushing off to surf again. On at least one occasion (most recently, winter 2006), a boat that surfers were using overturned and came ashore, causing some minor, and relatively short-term damage to the rocky intertidal zone (Andrea Compton, Chief of Natural Resource Science, CABR, pers. comm.) Also, people on jet skies or other personal watercraft are occasional visitors. These personal watercraft users most frequently ride from San Diego Bay. They are not technically allowed within administrative boundary of the monument, however, CABR does not have any boats to enforce the regulations for those that do. Surfers sometimes gain access to Zone III via the U.S. Coast Guard facility (the lighthouse and residences) at the end of the peninsula, and walk across the intertidal zone to a nearby surf break (Andrea Compton, Chief of Natural Resource Science, CABR, pers. comm.). There is no information about whether this sporadic activity is causing any damage.

C.3. Whale watching

Whale watching from private boats and commercial whale watching boats takes place to some degree within the administrative boundary of CABR (Andrea Compton, Chief of Natural Resource Science, CABR, pers. comm.). This activity might alter whale behavior in waters off CABR. Whales are interpreted by the NPS at CABR through a Whale Watch Weekend and Intertidal Life Festival each January, and Whale Watch Overlook is a structure in the Monument at the top of the ridge that is currently scheduled to be remodeled. Information about whale watching was not reviewed for this report.

D. Marine Vessel Traffic[19]

The San Diego shipping channel consists of a central navigation channel with no branches or stems from the entrance of the bay to the 24th Street Terminal. Approximately 9,000 deep draft vessels transit the bay per year. A major choke point in the central navigation channel is close to the entrance to the bay, at Ballast Point. This is the narrowest point in the channel and just seaward of the U.S. Naval Submarine Base. Bayward of the submarine base, on the port hand, is the Fuel Pier at the Navy Fuel Tank Farm where contract tankers and, occasionally naval combatants, load and discharge fuel. To starboard in this same stretch is a naval ammunition pier on North Island. At the end of Shelter Island is the outlet from the Shelter Island Yacht Harbor. A large measure of the small craft traffic will be found in this vicinity, particularly on weekends. At the other end of Shelter Island is the entrance to the Commercial Basin where the majority of sportfishing boats are berthed.

After an eastward leg, the channel enters a turning basin area before heading toward the center spans of the San Diego/Coronado Bridge. Bordering the turning basin is the Embarcadero with its Cruise Ship Terminal. Across the channel and turning basin are the Naval aircraft carrier berths on Naval Air Station, North Island. The next channel leg toward the Coronado Bridge

[19] The description of vessel traffic and port facilities is adapted from material at http://www.globalsecurity.org/military/facility/san_diego.htm

has the City's 10th Avenue Marine Terminal on the port hand. Between this section and on through the bridge, commercial shipyards give way to the U.S. Naval Station. The channel then narrows, then proceeds to the 24th Street Terminal.

The Port of San Diego serves as the first or last Port of Call along the western trade route including the ports of Los Angeles, Long Beach, San Francisco/Oakland, Portland, Seattle and Vancouver. Three separate marine terminals provide facilities for a variety of commercial cargo handling and cruise ship operations. Principal cargo includes lumber, newsprint, fertilizer, fresh, frozen, and canned foodstuffs, automobiles, palm oil, minerals, and fuel oil. Passenger cruise ships frequent the harbor on a daily basis. On average, there are two to three large commercial vessels (bulk freighters, break-bulk freighters, roll on/roll off (RO-RO) automobile carrier vessels, or cruise ships) in the port at any one time. RO-RO's call on the port's National City Marine Terminal at a frequency of three vessels per week. Various bulk and break-bulk freighters call at the port's Tenth Avenue Marine Terminal (TAMT), also at a frequency of three vessels per week. Barges transporting sand and aggregate materials operate on a daily basis between TAMT and the Port of Ensenada, Baja California. A number of locally-based work barges also transit the waterway in support of a variety of maritime-industrial business activities. Cruise ships make regular calls at the Port's B Street Pier Cruise Ship Terminal. Over 100 cruise ships call at the Port per year, including a scheduled weekly liner.

A commercial fishing fleet, consisting mainly of sportfishing vessels, operates out of the America's Cup Harbor Basin at Shelter Island and the port's commercial fishing berthing facility at the G Street Mole. CPFVs are also plentiful and operate primarily from the America's Cup Harbor. The Port of San Diego's commercial vessel traffic has continued to grow as the Port continues to develop its marine terminal facilities.

One third of the U.S. Naval Pacific Fleet is home ported in San Diego Bay. Military vessels make up the bulk of large vessel traffic in San Diego Bay and frequently transit the bay enroute to berths at the 32nd Street Naval Station, the Naval Pier (south of Broadway Street pier), the North Island Naval Air Station, the submarine base at Ballast Point, and Amphibious Base Coronado in Glorietta Bay. Naval vessels of all classes, from 50' long amphibious landing craft to 1115-foot long aircraft carriers, can be found in the bay. Landing craft and smaller vessels usually moor at the amphibious base in Glorietta Bay. Aircraft carriers moor at piers along the Naval Air Station, while the bulk of the fleet moors at the 32nd Street Naval Station. U.S. Naval service vessels moor downtown at the Naval Pier adjacent to the U.S. Naval Supply Center.

There are three USCG 110' patrol boats and two 178' patrol vessels stationed at the Ballast Point Mooring, near Point Loma. The USCG station northeast of Harbor Island has two 41' utility boats. Various classes of cutters frequent San Diego for training purposes and usually moor at the Naval Pier downtown or at the 32nd Street Naval Station. The U.S. Navy houses their Afloat Training Group (ATG) at the 32nd Street Naval Station. ATG trains and tests all U.S. Military ships larger than 110' feet in length. These tests are administered through a program called Tailored Ship Training Availability. The testing vessels normally anchor south of Harbor Island. Underway drills are conducted outside of San Diego Bay. Drills and training that can be conducted pier-side are conducted at either the 32nd Street Naval Station or at North Island Naval Air Station.

The USCG is the federal government's primary maritime law enforcement agency, enforcing federal laws and treaties of the United States on the high seas and in federal waters. Within three miles of California shore, the USCG shares jurisdiction with the State of California. Enforcement of water quality conservation regulations and prohibitions on discharges is thus largely the responsibility of the USCG; other water quality related laws and regulations this agency enforces include the Federal Water Pollution Control Act of 1972, the Oil Pollution Act of 1990, Hazardous Materials Transportation Act of 1974, Marine Pollution by Dumping of Wastes and Other Matter Convention, Act to Prevent Pollution from Ships of 1980, and others (Polgar et. al 2005).

The diversity and volume of marine vessel traffic in and out of San Diego Bay poses a variety of potential impairments to marine habitat at CABR. Aerial imagery by Ocean Imaging Corp. has documented bilge water releases in the vicinity of Point Loma via tell-tale slicks originating in the wake of ships headed toward the entrance of San Diego Bay (see example in Svejkovsky 2004). Previously, the California Ocean Plan did not regulate discharges from oceangoing vessels. However, on Jan. 1, 2006, new legislation, the California Clean Coast Act of 2005 (SB 771), took effect, which targets discharges from "oceangoing ships" (private, commercial, government, or military vessel of 300 gross registered tons) and cruise ships. Discharges of (1) hazardous waste, (2) oily bilgewater, (3) "other waste" (dry-cleaning, photographic film-developing and medical), and (4) graywater, are now prohibited within State marine waters (i.e., within 3 nautical miles of shore). Small vessel groundings have occurred infrequently at CABR, but are of concern primarily owing to potential diesel fuel spills (Andrea Compton, Chief of Natural Resource Science, CABR, pers. comm.). Dry fall of particulates from diesel fuel exhaust directly onto the ocean surface at CABR constitutes an unmeasured background source of pollution in the monument. General concerns regarding ship traffic that are pertinent to CABR are as follows:

<u>Naval Submarine Base and Navy Fuel Tank Farm)</u>

- Owing to docking and fueling activity for ships and submarines in the Front Bay, a fuel spill at these facilities has potential to be entrained in tidal currents and advected seaward toward CABR.

<u>Large Vessels: Naval ships, Container Ships, Bulk and Cargo Ships, Oil Tankers</u>

- Potential Releases: bilge water, ballast water, diesel exhaust, cargo spill

<u>Cruise Ships</u>

- Potential Releases: bilge water, diesel exhaust, large volumes of untreated sewage, black and gray water, and hazardous wastes from on-board facilities for dry cleaning, photo-developing, etc., anthropogenic debris

<u>Commercial Fishing Vessels, Commercial Passenger Fishing Vessels (CPFVs), whale watching Vessels</u>

- Potential Releases: bilge water, diesel fuel spills, faulty operation of Type I or Type II marine sanitation devices or releases from Type III-holding tanks, anthropogenic debris, discarded fishing gear, leaching of copper or tributyltin from anti-fouling paint on hulls (tributyltin currently only allowed in paint on vessels > 75 m in length).

Recreational Motor Boats and Sailboats

- Potential discharges: untreated sewage from Type III marine sanitation devices, bilge water, anthropogenic debris, diesel fuel spils, leaching of copper from anti-fouling paint on hulls.

E. PHYSICAL EFFECTS

E.1. Dredging in the Front Bay

(a) Recent History of Dredging

Dozens of dredging projects have been carried out in San Diego Bay over the last several decades by the U.S. Navy, the Port of San Diego, the U.S. Coast Guard, commerical boat yards, and San Diego Gas & Electric (Figure 12). The entrance to San Diego Bay and the "North Bay Channel", including the Carrier Turning Basin, is dredged to 42 feet. The entrance channel has been dredged to a width of 800 feet to mile 2.4 , narrowing to 600 feet at mile 3.0 and continuing at that width to the Carrier Turning Basin adjacent to the north side of Coronado on North Island. The Central Bay Channel is dredged to a depth of 40 feet between mile 7.1 and 8.84, and the South Bay Channel is authorized to a depth of 35 feet between miles 8.84 and 12.0.

When dredged material is from portions of San Diego Bay considered highly contaminated, it is disposed of upland (Eileen Maher, Port of San Diego, pers. comm.). Currently, dredge material considered "clean" from San Diego Bay (but see below) has one of three fates:

1) when sand content is >80%, dredged material is used for beach replenishment at Imperial Beach,
2) when sand content is <80%, dredged material is dumped at sea at the Army Corps of Engineers Ocean Disposal Site LA-5, which is about 6 km from shore at the 100 fathom contour (Figure 18), or
3) dredged material is relocated within the bay to serve as artificial reefs (less frequent).

For the purposes of this report, dredging projects outside of the Front Bay were not evaluated. Only four dredging projects have occurred in the last decade in the Front Bay. From 1/1/1997 to 8/10/1998 the US Navy deepened the main navigation channel along the axis of San Diego Bay from Harbor Island to past Point Loma. This resulted in a total of 6,258,583 cubic meters of dredged material, which was transported to ocean disposal site LA-5. From March 3-22, 2001, the US Navy dredged 7799 cubic meters from Arco Dry Dock Facility at the Naval Submarine Base which were also transported to LA-5. Dredging takes place approximately every 5 years at the US Coast Guard Ballast Point Mooring. This work produced 26,759 cubic meters and 31,347 cubic meters of dredged material in 1995 and 2000, respectively (Roy Clark, USCG, pers. comm.). This material is used for beach replenishment at Imperial Beach. The next dredging at the Ballast Point Mooring is likely to take place in 2006.

Unfortunately, very few water quality parameters are measured during dredging operations. For example, during the navigation channel dredging of 1997-1998, transmissivity, DO, pH, salinity and temperature were measured by the Navy, but organic contaminants and trace metals were not measured in the water column. During many dredging operations, such as at the Ballast Point mooring, only water transparency is measured (Roy Clark, USCG, pers. comm.). In July and November, 1997, the Navy mapped TSS, PAH and dissolved copper concentrations throughout

San Diego Bay (Katz 1998). The study was not motivated by channel dredging; nonetheless, the November survey coincided with dredging near Ballast Point. Although the dredging raised TSS up to 14.5 mg/L near the Navy Fuel Tank Farm (Figure 63) it did not elevate PAH or dissolved copper in the Front Bay (Figures 64, 65).

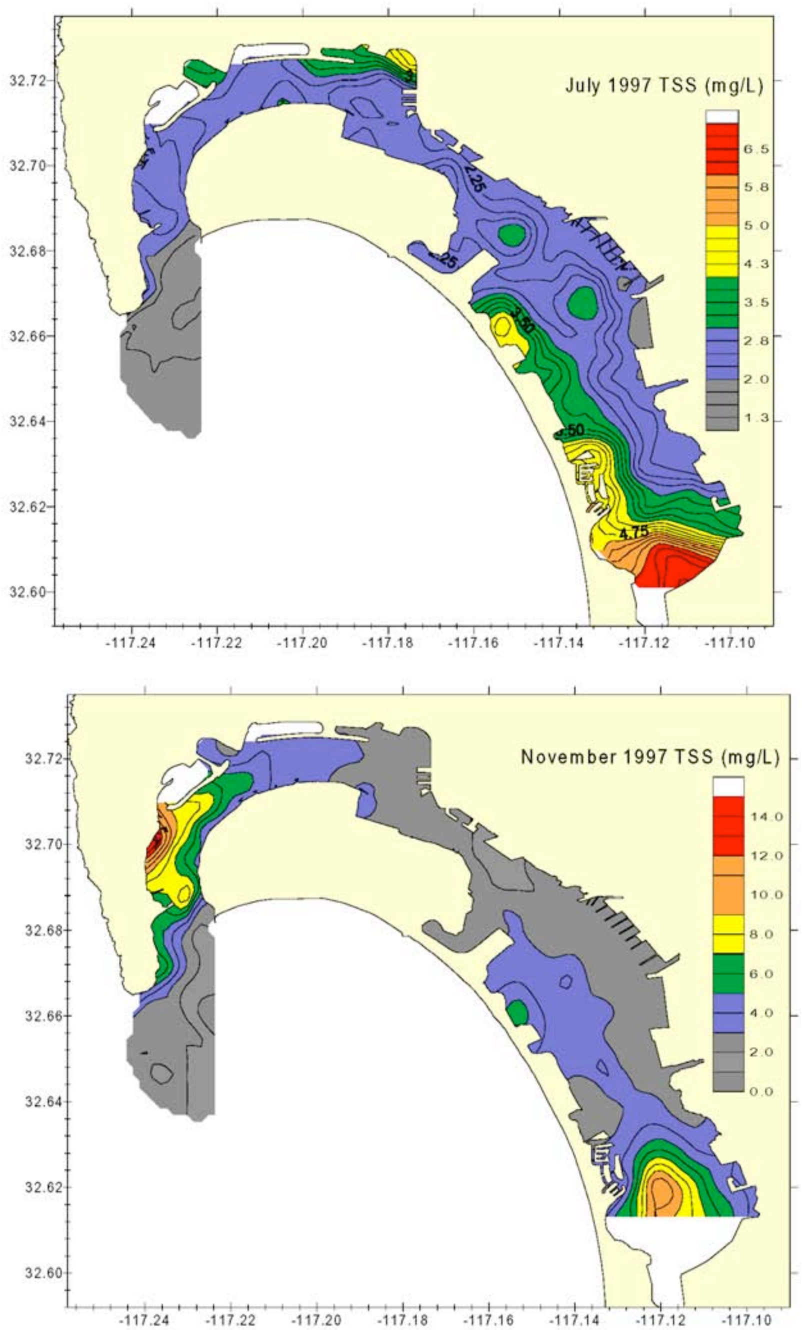


Figure 63. Patterns for total suspended solids (TSS) observed in San Diego Bay in July, 1997 when dredging was not occurring (top panel), and in Nov. 1997, when dredging was taking place in the entrance to the bay (bottom panel) (from Katz 1998).

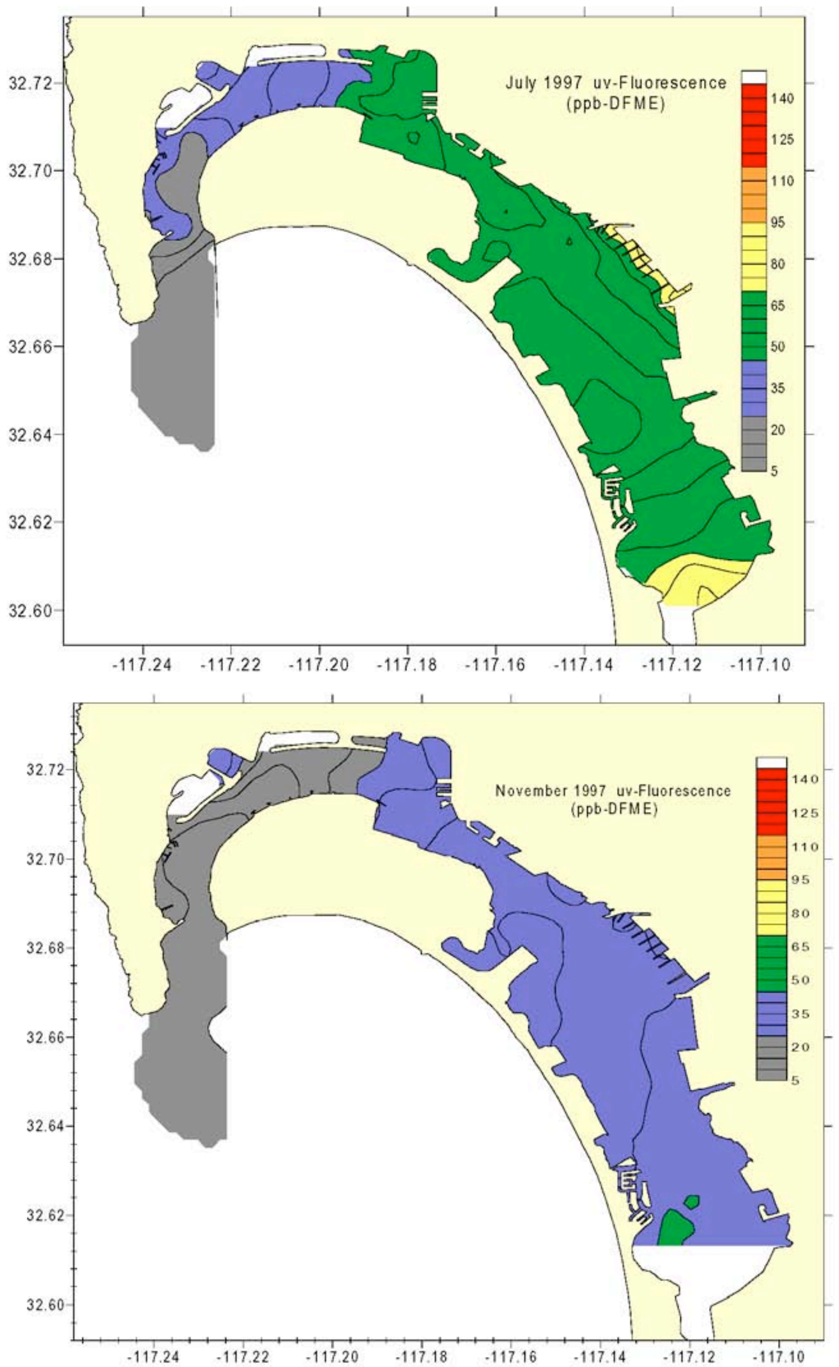


Figure 64. PAH distribution in the water column of San Diego Bay in July, 1997, when dredging was not occurring (top panel), and in Nov. 1997, when dredging was taking place in the entrance to the bay near Ballast Point (bottom panel). UV-fluorescence (as diesel fuel marine equivalents, or "DFME") was used as a surrogate measurement for PAH (adapted from Katz 1998).

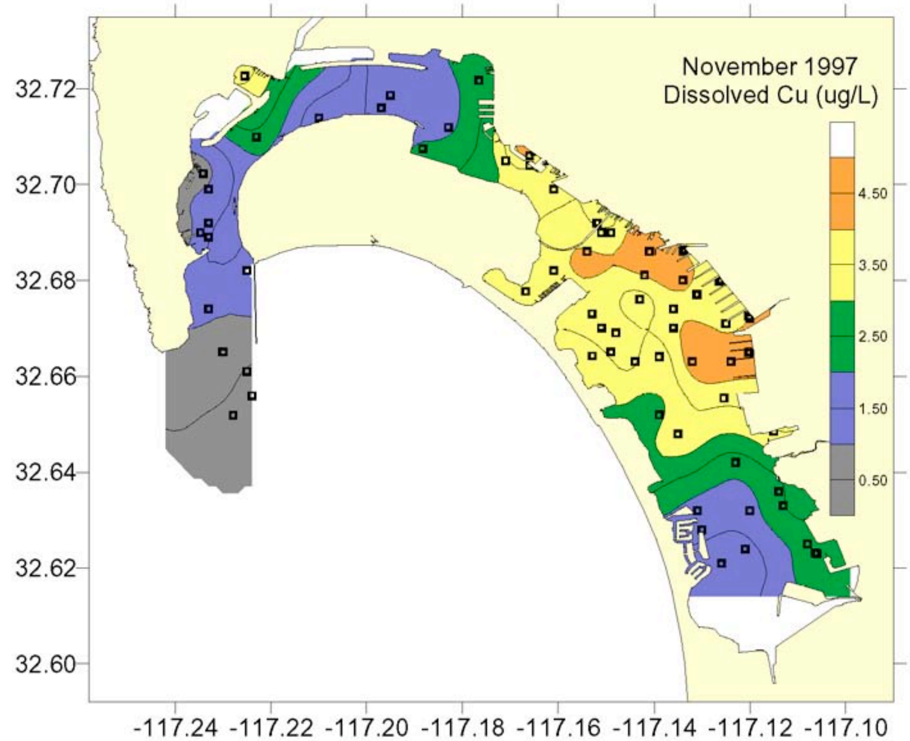


Figure 65. Distribution of dissolved copper in San Diego Bay in Nov. 1997, when dredging was taking place in the entrance to the bay (bottom panel) (from Katz 1998).

(b) Dredge disposal site LA-5

Most of the dredged material disposed at LA-5 originates in San Diego Bay. Although dredged material destined for LA-5 is purportedly "clean", chemical analysis conducted on material slated for disposal there reveals that dredged material contains a wide range of contaminants (Table 20). The results of a recent multibeam sonar survey (Gardner et al. 1998, cited in SIO 2004) indicate that disposed material is not all located within the designated disposal area. A total of 252 mounds were observed outside the disposal site (Figure 66), and many of these were elliptical, indicating that material was dumped while vessels were underway. Within LA-5, ten mounds were observed covering ~54% of the area. The LA-5 site is located immediately offshore of a ~50 m scarp, therefore, mounds illegally dumped just inshore of the site are much shallower than the intended disposal site, and more prone to resuspension (SIO 2004).

Table 20. Estimated total quantities (metric tons, mt) of contaminants in dredged material disposed at the LA-5 dredge disposal site from (1991-1997). Data are from Steinberger et al. 2003, and do not include the large volume of dredged material disposed at LA-5 during 1998.

Parameter	**Amount**
Volume	2,012,605 m3
TOC	15,862 mt
Cadmium	1.6 mt
Chromium	61 mt
Copper	105 mt
Lead	63 mt
Mercury	0.38 mt
Nickel	18 mt
Selenium	0.49 mt
Silver	1.3 mt
Zinc	163 mt
Petroleum Hydrocarbons	38 mt
Aldrin	nd
Chlordanes	1.9 kg
Dieldrin	0.07 kg
Total DDT	2.4 kg
Total Organotins	6173 kg
Total PAH	1,353 kg
Total PCB	56 kg

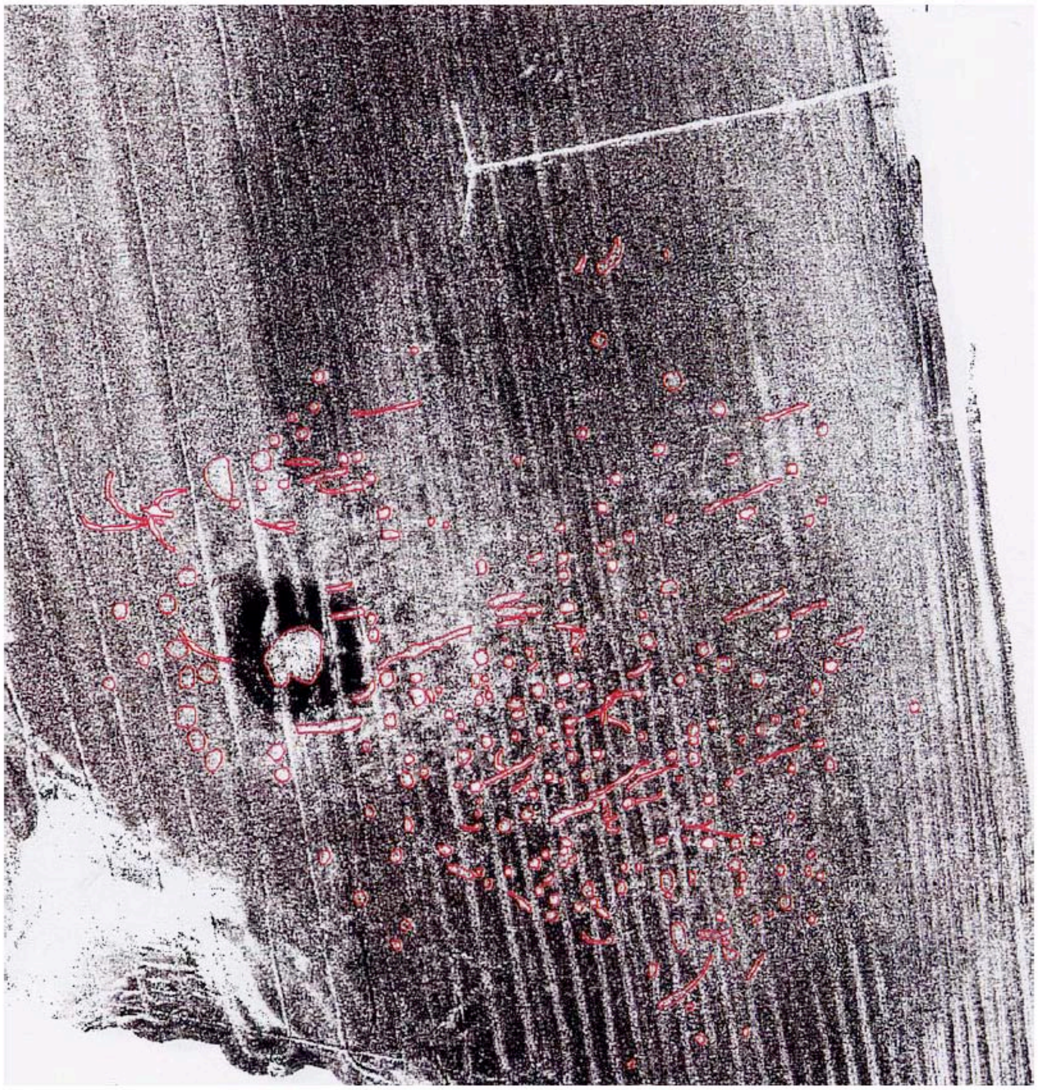


Figure 66. Backscatter image showing spatial distribution of dredge disposal mounds (outlined in red). Dark circle with concentric lighter circle is the LA-5 dredge disposal site. The Pt. Loma Ocean Outfall is clearly visible (from SIO 2004, credited to Gardner et al. 1998).

The chemical composition of the sea floor at LA-5 is not monitored. However, sediment chemistry is monitored at stations close to LA-5 in the PLOO Ocean Monitoring Program (Figure 35). Contaminants poorly associated with wastewater treatment plant effluent, but known to occur in contaminated San Diego Bay sediment, are often detected in PLOO sediment monitoring sites near LA-5. For example, although PCBs were mostly undetected at the City's grid of benthic survey sites during 2004, the sediments at station E2 contained two arochlors, PCB101 and PCB110. In addition (in 2004), the second highest concentrations of total PAHs (1545 ppb), and second greatest mix of PAH compounds (12), were found north of the LA-5 at station E9. Station E9 is one of four stations (E1, E2, E3, E9) within the City's benthic survey area where PAHs have been frequently detected. Total DDT in sediment in the benthic survey area for the PLOO peaked in 1993 (Figure 67). There has been speculation that this pattern was related to heavy use of the LA-5 dredge disposal area at that time, owing to San Diego Bay channel dredging projects (Steinberger et al. 2003, CSD 2005a). However, the record of disposal volumes at LA-5 (Figure 68) shows that the early 1990's were not a period of heavy use of LA-5, and that LA-5 was most heavily used during 1997-1998, when the central navigation channel in San Diego Bay was most recently dredged. This raises two possibilities: (1) dredged material enriched with DDT, but not necessarily large in volume, was disposed at LA-5 during the early 1990's and advected from the disposal site to nearby PLOO sediment stations, or (2) the DDT in PLOO sediment stations originated from another temporally restricted source of contamination.

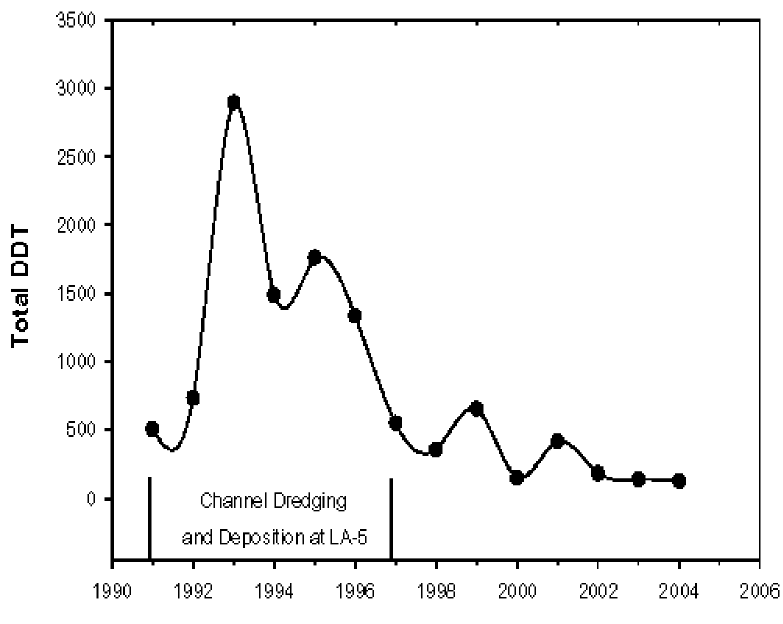


Figure 67. Average total DDT in sediment for benthic survey sites in the City of San Diego's Ocean Monitoring Program for the PLOO. The indicated period of channel dredging incorrectly omits 1998, during which more material was disposed at LA-5 than during any other year for the last three decades (from CSD 2005).

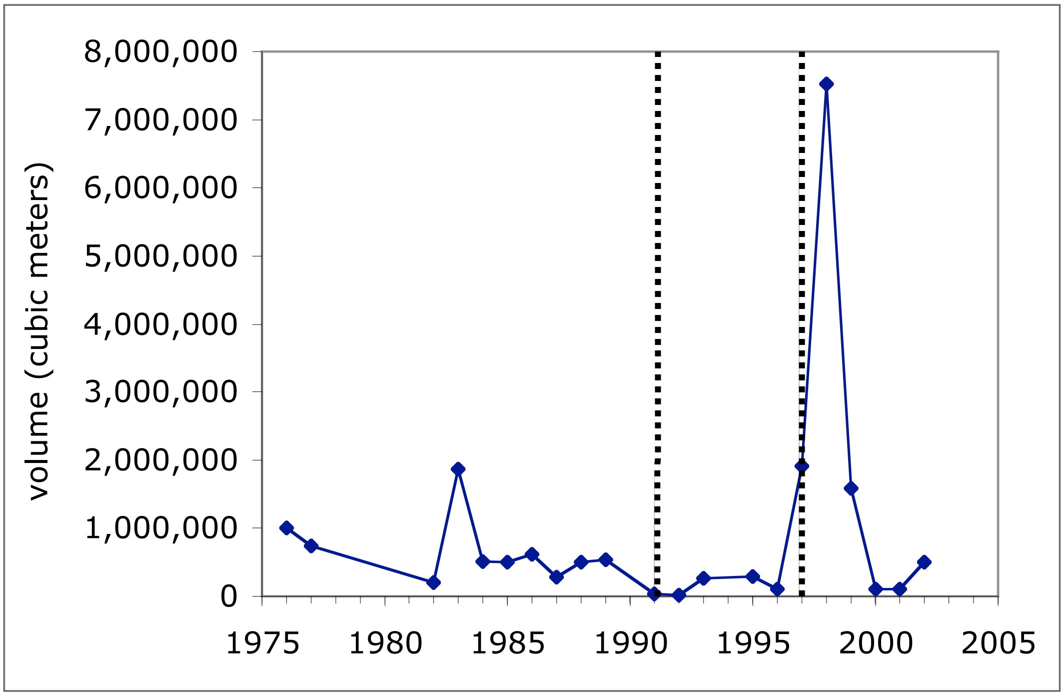


Figure 68. Volume of dredged material disposed at LA-5 from 1976 to 2003. Dotted lines mark the period during which DDT peaked in sediment at PLOO benthic monitoring sites (see Figure 67). Data are from the US Army Corp of Engineers Ocean Disposal Database.

IV. CONCLUSIONS AND RECOMMENDATIONS

A. Information Gaps Concerning Water Quality In the Monument

Seeps
Seeps at CABR are unmapped and undescribed.

Groundwater
Groundwater at CABR is unstudied.

Direct Runoff to the Ocean from the Point Loma Peninsula
The U.S. Navy, U.S. Coast Guard, and the City of San Diego do not monitor stormwater discharged from the outer coast of the Point Loma Peninsula directly into the coastal ocean. The PLWTP should hold an industrial stormwater permit, in which case some stormwater monitoring data should exist for this facility in reports held by the SDRWQCB.

Seawater at the Monument
The only shoreline water quality monitoring that takes place within the Administrative Boundary of CABR is for bacterial abundances at two sites (which occurs as part of the City of San Diego's Point Loma Ocean Outfall ocean monitoring program) and water temperature (via temperature loggers located in intertidal Zones I, II, and III). The City of San Diego also measures bacterial abundances and depth profiles of chlorophyll-a, salinity, transmissivity, pH, DO and temperature five times per month directly offshore from CABR at two stations following the 30-ft depth contour, and at three stations following the 60-ft depth contour.

Direct measurements of pollutants in water or sediment at CABR are lacking[20]. Sentinel mussel programs provide indirect evidence that a suite of trace metals and synthetic organics contaminates the nearshore water column on the ocean side of Point Loma. NOAA sampled mussels from a site representing conditions at CABR 13 times between 1986 and 2005, providing a time series for mussel body burdens of fifteen trace elements (Al, An, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Sb, Sn, Zn); 23 different polycyclic aromatic hydrocarbons (PAHs); PCBs; DDT and its metabolites; other biocides such as aldrin, dieldrin, endosulfan, chlordane, mirex, chlorpyrifos, and organotins; and other chlorinated hydrocarbons such as tetrachlorobenzene.

Suspended Sediments and Sand Migration into and out of CABR
NPS staff have concerns that local coastal and bluff erosion, and migration of sand from beach replenishment projects to the north (e.g., at Mission Beach) and the south (e.g., at Imperial Beach) of CABR may affect water quality and intertidal habitat structure at CABR. Published information about these processes at CABR is not available, and the subject is not evaluated in this report.

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[20] Several trace elements were measured in water at Point Loma once in 2001, but authors do not report results for the site separately from other coastal sites (Becker et al. 2005).

B. Conclusions about Known or Potential Degradations of Marine Resources

Below are conclusions about the principal anthropogenic factors examined in this report that may compromise water quality, or otherwise negatively impact the marine resources of CABR. Table 21 categorizes the documented, and suspected, problems affecting the Monument's aquatic resources.

Notable trends for marine taxa at the Monument are:

Owl limpets: Although owl limpet average size is declining in CABR, a number of additional studies have demonstrated that individuals of this species are particularly large in the park compared to other areas in southern California. Owl limpets have not been successfully recruiting into Zone III for unknown reasons.

Mussels: Mussels declined dramatically in Zones II and III between 1990 and 1995, and remain at very low levels in those areas.

Surfgrass: A dramatic expansion of surfgrass, which continued throughout much of the study period, is now slowing or reversing.

Red algal turf: Red algal turf communities are particularly impacted by the human visitation to the tidepools, and the closure of Zone III has resulted in higher biomass and diversity in red algal turfs in that area.

Black abalone: Black abalone are absent at CABR, although external studies indicate that this disappearance is occurring on a large scale throughout southern California, and is explained by a combination of overexploitation and disease.

Ochre sea stars: Ochre sea stars are absent at CABR, although they are present at points north and south of the Monument.

Seabirds and shorebirds: There is a strong negative relationship between birds and visitors in the intertidal zone.

Point Loma Wastewater Treatment Plant and Point Loma Ocean Outfall (PLOO)

Effluent from the Point Loma Wastewater Treatment Plant (PLWTP) is discharged from its outfall at a depth of 98 m near the edge of the continental shelf approximately 7.2 km from land. The City uses bacterial abundances to monitor the horizontal and vertical extent of the PLOO effluent plume. Such data from offshore monitoring stations suggests that the effluent plume is usually confined to depths greater than 60 m, although it is detected at depth at stations up to 13 km to the north, and 5.9 km to the south, of the outfall. Cross-shore patterns of bacterial abundance indicate that the PLOO effluent plume does not penetrate the kelp bed offshore of CABR. Since the outfall pipe was extended in 1993, bacteriological water quality objectives for recreational water contact in the kelp bed have rarely been exceeded except during extremely wet weather (such as in the winter of 2004/2005) when terrestrial runoff was implicated as the source of bacteria. Internal waves in other locations are known to enhance the vertical transport of effluent plumes from ocean outfalls. However the Point Loma kelp bed would probably impede the shoreward advection of the PLOO plume if conditions conspired to move it toward shallower waters. Internal waves in the Point Loma kelp bed move water in the cross-shore direction through kelp only about 150 m during half of a wave cycle (about 4 hours). Cross-shore excursions of water through the kelp bed of more than 600 m in 24 hours are rare. There is no evidence that the effluent field has affected bacterial abundances, pH, DO or other measured variables, at any of the shoreline sampling sites in the vicinity of the outfall. Using these data alone, it seems reasonable to conclude that the effluent plume from PLOO is not directly compromising water quality within the administrative boundary of CABR. Alternative tracers for treated sewage are not utilized in the City's monitoring program, and according to some sources, the shape, extent, and fate of the effuent plume from the PLOO has not been adequately characterized for the range of circulation patterns and temperature and density fields that are reasonably anticipated in the vicinity of the diffuser.

Using annual average concentrations from 2004, the following contaminants are detected in the effluent discharged from the PLOO:

Trace metals: Antimony, Arsenic, Cadmium, Chromium, Copper, Nickel, Selenium, Silver, Zinc

Other: cyanide, ammonia, non-chlorinated phenols, lindane, diethyl phthalate, toluene, bis(2-ethylhexyl)phthalate, chlordane, chloroform, 1,4-dichlorobenzene, dichloromethane, halomethane.

This raises the possibility that the PLOO contributes to background concentrations of these constituents in the coastal ocean (i.e., farfield effects). Four of the analytes detected (copper, silver, cyanide and ammonia) were concentrated enough on average in effluent during 2004 to exceed EPA daily maxima or acute exposure criteria for marine life. Although the circumstances that could result in cross-shore transport of the PLOO effluent plume all the way to CABR have not been described, it is possible that exposure to poorly diluted effluent could harm some biota. Such an exposure occurred in 1992 at CABR when the outfall pipe was ruptured near shore. Several analytes that were found as recently as 2003 by NOAA in mussels at the PLWTP were *not* detected in PLWTP effluent (at least in 2004). They are PAH, PCBs, DDT, tributyltin, lead, dieldrin, aldrin, mercury. Other years of PLWTP effluent monitoring data were not inspected for this report, thus we do not know if the PLOO can be reasonably ruled out as a source of these pollutants in the ocean near CABR.

South Bay Ocean Outfall (SBOO)

The SBOO is located offshore just north the U.S./Mexico border. It terminates approximately 5.6 km from land at a depth of about 27 m. The SBOO discharges treated wastewater from the South Bay International Wastewater Treatment Plant (IWTP) plus effluent from the South Bay Water Reclamation Plant. The IWTP is federally owned and operated, and provides primary treatment of 25 MGD of sewage from Mexico.

Results from the City's ocean monitoring program indicate that the wastewater plume from the SBOO is confined below a stratified water column from April through November and disperses rapidly whenever transported laterally. Elevated bacterial counts are evident near the surface only during winter months when the water column is poorly stratified. Aerial imagery of surface slicks confirms that the SBOO plume surfaces at times in the vicinity of the diffusers. Monthly monitoring of bacterial indicators detects the wastewater plume at depths of ≤18 m and predominantly near the discharge site during most of the year.

For this report, monitoring data for effluent from the ITWTP or the South Bay Water Reclamation plant were not inspected for three reasons: (1) the SBOO is twice as far from CABR (>15 km) than the PLOO, (2) although the SBOO is shallower than the PLOO, it is located along an isobath that runs well outside the administrative boundary of CABR (decreasing opportunities for lateral transport of effluent to CABR at depth), and (3) the prevailing surface flows in the region are southward. In addition, pollutants from the SBOO that enter sediments near the outfall are likely confined to the Silver Strand Littoral Cell at depth.

Outflow from the San Diego and Tijuana Rivers

Except for bacterial abundances measured at shoreline site D11 in the City's PLOO ocean monitoring program, water quality is not monitored at the mouth of the San Diego River. Although quarterly CTD casts and bacterial measurements are conducted offshore of the San Diego River mouth at sampling site F02 in the same program, these measurements are too infrequent to reveal the pattern of occurrence of storm plumes and too limited in scope to reveal much about water quality during terrestrial runoff events. Similarly, metals, pesticides and other organics are not routinely measured in seawater at the mouth of the Tijuana River. Consequently, we have no data by which to directly guage the threat posed by San Diego or Tijuana River plumes to the marine organisms that are exposed to them.

As part of the SBOO ocean monitoring program, bacterial abundances are measured five times per month at several shoreline and nearshore sites, and monthly at several offshore sites, proximal to the mouth of the Tijuana River. Patterns of bacterial abundance at these sites during wet weather indicate that outflow from the Tijuana River frequently contaminates the nearshore ocean surface between the river mouth and Imperial Beach. During the most recently reported monitoring year (2004) the highest densities of indicator bacteria occurred during months of heavy rainfall at sites closest to the river mouth, as opposed to sites at Imperial Beach, on the Silver Strand, or at Coronado. Normally, the northernmost reach of Tijuana River plumes is in the vicinity of Imperial Pier, far to the south of Point Loma.

Stormwater in the lower reaches of the San Diego and Tijuana Rivers is chemically evaluated by the City during three storms per year at two of the Copermittee Wet Weather Monitoring Program's mass loading stations (MLSs). These data provide an extremely conservative avenue for evaluating whether storm plumes from these two rivers have the potential to harm aquatic biota at CABR. Levels of contaminants in the lower reaches of these rivers during stormflow reasonably estimates the upper end of contamination expected in a storm plume directly offshore of the river mouth. These data indicate that stormwater from both the rivers contains levels of several constituents that exceed thresholds for acute and/or chronic toxicity established by the USEPA or the State for marine organisms.

Undiluted San Diego River stormwater contains (at a minimum) oil and grease, bacteria, ammonia, chlorpyrifos, diazinon, and the following trace metals: antimony, arsenic, chromium, copper, lead, nickel, selenium and zinc[21]. Of these, chlorpyrifos, copper, zinc, and suspended matter (turbidity) have occurred in concentrations that are potentially acutely and/or chronically

[21] Chlorpyrifos, diazinon, and malathion are the only organopesticides measured in MLS samples

toxic. Undiluted Tijuana River stormwater contains the same constituents as San Diego River water, with the addition of cadium and malathion; potentially toxic levels of ammonia, chlorpyrifos, diazinon, malathion, copper, nickel, and zinc have occurred. Toxicity tests performed on MLS water show that Tijuana River storm flow is more dangerous to aquatic organisms than San Diego River storm flow. For example, *Ceriodaphnia* can die when exposed to water containing as little as 20% Tijuana River water.

Recently, the Southern California Coastal Water Research Project (SCCWRP) coordinated sampling of plumes generated by the San Diego and Tijuana Rivers during two winter storms (in Feb. 2004 and in Feb. 2005, Paul DiGiacomo, Jet Propulsion Laboratory, pers. comm.). Among other measurements, toxicity tests (sea urchin egg fertilization) were conducted on surface water within the plumes from multiple stations at sea. Unfortunately, results of this synoptic study will not become available until Fall 2006, and until then there is no comparable information by which to directly evaluate the toxicity of outflow from the San Diego or Tijuana Rivers after it has entered the ocean.

Aerial imaging and modeling results indicate that storm plumes from both rivers are occasionally transported as far as Point Loma. In the case of the Tijuana River, this requires that wet weather coincide with a semi-monthly phenomenon during which prevailing surface flow in the area switches from being southerly to northerly. These events usually last 1-3 days, and occur intermittently throughout the year. Aerial imagery suggests that after some storms the San Diego River plume is diverted to the offshore side of the Point Loma kelp bed as it is transported southward. If true, this phenomenon would tend to insulate the shoreline at CABR from San Diego River ouput.

As of this writing, there is no direct evidence that river water bearing acutely or chronically toxic levels of pollutants reaches CABR during major terrestrial runoff events (acute toxicity is extremely unlikely). Inside San Diego Bay, where dilution rates of storm plumes are likely to be lower than in the coastal ocean, toxicity can persist for at least 3 days in storm plumes emanating from Chollas Creek (purple sea urchin fertilization tests). Nevertheless, so far, the toxic portion of Chollas Creek plumes appears to extend no further than about 1 km away from the mouth of the creek. Although mixing processes are not equivalent in San Diego Bay and the coastal ocean, the toxicity of Chollas Creek water is comparable to that of Tijuana River water; seawater was shown toxic (albeit to different test organisms) when it contained ≥10% Chollas Creek water, versus ≥20% Tijuana River water. This implies that stormflow from the Tijuana River would be toxic to sensitive marine life only very close to its discharge point on the mainland coast.

San Diego Ebb Tide Jet

Surprisingly few measurements of marine pollutants are available from the water that actually flows out of the mouth of San Diego Bay during ebb tide. Much more information is available about sediment chemistry in San Diego Bay than water chemistry. No stakeholder in the area is responsible for monitoring pollutants seawater in the central navigation channel near, or outside, the entrance to the bay. In this report we developed the justification for selectively evaluating seawater chemistry within a defined subset of the bay (which we call the *Front Bay*) based on two principal kinds of evidence: (1) similarities between trace metal concentrations measured in real time in the ebb tide jet at sea and values obtained at points along the axis of the bay during ebb flow, and (2) the apparent scale of the longitudinal excursion (both into and out of the bay) of a spectrophotometric tracer of bay water, ultraviolet fluorescence (UVF). Unfortunately, such information was available from only two published studies, the most recent of which took place in 1999. Some contaminants have been, or are being, measured in seawater at bayside facilities (such as the Naval Submarine Base) or within enclosed harbors (such as the Commercial Basin, and Shelter Island Yacht Basin) in response to TMDL development, stormwater permitting requirements, or other projects. However, owing to bay bathymetry, the water entrained into the ebb tide jet may not closely resemble the water residing in more protected locations outside of the central navigation channel of the bay. For example, in 1999, PCBs were much more concentrated in water sampled at the Fuel Pier in front of the Navy Fuel Tank Farm (Navy data) than they were in mid-channel at Ballast Point (data from Zeng et al. 2002)[22]. Although no other approach was available to us during this project, it seems apparent that direct measurements of pollutants in the water leaving the bay during ebb tide would be a better approach for evaluating this potential threat to the Monument than compiling potentially pertinent measurements taken further inside the bay during disparate sampling programs motivated by other needs.

For inclusion in this report, we were unable to obtain water chemistry results from the Front Bay more recent than 1999 (for most constituents). At that time, the following compounds (at a minimum) were present in the water column of the Front Bay:

PAHs (31 different analytes)

DDT and its metabolites

20 other pesticides or residues (including tributyltin)

PCBs (at least 27 different arochlors)

Ag, As, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Zn

Among the analytes which exceeded either state or federal threshholds for the protection of marine life were 4,4'-DDT, total PCBs, total PAH, and tributyltin.

Early results of the CABR mussel transplantation study (tissue concentrations of toxicants) suggest that mussels on the *bay* side of Point Loma are not necessarily exposed to more polluted water than those on the *ocean* side of Point Loma, but that, *as a group*, Point Loma mussels accumulate more PCBs and copper than those further north on the coast. This may indicate that the most concentrated tidal outflow from San Diego Bay may not directly contact the bay-side shore of Point Loma. Cross sectional UVF data from the mouth of San Diego Bay at low tide support this explanation[23]. Instead, tidal flushing of San Diego Bay may principally influence shoreline communities at Point Loma by elevating background levels of pollutants in seawater outside the mouth of the bay.

Some of the trends suggested by NOAA's 17-year record of mussel body burdens at Point Loma are consistent with nationwide, or statewide, trends in chemical use. For example, although the pesticide lindane is still widely used in the U.S., it is banned in California. All uses of DDT and

[22] The Ballast point sample integrated conditions over 3-4 days.
[23] Data are from Chadwick & Largier (1999), but are not presented in this report.

dieldrin were banned in the U.S. in the 1970s. PCB use in the United States began being phased out in 1971, and a ban on new uses took effect in 1976. There was a substantial decrease in the use of silver by the U.S. in the late 1970s owing to a decrease of silver use in the photographic industry. Consequently, declining levels of PCBs, DDTs, lindane, and silver in mussels at Point Loma reflect expected regional trends and do not pinpoint San Diego Bay as a source (although it may well be). Although the ban on tributlytin in 1988 (for vessels under 75 feet in length) was nationwide, it seems reasonable, given the enormous volume of ship traffic and dockage in San Diego Bay, that declining levels of mono-, di- and tributyltin in mussels at Point Loma accurately reflect changes occurring in the water column of San Diego Bay.

Mussel body burdens of PAH and copper also appear to reflect changes occurring in San Diego Bay. The mass balance of copper in San Diego Bay is dominated by chronic sources, and is currently in steady state. Similar levels of dissolved copper have been measured in San Diego Bay in studies separated by the last 25 years. In agreement with these observations, copper in Point Loma mussels has only slightly declined since 1987. NOAA-MWP data suggest that some phenomenon raised mussel exposure to PAHs near Point Loma between 1989 and 1991, and that a decline to earlier levels of exposure is still underway. Unfortunately, data are lacking for PAH levels in seawater from San Diego Bay prior to 1990. The Navy began to eliminate two major sources of PAH in San Diego Bay in the mid-1990s (bilge water discharges into the bay and creosote impregnated pilings). These efforts significantly lowered PAH levels in the bay between 1992 and 1997. Mussel data provide no compelling evidence that exposure to zinc, cadmium, tin, chromium, nickel, and lead has changed much since 1986 near CABR.

Surface currents outside the bay will ordinarily advect pollutants from San Diego Bay to the south, or entrain them into eddies. However, during episodes of northerly flow, bay-derived pollutants may be advected to the ocean side of the Point Loma Peninsula (and thus CABR). Conceivably, the Point Loma kelp bed could divert northerly flow away from the nearshore habitat at CABR (in the same way that outflow from the San Diego River may be diverted to the offshore side of the kelp bed).

Fishing

There is some disagreement among stakeholders as to whether the federal government or California has jurisdiction over fishing in the marine habitat administered by CABR. A subset of these waters within 150 feet of shore constitutes a state marine protected area - the Mia Tegner State Marine Conservation Area, within which recreational take of finfish is allowed, commercial take of finfish and marine plants is allowed, but *any* take of invertebrates is prohibited by state law. The National Park Service recognises the *existence* of the Mia Tegner SMCA and agrees that all take (commercial or recreational) of *invertebrates* is disallowed there, but contends that other (federal) law (1) extends this prohibition to the entire marine area administered by CABR, and (2) includes finfish and marine plants as prohibited targets of commercial take. Conflicting definitions of jurisdiction notwithstanding, the Point Loma kelp bed offshore from CABR are a popular destination for recreational fishermen and dive boats. Commercial trapping for lobster and crab reportedly takes place to some degree within the administrative boundary of CABR and some fraction of the region's commercial nearshore finfish, red sea urchin, spiny lobster, and crab catch takes place in and near the kelp offshore of CABR. A recent review indicates that broomtail groupers, black sea bass, California sheephead, white seabass, yellowtail, elasmobranchs (rays, sharks), lobsters, abalone, and red sea urchins, in particular, show signs of overexploitation in the Point Loma kelp bed.

CABR staff do not conduct counts or interviews of recreational, shore-based anglers within the Monument, nor are counts made of fishing boats that use waters within the administrative boundary of CABR. In its database of commercial fishing effort, the CF&G assigns the waters off of CABR to one of two 10 x10 minute blocks that, together, include the coastal ocean from La Jolla to south of the U.S./Mexico border. Consequently it is difficult to discover how much of the commercial take of fish or invertebrates in the region comes from the vicinity of CABR. However, combined commercial landings for San Diego Bay harbors show that red sea urchin, California spiny lobster, swordfish, albacore tuna, and rock crab (in that order) are the most important commercial species in the San Diego area, with red sea urchin far ahead of the other species. Only 8 out of the top 20 commercially important species for the San Diego area are on species lists for CABR: red sea urchin, California spiny lobster, rock crab, California sheephead, yellowtail, white seabass, and warty sea cucumber.

A somewhat different picture emerges from the recreational fishery in the San Diego area. Annual landings for the San Diego and Mission Bay Harbors' Commercial Passenger Fishing Vessel (CPFV) fleet reveal that 15 of the top 23 species caught by recreational fishermen on charter boats in 2004 are on species lists for CABR. However, several of the species most sought after by the CPFV fleet, such as albacore tuna, dolphinfish, and striped marlin, are not found (or at least not reported) in Monument waters. Finally, a sample of survey data from recreational fishermen on private boats and CPFVs[24] that fished between 1999-2005 in waters up to 120 feet deep from the tip of Point Loma to the northern border of the Monument revealed that 2 of the top 5 species caught on CPFVs offshore from CABR (ocean whitefish and lingcod) are not on the CABR species list, and are normally deeper water fish. However, all of the top five species caught on private recreational fishing boats (kelp bass, barred sandbass, California halibut, California scorpionfish, and vermillion rockfish) are on the CABR species list. The difference may indicate that a high proportion of CPFVs in the San Diego area target pelagic fish found offshore (such as tuna, marlin, dophinfish, yellowtail), and thus are not utilizing nearshore habitat, such as the Point Loma kelp bed, as much as the private boats do.

Visitation

It has now been ten years since visitors were excluded from Zone III. Very few of the changes in intertidal plant and animal populations (see list above) that have occurred at CABR are attributed to patterns in visitor use. For example, owl limpets and mussels are not successfully recruiting into Zone III, despite the exclusion of visitors. Surfgrass expansion during much of the last fifteen years has occurred in all three zones, regardless of levels of visitor use. However, the diversity and biomass in red algal turf is now higher in Zone III than in the other two zones, and this difference has been attributed to lower trampling rates in Zone III. In addition, birds clearly avoid visitors in the CABR intertidal, and are most abundant in Zone III. Interestingly, shore birds - and subsequently wading birds - began to comprise larger proportions of total bird sightings in Zone III starting in 2000. This change began four years after visitors were prohibited in Zone III, thus it is not clear that it is related to patterns of human use.

[24]Collected by the California Recreational Fisheries Survey

Marine Vessel Traffic

Boats do not land or dock within the marine habitat at CABR. However, its position at the entrance to San Diego Bay makes Point Loma vulnerable to accidental and intentional discharges and spills from a wide variety of marine vessels. Approximately 9,000 deep draft vessels transit San Diego Bay per year. One third of the U.S. Naval Pacific Fleet is home ported in San Diego Bay. Military vessels make up the bulk of large vessel traffic in the bay enroute to berths at the 32nd Street Naval Station, the Naval Pier (south of Broadway Street pier), the North Island Naval Air Station, the submarine base at Ballast Point, and Amphibious Base Coronado in Glorietta Bay. Naval vessels of all classes, from 50' long amphibious landing craft to 1115' long aircraft carriers, use the bay. In addition, the bay hosts three commercial terminals, several public marinas, a commercial fishing fleet, and a commercial shipyard. Cargo ships transport lumber, newsprint, fertilizer, foodstuffs, automobiles, palm oil, minerals, and fuel oil. Barges transport sand, aggregate, and dredged material.

The diversity and volume of marine vessel traffic in and out of San Diego Bay poses a variety of threats to marine habitat at CABR. Among them are fuel and cargo spills, hydrocarbons in bilge water, exotic organisms in ballast water, copper and tributyltin from hull paint, black and gray water, trash, and dryfall of particulates from diesel exhaust. Recent new state law makes releases of bilge water, black and gray water, and chemical and medical waste from oceangoing ships illegal within 3 nautical miles of shore. Nonetheless, aerial imagery by Ocean Imaging Corp. has documented bilge water releases very close to Point Loma via tell-tale slicks in the wake of ships headed toward the entrance of San Diego Bay. Small vessel groundings have occurred infrequently at CABR, and could result in diesel fuel spills.

Dredging and Disposal of Dredged Materials

Despite the fact that dozens of small and large scale dredging projects have taken place in San Diego Bay over the last several decades, almost nothing is known about whether dredging affects water quality in the bay. Entities that carry out dredging in the bay, such as the Coast Guard, the Navy, the Port of San Diego, and the commercial boat yards, are not required to measure much more than TSS in the water column during dredge operations. The only pertinent information we obtained was coincidental (from a Navy study that coincided with channel dredging in Nov. 1997), and suggested that TSS was elevated by dredging, but that PAH and dissolved copper were not.

Dredged material that is ultimately disposed at dredge disposal site LA-5 (most of which is brought from San Diego Bay) contains (at a minimum) Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn, chlordane, dieldrin, DDT, organotins, PAH, and PCB. Of these, zinc and copper contribute the most to sediment mass. Both of these metals have produced toxicity in the water column of San Diego Bay: dissolved copper at Shelter Island Yacht Basin, and dissolved zinc in storm plumes from Chollas Creek. It seems reasonable to expect that dredging operations result in a temporary deterioration of water quality. The largest dredging operation in the Front Bay in recent years was a deepening of the central navigation channel along the axis of the bay from Harbor Island past Point Loma during 1997-1998[25]. Sentinel mussels taken near Point Loma in 1997 and 1999 do not provide any evidence that exposure to metals or organics increased during this period. Instead, mussel data suggest that, during the 1990s, 1995 was a peak year for exposure near Point Loma for several analytes (Al, Sn, Ag, Se and DDT), and that some event may have briefly raised exposure to lindane, total PAH, organotins, Hg, and Ni near Point Loma in 1991.[26]

The transport of dredged material past Point Loma toward dredge disposal site LA-5 creates another opportunity for dredging operations to degrade water quality in the vicinity of CABR. More than 250 tell-tale elliptical mounds, indicating the illegal dumping of dredged materials while vessels are underway, have been detected by sonar on the ocean floor over a wide area up to several km shoreward of the official dredge disposal site. The illegal mounds are in shallower water than LA-5, closer to Point Loma than LA-5, and more prone to resuspension and lateral transport than material deposited at LA-5. In recent years, concentrations of PAHs and PCBs have been higher in sediment at the southern "E" stations in the PLOO monitoring area (E1, E2, E3, E9 - which are close to LA-5), than elsewhere off San Diego. In addition, DDT is detected at sediment sites in the PLOO monitoring area. Effluent discharged from the PLOO is not a known source of these compounds, implicating dredged material as the source. Depending on how close to Point Loma an illegal dump occurs, contaminated sediment particles might temporarily occupy the water column just a few kilometers from CABR after an illegal dump.

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[25] The central navigation channel of San Diego Bay, from the carrier turning basin to the Coronado bridge was deepened in 2004. However, this activity did not take place in the Front Bay, as we define it in this report.
[26] These observations result from visual inspection (only) of time series data.

Table 21. Stressors and contributors pertaining to the aquatic resources at Cabrillo National Monument. Codes are as follows: EP - existing problem based on direct evidence; PP - potential problem; OK - not currently, or expected to be, a problem; Shaded - evidence is lacking, limited, or indirect; ? - not enough information available to categorize; blank - not applicable.

Stressors and Contributors	Ground-water	Rocky intertidal	Subtidal habitat
Fecal bacteria			
PLOO - operating normally		OK	OK
Sewage Spills/Outfall Pipe Break		EP	EP
San Diego and Tijuana Rivers		OK	OK
San Diego Bay outflow		PP	PP
SBOO		OK	OK
Infiltration or Runoff from Peninsula	?	EP	EP
Dredging		OK	OK
Marine Vessels		OK	OK
Chronic exposure to metals and organics			
PLOO - operating normally		PP	PP
Sewage Spills/Outfall Pipe Break*			
San Diego and Tijuana Rivers		PP	PP
San Diego Bay outflow		EP	EP
SBOO		PP	PP
Infiltration or Runoff from Peninsula	PP	?	?
Dredging		?	?
Marine Vessels		PP	PP
Acutely toxic levels of exposure to metals and organics			
PLOO - operating normally		OK	OK
Sewage Spills/Outfall Pipe Break		PP	PP
San Diego and Tijuana Rivers		OK	OK
San Diego Bay outflow		OK	OK
SBOO		OK	OK
Infiltration or Runoff from Peninsula	?	?	?
Dredging		?	?
Marine Vessels		PP**	PP**
Other stressors			
Fishing***		OK	PP
Visitation		EP	OK
Disease		PP	PP

*considers sewage spills and pipe breaks as temporally restricted events, thus not potential sources of chronic exposure

**considers cargo or fuel spills

***includes invertebrates, plants, fish

C. Recommendations for Addressing Information Gaps

Below, steps are suggested for addressing many of the information gaps related to potential or known degradations of aquatic resources at CABR. The continuation of CRIMP is assumed, and recommended. Recommendations below are assigned the letters H, M, or L to indicate high, medium, and low priority, respectively.

1. **Evaluate the extent to which the San Diego Bay ebb tide jet affects water quality at CABR (H).** The steps below (i-iii) are in suggested chronological order.

   i. <u>Monitor the influence of tidal outflow from San Diego Bay at stations around the end of Point Loma using moored UVF sensors</u>. This should indicate whether the marine habitat of CABR is bathed by the San Diego Bay ebb tide jet, and if so, how often and during which local current regimes.

   ii. <u>Conduct toxicity tests and larval settlement tests *using water collected specifically from the ebb tide jet.*</u> It appears unlikely that San Diego Bay outflow is acutely toxic to marine organisms. However, chronic exposure to bay-derived pollutants might be responsible for some of the biological trends observed in Zone III. Because the City conducts toxicity tests on several taxa using MLS water three times per year, toxicity tests could conceivably be folded into their wet weather sampling program. Larval settlement tests should be conducted using sessile marine species that occur at CABR.

   iii. <u>Evaluate the feasibility of employing drogues to identify the sources of water in the ebb tide jet from San Diego Bay, and the physical fate of the ebb tide jet at sea</u>. Drogues could be used (1) outside the mouth of San Diego Bay to track the fate of the ebb tide jet at sea, starting immediately outside a line drawn from the end of Zuniga Jetty to Point Loma, and (2) within the Front Bay to discover the zone inside the bay from which water is entrained into the ebb tide jet.

      Example questions to be answered: Does water from within the Naval Submarine Base, and other shoreline facilities in the Front Bay, become entrained into the ebb tide jet? Or are sources further inside the bay (perhaps in better communication with the central navigation channel) more important contributors to pollutants in the ebb tide jet?

2. **Measure priority pollutants in seawater within Monument boundaries using passive in-situ exposure samplers or best available techniques (H).** Body burdens in sentinel mussels within and near the administrative boundary of CABR prove that within the last decade (and as recently as 2002 in some cases) the following constituents (at a minimum) resided at least part time in the water column at the Monument:

Trace elements:	Ag, Al, As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Sb, Zn
Organics:	alphachlordane
	transnonachlor
	heptachlor

heptachlor-epoxide
DDT, DDD, DDE
PAHs (any of:1,6,7-trimethylnaphthalene, 1-methylnaphthalene, 2,6-dimehtylnaphthalene, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(k)fluoranthene, benzanthracene, benzo(g,h,i)perylene, benzo-a-pyrene, benzo-b-pyrene, benzo-e-pyrene, benzo-k-flouranthene, biphenyl, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, perylene, phenanthrene, pyrene)
PCBs
aldrin
dieldrin
organotin (tri-, di-, monobutyltin)
chlorpyrifos
cis-nonachlor
gamma chlordane
chrysene
dibenzothiophene
endosulfan I, II
alpha, beta and delta HCH
lindane
hexachlorobenzene
fluoranthene
mirex
naphthalene
oxychlordane
pentachloroanisole
tetrachlorobenzene

Concentrations of *selected* organics and trace elements should be compared in the nearshore at CABR, at the inshore and offshore edge of the Point Loma kelp bed, and in the direct pathway of the San Diego ebb tide jet. *NOTE: Real time measurements will not provide useful information concerning the influence of San Diego Bay on water quality at CABR unless the measurements are made during ebb flow.*

Synoptic studies using towed or ship-board instruments that are focused on the ebb tide jet would be beneficial to CABR. However, they would be expensive and would require collaborators with research vessels and appropriate equipment. Filtration methods can require the processing as much as 2500 L to achieve detection for organic constituents and trace elements in seawater (e.g., Zeng et al. 2002). Other methods for real-time measurements exist. For example, real-time measurements of trace metals in seawater were achieved by Esser & Volpe (2002) using separation chemistry with inductively coupled plasma mass spectrometry. The U.S. Navy employs a real-time data acquisition system dubbed MESC for synoptic surveys in San Diego Bay. The MESC includes a towed sensor package and on-board equipment that measures dissolved copper (using potentiometric stripping analysis) and PAH (using uv-fluorescence).

A more practical way to directly measure trace metals and organics in seawater at the Monument would be to moor passive *in-situ* exposure samplers which integrate background levels in the water column over weeks or months. If strategically placed, these samplers would yield information about the relative importance of suspected sources that contribute to background levels of pollutants in seawater at CABR. We did not conduct a review of these techniques for this report. In-situ exposure techniques in use for trace metals in natural waters include diffusion gradient thin-film gels (DGT), hollow fiber permeation liquid membranes (HFPLM), and Donnan membrane technique (DMT) (Sigg et al. 2006). Solid phase microextraction samplers, which consist of glass fiber coated with poly(dimethylsiloxane) in copper casings were moored at coastal sites along southern California for 2-3 months at a time to measure p,p'-DDE in seawater (Zeng et al. 2005). Another option is passive samplers called *Semi-permeable membrane devices* (SPMD)[27]. SPMDs are porous plastic tubes containing a fatty material that mimics fish membrane lipids. As water passes through the membrane material, hydrophobic compounds are retained as they would be in fish fatty tissues. These sampling devices are usually deployed in an aquatic environment for three to four weeks and target hydrophobic contaminants such as organopesticides, PAHs, and PCBs.

3. **Continue to work with researchers to understand larval settlement of mussels and owl limpets in Zones I, II, and III (H).** There is the possibility that the recruitment failure of mussels and owl limpets in Zones II and III is unrelated to water quality, but rather a deficiency in larval settlement. Example questions to be answered (in part from Becker 2006): Why do mussels not recruit into the Monument? At what point in the life cycle (larvae, metamorphosis) are mussels failing at the Monument? Where do CABR owl limpet recruits originate? What roles do recruitment rates, food supply, water quality, and/or disease play in the decline and lack of recovery of mussels at CABR? Will alterations in kelp harvest along the Point Loma peninsula, or in the transplantation of kelp after large storms, affect larval recruitment at CABR?

4. **Review recent stormwater monitoring reports, and related products, for industrial stormwater permittees proximate to CABR (M).** These products should yield insights as to whether stormflow from industrial sites near CABR sufficiently compromises water quality in the Front Bay to be a priority concern for the NPS. The pertinent products include:
    - Industrial stormwater monitoring reports for the facilities within the US Naval Base Point Loma, the US Naval Air Station, North Island, and the PLWTP. These products will probably have to be obtained in person through the offices of the Southern Watershed Unit of the SDRWQCB in downtown San Diego (key contacts are at http://www.waterboards.ca.gov/sandiego/units/watershed%20units/souwatershed.html).
    - The toxicity study report (SSC-SD TR1938) for the Navy Submarine Base, which should become public sometime in 2006.

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[27] see Huckins, JN, Petty, JD, Lebo, JA, Orazio, CE, Clark, RC, Gibson, VL. (January 3, 2002). SPMD Technology Tutorial (3rd Edition). U.S. Geologic Survey (USGS). Retrieved on June 15, 2006 from http://wwwaux.cerc.cr.usgs.gov/SPMD/SPMD-Tech_Tutorial.htm

- The TMDL for toxicity at the Naval Submarine Base which should become public in 2006 or early 2007, and which should be posted at http://www.waterboards.ca.gov/sandiego/tmdls/tmdl.html.

5. **Review the results of SCCWRP's San Diego and Tijuana River plume toxicity studies when they become public later in 2006 (H).**

6. **Better utilize CODAR and OI data to understand the behavior of San Diego and Tijuana River plumes (M, or H if step 5 above shows toxicity at sea in these river plumes)**. Initial exploration could include these steps:

    1) Review the archive of OI imagery provided to the City by Ocean Imaging (much of which does not appear in on-line reports), and catalog dates revealing large river plumes.
    2) Associate large river plumes with the rainfall amounts that produced them. Identify the frequency of rain events large enough to produce river plumes that could directly impact water quality at CABR.
    3) Collaborate with SDCOOS to obtain the surface flow fields for the dates above.

7. **Collaborate with SDCOOS to establish a CODAR station that would reveal surface currents in areas along the outer coast of the Point Loma peninsula which are currently in the shadow of the existing CODAR array (H).** This information is necessary to correctly evaluate the likelihood that pollutants from regional point sources are transported to CABR, the effect of the Point Loma kelp bed on the local current regime, and the role of physical processes in determining larval transport to CABR.

8. **Conduct interviews with shore-based anglers to determine fish species caught from shore (M). Also, count fishing boats within the administrative boundary of CABR (H).** NPS staff can incorporate these general techniques to gain some informal but local knowledge about the potential impacts of fisheries on CABR populations. Invite CRFS to include the shoreline at CABR as one of their routine shoreline angler survey sites.

9. **Determine the numbers of red sea urchins and California spiny lobsters caught within the administrative boundary of CABR to aid in the assessment of the impact of the commercial fisheries on CABR resources (H).** Red sea urchins and California spiny lobsters rank as the top two commercially harvested species in the San Diego area, and are linked to giant kelp in trophic cascades that have important effects on areal extent of kelp forest in California. Example questions: What is the current status of lobster and urchin populations (red and purple) within and offshore of CABR? What is the relative contribution of CABR lobsters to local populations? Is the current harvest of lobsters and sea urchins offshore of Point Loma sustainable? How is the harvest of red sea urchins affecting purple sea urchin populations?

10. **Survey available information about the condition of the groundwater on the Point Loma Peninsula, its extent, and whether it could influence the rocky intertidal areas (M).**

11. **Survey resources available to reconstruct past changes in the extent of sand coverage at CABR, and to monitor future changes in sand coverage (L).** Existing resources include photographs of Grunion Beach taken in conjunction with other CABR monitoring activities, and aerial photographs and other imagery archived by Ocean Imaging or the City.

12. **Investigate the feasibility of using mineral fingerprints to identify the sources of sand that appear at CABR (L).**

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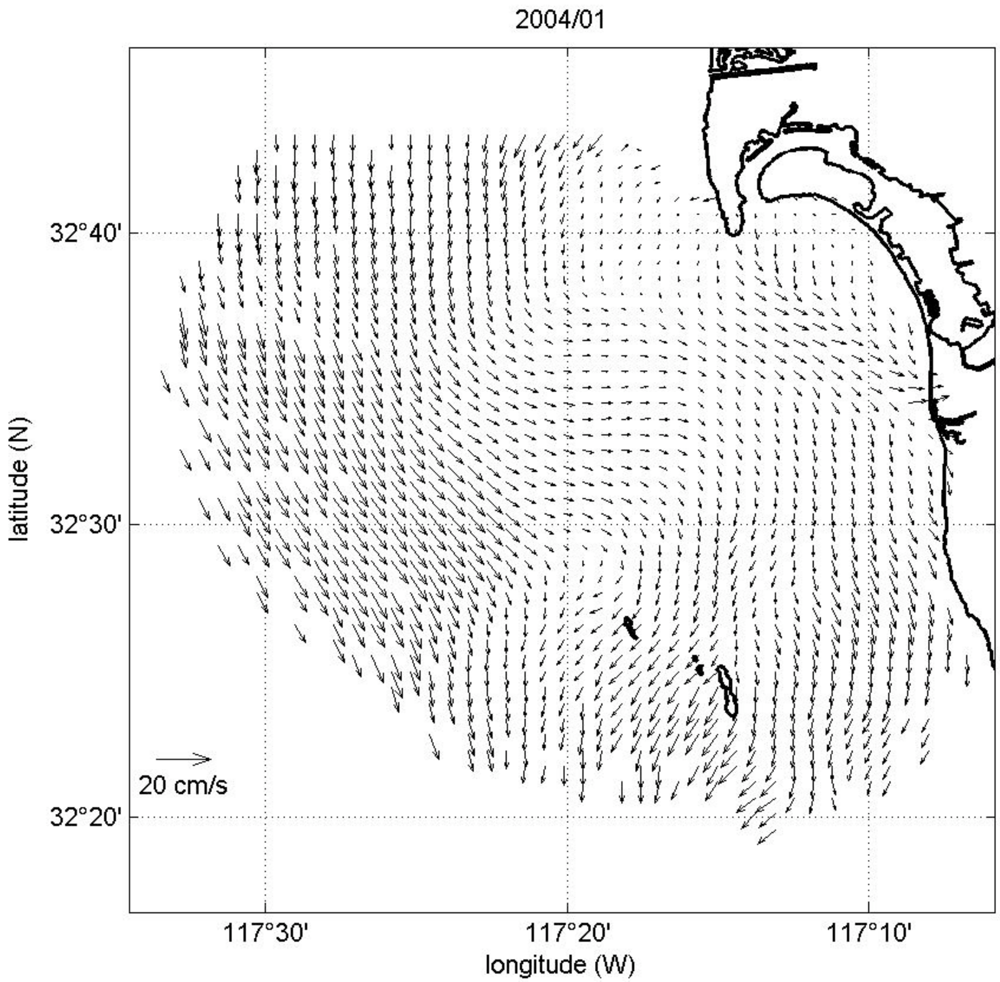
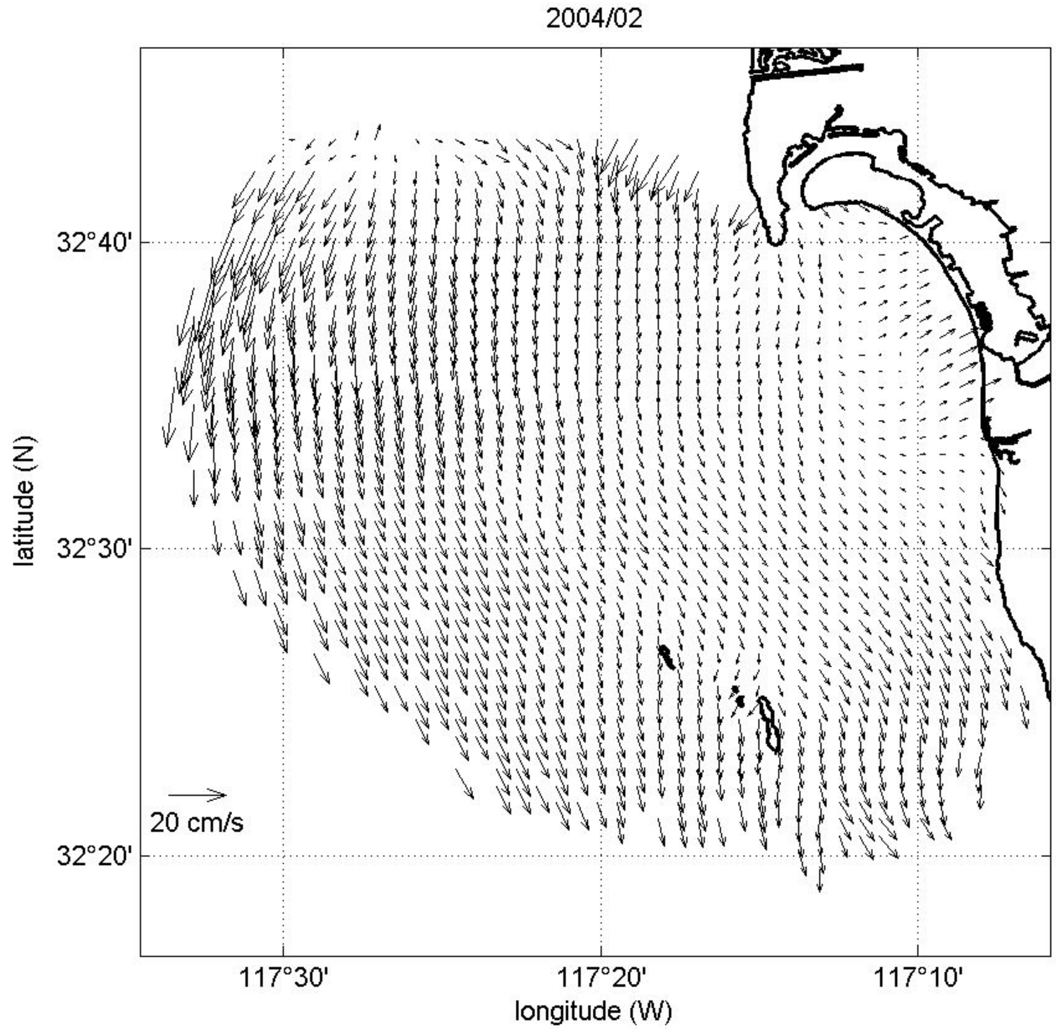
APPENDIX A .

Mean monthly surface flow fields in the coastal ocean near San Diego Bay. Figures are courtesy of the San Diego Coastal Ocean Observing System, Scripps Oceanographic Institution, University of California, San Diego, CA.

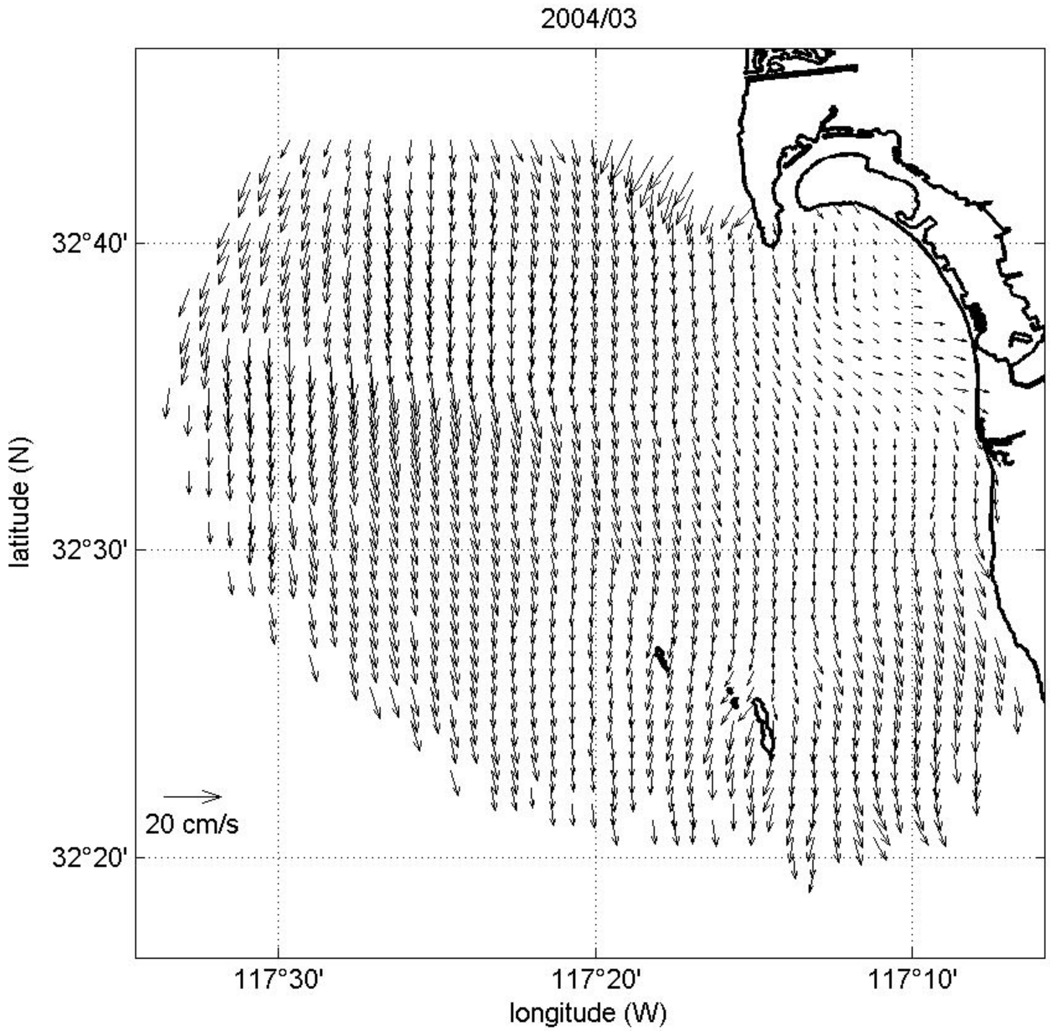
JANUARY 2004



FEBURARY 2004

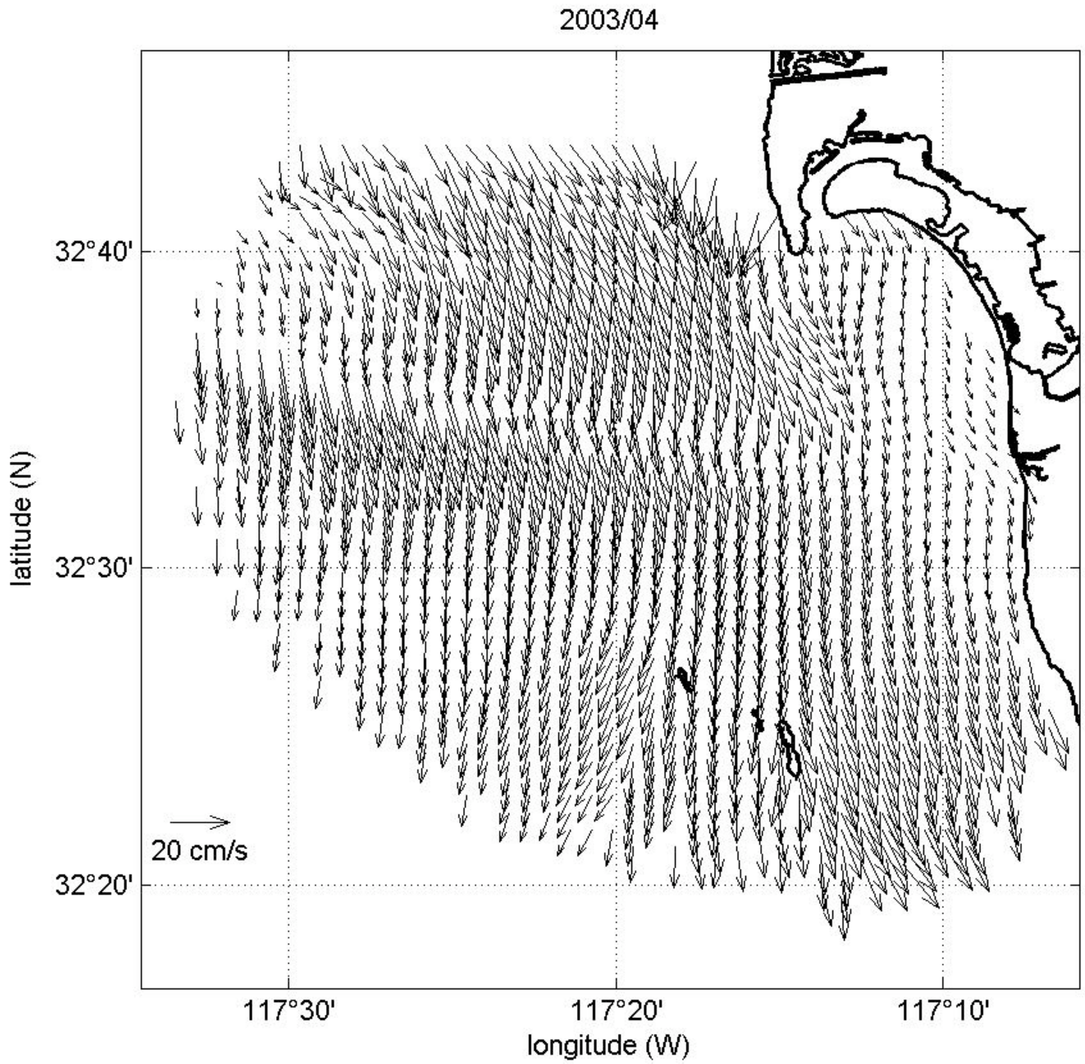


MARCH 2004

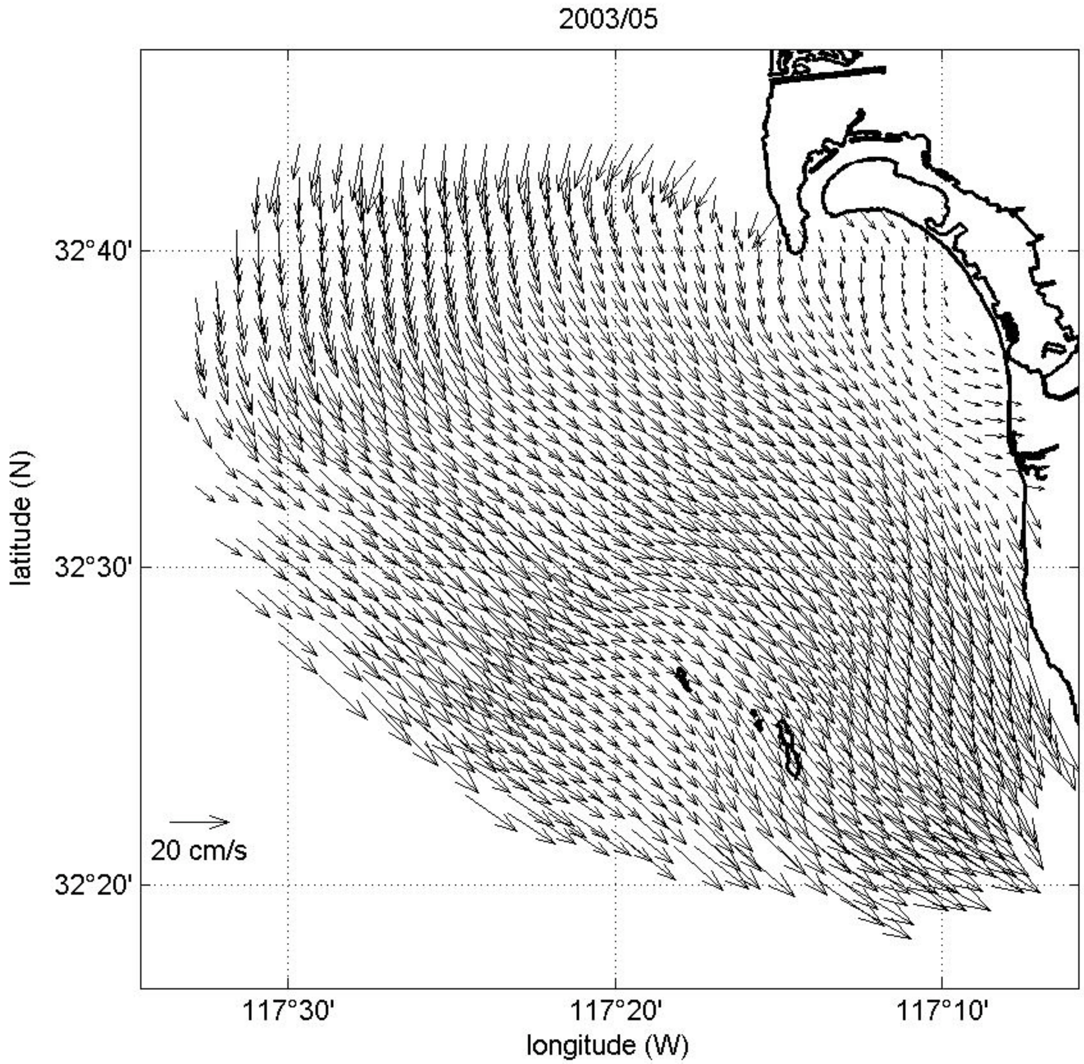


2004/03
32°40'
32°30'
32°20'
latitude (N)
117°30'
117°20'
117°10'
longitude (W)
20 cm/s

APRIL 2003

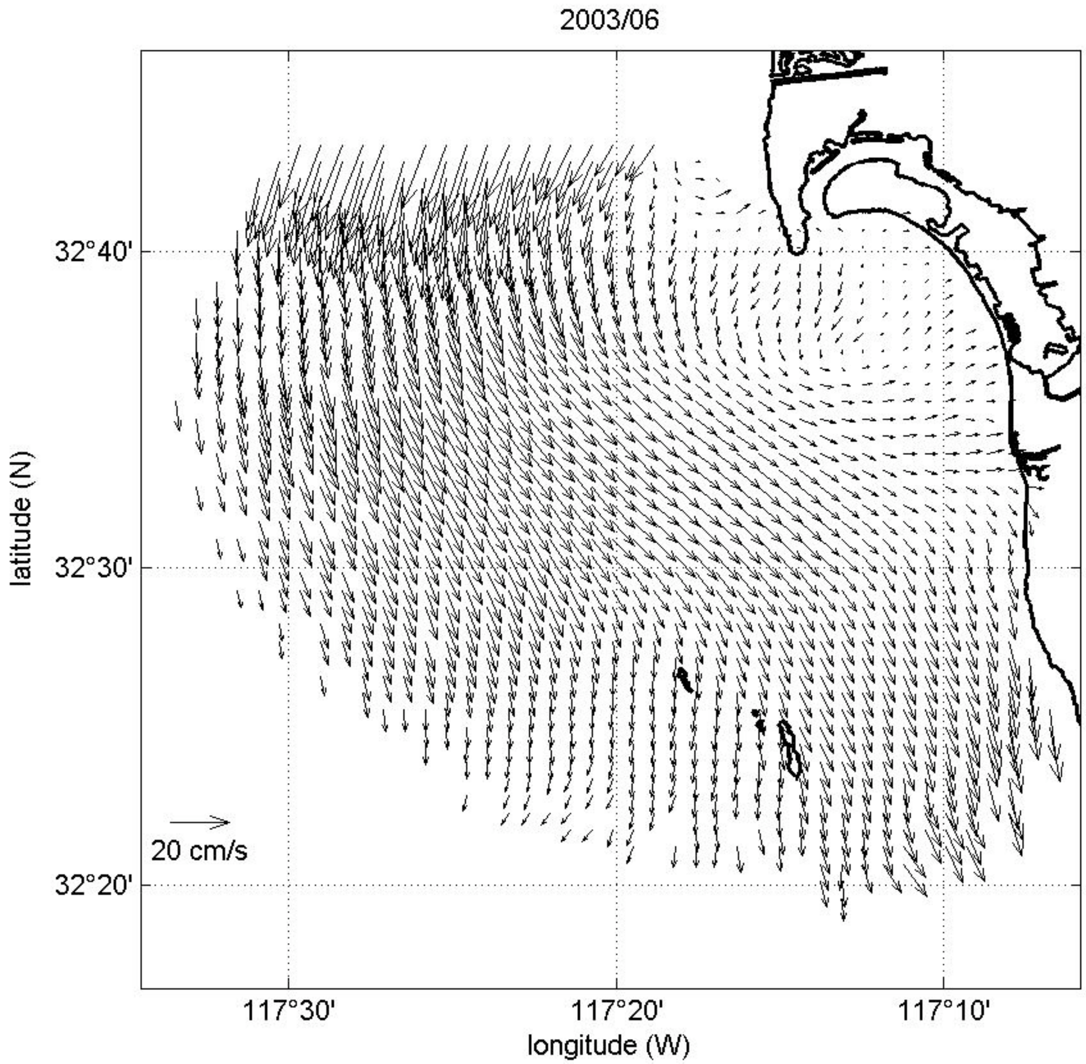

2003/04
32°40'
32°30'
32°20'
latitude (N)
20 cm/s
117°30'
117°20'
117°10'
longitude (W)

MAY 2003

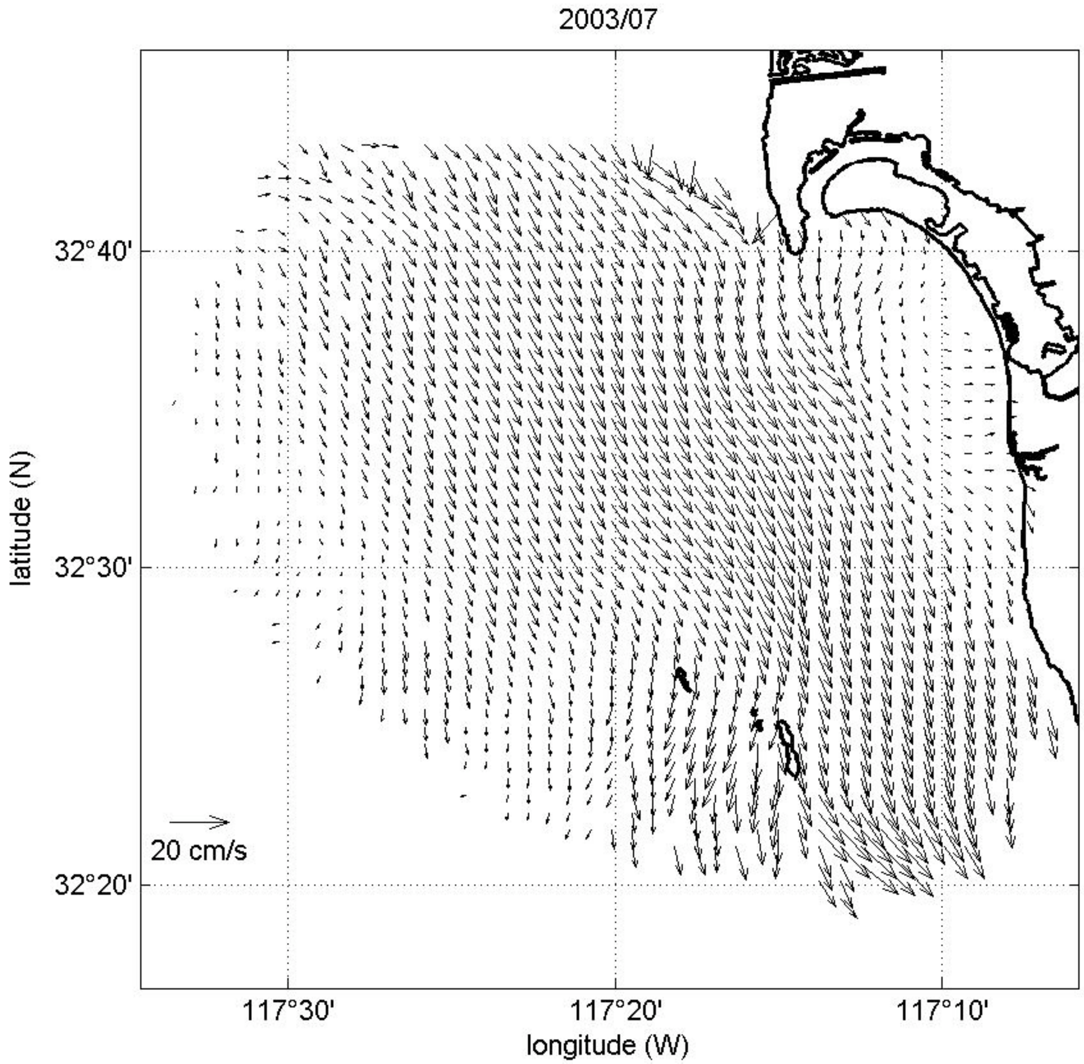


2003/05
32°40'
32°30'
32°20'
latitude (N)
20 cm/s
117°30'
117°20'
117°10'
longitude (W)

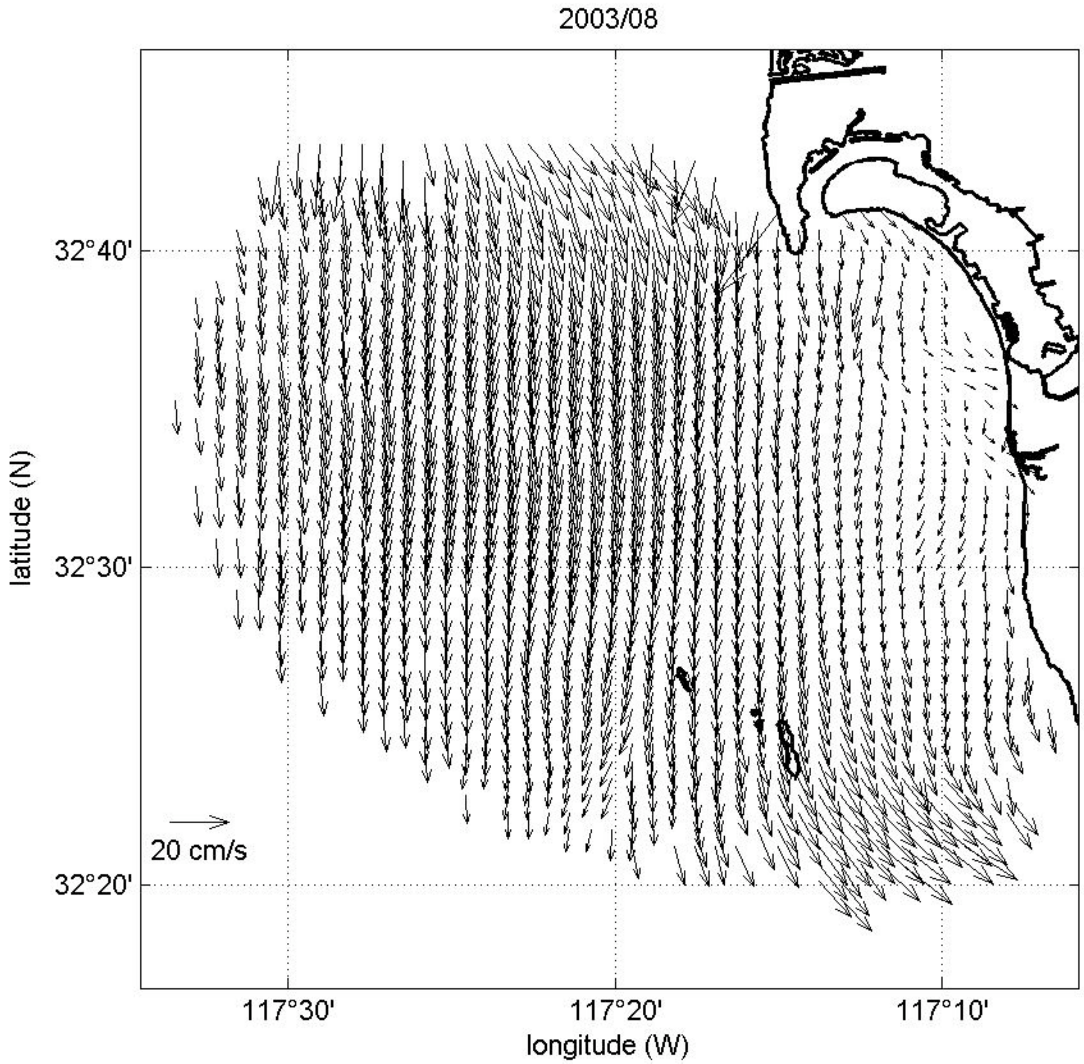
JUNE 2003


2003/06
latitude (N)
32°40'
32°30'
32°20'
117°30'
117°20'
117°10'
longitude (W)
20 cm/s

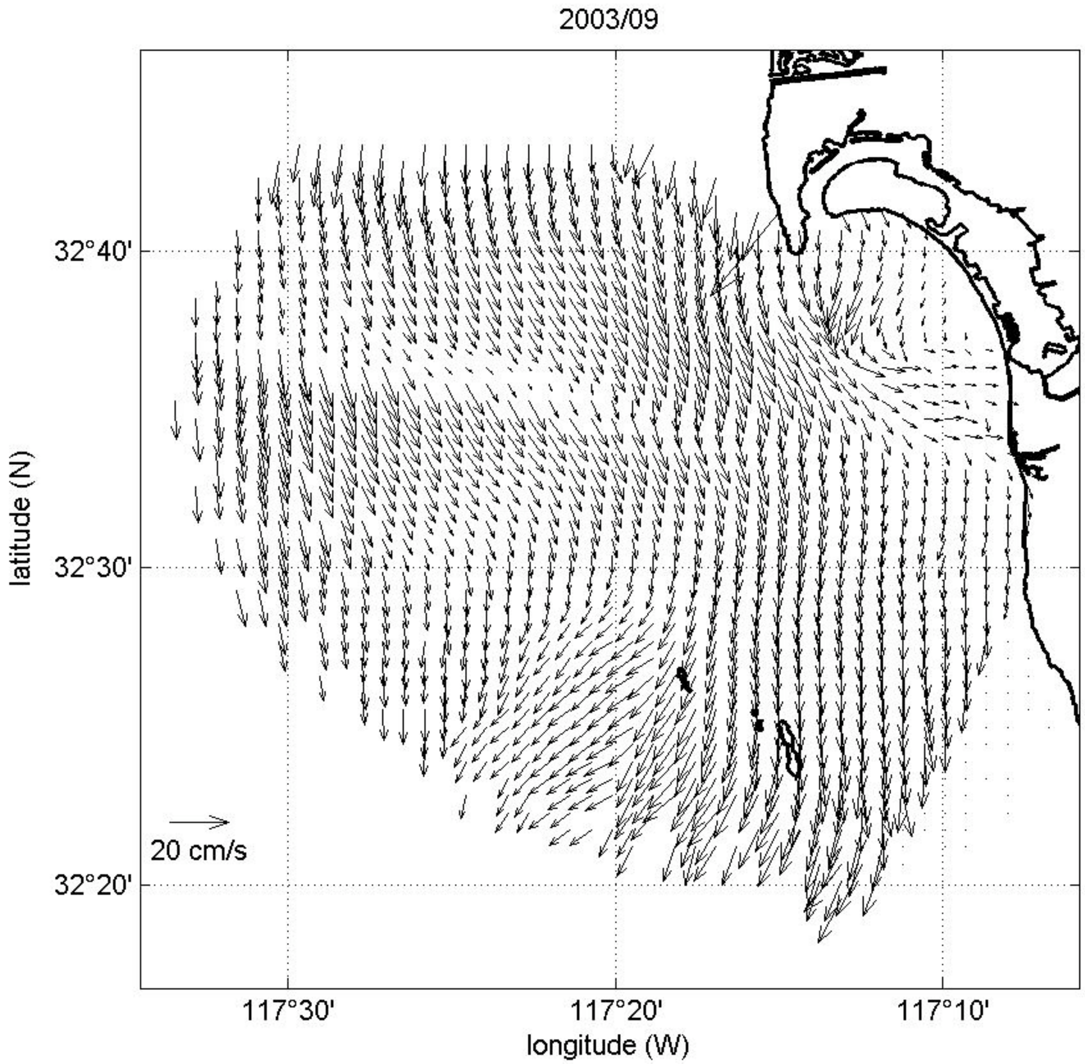
JULY 2003


2003/07
32°40'
32°30'
32°20'
latitude (N)
117°30'
117°20'
117°10'
longitude (W)
20 cm/s

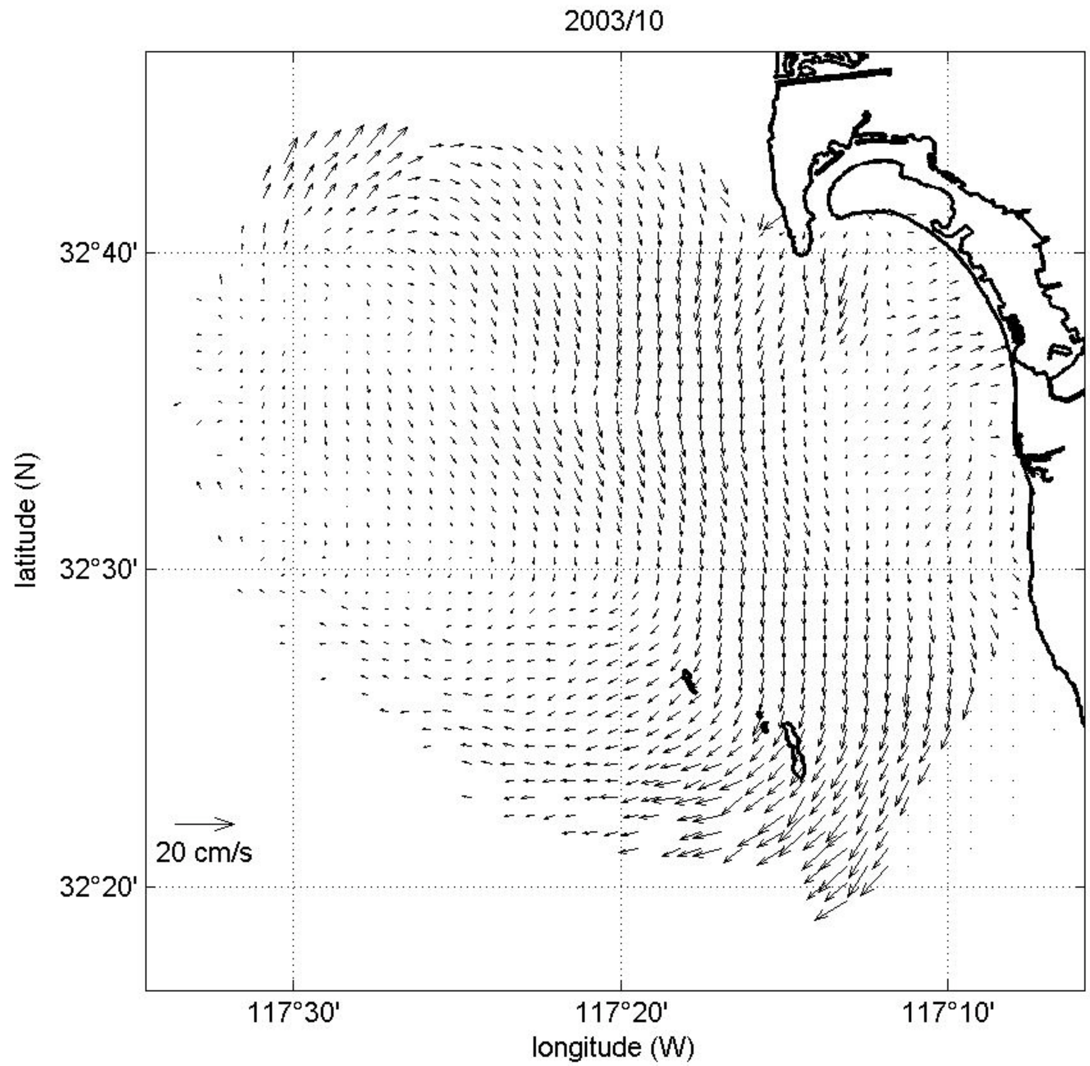
AUGUST 2003


2003/08
32°40'
32°30'
32°20'
latitude (N)
117°30'
117°20'
117°10'
longitude (W)
20 cm/s

SEPTEMBER 2003



OCTOBER 2003



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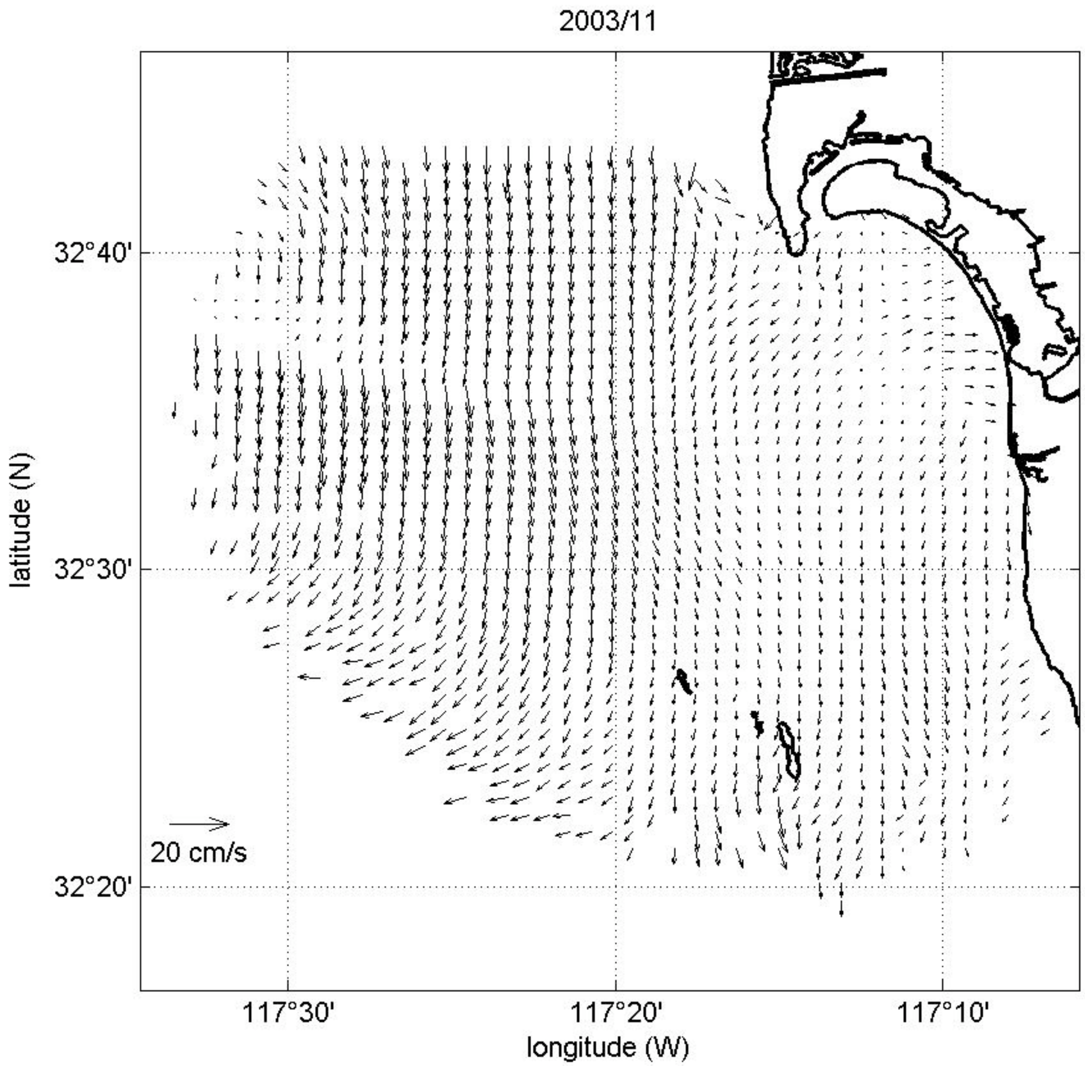
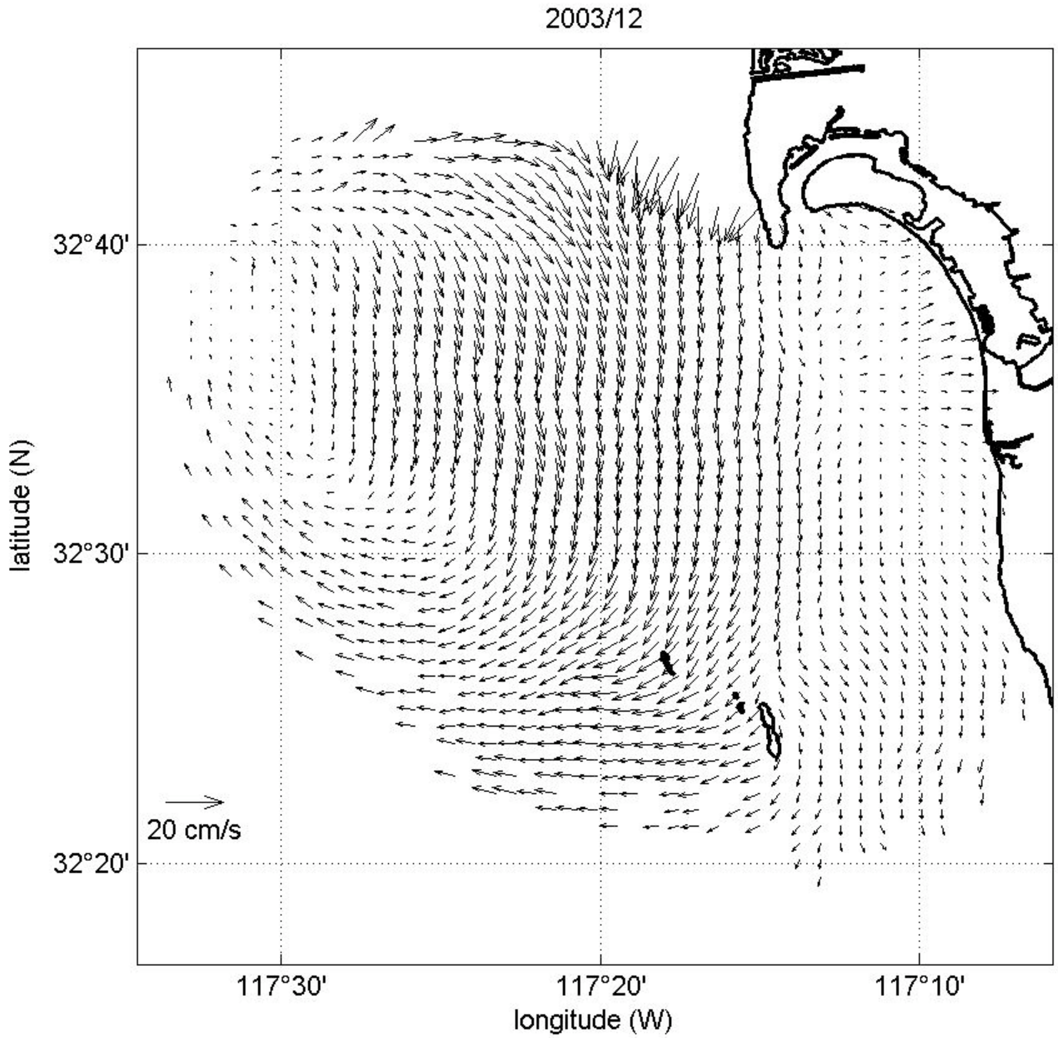


DECEMBER 2003



APPENDIX B

MARINE MACROALGAE SPECIES LIST FOR CABRILLO NATIONAL MONUMENT
SOURCE: MILLER (2005)

CHLOROPHYTA

Bryopsis pennatula J. Agardh

Chaetomorpha aerea (Dillwyn) Kützing

Chaetomorpha spiralis Okamura

Cladophora microcladioides Collins

Codium fragile (Suringar) Hariot

Ulva californica Wille

Phyllospadix torreyi Watson

HETEROKONTOPHYTA, CLASS PHAEOPHYCEAE

Colpomenia sinuosa (Mertens ex Roth) Derbès & Solier

Colpomenia tuberulata Saunders

Dictyopteris undulata Holmes

Egregia menziesii (Turner) Areschoug

Eisenia arborea Areschoug

Endarachne binghamiae J. Agardh

Halidrys dioica Gardner

Macrocystis pyrifera (L.) C. Agardh

Pachydictyon coriaceum (Holmes) Okamura

Pelagophycus porra (Leman) Setchell

Petrospongium rugosum (Okamura) Setchell & Gardner

Pseudolithoderma nigrum Hollenberg

Pterygophora californica Ruprecht

Ralfsia spp.

Sargassum agardhianum J. Agardh

Sargassum muticum (Yendo) Fenscholt

Scytosiphon dotyi Wynne

Silvetia compressa (J. Agardh) Serrão, Cho, Boo & Brawley

Sphacelaria californica Sauvageau

Sphacelaria rigidula Kützing

Taonia lennebackerae J. Agardh

Zonaria farlowii Setchell & Gardner

RHODOPHYTA

Acrosorium ciliolatum (Harvey) Kylin

Ahnfeltiopsis leptophylla P.C. Silva & DeCew

Amphiroa beauvoisii Lamouroux

Bangia vermicularis Harvey

Bossiella orbigniana ssp. *orbigniana* (Decaisne) Silva

Callophyllis violacea. J. Agardh

Caulacanthus ustulatus (Mertens ex Turner) Kützing

Centroceras clavulatum (C. Agardh) Montagne

Ceramium sinicola Setchell & Gardner

Chondracanthus canaliculatus (Harvey) Guiry in Hommersand, Guiry, Fredericq & Leister

Chondracanthus spinosus (Kützing) Guiry in Hommersand, Guiry, Fredericq & Leister

Chondria acrorhizophora Setchell & Gardner

Chondria nidifica Harvey

Corallina chilensis Decaisne

Corallina pinnatifolia (Manza) Dawson

Corallina vancouveriensis Yendo

Corallophila eatoniana (Farlow) DeToni

Cryptopleura corallinara (Nott) Gardner/*Cryptopleura crispa* Kylin

Cryptopleura ruprechtiana (J. Agardh) Kylin

Cryptopleura violacea (J. Agardh) Kylin

Cumagloia andersonii (Farlow) Setchell & Gardner

Dasya binghamiae A.J.K. Millar

Erythrocystis saccata (J. Agardh) Silva

Erythroglossum californicum (J.Agardh) J.Agardh

Gastroclonium compressum (Hollenberg) Chang & Xia

Gastroclonium parvum (Hollenberg) Chang & Xia

Gastroclonium subarticulatum (Turner) Kützing

Gelidium coulteri Harvey

Gelidium purpurascens Gardner

Gelidium pusillum (Stackhouse) LeJolie

Gelidium robustum (Gardner) Hollenberg & Abbott

Gymnogongrus chiton (Howe) P.C. Silva & DeCew in Silva

Haliptilon gracile (Lamouroux) Johansen

Herposiphonia verticillata (Harvey) Kylin

Heterosiphonia erecta Gardner

Hildenbrandia sp.

Hypnea valentiae (Turner) Montagne

Hypnea variabilis Okamura

Jania crassa Lamouroux

Laurencia masonii Setchell & Gardner

Laurencia pacifica Kylin

Laurencia subopposita (J. Agardh) Setchell

Leptocladia binghamiae J. Agardh

Lithophyllum neofarlowii Setchell & Mason

Lithothrix aspergillum Gray

Lomentaria hakodatensis Yendo

Mazzaella affinis (Harvey) Fredericq in Hommersand, Guiry, Fredericq & Leister

Mazzaella leptorhyncus (J. Agardh) Leister in Hommersand, Guiry, Fredericq & Leister

Melobesia marginata Setchell & Foslie

Melobesia mediocris (Foslie) Setchell & Mason

Nienburgia andersoniana (J. Agardh) Kylin

Ophiocladus simpliciusculus (Crouan & Crouan) Falkenberg

Osmundea spectabilis var. *diegoensis* (Dawson) Nam

Osmundea sinicola (Setchell & Gardner) Nam

Laurencia sinicola Setchell & Gardner

Plocamium pacificum Kylin

Polysiphonia scopulorum var. *villum* (J. Agardh) Hollenberg

Polysiphonia spp.

Porphyra perforata J. Agardh

Prionitis angustata (Okamura) Okamura

Prionitis lanceolata (Harvey) Harvey

Pterocladiella capillacea (S.G.Gmelin) Santelices & Hommersand

Pterosiphonia baileyi (Harvey) Falkenberg

Pterosiphonia dendroidea (Montagne) Falkenberg

Rhodymenia californica Kylin

Rhodymenia pacifica Kylin

Schizymenia pacifica (Kylin) Kylin

Scinaia confusa (Setchell) Huisman

Smithora naiadum (Anderson) Hollenberg

Spyridia filamentosa (Wulfen) Harvey

Tiffaniella snyderae (Farlow) Abbott

APPENDIX C .

Marine macroinvertebrates observed at Cabrillo National Monument. List was compiled by CABR staff using results of several studies and many observers; not all species are confirmed (B. Becker, Marine Biologist, CABR, pers. comm.).

Genus	Species	Common name
Phylum: Annelida		Class: Polychaeta
Eupomatis	gracilis	
Spirorbis	eximius	
Spirorbis	spirillum	
Spirorbis	spp	
Autolytus	spp	
Exogone	lourei	
Mooreonuphis	stigmatis	
Pareurythoe	californica	
Notomastus	tenuis	
Axiothella	rubrocincta	
Petaloproctus	neoborealis	
Arabella	iricolor	
Arabella	semimaculata	
Drilonereis	spp	
Lumbrineris	spp	
Flabelliderma	essenbergae	
Naineris	dendritica	
Hemipodus	borealis	
Nereis	mediator	
Platynereis	bicanaliculata	
Eulalia	spp	
Pterocirrus	spp	
Synelmis	spp	
Halosydna	brevisetosa	Scaleworm
Typosylis	ui	
Salmacina	tribranchiata	
Serpula	vermicularis	
Macrochaeta	spp	
Cirriformia	spirabrancha	
Dodecaceria	fewkesi	
Poecilochaetidae	ui	
Phragmatopoma	californica	Sandcastle worms
Polycirrus	spp	
Phylum: Arthropoda		Class: Crustacea
Alpheus	sp	decapod
Cancer	antennarius	Rock crab
Cancer	branneri	decapod
Crangon	alba	decapod

Genus	Species	Common name
Crangon	nigricauda	decapod
Cycloxanthops	novemdentatus	decapod
Heptacarpus	pictus	Caridean shrimp
Heptacarpus	taylori	decapod
Lebbeus	lagunae	decapod
Lophopanopeus	bellus	decapod
Loxorhynchus	crispatus	masking crab, moss crab
Lysmata	californica	red rock shrimp
Pachygrapsus	crassipes	Lined shore crab
Pagurus	hirsutiusculus	hermit crab
Pagurus	samuelis	hermit crab
Panulirus	interruptus	California Spiny Lobster
Paraxanthias	taylori	Lumpy pebble crab
Petrolisthes	cinctipes	Flat Porcelain Crab
Pilumnus	spinohirsutus	decapod
Pugettia	dalli	decapod
Pugettia	producta	decapod
Spirontocaris	picta	decapod
Taliepus	nuttali	Globose kelp crab
Pentidotea	resecata	isopod
Cirolana	harfordi	isopod
Idotea	urotoma	Flat-tailed Isopod
Ligia	occidentalis	Rock louse
Idotea	aculeata	isopod
Idotea	kirchanskii	isopod
Paranthura	elegans	isopod
Unidentified tanaid	sp	
Balanus	glandula	Acorn barnacle
Chthamalus	fissus	Acorn barnacle
Chthamalus	spp	barnacle
Pollicipes	polymerus	Goose Barnacle
Tetraclita	rubescens	Pink thatched barnacle
Phylum: Cnidaria		Class: Anthozoa
Astrangia	lajollaensis	
Anthopleura	eleganitssima	Aggregating Anemone
Anthopleura	sola	Solitary anemone
Epiactus	prolifera	Brooding anemone
Phylum: Echinodermata		Class: Asteroidea
Astrometis	sertulifera	Soft seastar
Pisaster	giganteus	Knobby seastar, blue seastar
Pisaster	ochraceus	Ochre seastar
Asterina	miniata	Bat star

Genus	Species	Common name
Phylum: Echinodermata		Class: Echinodea
Strongylocentrotus	franciscanus	Red sea urchin
Strongylocentrotus	purpuratus	Purple sea urchin
Lytechinus	anamesus	
Phylum: Echinodermata		Class: Holothruoidea
Parastichopus	parvimensis	Warty sea cucumber
Phylum: Echinodermata		Class: Ophiuroidea
Amphipholis	pugetana	
Ophioderma	panamense	Panamanian serpent star
Ophionereis	annulata	Banded brittle star
Ophiothrix	rudis	
Ophiothrix	spiculata	Spiny brittle star
Ophioplocus	esmarki	Esmark's Serpent Star
Ophiopteris	papillosa	Flat-Spined Brittle Star
Phylum: Ectoprocta		
Brown bryozoan	spp	
Cauloramphus	spiniferum	
Crisia	maxima	
Eurystomella	bilabiata	
Figularia	hilli	
Membranipora	fusca	
Red bryozoan	spp	
Unidentified ectoprocts	spp	
Phylum: Mollusca		Class: Bivalvia
Codakia	californica	
Cumingia	californica	
Hiatella	arctica	Little Gaper
Platyodon	cancellatus	Checked Borer
Netastoma	rostrata	Beaked Piddock
Penitella	penita	Flap-tipped Piddock
Modiolus	capax	Fat Horse Mussel
Adula	falcata	Rough Pea-Pod Borer
Lithophaga	plumula	Date Mussel
Mytilus	californianus	California mussel, sea mussel
Mytilus	galloprovincialis	Bay mussel
Septifer	bifurcatus	Platform mussel
Leptopecten	monotimeris	Broad-Eared Pecten
Ostrea	lurida	Native Oyster, Olympia Oyster
Hinnites	giganteus	Rock Scallop
Trachycardium	quadragenarium	Spiny Cockle
Glans	carpenteri	Little Heart Clam
Chama	arcana	
Pseudochama	exogyra	Reversed chama

Genus	Species	Common name
Nuttallia	nuttallii	Purple Clam
Semele	decisa	Clipped Semele
Semele	rupicola	Semele-of-the-rocks
Diplodonta	orbella	Round Diplodonta
Chione	undatella	Wavy Chione
Protothaca	staminea	Common Littleneck Clam
Phylum: Mollusca		Class: Cephalopoda
Octopus	bimaculoides	Two-spotted octopus
Phylum: Mollusca		Class: Gastropoda
Aplysia	californica	California Brown Sea Hare
Aplysia	vaccaria	California Black Sea Hare
Acmaea	rosacea	
Lottia	conus	
Lottia	strigatella	
Lottia	asmi	Black limpet
Lottia	digitalis	Ribbed limpet, fingered limpet
Lottia	gigantea	Owl limpet
Lottia	limatula	File Limpet
Lottia	paradigitalis	
Lottia	pelta	Shield limpet
Macklintockia	scabra	Rough limpet
Notoacmea	insessa	Seaweed Limpet
Tectura	paleacea	Surfgrass Limpet
Diodora	aspera	Rough Keyhole Limpet
Fisurella	volcano	Volcano Limpet
Megathura	crenulata	Giant keyhole limpet
Haliotis	corrugata	Pink Abalone
Haliotis	cracherodii	Black Abalone
Haliotis	fulgens	Green abalone
Haliotis	rufescens	Red Abalone
Norrisia	norrisi	Norris' top snail
Tegula	aureotincta	snail
Tegula	eiseni	Banded tegula
Tegula	funebralis	Black turban snail, Black Tegula
Homalopoma	luridum	snail
Lithopoma	gibberosum	snail
Lithopoma	undosa	Wavy Turban Snail
Caecum	californicum	
Cerithiopsis	cosmia	
Fartulum	orcutti	
Hipponix	antiquatus	
Nassarina	penicillata	
Notoacmea	fenestrata	

Genus	Species	Common name
Seila	monteryensis	
Teinostoma	supravallatum	
Tricolia	pulloides	
Triphora	pedroana	
Turbonilla	jewetti	
Turbonilla	kelseyi	
Turbonilla	tenuicula	
Caecum	crebricinctum	
Hyalina	taeniolata	
Pedipes	unisulcatus	
Tricolia	rubrilineata	
Trimusculus	reticulatus	Reticulate Button Snail
Navanax	inermis	snail
Haminoea	virescens	snail
Crepidula	aculeata	Spiny Slipper Snail
Crepidula	adunca	Hooked Slipper Snail
Crepidula	norrisiarum	snail
Crepidula	onyx	Onyx Slipper Snail
Crepidula	perforans	Western White Slipper Snail
Crepipatella	lingulata	Half-Slipper Snail
Cypraea	spadicea	Chestnut cowrie
Epitonium	tinctum	Tinted Wentletrap
Opalia	funiculata	Sculptured Wentletrap
Janthina	janthina	snail
Lacuna	unifasciata	snail
Littorina	keenae	Gray Periwinkle
Littorina	scutulata	Checkered periwinkle
Erato	vitellina	Apple-Seed Erato
Trivia	californiana	snail
Trivia	solandri	Solander's Trivia
Serpulorbis	squamigerus	Scaly tube snail
Vitrinella	oldroydi	snail
Kelletia	kelleti	Kellet's whelk
Macron	lividus	Livid macron
Amphissa	versicolor	snail
Mitrella	carinata	Carinated Dove Snail
Conus	californicus	California Cone
Mitra	idae	Ida's Miter
Ceratostoma	nuttalli	Nuttall's Hornmouth
Ocenebra	circumtexta	Circled Rock Snail
Roperia	poulsoni	Poulson's Rock Snail
Olivella	biplicata	Purple Olive, Purple Olivella
Acanthina	spirata	Angular unicorn

Genus	Species	Common name
Pseudomelatoma	penicillata	snail
Aeolidiella	chromosoma	nudibranch
Aeolidiella	oliviae	Olive's aeolid
Cadlina	flavomaculata	Yellow-spotted cadlina
Cadlina	sparsa	nudibranch
Mexichromis	porterae	Porter's chromodorid
Conualevia	alba	White dorid
Doriopsilla	albopunctata	nudibranch
Doriopsilla	spp	Yellowgill porostome
Dirona	picta	nudibranch
Diaulula	sandiegensis	San Diego dorid
Thordisa	bimaculata	nudibranch
Doto	kya	Seal doto
Eubranchus	rustyus	nudibranch
Facelina	stearnsi	nudibranch
Hermissenda	crassicornis	Hermissenda
Phidiana	hiltoni	Hilton's aeolid
Flabellina	iodinea	nudibranch
Flabellina	trilineata	Three lined aeolid
Hopkinsia	rosacea	Hopkin's Rose
Aegires	albopunctatus	nudibranch
Laila	cockerelli	nudibranch
Triopha	catalinae	Catalina triopha
Triopha	maculata	nudibranch
Rostanga	pulchra	nudibranch
Tritonia	myrakeenae	Myra's tritonia
Elysia	hedgpethi	Hedgpeth's sea hare
Aplysiopsis	enteromorphae	sea hare
Phyllum: Mollusca		Class: Pelecypoda
Barbatia	bailyi	Baily's Ark
Phyllum: Mollusca		Class: Polyplacophora
Nuttalina	californica	
Nuttalina	fluxa	Troglodyte chiton
Lepidochitona	hartwegii	
Lepidozona	californiensis	
Stenoplax	conspicua	Conspicuous Chiton
Mopalia	muscosa	Mossy Chiton
Phyllum: Platyhelminthes		Class: Turbellaria
Prostheceraeus	bellostriatus	Polyclad worm
Phyllum: Porifera		
Hymeniacidon	spp	
Leucosolenia	spp	
Mycale	macginitiei	

Genus	Species	Common name
Plocamia	karykina	
Xestospongia	vanilla	
Cliona	celata var californiana	
Phyllum: Urochordata		
Ascidia	paratropa	
Cnemidocarpa	finmarkiensus	
Euherdmania	claviformis	

APPENDIX D. Fish Fauna of Cabrillo National Monument. For details on how fishing is regulated within and adjacent to the monument, see Section III.B. Species list was obtained from the NPSpecies database.

Common Name	Scientific Name	Target of Fishing?[a]		Occurrence[b]	Where Found
		Sport	Commercial		
NEARSHORE SPECIES					
NEARSHORE ROCKFISH [c]					
Black and yellow rockfish	Sebastes chrysomelas	Yes	Yes	Prob. Present	Intertidal-36m
Grass rockfish	Sebastes rastrelliger	Yes	Yes	Present	Intertidal-6m
Kelp rockfish	Sebastes atrovirens	Yes	Yes	Present	5-15m, water column in kelp
Blue rockfish	Sebastes mystinus	Yes	Yes	Prob. Present	Intertidal-91m, kelp canopy
Brown rockfish	Sebastes auriculatus	Yes	Yes	Prob. Present	3-55m, subtidal reefs
Olive rockfish	Sebastes serranoides	Yes	Yes	Prob. Present	1-121m
Treefish	Sebastes serriceps	Yes	Yes	Prob. Present	3-45m
NEARSHORE GROUNDFISH					
California Halibut	Paralichthys californicus	Yes	Yes	Prob. Present	usually < 100m, most abundant <30m
Sanddab, Speckled	Citharichthys stigmaeus	Yes	Yes	Prob. Present	sand, mud surface to 1200 ft
NEARSHORE CROAKERS					
California Corbina	Menticirrhus undulatus	Yes	PROHIBITED	Present	sandy beaches to 15m
Queenfish	Seriphus politus	Yes		Present	
White Seabass	Atractoscion nobilis	Yes	Yes	Present	rocky bottoms and kelp beds
White Croaker	Genyonemus lineatus	Yes	Yes	Prob. Present	sand and mud, usually 3-30m
Yellowfin Croaker	Umbrina roncador	Yes	PROHIBITED	Present	mostly <10m
Black Croaker	Cheilotrema saturnum			Present	
SURFPERCHES (family Embiotocidae)					
Black perch	Embiotoca jacksoni	Yes	Yes	Present	rock & kelp
Dwarf perch	Micrometrus minimus			Present	rock & kelp
Kelp perch	Brachyistius frenatus			Present	water column in kelp
Pile perch	Rhachochilus vacca			Present	various shallow
Shiner perch	Cymatogaster aggregata			Prob. Present	various shallow
Sharpnose seaperch	Phanerodon atripes			Prob. Present	rock & kelp
Striped seaperch	Embiotoca lateralis			Prob. Present	rock & kelp
White seaperch	Phanerodon furcatus			Present	various shallow
Walleye surfperch	Hyperprosopon argenteum			Present	various shallow
Rainbow seaperch	Hypsurus carvi			Present	rock & kelp
Rubberlip seaperch	Rhacochilus toxotes			Present	various shallow

Common Name	Scientific Name	Target of Fishing?[a] Sport	Commercial	Occurrence[b]	Where Found
OTHER NEARSHORE FISH TAKEN (or historically taken) BY FISHERMEN					
Cabezon	Scorpaenichthys marmoratus	Yes	Yes	Present	Intertidal-76m
California Scorpionfish	Scorpaena guttata	Yes	Yes	Present	3-182m
California Sheephead	Semicossyphus pulcher	Yes	Yes	Present	3-55m
Greenling, Painted	Oxylebius pictus	Yes	Yes	Prob. Present	
Giant Seabass	Stereolepis gigas	PROHIBITED	PROHIBITED	Prob. Present	prefer nearshore rocky reefs 12-43m
Kelp Bass	Paralabrax clathratus	Yes	PROHIBITED	Present	shallow to 50m, water column in kelp
Barred Sand Bass	Paralabrax nebulifer	Yes	PROHIBITED	Present	usually < 30m
Spotted Sand Bass	Paralabrax maculato-fasciatus	Yes	PROHIBITED	Prob. Present	shallow sandy-mud bays with surfgrass or eelgrass
Garibaldi	Hypsypops rubicundus	PROHIBITED	PROHIBITED	Present	subtidal reefs
Wolf eel, northern wolfish	Anarrhichthys ocellatus		PROHIBITED	Prob. Present	inshore, soft bottoms
Striped mullet	Mugil cephalus	Yes	Yes	Prob. Present	
California moray	Gymnothorax mordax		Yes	Prob. Present	
Sargo	Anisotremus davidsoni	Yes		Present	
Salema	Xenistius californiensis	Yes		Present	
Opaleye	Girella nigricans	incidental	incidental	Present	kelp beds, found to 30m
Yellowtail	Seriola lalandi	Yes	Yes	Prob. Present	bathypelagic, to 690m, but usually caught in shallower water, near kelp
Bonefish	Albula vulpes	Yes	Yes	Prob. Present	reefs, shallows, bays
OTHER NEARSHORE FISH					
Zebra perch	Hermosilla azurea			Present	
Senorita	Oxyjulius californica			Present	kelp canopy
Wooly sculpin	Clinocotius analis			Present	rocky intertidal
Lavender sculpin	Leiocottus hirundo			Prob. Present	
Coralline sculpin	Artedius corallinus			Prob. Present	
Bonehead sculpin	Artedius notospilotus			Prob. Present	
Roughback sculpin	Chitonotus pugetensis			Prob. Present	
Yellowchin sculpin	Icelinus quadriseriatus			Prob. Present	
Rosy sculpin	Oligocottus rubellio			Prob. Present	
Snubnose sculpin	Orthonopias triacis			Prob. Present	
Roughcheek sculpin	Ruscarius creaseri			Prob. Present	
Reef finspot	Paraclinus integripinnis			Present	rocky intertidal
Rockpool blenny	Hypsoblennius gilberti			Present	rocky intertidal
Bay blenny	Hypsoblennius gentilus			Present	
Mussel blenny	Hypsoblennius jenkinsi			Present	

Common Name	Scientific Name	Target of Fishing?[a] Sport	Target of Fishing?[a] Commercial	Occurrence[b]	Where Found
rockweed gunnel	Apodichthys fucorum			Prob. Present	
Slimy snailfish	Liparis mucosus			Prob. Present	
Finescale triggerfish	Balistes polylepis			Prob. Present	
Rock wrasse	Halichoeres semicinctus			Present	
Blacksmith	Chromis punctipinnis			Prob. Present	kelp canopy
Kelp gunnel	Ulvicola sanctaerosae			Prob. Present	
Island kelpfish	Alloclinus holderi			Prob. Present	
Giant kelpfish	Heterostichus rostratus			Present	water column in kelp
Spotted kelpfish	Gibbonsia elegans			Present	intertidal
Rough ronquil	Rathbunella alleni			Present	
Stripedfin ronquil	Rathbunella hypoplecta			Prob. Present	
Sarcastic fringehead	Neoclinus blanchardi			Prob. Present	
California clingfish	Gobiesox rhessodon			Present	intertidal
Kelp clingfish	Rimicola muscarum			Prob. Present	
Slender clingfish	Rimicola eigenmanni			Present	
Spotted cusk eel	Chilara taylori			Prob. Present	
Great pipefish	Syngnathus californiensis			Prob. Present	
Bay pipefish	Syngnathus leptorhynchus			Prob. Present	
Half Moon	Medialuna californiensis	incidental	incidental	Present	shallow subtidal and kelp beds, found to 30m
SKATES and RAYS					
Shovelnose guitarfish	Rhinobatos productus	Yes		Present	sand and mud to 17m
Banded guitarfish	Zapteryx exasperata			Prob. Present	
Bat ray	Myliobatis californica	Yes		Prob. Present	mud, sand, rocks and kelp; down to 50m
Thornback	Platyrhinoidis triseriata			Prob. Present	shallow to 50m in sand
Round stingray	Urolophus halleri	Yes		Prob. Present	mostly < 17m, loose sand and mud
Spiny Dogfish	Squalus acanthius			Prob. Present	shallow bays, sandy beaches

Common Name	Scientific Name	Sport	Commercial	Occurrence	Where Found
SILVERSIDES					
Jacksmelt	Atherinopsis californicus	Yes	Yes	Present	bays and up to few miles offshore, spawn in eelgrass
Topsmelt	Atherinops affinis	Yes	Yes	Present	bays and nearshore
Grunion	Leuresthes tenuis	Yes		Present	nearshore down to 20m
GOBIES					
Arrow goby	Clevelandia ios		minor aquarium trade	Prob. Present	hard substrates
Cheekspot goby	Ilypnus gilberti			Prob. Present	hard substrates

Common Name	Scientific Name	Target of Fishing?[a] Sport	Commercial	Occurrence[b]	Where Found
Shadow goby	Quietula y-cauda			Prob. Present	
Blind goby	Typhlogobius californiensis			Present	
Longjaw mudsucker	Gillichthys mirabilis			Prob. Present	
Blackeye goby	Coryphopterus nicholsi			Prob. Present	hard substrates
NEARSHORE SHARKS [b]					
Pacific Angel Shark	Squatina californica	Yes		Prob. Present	range from 1-200m, remain buried in sand during day
Leopard Shark	Triakis semifasciata	Yes		Present	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		Prob. Present	females <15m, males >22m, close inshore up to 500m
Swell shark	Cephaloscyllium ventriosum			Prob. Present	
Horn shark	Heterodontus francisci			Present	2-150m, demersal
Spotted ratfish	Hydrolagus colliei			Prob. Present	
Bronze whaler, narrowtooth shark	Carcharhinus brachyurus			Prob. Present	reef associated 0-100m
Gray Smoothhound	Mustelus californicus	Yes		Present	
Usually DEEPER FISH					
SHELF ROCKFISH: A state designated category of 20 particular species of Sebastes					
Rockfish, Vermillion	Sebastes miniatus	Yes	Yes	Prob. Present	shallow subtidal to 466m
DEEPER FLATFISH, generally					
English sole	Pleuronectes vetulus	Yes	Yes	Prob. Present	40-300 m
Fantail Sole	Xystreurys liolepis			Prob. Present	shallow to 100 m
California tonguefish	Symphurus atricauda			Prob. Present	
Hornyhead turbot	Pleuronichthys verticalis			Prob. Present	
Spotted turbot	Pleuronichthys ritteri			Prob. Present	
Diamond turbot	Hypsopsetta guttulata			Prob. Present	
C-O sole	Pleuronichthys coenosus			Prob. Present	
OTHER DEEPER-WATER FISH: Benthopelagic/Bathypelagic/Bathydemersal					
Specklefin midshipman	Porichthys myriaster			Present	
Plainfish midshipman	Porichthys notatus			Prob. Present	bathypelagic, 100-1500m
Pacific porgy	Calamus brachysomus			Prob. Present	0-200, sand and mud bottoms
Spiny dogfish	Squalus acanthias	Yes	Yes	Prob. Present	

Common Name	Scientific Name	Target of Fishing?[a] Sport	Commercial	Occurrence[b]	Where Found
EPIPELAGIC AND COASTAL PELAGIC SPECIES					
Pacific Bonito	Sarda chiliensis	Yes	Yes	Prob. Present	deep coastal waters and open ocean
California Barracuda	Sphyraena argentea	Yes	Yes	Present	
Pacific Sardine	Sardinops sagax	Yes	Yes	Prob. Present	
Northern Anchovy, Californian anchoveta	Engraulis mordax	Yes	Yes	Prob. Present	
Pacific mackerel	Scomber japonicus	Yes	Yes	Prob. Present	
Jack Mackerel	Trachurus symmetricus	Yes	Yes	Present	
Pacific Herring	Clupea pallasii		Yes	Prob. Present	inshore, bays
Slough Anchovy	Anchoa delicatissima			Prob. Present	0-50 m, inshore, bays
Deepbody Anchovy	Anchoa compressa			Prob. Present	inshore, bays

[a] Green shading: species ranked among the top 25 taxa in CPFV landings (lbs) for San Diego area ports in 2004.

Pink shading: species ranked among the top 20 taxa in total commercial landings (lbs) at San Diego, Point Loma and Mission Bay harbors combined.

[b] Present: species listed as "present" in the NPSpecies list for CABR, and in the fish inventory of Craig & Pondella (2005);

Prob. Present: species listed as "probably present" on the NPSpecies list for CABR.

[c] As a group, unspecified rockfish ranked fifth, and unspecified sharks ranked 22nd, in 2004 CPFV landings for San Diego area ports.

APPENDIX E . Sampling history (E: trace elements, O: organics) for California State Mussel Watch Project in the San Diego region. Stations are shown from south to north from the Mexican Border to the north jetty at the entrance to Mission Bay. Stations near Cabrillo National Monument are highlighted in yellow. Blanks indicate no sampling. Other stations located inside Mission Bay and upstream of the mouth of the San Diego River are not included.

Station #	Station Name	Latitude °N	Longitude °W	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00
906.0	Mexican Border	32.5336	117.1433									EO														
905.0	Tijuana River	32.5519	117.1344							EO																
904.8	Tijuana River/Imperial Beach	32.5683	117.1486								EO	EO														
904.0	Imperial Beach/Pier	32.5797	117.1361							E							EO									
842.0	Imperial Beach	32.5850	117.1325				E																			
881.5	San Diego Bay/Rohr Channel Mouth	32.6306	117.1103																E							
881.1	San Diego Bay/California Crane	32.6314	117.1078						E																	
881.4	Sweetwater River/Mouth 2	32.6419	117.1197															EO								
881.3	Sweetwater River/Mouth 1	32.6426	117.1200														EO	EO								
880.0	National City	32.6478	117.1186				O																			
881.0	San Diego Bay/ Sweetwater Marsh	32.6497	117.1106						EO						E											
883.0	San Diego Bay/Navy Amphibious Base	32.6531	117.1475				O	O	E																	
882.0	24th St Maritime Terminal/South	32.6543	117.1217					EO	E	E	E	E	E	E				E		E	EO					
882.2	24Th St Maritime Terminal/North	32.6569	117.1225						E						E	E			E			E				
852.0	Point Loma/A10s	32.6578	117.2694						E																	
882.4	San Diego Bay/Navy Pier 13	32.6622	117.1233						E	E	E															
850.0	Point Loma/STP/A8s	32.6639	117.2819					E																		
882.5	San Diego Bay/NASSCO Pier 12	32.6639	117.1236											EO												
850.5	Point Loma	32.6641	117.2683						E																	
840.2	Point Loma/Coast Guard Station	32.6653	117.2422									E														
902.0	Zuniga Jetty/Buoy	32.6656	117.2267				O																			

Station #	Station Name	Latitude °N	Longitude °W	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00
840.0	Naval Ocean Sys Cntr/Dolphin Tanks	32.6669	117.2436				E	E	EO		EO	E			E				E							
903.0	Zuniga Jetty	32.6672	117.2231							EO	E	EO														
885.0	San Diego Bay/Buoy 30	32.6692	117.1278					O																		
885.3	San Diego Bay/7th Street Ch/Mid	32.6697	117.1230																				EO	EO		
883.6	San Diego Bay/7th Street Channel	32.6725	117.1189											EO	EO		EO	EO				EO	EO		EO	EO
885.1	San Diego Bay/Paleta Creek/End	32.6742	117.1156																				EO			
884.0	San Diego Bay/Glorietta Bay	32.6769	117.1683					EO																		
839.2	Point Loma/STP Outfall	32.6789	117.2481									E	E													
841.0	Coronado Hotel	32.6800	117.1800				E																			
849.0	Point Loma/A9d	32.6800	117.2861						E																	
849.5	Point Loma/A9s	32.6800	117.2861						E																	
885.2	San Diego Bay/32nd Street	32.6808	117.1310												EO											
883.3	San Diego Bay/ Chollas Creek/End	32.6844	117.1350																				EO	EO		
883.1	San Diego Bay/Chollas Creek	32.6869	117.1333												EO					EO		O	EO			EO
901.0	San Diego Bay/ Degausing Station	32.6869	117.2275					EO	EO								EO	EO								EO
885.4	San Diego Bay/ NASSCO 28th St Pier	32.6872	117.1393												O											
883.2	San Diego Bay/ Chollas Creek/Mouth	32.6875	117.1292																				EO			
886.0	San Diego Bay/ NASSCO	32.6883	117.1400						E													EO				
882.7	San Diego Bay/ Sampson Street Pier	32.6913	117.1460										O	EO	EO				EO			EO				
888.0	San Diego Bay/Coronado Bridge	32.6917	117.1511			EO	EO											EO	EO				EO			
882.6	San Diego Bay/Sampson St Extension	32.6924	117.1450									EO														
887.0	San Diego Bay/Evans Street	32.6925	117.1494					EO	EO								EO	EO	EO					EO		EO
882.8	San Diego Bay/KELCO Pier	32.6928	117.1483										O		EO			EO								
886.2	San Diego Gas & Electric Silvergate	32.6928	117.1461												EO										EO	
882.9	San Diego Bay/ Coronado Brdg/East	32.6933	117.1500										O		EO											

Station #	Station Name	Latitude °N	Longitude °W	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00
883.4	San Diego Bay/ Continental Maritime	32.6942	117.1494												E				EO	EO					EO	
900.5	San Diego Bay/Bait Tanks	32.6944	117.2361								E															
901.2	San Diego Bay/N Island/Ammo Pier	32.6958	117.2278								EO															
883.7	San Diego Bay/ Terminal S-10th St	32.6967	117.1528																EO							
883.5	San Diego Bay/Tuna Docks	32.7017	117.1603										O		E					EO			EO			
883.8	San Diego Bay/Switzer Creek	32.7019	117.1579																	EO		O	EO		EO	EO
890.0	San Diego Bay/8th Avenue	32.7031	117.1614					O	EO																	
889.0	San Diego Bay/Coronado Island	32.7039	117.1808					O																		
900.0	San Diego Bay/Range Marker	32.7047	117.2328								E															
839.0	Point Loma/Pink House	32.7054	117.2557				E	EO																		
899.1	San Diego Bay/ Shelter Is/Duffy's	32.7100	117.2331										E													
896.2	San Diego Bay/N Is/DPDO Dumpsite	32.7103	117.2178								EO	EO														
892.0	San Diego Bay/N Island/Boathouse	32.7117	117.1881								EO															
899.0	San Diego Bay/ Shelter Is/Fshg Pier	32.7117	117.2283		O	EO	EO								E	E		EO	EO		EO			EO	EO	EO
891.0	San Diego Bay/G Street Pier	32.7122	117.1758			E	EO	EO	O					E												
898.5	SD Bay/N Island/ Aircraft Platform	32.7128	117.1894																					EO		
898.2	San Diego Bay/N Is/Launch Docks	32.7144	117.1939							EO																
898.4	San Diego Bay/North Island Plat	32.7153	117.2044							E																
893.5	San Diego Bay/B Street Pier	32.7172	117.1769																			O			EO	
899.2	San Diego Bay/Shelter Island	32.7181	117.2272								E								EO							
899.4	San Diego Bay/ Shelter Is/Fuel Dock	32.7186	117.2261										EO	EO												EO
897.0	San Diego Bay/Shelter Is/East	32.7189	117.2183					E	EO																	
898.0	Commercial Basin/Carlton Street	32.7219	117.2267					O	EO						EO	EO			EO							EO
895.6	San Diego Bay/Grape St Storm Drain	32.7225	117.1736																EO							EO

Station #	Station Name	Latitude °N	Longitude °W	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00
895.0	Harbor Island Drive/East	32.7239	117.1886					E	O																	
894.3	SD Bay/Harbor Is/E Basin/Mid Chan	32.7242	117.1875												EO											
897.5	Commercial Basin/ North Harbor Dr	32.7247	117.2256						O			EO	EO	EO												
894.1	SD Bay/Harbor Is/E Basin/Storm Dr2	32.7258	117.1883							EO					EO									EO	EO	EO
895.4	Harbor Island/West Bay/West	32.7264	117.2128								E															
894.5	SD Bay/Harbor Is/E Basin/W End Doc	32.7267	117.1911						O	EO																
894.6	SD Bay/Harbor Is/E Basin/W End	32.7269	117.1947										EO													
894.2	SD Bay/Harbor Is/E Basin/E End Doc	32.7272	117.1875												EO											
893.0	San Diego Bay/Laurel Street	32.7275	117.1785								O								EO			O		EO		
894.8	Laurel Street Storm Drain	32.7275	117.1783												EO										EO	
895.2	Harbor Island/West Bay/East	32.7275	117.1989								E															
894.0	SD Bay/Harbor Is/E Basin/Storm Dr	32.7278	117.1856					O	EO		O	EO		EO	EO	EO	EO	EO	EO	EO	EO		EO			
838.2	Point Loma/Sunset Cliffs	32.7294	117.2564									E	E	E	E	E	EO	E	E							
837.0	Mission Bay/South Jetty	32.7558	117.2583				E	E																		
874.0	San Diego River/Channel	32.7572	117.2497							EO																
873.0	Mission Bay/Entrance	32.7578	117.2453				EO																			
836.0	Mission Bay/North Jetty	32.7583	117.2583				E																			

APPENDIX F

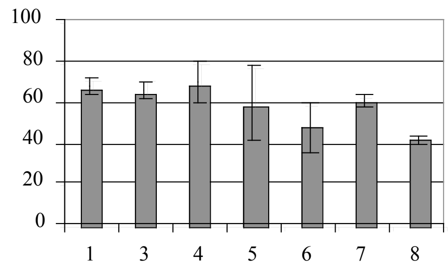
Preliminary figures from the sentinel mussel project conducted by Cabrillo National Monument from 2004-2005. Units for aluminum and copper are ppm. Units for PCB101, and PCB118, and fluroanthene are ppb. Site locations (x-axes) are as follows (see text for map of sites and other details):

0=inner bay intertidal (vs. 1 which is from inner bay pier)
1= inner bay
2= outer bay
3 = Cabr3
4 = Cabr2
5 = Cabr1
6 = Oceanside
7 = SIO Pier
8= cage control (mussels taken directly from SIO pier)

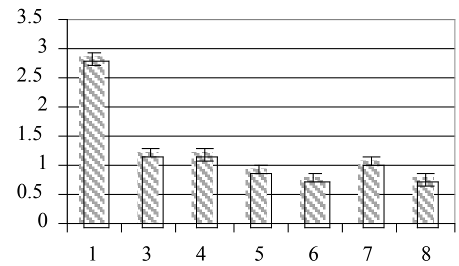
First quarter Aug-Nov. 2004
Second quarter Dec 2004-Mar 2005C
Third quarter Mar-May 2005
Fourth quarter June-Sept 2005

All figures were provided by Bonnie Becker, Cabrillo National Monument.

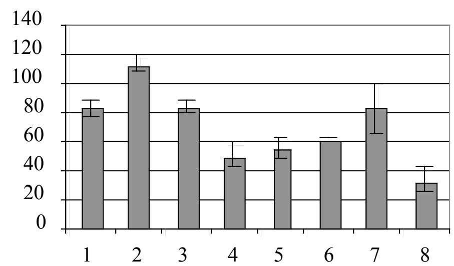
First Quarter--Aluminum



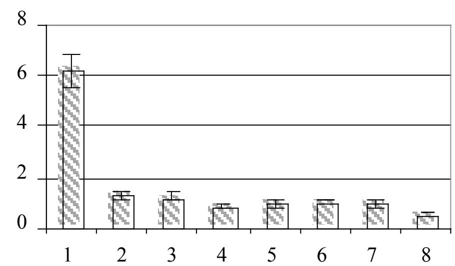
First Quarter--Copper



Second Quarter--Aluminum



Second Quarter--Copper



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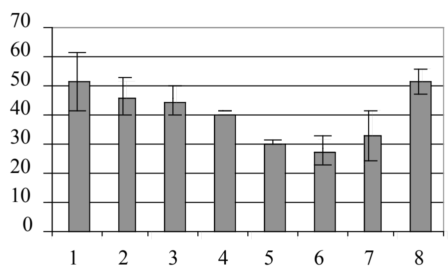
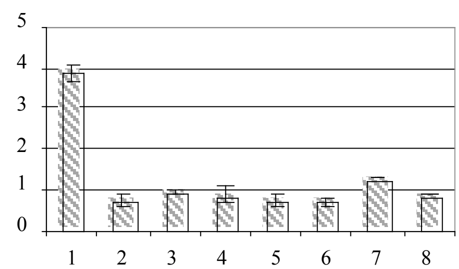


Third Quarter--Copper



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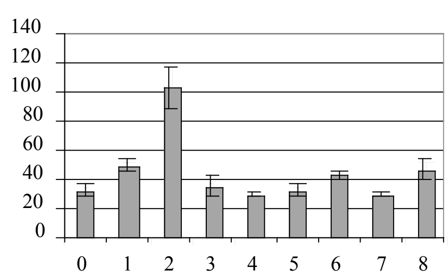
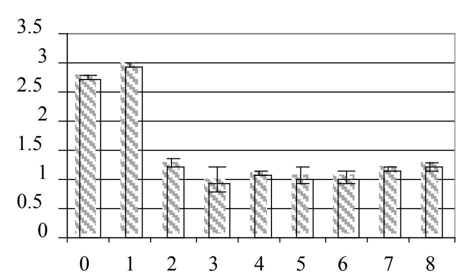
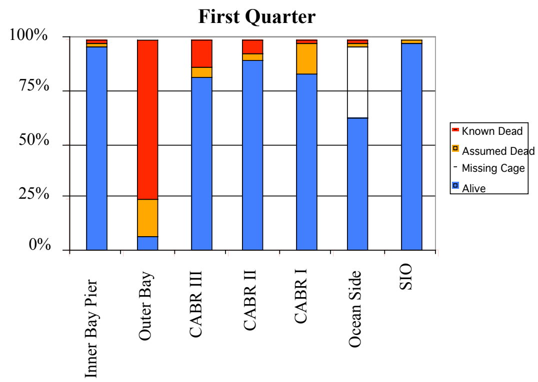
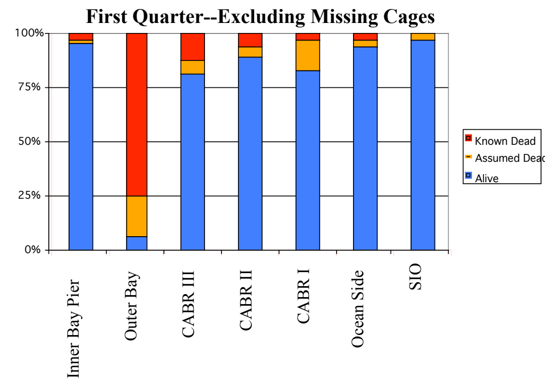
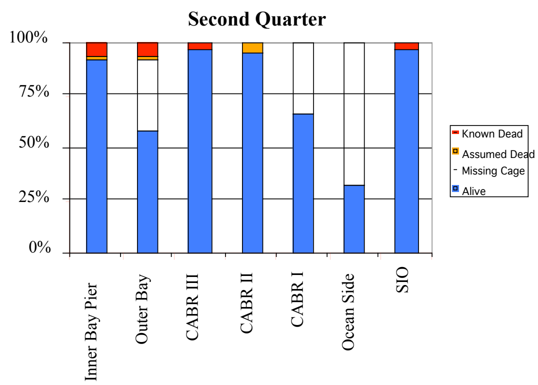


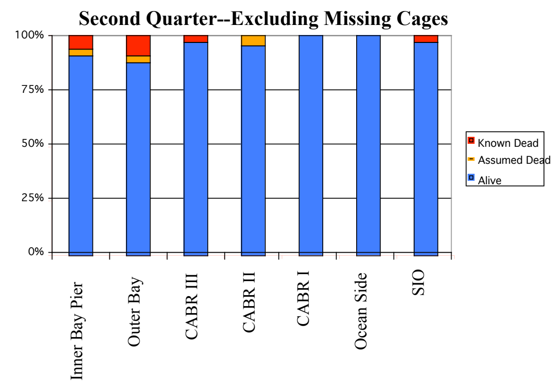
Fourth Quarter--Copper

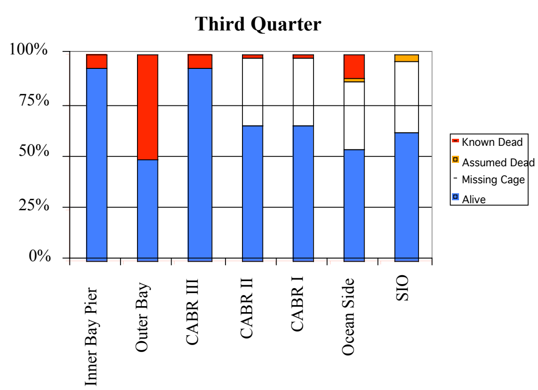


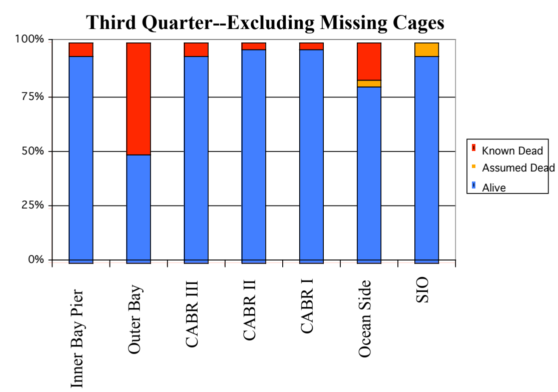

First Quarter
100%
75%
50%
25%
0%
Inner Bay Pier
Outer Bay
CABR III
CABR II
CABR I
Ocean Side
SIO
Known Dead
Assumed Dead
Missing Cage
Alive

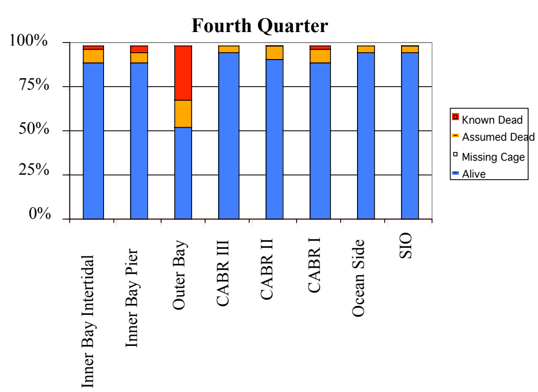

First Quarter--Excluding Missing Cages
100%
75%
50%
25%
0%
Inner Bay Pier
Outer Bay
CABR III
CABR II
CABR I
Ocean Side
SIO
Known Dead
Assumed Dead
Alive

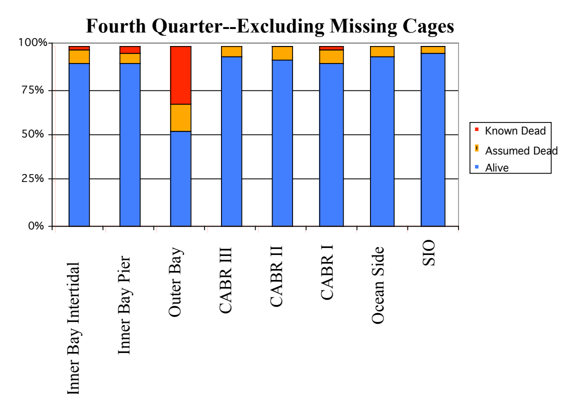

Second Quarter
100%
75%
50%
25%
0%
Inner Bay Pier
Outer Bay
CABR III
CABR II
CABR I
Ocean Side
SIO
Known Dead
Assumed Dead
Missing Cage
Alive


Second Quarter--Excluding Missing Cages
100%
75%
50%
25%
0%
Inner Bay Pier
Outer Bay
CABR III
CABR II
CABR I
Ocean Side
SIO
Known Dead
Assumed Dead
Alive

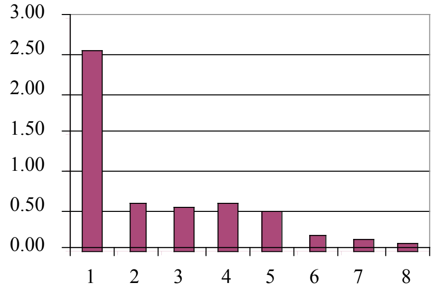

Third Quarter
100%
75%
50%
25%
0%
Inner Bay Pier
Outer Bay
CABR III
CABR II
CABR I
Ocean Side
SIO
Known Dead
Assumed Dead
Missing Cage
Alive


Third Quarter--Excluding Missing Cages
100%
75%
50%
25%
0%
Inner Bay Pier
Outer Bay
CABR III
CABR II
CABR I
Ocean Side
SIO
Known Dead
Assumed Dead
Alive

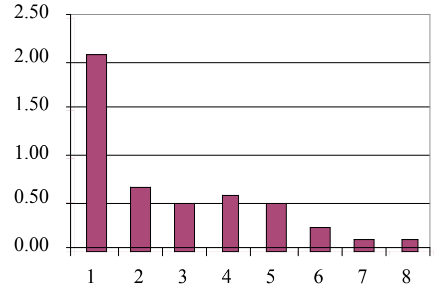

Fourth Quarter
100%
75%
50%
25%
0%
Inner Bay Intertidal
Inner Bay Pier
Outer Bay
CABR III
CABR II
CABR I
Ocean Side
SIO
Known Dead
Assumed Dead
Missing Cage
Alive


Fourth Quarter--Excluding Missing Cages
100%
75%
50%
25%
0%
Inner Bay Intertidal
Inner Bay Pier
Outer Bay
CABR III
CABR II
CABR I
Ocean Side
SIO
Known Dead
Assumed Dead
Alive

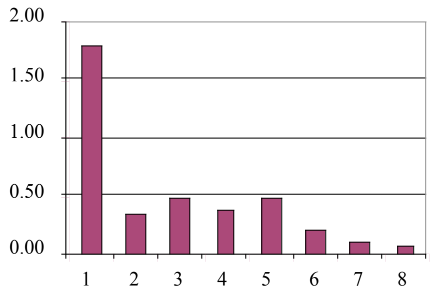
First Quarter--PCB 101



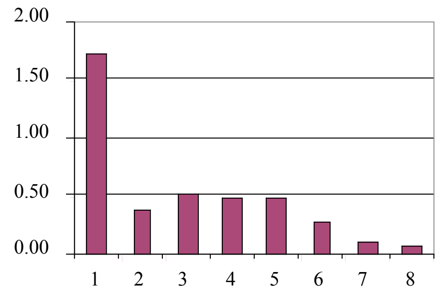
First Quarter--PCB 118



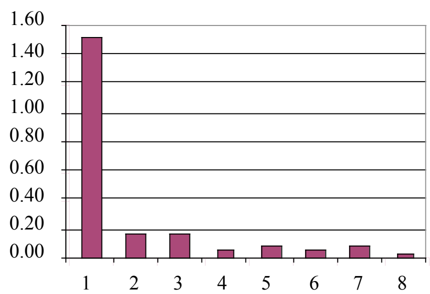
Second Quarter--PCB 101



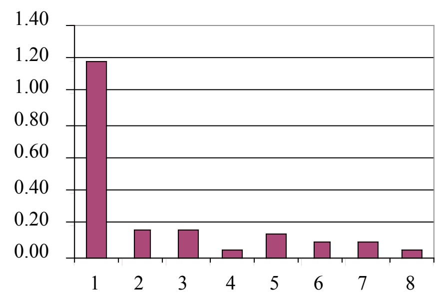
Second Quarter--PCB 118



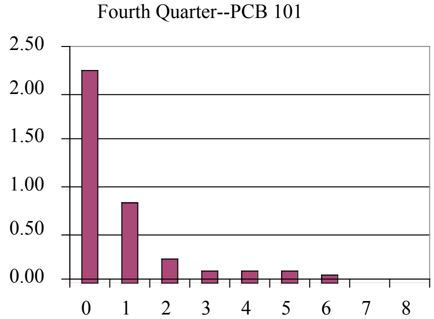
Third Quarter--PCB 101



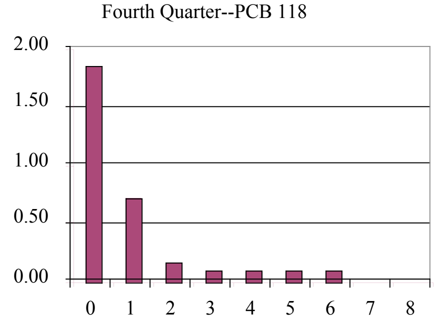
Third Quarter--PCB 118

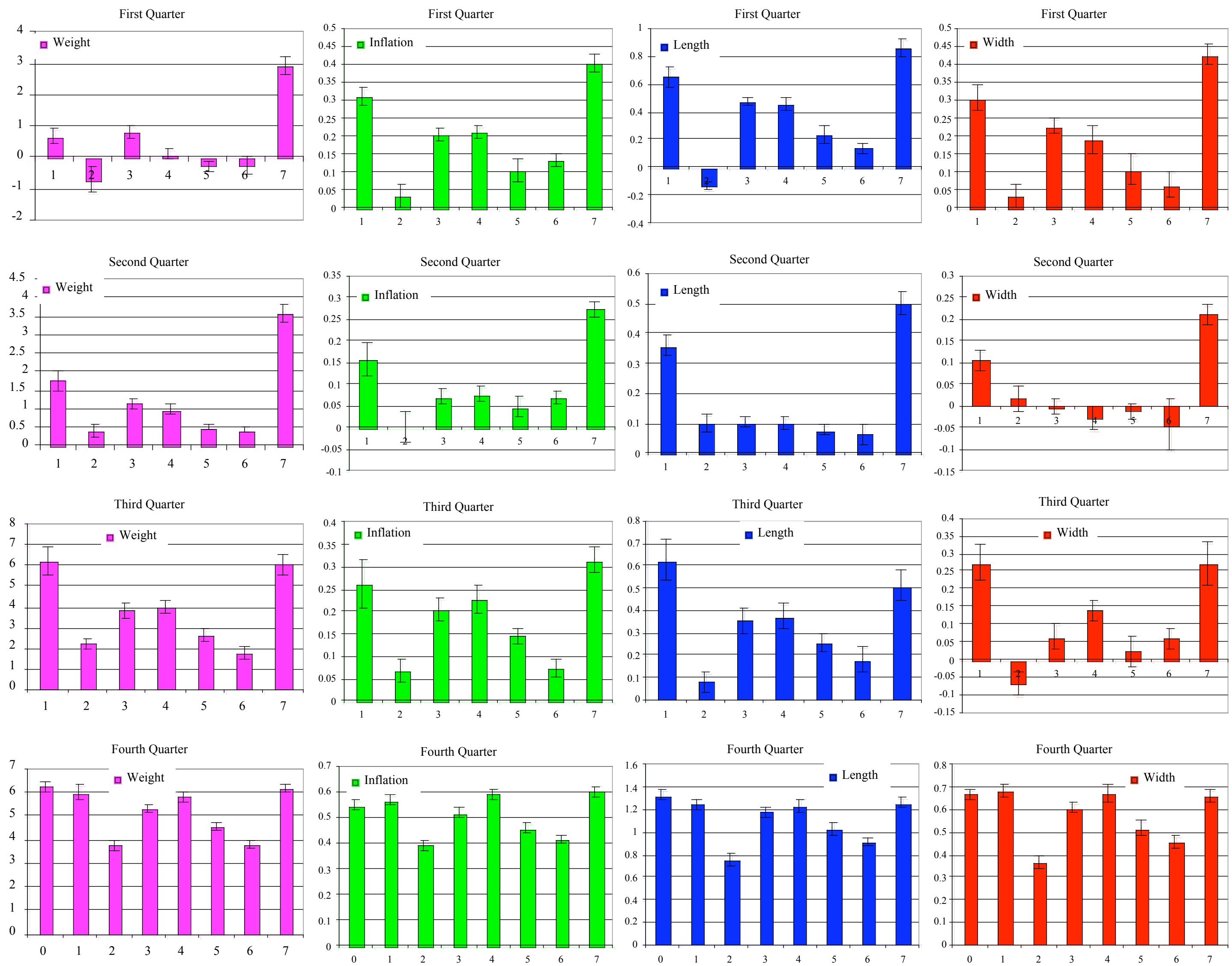


Fourth Quarter--PCB 101



Fourth Quarter--PCB 118




First Quarter
Weight
First Quarter
Inflation
First Quarter
Length
First Quarter
Width
Second Quarter
Weight
Second Quarter
Inflation
Second Quarter
Length
Second Quarter
Width
Third Quarter
Weight
Third Quarter
Inflation
Third Quarter
Length
Third Quarter
Width
Fourth Quarter
Weight
Fourth Quarter
Inflation
Fourth Quarter
Length
Fourth Quarter
Width

APPENDIX G

Synopsis of California state fishing regulations for fish occurring in Cabrillo National Monument that are targets of commercial or sport fishing in California, along with information about pertinent regulatory actions. Several state or federally designated categories of fish (e.g., state rockfish categories, federally regulated groundfish) contain more species than are listed here; only fish appearing on species lists for Cabrillo National Monument are included in the appendix. The appendix is not an exhaustive list of state fishing regulations. The timing of seasons for commercial and recreational catch are subject to change from year to year. See text for details on federal regulations pertaining to these species.

Common Name	Scientfic Name	On-line Inform. sources*	Pertinent Regulatory Actions**	Details about commercial or recreational catch.
ALL FISH	Owing to the MRPA **gill nets and trammel nets shall not be used** in waters between a line extending due west true from Point Arguello in Santa Barbara County south to the U.S.-Mexico border that are within 3 nautical miles of shore. Owing to SB 1459, **bottom trawling is prohibited** for all species within 3 nautical miles of the mainland in District 19, with the exception of halibut in designated halibut trawlling grounds.			
NEARSHORE FISH				
Rockfish, Generally	Sebastes spp.	A	CA-NFMPlan CA-RCG CCCA	Commercial catch of all rockfish is regulated owing to status as Federally managed groundfish, and inclusion in the state Nearshore Fisheries Management Plan . **COMMERCIAL CATCH** of shallow nearshore rockfish (see below) requires a Limited Entry Nearshore Fishery Permit. Take by finfish trap requires a Nearshore Finfish Trap Endorsement. No more than 50 traps may be used in state waters along the mainland shore. Seasons, area and depth restrictions apply. **RECREATIONAL CATCH** is regulated by **Rules for the RCG Complex** (includes all species of Rockfish, Cabezon and Greenlings in combination), which in 2006 state that catch by boat-based anglers open Mar.1-Dec. 31 in waters 0-60 fm, except during Sep. and Oct. when restricted to waters 0-30 fm. Shore-based anglers and divers open year round. The aggregate daily bag and possession limit is 10 fish per person within the RCG Complex (includes all species of Rockfish, Cabezon and Greenlings in combination) with smaller sub-limits on bocaccio, cabezon, and greenlings, which become included in the 10-fish RCG Complex aggregate limit. Recreational catch of **Yelloweye rockfish, canary rockfish and cowcod are PROHIBITED** (bag limit: zero).
Shallow Nearshore Rockfish (this state designated category contains more species than listed here***)		**Commercial catch of these species is affected by general rockfish rules above. In addition, a Limited Entry Nearshore Fishery Permit is required for these species.** Seasonal closures apply. As of 2006, only 57 permits are available in the South coast Region with 39 finfish trap endorsements. Without a **Nearshore Finfish Trap Endorsement**, fishing can only be by line. It is unlawful to use more than 150 hooks on a vessel, or to use more than 15 hooks per line, to take nearshore fish stocks for commercial purposes in ocean waters within one mile of shore within Fish and Game Districts 19. **Recreational catch** subject to RCG Complex rules, described under "Rockfish".		
Black and yellow rockfish	Sebastes chrysomelas	A, C, D	CA-NFMPlan NFPermit GMP CA-RCG CCCA GMP	Taken primarily by recreational anglers from boat or shore, or by divers, minor component of commercial and recreational catch, caught primarily north of Pt Conception.
Grass rockfish	Sebastes rastrelliger	A, B, D	CA-NFMPlan NFPermit GMP CA-RCG CCCA	

Common Name	Scientfic Name	On-line Inform. sources*	Pertinent Regulatory Actions**	Details about commercial or recreational catch.
Kelp rockfish	Sebastes atrovirens	A, B, D	CA-NFMPlan NFPermit GMP CA-RCG CCCA	
Deeper Nearshore Rockfish (this state designated category contains more species than listed here)		**Commercial catch of these species is affected by general rockfish rules above. In addition, a Deeper Nearshore Species Fishery Permit is required for these species.** Catch by Traps requires a **Nearshore Fishery Trap Endorsement.** Recreational catch of these species is subject to **RCG Complex** rules.		
Blue rockfish	Sebastes mystinus	A, B, C, D	CA-NFMPlan DNSFPermit GMP CA-RCG CCCA	Caught in N. Channel Islands and northward (hook&line, limited entry for finfish traps), important to divers, one of most important sp. for recreational anglers on skiffs and CPFVs
Brown rockfish	Sebastes auriculatus	A, B, C, D	CA-NFMPlan DNSFPermit GMP CA-RCG CCCA	Important sport fish from boat or shore, 3rd most common rockfish landed in commercial nearshore fishery, caught for dead and live fish markets with hook&line
Olive rockfish	Sebastes serranoides	A, B, C, D	CA-NFMPlan DNSFPermit GMP CA-RCG CCCA	Minor part of commercial take by hook&line and small number end up in live fish fishery, common in N. Channel Islands
Treefish	Sebastes serriceps	B, D	CA-NFMPlan DNSFPermit GMP CA-RCG CCCA	Taken primarily by recreational anglers from boat or shore, or by divers, minor component of commercial and recreational catch
Nearshore Groundfish				
California Halibut	Paralichthys californicus	A, F, G	trawliing in state waters restricted to the "California Halibut Trawling Grounds", this sp. not on the list of federally regulated groundfish	Important commerical and recreational sp., commercial catch w. hook&line, set nets (in EEZ), and bottom trawls **Note: trawling for any spp. is PROHIBITED in state water** except that targeting California Halibut in a strip of coast between 1-3 mile offshore between Pt. Magu and Pt. Arguello *called THE CALIFORNIA HALIBUT TRAWLING ZONE*; **gill nets and trammel nets PROHIBITED within 3 nautical miles from shore owing to the creation in 1990 of the Marine Resources Protection Zone.** **Recreational catch** by hook&line, spear, or hand ; sport fishing size limit applies
Sanddab, Speckled	Citharichthys stigmaeus	A		prized for edibility, recreational anglers from boats
Nearshore Croakers				
California Corbina	Menticirrhus undulatus	A, F		**Commercial catch illegal**. No sport catch allowed via nets. Popular w. sport anglers owing to fighting behavior.
Queenfish	Seriphus politus	F		Sport finfish regulations apply.
White Seabass	Atractoscion nobilis	A, F, G	CA-WSFMP	Seasons, size limits, bag limits and gear restrictions apply. Catch concentrated south of Pt. Conception and at Channel Islands, set gillnet catch PROHIBITED in 1994, drift gillnet primary method used currently plus some commercial hook&line. Popular with anglers using live bait, spearfishing by free divers. The recreational fishery for white seabass is open year round. The daily bag and possession limit is three fish except that only one fish may be taken in waters south of Point Conception between March 15 and June 15. The minimum size limit is 28 inches total length or 20 1⁄2 inches alternate length.
White Croaker	Genyonemus lineatus	A, F		Commercial catch allowed-occurs mostly by gillnet, sold in fresh fish market . Most sport catch in SoCal by anglers from piers, and boats. Consumption prohibited for those caught on Palos Verdes shelf, owing to DDT contamination.

Common Name	Scientfic Name	On-line Inform. sources*	Pertinent Regulatory Actions**	Details about commercial or recreational catch.
Black Croaker	Cheilotrema saturnum			
Yellowfin Croaker	Umbrina roncador	A, F		**Commercial catch illegal.** No sport catch allowed via nets. Anglers from shore and piers. Found south of Santa Barbara
Surfperches (family Embiotocidae)				
Black perch	Embiotoca jacksoni	G		Popular recreational fishes - easy to catch angling from beaches, jetties, and boats. Commerical landings have declined since early 1980s. The recreational fishery for surfperch (family Embiotocidae) remains open all year. The daily bag and possession limit is 5 fish in combination of all species except shiner surfperch (Cymatogaster aggregata) , which have a separate bag limit of 20 fish.
Dwarf perch	Micrometrus minimus	G		
Kelp perch	Brachyistius frenatus	G		
Pile perch	Rhachochilus vacca	A		
Shiner perch	Cymatogaster aggregata	F		
Sharpnose seaperch	Phanerodon atripes	G		
Striped seaperch	Embiotoca lateralis	A		
White seaperch	Phanerodon furcatus	G		
Walleye surfperch	Hyperprosopon argenteum	A, F		
Rainbow seaperch	Hypsurus carvi	G		
Rubberlip	Rhacochilus toxotes	A, F		
Other Nearshore Fish				
Cabezon	Scorpaenichthys marmoratus	A	CA-NFMPlan NFPermit GMP CA-RCG CCCA	Federally regulated groundfish. Also, a limited entry **Nearshore Fishery Permit** required for commercial catch of Cabezon. Prized by sport divers, less important for anglers on CPFVs, commercially caught for live fish industry (ca. 90%) with limited entry traps and hook&line. **Recreational** catch regulated by the RCG Complex Rules (see "Rockfish", above) , except that only one Cabezon at least 15" is allowed per day.
California Scorpionfish	Scorpaena guttata		CA-NFMPlan NFPermit GMP CCCA	Federally regulated groundfish. Also, a limited entry **Nearshore Fishery Permit** required for commercial catch of California Scorpionfish._ Ca. 80% of commerical catch is for live fish industry by finfish traps and hook&line, moderate take from sport boats. **Recreational** catch regulated by the RCG Complex Rules (see "Rockfish", above) , except that Daily bag limit =5 for this species, with size limit of 10"
California Sheephead	Semicossyphus pulcher		CA-NFMPlan NFPermit CCCA	Federally regulated groundfish. Also, a limited entry **Nearshore Fishery Permit** required for commercial catch of California Sheephead. _**Commercial take PROHIBITED < 13 inches.** Recent renewed commercial interest, some finfish traps used, taken by sport divers and angler, and increasingly caught for live fish commercial industry. **Recreational** catch regulated by the RCG Complex Rules (see "Rockfish", above) , except that Daily bag limit =5 for this species, with size limit of 12"**.**
Greenling, Painted	Oxylebius pictus		CCCA	Cowcod Conservation Area rules apply
Giant Seabass	Stereolepis gigas	A, F, G		**Commercial catch PROHIBITED.** In permanent decline for several decades. Only 1 fish in incidental catch per trip allowed for commercial fishermen
Kelp Bass	Paralabrax clathratus	A, F		**Commercial catch PROHIBITED.** Popular nearshore sportfish using hook&line from peirs, shore, boats. Channel Islands are one of more productive kelp bass fishing areas.
Barred Sand Bass	Paralabrax nebulifer	A, F		**Commercial catch PROHIBITED.** Sport size and bag limits apply, CPFV catch increasing, sport catch by hook&line. No depth restrictions for recreational catch.
Spotted Sand Bass	Paralabrax maculato-fasciatus	A, F		**Commercial catch PROHIBITED.** Rare north of Santa Monica Bay, popular with nearshore sport anglers, exclusive tournaments exist for the species. No depth restrictions for

Common Name	Scientfic Name	On-line Inform. sources*	Pertinent Regulatory Actions**	Details about commercial or recreational catch.
				recreational catch.
Yellowtail	Seriola lalandi	A		sport and commercial catches confined to south of Pt. Conception, catch usually nearshore near kelp, hook&line, catch by gillnet legal only outside 3 miles from shore. No depth restrictions for recreational fishing.
Opaleye	Girella nigricans	A		not part of designated fishery, appears as incidental catch, small number entering live fish market. Recreational Catch regulated
Garibaldi	Hypsypops rubicundus			**Commercial and sport take PROHIBITED**.
Wolf eel, northern wolfish	Anarrhichthys ocellatus			**Commercial take PROHIBITED.**
Striped mullet	Mugil cephalus			general finfish regulations (bag limits etc.) apply
California moray	Gymnothorax mordax			general finfish regulations (bag limits etc.) apply
Bonefish	Albula vulpes			general finfish regulations (bag limits etc.) apply
Sargo	Anisotremus davidsonia			general finfish regulations (bag limits etc.) apply
Salema	Xenistius californiensis			general finfish regulations (bag limits, etc.) apply
Half Moon	Medialuna californiensis	A		not part of designated fishery, appears as incidental catch, small number entering live fish market. General finfish regulations apply
Skates and Rays				
Shovelnose guitarfish	Rhinobatos productus	A, F		target of small sport fishery
Bat ray	Myliobatis californica	A, F		target of small sport fishery
Round stingray	Urolophus halleri	A, F		mostly caught south of Pt. Conception
Silversides - principal commercial effort is in bays using gillnets, lampara nets and round haul nets				
Jacksmelt	Atherinopsis californicus	A		no commercial limits, not desired by anglers
Topsmelt	Atherinops affinis	A		no commercial limits, most ubiquitous and abundant sp. in surfgrass - important prey for least terns
Grunion	Leuresthes tenuis	A		not commercially targeted, provides recreational fishery (hands only) on beaches during grunion runs. The recreational fishery for California grunion is open from June -March.
Gobies				
Bluebanded goby	Lythrypnus dalli	A		minor aquarium trade
Arrow goby				
Cheekspot goby				
Shadow goby				
Blind goby				
Longjaw mudsucker				
Blackeye goby				
Nearshore Sharks.	Drift gill net fishery for shark and swordfish subject to permit, season, and area restrictions. Sharkfins may not be landed without a corresponding carcass. Gill nets banned in ocean waters 3 nm from mainland shore of California.			
Pacific Angel Shark	Squatina californica			large commercial fishery developed off Santa Barbara Co. and around Santa Cruz and Santa Rosa Islands in 1980s, using drift gillnets. Gillnet ban in most state waters in 1991 contributed to dramatic decline in catch.

Common Name	Scientfic Name	On-line Inform. sources*	Pertinent Regulatory Actions**	Details about commercial or recreational catch.
Leopard Shark	Triakis semifasciata	F	GMP CCCA	Commercial catch < 36 inches PROHIBITED. Commercial catch by set net, hook&line and trawl and is now mostly incidental. Sport catch by angling and spearfishing. Sport size and bag limits apply in sport fishery, size limit applies to commercial fishery. As a federally regulated groundfish, commercial limits and quotas apply and the recreational catch depth restrictions and seasons match those for the RCG complex (see Rockfish, generally, above) - except in Newport, San Diego and Mission Bays - in which boat based anglers are allowed year round at all depths. Specific depths are closed for this species during specific months in the Cowcod Conservation Areas (one of which surrounds Santa Barbara Island).
Gray smoothhound	Mustelus californicus			taken by sport fishermen
Soupfin Shark	Galeorhinus galeus		GMP CCCA	Prized by recreational anglers, commercial catch (historically sought for shark liver oil) has declined since 1980s (although listed here, this sp. is also **Highly migratory).** As a federally regulated groundfish, commercial limits and quotas apply and the recreational catch depth restrictions and seasons match those for the RCG complex (see Rockfish, generally, above). Specific depths are closed for this species during specific months in the Cowcod Conservation Areas (one of which surrounds Santa Barbara Island).
DEEPER FISH				
SHELF ROCKFISH (this state designated category contains more species than listed here)	Commercial catch of these species is affected by general rockfish rules above. As federally regulated groundfish, **commercial** limits and quotas for these species apply. Commercial catch is mostly by trawl, set gillnet (little used now), and hook & line. For Recreational fishing, the **RCG Complex** rules for seasons, equipment, aggregate bag limits and size limits apply (as described under "Rockfish, generally" above).			
Vermillion Rockfish	Sebastes miniatus	A C	GMP CA-RCG CCCA	moderately important in commercial and sport fishery, comprised 8% of rockfish catch from 1983-1988 landed south of Pt. Conception.
Deeper Flatfish, generally		Those marked GMP are federally regulated groundfish, the recreational catch equipment rules and seasons match those for the RCG complex (see Rockfish, generally, above). Also, specific depths are closed for the species marked CCCA during specific months in the Cowcod Conservation Areas (one of which surrounds Santa Barbara Island).		
English sole	Pleuronectes vetulus	A	GMP CCCA	Was a leading commercial flat fish until Dover sole fishery developed, little taken south of Pt. Conception.
Fantail Sole	Xystreurys liolepis			These deeper flatfish occur mostly as incidental catch in otter trawls.
California tonguefish	Symphurus atricauda			
Hornyhead turbot	Pleuronichthys verticalis	C		
Spotted turbot	Pleuronichthys ritteri	C		
Diamond turbot	Hypsopsetta guttulata			
C-O sole	Pleuronichthys coenosus	C		
OTHER DEEPER WATER FISH: Benthopelagic/Bathypelagic/Bathydemersal				
Spiny dogfish	Squalus acanthias	F	GMP	Federally managed groundfish. Recreational catch limits, equipment rules and seasons match those for the RCG complex (see Rockfish, generally, above)
EPIPELAGIC AND COASTAL PELAGIC SPECIES				
Pacific Bonito	Sarda chiliensis	A, F		Bonito is one of top 15 recreational spp. by hook&line and trolling with lures. commercial catch mostly by purse seine (seasonally targeted by "wetfish" seiners that usually harvest mackeral and sardines) but also taken by troll, gillnets, pole&line. Nearly all wetfish seiners are based in San Pedro and fish in San Pedro and Santa Barbara Channels, market demand low, commercial landings down in 1990s

Common Name	Scientfic Name	On-line Inform. sources*	Pertinent Regulatory Actions**	Details about commercial or recreational catch.
California Barracuda, Pacific Barracuda	Sphyraena argentea	A		Barracuda commercially caught by gillnet and hook&line. Size limits apply. Sport anglers use live bait, or lures, sometimes w. chumming. No depth restrictions apply to recreational fishing.
Pacific Sardine	Sardinops sagax	A	CPSMP	There is a limited-entry purse seine fleet for *coastal pelagic fisheries* that operates in Southern California bight, including the Channel Islands. This fishery targets Pacific sardine, Northern Anchovy, Pacific mackerel and jack mackerel and market squid using purse and drum seine and lampara nets. Anchovy catch for reduction (fish meal, oil) is limited by specific permits in state waters. Pacific Mackerel taken by sport fishermen, owing to abundance rather than desire. Sardines are used for human food and pet food.
Northern Anchovy, Californian anchoveta	Engraulis mordax	A	CPSMP Special permits required in state waters if caught for reduction	
Pacific mackerel	Scomber japonicus	A, F	CPSMP	
Jack Mackerel	Trachurus symmetricus	A	CPSMP	
Pacific herring	Clupea pallasii	A		Pacific herring permit required for commercial take.

***SOURCES OF ON-LINE INFORMATION ABOUT SPECIES**

A: California Dept. Fish & Game, Status of Living Marine Resources (http://www.dfg.ca.gov/mrd/status/index.html)

B: Nearshore Fishery Management Plan (NFMP). Appendix D. Description of Stocks. http://www.dfg.ca.gov/mrd/nfmp/pdfs/appendix_d.pdf

C: Chapter 4. Environmental Settings. Final Environmental Document. Marine Protected Areas in NOAA's Channel Islands National Sanctuary (http://www.dfg.ca.gov/mrd/ci_ceqa/index.html)

D: Nearshore Finfish Profiles. Detailed pdf downloads for selected nearshore finfish species (http://www.dfg.ca.gov/mrd/rockfish/index.html)

E: Status of the California Sheephead Stock for 2004 (1st stock assessment completed under the Marine Life Management Act -NFMP) (http://www.dfg.ca.gov/mrd/sheephead2004/index.html)

F: California Dept. Fish & Game, California Marine Sportfish, http://www.dfg.ca.gov/mrd/msfindx0.html

G: Annual Status of the Fisheries Report Through 2003, California Dept. Fish & Game (http://www.dfg.ca.gov/mrd/status/index.html)

****EXPLANATIONS OF CODES FOR PERTINENT REGULATORY ACTIONS**

MZPA = Marine Zone Protection Act of 1990 (led to certain gear restrictions in state waters)

MRPZ = Marine Resources Protection Zone (within 3 miles of mainland and 1 mile, or 70 fathoms depth, of Channel Islands)

CA-WSFMP = Cal. Fish & Game White Seabass Fishery Management Plan (http://www.dfg.ca.gov/mrd/wsfmp/index.html), not yet law.

CA-NFMPlan = 19 species are regulated by the Cal. Fish & Game Nearshore Fishery Management Plan:
(1) black rockfish *(Sebastes melanops)*, (2) black-and-yellow rockfish *(S. chrysomelas)*, (3) blue rockfish *(S. mystinus)*, (4) brown rockfish *(S. auriculatus)*, (5) cabezon *(Scorpaenichthys marmoratus)*, (6) calico rockfish *(Sebastes dallii)*, (7) California scorpionfish (sculpin) *(Scorpaena guttata)*, (8) California sheephead *(Semicossyphus pulcher)*, (9) China rockfish *(Sebastes nebulosus)*, (10) copper rockfish *(Sebastes caurinus)*, (11) gopher rockfish *(Sebastes carnatus)*, (12) grass rockfish *(Sebastes rastrelliger)*, (13) greenlings of the genus *Hexagrammos (2 spp)*, (14) kelp rockfish *(Sebastes atrovirens)*, (15) monkeyface eel *(Cebidichthys violaceus)*, (16) olive rockfish *(Sebastes serranoides)*, (17) quillback rockfish *(Sebastes maliger)*, and (18) treefish *(Sebastes serriceps)* (http://www.dfg.ca.gov/mrd/nfmp/index.html).

NFPermit = Cal. Fish & Game issued commercial Nearshore Fishery Permit (NFPermit) required for the commercial take of the following species of nearshore fish stocks: black-and-yellow rockfish, gopher rockfish, kelp rockfish, California scorpionfish, greenlings of the genus *Hexagrammos*, China rockfish, grass rockfish, California sheephead, and cabezon. Size and gear limits apply to these species. Within one mile of shore - no commercial catch allowed except by rod and reel or hand lines - and hook numbers, rod numbers, and line strength are regulated.

DNSFPermit = Cal. Fish & Game issued Commercial Deeper Nearshore Species Fishery Permit (DNSFP) required for these species in state water

GMP = species federally regulated by the Pacific Fishery Management Council's Groundfish Management Plan (fishing regs. for state waters must be consistent with federal law)

SMP = species federally regulated by the Pacific Fishery Management Council's Salmon Management Plan (fishing regs. for state waters must be consistent with federal law)

HMSMP = species federally regulated by the Pacific Fishery Management Council's Highly Migratory Management Plan (fishing regs. for state waters must be consistent with federal law)

CPSMP - species federally regulated by the Pacific Fishery Management Council's Coastal Pelagic Species Fishery Management Plan (fishing regs. for state waters must be consistent with federal law)

CA-RCG = Recreational Catch regulated in state waters by Cal. Fish & Game Rockfish Cabezon Greenling Complex regulations

CCCA = Ocean depth restricts allowable fishing locations for these species within the California Cowcod Conservation Areas

*****SPECIES REGULATED AS NEARSHORE FINFISH ARE::**

(1) black rockfish *(Sebastes melanops)*, (2) black-and-yellow rockfish *(Sebastes chrysomelas)*, (3) blue rockfish *(Sebastes mystinus)*, (4) brown rockfish *(Sebastes auriculatus)*, (5) cabezon *(Scorpaenichthys marmoratus)*,
(6) calico rockfish *(Sebastes dallii)*, (7) California scorpionfish (sculpin) *(Scorpaena guttata)*, (8) California sheephead *(Semicossyphus pulcher)*, (9) China rockfish *(Sebastes nebulosus)*, (10) copper rockfish *(Sebastes caurinus)*, (11) gopher rockfish *(Sebastes carnatus)*, (12) grass rockfish *(Sebastes rastrelliger)*, (13) greenlings of the genus *Hexagrammos*, (14) kelp rockfish *(Sebastes atrovirens)*, (15) monkeyface eel *(Cebidichthys violaceus)*, (16) olive rockfish *(Sebastes serranoides)*, (17) quillback rockfish *(Sebastes maliger)*, and (18) treefish *(Sebastes serriceps)*,

APPENDIX H

Synopsis of California state fishing regulations for marine macroinvertebrates reported from Cabrillo National Monument. Omitted are sessile intertidal organisms, for which all take (commercial or recreational) is prohibited within the Mia Tegner State Marine Conservation Area. See text for details on federal regulations pertaining to these species.

Common Name	Scientific Name	Habitat in Channel Islands	Geo-graphic range	Selected Commercial or Sport Take Regulations
California Spiny Lobster	Panulirus interruptus (Crustacea)	Under rocks and in crevices during day, in open at night in low intertidal and subtidal to 60m.	San Luis Obispo Co., CA to Bahia Rosala, Baja California	CCR Title 14/Div. 1/Subdiv. 1/Ch.4/Sect. 29.90 CCR Title 14/Div.1/Subdiv. 1/Ch.6/Sect.122 CF&G Sect. 7256, 8250-8259, 9000-9024 (traps)[a] **Commercial take**: The southern California Lobster Fishery is now a limited-entry fishery, and is considering adopting an individual transferrable quota system (ITQ). Lobsters must be over 3.25in long. May only be taken during Oct-Mar. Traps can only be raised or placed from dusk to dawn, each trap must be have a buoy with commercial license number displayed, must not be within 750 ft of public pier, etc. and not set within 250 ft of navigation channels. **Sport**: May only be taken with sport fishing license and using hoop net or by hand. Limit 7, min. size 3.25in. Same season as for Commerical take.
Red Rock Shrimp	Lysmata californica (Crustacea)	Among rocks and alage in low intertidal, subtidal to 60m.	Santa Barbara, CA to Bahia Sebastian Vizcaino, Baja California.	CCR Title 14/Div. 1/Subdiv. 1/Ch.4/Sect. 29.80 CCR Title 14/Div.1/Subdiv. 1/Ch. 6/Sect. 120 CF&G Sect. 8590-8595, 8830-8843, 9000-9024 (traps) [a] **Commercial take**: Depth, equipment (re. trawls and traps), season and incidental catch restrictions apply. Trawling only allowed >3 nautical miles from land. Traps may not be used S. of Pt Conception inside 50 fathom depth contour. **Sport take**: May only be taken by hand, or by shrimp and prawn traps with openings ≤0.5in (south of Pt. Conception).

Common Name	Scientific Name	Habitat in Channel Islands	Geo-graphic range	Selected Commercial or Sport Take Regulations
Red Crab	Cancer productus (Crustacea)	Middle intertidal and subtidal to 79m, common in gravel and boulder beaches. Protected coasts and bays.	Kodiak, Alaska to San Diego	CCR Title 14/Div. 1/Subdiv. 1/Ch.4/Sect.29.85 CCR Title 14/Div. 1/Subdiv. 1/Ch.6/Sect. 123 CF&G Sect. 8254, 9000-9024 (traps) [a] **Commercial take**: Permit required for commercial take between high tide mark and 1000 ft below low tide mark. Are allowed as bycatch in permitted lobster traps. **Sport**: Open season all year, limit=35, must be ≥4 in.
Rock Crab	Cancer antennarius (Crustacea)	low rocky intertidal and subtidal to 40m around bases of kelp and in gravel.	Coos Bay, Oregon to Baja California	CCR Title 14/Div. 1/Subdiv. 1/Ch.4/Sect.29.85 CCR Title 14/Div. 1/Subdiv. 1/Ch.6/Sect. 125 (rock crab) CF&G Sect. 8254, 9000-9024 (traps) [a] **Commercial take:** Commerical permit needed for rock crab. **Sport**: Same as for Red Crab.
Warty Sea Cucumber	Parastichopus parvamensis (Echinodermata)	sandy/mud surfaces between rocks in low intertidal in bays - and rocks, sand, or mud in well-protected rocky shores, subtidal to 27 m		CF&G Sect. 8405-8405.4 **Commercial harvest**: Permits required. Most of sea cucumber harvest occurs off the Northern Channel Islands in water 6-20 fm.Harvest is almost exclusively by divers. A holder of a commercial sea cucumber permit is not required to possess a Tidal Invertebrate Permit (CCR Sect. 123, Title 14)
Red Sea Urchin	Strongylo-centrotus franciscanus (Echinodermata)	uncommon in very low intertidal on open, rocky shore; more abundanct subtidally to 90m		CF&G Sect. 9054-9055 CCR Title 14/Div. 1/Subdiv. 1/Ch.6/ Sect.120.7. Red sea urchins harvested by divers equipped with hooka gear. Majority of SoCal landings come from the northern Channel islands. **Commercial harvest**: Permits required. Intermittent closures (certain days and weeks). Catch limits for small urchins apply. A sea urchin diver or sea urchin crewmember operating under the provisions of this section is not required to possess a Tidal Invertebrate Permit (CCR Title 14/Div. 1/Subdiv. 1/Ch.6/ Sect. 123)
Pink Abalone	Haliotis corrugata	subtidal from 6-60 m on exposed rock, commonly in giant kelp		CCR Title 14/Div. 1/Subdiv. 1/Ch.4/Sect.29.15. **No commercial or sport take allowed.**

Common Name	Scientific Name	Habitat in Channel Islands	Geo-graphic range	Selected Commercial or Sport Take Regulations
Black Abalone	Haliotis cracherodii	under rocks and in crevices in high intertidal down to 6 m		As for pink abalone.
Green Abalone	Haliotis fulgens	low intertidal and subtidal to 10 m. In crevices where surfgrass and algae is dense, esp. at 2-3 m in deep crevices in strong waves.		As for pink abalone.
Red Abalone	Haliotis rufescens	intertidal in rocky shores with strong waves, more abundant subtidal 6-17m, possible down to >180m		CCR Title 14/Div. 1/Subdiv. 1/Ch.4/Sect. 29.15. **No commercial take allowed.** **Sport take**: Red abalone may only be taken north of line drawn due west magnetic through center of mouth of San Fransisco Bay, daily bag limit is 3, annual bag limit 24.
White Abalone	Haliotis sorenseni	subtidal from 25-66m, in open, exposed areas		As for pink abalone.
California Mussel	Mytilus californianus	Abundant on rocks in upper-middle intertidal, subtidal to 24 m	Aleutian Islands, Alaska to S. Baja California	CCR Title 14/Div. 1/Subdiv. 1/Ch.6/Sect. 123 CF&G Sect. 8344, 5669-5675 (bivalve toxic areas), 5700-5702 **Commercial take**: Tidal Permits required for commercial take between high tide mark and 1000ft below the low tide mark. **Sport take**: limit of 10 lbs (in shell) for California mussels + bay mussel in combination.
Bay mussel	Mytilus edulis	intertidal		CCR Title 14/Div. 1/Subdiv. 1/Ch.6/Sect. 123 CF&G Sect. 8344, 5669-5675 (bivalve toxic areas), 5700-5702 **Commercial take**: Tidal Permits required for commercial take between high tide mark and 1000ft below the low tide mark. **Sport take**: limit of 10 lbs (in shell) for California mussels + bay mussel in combination.

Common Name	Scientific Name	Habitat in Channel Islands	Geo-graphic range	Selected Commercial or Sport Take Regulations
Rock Scallop	Hinnites giganeus (multirugosus) or Crassedoma giganteus	Common is rock crevices in low intertidal and subtidal to 50m.	Queen Charlotte Islands, British Columbia, to Punta Abreojos, Baja California	CCR Title 14/Div. 1/Subdiv. 1/Ch.4/Sect. 29.60 CF&G Sect. 8345, 5669-5675, 5700-5702 **Commerical**: It is unlawful for any person to sell or purchase any rock scallops (Hinnites multirugosus) or scallops (Pecten circularis), except scallops cultivated pursuant to Division 12 (commencing with Section 15000) which may be sold or purchased subject to regulations of the commission. **Sport take**: Limit is 10. Can only be taken by hand using dive knives or abalone irons in compliance with Sect. 29.15(e).
Market Squid [b]	Loligo opalescens (Mollusca)	Pelagic except when schooling and spawning on muddy sand in shallow inshore areas	S. British Columbia to Isla Guadalupe (Mexico) and Bahia Asuncion, Baja California	CCR Title 14/Div. 1/Subdiv. 1/Ch.4/Sect. 29.70 CF&G Sect. 8420-8429.7 **Commercial take**: Vessel permits required, must use dip, purse seine or lampara nets. No permit needed if used for live bait. From the US-Mexico border north, squid may be taken for commercial purposes between noon on Sunday and Noon on Friday each week. This does not apply to vessels pursuing squid for live-bait purposes only. Not more that 2 tons may be taken per day without a valid Market Squid Vessel Permit. Each vessel fishing for squid or attracting squid shall shield the entire filament of each bulb used to attract squid. The illumination shall be oriented directly downward or be completely under the surface of the watter. Vessels fishing for squid or lighting for squid will utilize a total of no more than 30,000 watts to attract squid at any time. **Sport take**: No limit. May only be taken with hand-held dip nets.

[a] Every trap or string of traps must be marked with buoys bearing the commercial fishing license identification number issued to operator (FGC§9006). Traps made of wire mesh, not less than 1 7/8 inches by 3 7/8 inches inside measurement, with the 3 7/8 inches measurement parallel to the floor of the trap shall have at least one rigid circular opening of not less than 3 1/4 inches inside diameter in an outside wall of the rearmost chamber of the trap. All other traps must have two such openings in an outside wall of the rearmost chamber of the trap Traps must be emptied at least every 96 hours (weather permitting), and must not be abandoned. Every trap must have at least one destruct device which meets specifications approved by the Department (FGC§9004).

[b] Market squid are not on the species list for Cabrillo National Monument, but are commercially harvested in the San Diego area.

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