STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER QUALITY
P.O. BOX 100
SACRAMENTO, CA 95812-0100

DRAFT DATA REPORT

April 2008

PROJECT TITLE:
General Exception to the California Ocean Plan for the multiple applicants at Areas of Special Biological Significance

Table 1. List of Applicants and relative ASBS

Applicant	ASBS
City of Carmel by the Sea	Carmel Bay
Conolly-Pacific Company	Southeast Santa Catalina Island
Department of Parks and Recreation	Redwoods National Park, Trinidad Head, King Range, Jughandle Cove, Gerstle Cove, James V. Fitzgerald, Año Nuevo, Carmel Bay, Point Lobos, Julia Pfeiffer Burns, Irvine Coast
Department of Transportation (CalTrans)	Redwoods National Park, Saunders Reef, James V. Fitzgerald, Año Nuevo, Carmel Bay, Point Lobos, Julia Pfeiffer Burns, Salmon Creek Coast, Laguna Point to Latigo Point, Irvine Coast
U.S. Dept. of Defense, Air Force	James V. Fitzgerald
Humboldt County	King Range
Humboldt Bay Harbor District*	King Range
Irvine Company	Irvine Coast
City of Laguna Beach	Heisler Park
Los Angeles County	Laguna Point to Latigo Point
City of Malibu	Laguna Point to Latigo Point
Marin County	Duxbury Reef
City of Monterey	Pacific Grove
City of Newport Beach	Robert E. Badham
City of Pacific Grove	Pacific Grove
Pebble Beach Company	Carmel Bay
Pelican Point Homeowners, in conjunction with City of Newport Beach	Irvine Coast
U.S. Dept. of Interior, Point Reyes National Seashore	Point Reyes Headlands, Duxbury Reef
San Diego City	La Jolla
San Mateo County	James V. Fitzgerald
Santa Catalina Island Company, including Santa Catalina Island Conservancy	Northwest Santa Catalina Island
Sea Ranch Association	Del Mar Landing
City of Trinidad City	Trinidad Head
Trinidad Rancheria	Trinidad Head
U.S. Dept. of Interior, Redwoods National and State Park	Redwoods National Park
U.S. Dept. of Defense, Navy	San Nicolas Island & Begg Rock
U.S. Dept. of Defense, Navy	San Clemente Island

* red print indicates that an exception was requested but the application was substandard

PREFACE

This is a draft data report as of March 18, 2008. The information in this draft report is in addition and complimentary to the August 2006 ASBS Status Report.

This draft report includes a preliminary summary of the available data from ASBS exception applications received in 2006. Additional applications have been received in 2007 and not all of that data has yet been assimilated into this report. This draft report will be subject to change following further staff review of the exception applications and other applicable data.

INTRODUCTION

The State Water Resources Control Board (State Water Board), under its Resolutions No. 74-28, No. 74-32, and No.75-61, designated certain Areas of Special Biological Significance (ASBS) in the adoption of water quality control plans for the control of wastes discharged to ocean waters. To date, thirty-four coastal and offshore island sites have been designated ASBS. The names of these ASBS were changed by the State Water Board in April 2005 (Resolution No. 2005-0035).

Since 1983, the California Ocean Plan (Ocean Plan) has prohibited the discharge of both point and nonpoint source waste to ASBS, unless the State Water Board grants an exception. The Ocean Plan allows the State Water Board to grant exceptions to plan requirements where the State Water Board determines that the exception "will not compromise protection of ocean waters for beneficial uses, and, [t]he public interest will be served." Prior to granting an exception, the State Water Board must hold a public hearing and comply with the California Environmental Quality Act, Public Resources Code §21000 et seq. (CEQA). In addition, the United States Environmental Protection Agency must concur.

ASBS are also accorded special protection under the Marine Managed Areas Improvement Act (Act), Public Resources Code §36600 et seq. Under the Act, ASBS are a subset of state water quality protection areas and, as such, “require special protection as determined by the [State Water Board]” pursuant to the Ocean Plan (Pub. Resources Code §36700(f)). In all state water quality protection areas, waste discharges must be prohibited or limited by special conditions, in accordance with state water quality law, including the Ocean Plan (*Id.* §36710(f)).

On October 18, 2004, the State Water Board notified responsible parties to cease storm water and nonpoint source waste discharges into ASBS or to request an exception under the Ocean Plan. Several responsible parties submitted requests, or conditional requests, for exceptions. Subsequently, the State Water Board provided general instructions for exception application packages via its website. The State Water Board sent letters (in a few cases later in 2005) to responsible parties, providing specific instructions and a deadline for submission of the application package by May 31, 2006.

The State Water Board has received 27 applications for the general exception to the Ocean Plan prohibition against waste discharges to ASBS. The applications were filed by permitted storm water dischargers and nonpoint source dischargers, who are identified in Table 1.

ENVIRONMENTAL SETTING

Location, Size, and Reasons for Designation of ASBS

Note: The estimates of the areas, lengths and percent of the coastline provided below are from the 1:24,000 scale coastline GIS layer “coastn27” from the State Lands Commission 1994, including the Northern and Southern Channel Islands, Ano Nuevo Island, Bird Rock, and the larger Farallon Islands. The estimates of percent of California coastline is based on a coast length of 1556 miles at a scale of 1:24,000, and does not include San Francisco Bay, other enclosed bays and inlets, or small coastal rocks/islands.

Redwoods National Park

The Redwoods National Park lies along the coast of northwestern California in Humboldt and Del Norte Counties. Inland, a series of overlapping jurisdictions include Federal Park Lands and three California State Parks: Jedediah Smith Redwoods State Park, Del Norte Coast Redwoods State Park and Prairie Creek Redwoods State Park. The coastal boundaries of Redwoods National Park are just south of Crescent City in the north (41°44.1' north latitude, 124°9.5' west longitude) and just to the north of Stone Lagoon in the south (41°15.7' north latitude, 124°5.7’ west longitude) (SWRCB 1981). The Redwoods National Park Area of Special Biological Significance (ASBS) encompasses 62,643 acres (97.88 mi^2; 253,510,283 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 35.9 miles (57.826 km), encompassing about 2.31% of California’s coastline.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. it has a variety of intertidal and subtidal habitats; 3. high turbidity of coastal waters has resulted in the development of an unusual assemblage of plants and animals unique to this area of the California coast; 4. this area has large stocks of annual flora; 5. sea stars *Solaster simpsoni* and *S. dawsoni* are common in this region, but no where else in California; 6. intertidal biota is transitional in character with both boreal and temperate marine elements.

Trinidad Head

The Kelp Beds at Trinidad Head ASBS is located at approximately 41°03’15" north latitude, 124°08’10" west longitude, which is 28 miles (45 km) north of Eureka, California and encompasses areas both north and south of Trinidad Head. The northern area is fully exposed to winds and waves, while the southern area is semi-exposed because of the sheltering effects of Trinidad Head (SWRCB 1979). The ASBS encompasses 297 acres (0.46 mi^2; 1,201,206 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 1.8 miles (2.947 km), encompassing about 0.12% of California’s coastline.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. it has a diversity of intertidal habitat types, with close assemblage and association of seabirds, marine mammals, and intertidal plants and animals, and the dense beds of bull kelp; 3. there is an abundance of brown seaweed, *Cystoseira osmundacea*, a diverse population of intertidal algae and other major plant material producers in the nearshore zone; 4. a lack of abundant herbivore populations related to the presence of large amounts of silt in the water for a substantial period each year or lack of suitable habitat, particularly for juveniles within the ASBS; 5. the sea strawberry, *Gersemia rubriformis*, is commonly found, as well as intertidal presence of *Cnemidocarpa finmarkiensis*; 6. there are dense beds of *Nereocystis luetkeana*, which are uncommon in many areas of the state.

King Range

The King Range ASBS, lies between the mouth of the Mattole River to the north (40°17'45" north latitude, 124°52'37" west longitude) and a point near Whale Gulch to the south (39°52' 37" north latitude, 123°58'34" west longitude). Most of the coastline is in Humboldt County, with approximately 4.5 miles (7.2 km) at the southern end of the Area in Mendocino County. Two towns of small size are near the ASBS: Garberville, 18 miles (29 km) east of the coastline at Point Delgada, and Petrolia, 5.5 miles (8.8 km) from the mouth of the Mattole River (SWRCB 1979).

The coastline is impassible at several points during high tides, but can be negotiated at almost all points during low tides. Except for an all-weather road to the Shelter Cove development on Point Delgada, travel along the coastline is by foot or four-wheel drive vehicle. From the mouth of the Mattole River to the southern border, 30.2 miles (48.3 km) of coastline (exclusive of offshore rocks) lies within the King Range National Conservation Area (SWRCB 1979). The ASBS encompasses 25,0555 acres (39.15 mi^2; 101,395,704 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 32.7 miles (52.621 km), encompassing about 2.10% of California's coastline.

King Range ASBS is overlapped by Punta Gorda Marine Protected Area (MPA) in about ¼ square-miles in the northwest corner of the ASBS.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. this is a remote area with very little human activity present; 3. most of the coastal area is fully exposed to wave impact, causing only the hardiest intertidal species to be successful in survival in the littoral zone; 4. in Shelter Cove, a highly diverse intertidal biota is encountered; 5. Mussel beds and associated intertidal habitats are more extensive and better developed than at any other location in Humboldt and Del Norte counties and also experience the most severe of impacts caused by human activities; 6. bladder kelp, *Macrocystis integrifolia*, is present both at the northerly intertidal limits and afloat at Shelter Cove.

Jughandle Cove

The Jughandle Cove ASBS is located in Mendocino County, California at approximately 39°22’45” north latitude, 123°49'15” west longitude, and is five miles south of Fort Bragg on Highway 1 (SWRCB 1981). The ASBS encompasses 203 acres (0.32 mi^2; 822,094 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 1.5 miles (2.479 km), encompassing about 0.10% of California’s coastline.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. it may include the northern extent of the ranges of the puffball sponge, *Tetilla arb*, the honeycomb worm, *Phragmatopoma californica*, and the compound ascidian, *Polyclium planum*.

Saunders Reef

The Saunders Reef ASBS is located in southern Mendocino County along the northern coast of California (38°51' north latitude, 123°40' west longitude), 4.6 miles (7.5 km) southeast of the town of Point Arena. The small town of Anchor Bay is located 5 miles (8 km) to the south. The ASBS includes an area of approximately 618 acres (250 ha), bordered on the east by 1 mile (1.6 km) of rocky intertidal zone extending north from Iverson Point, and on the west by the 100 ft. (30 m) isobath. The exposed portion of the reef occurs in the south-central portion of the ASBS, approximately 0.6 mile (1 km) west of Saunders landing and is marked by a navigation buoy. Cliffs, up to 100 ft. (30 m) high, border the eastern mean high tide boundary and Highway 1 parallels the ASBS near the edge of the cliffs (SWRCB 1980). The ASBS encompasses 730 acres (1.14 mi^2; 2,953,786 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 1.6 miles (2.559 km), encompassing about 0.10% of California’s coastline.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. localized high population densities and large size of individual red abalone, offshore reef surrounded by a bull kelp, *Nereocystis luetkeana*, forest; 3. this area is relatively undisturbed by humans.

The designation was recommended by the Regional Water Quality Control Board (RWQCB) and supported by the Department of Fish and Game (DFG). No opposition to this designation was submitted.

Del Mar Landing

The ASBS encompasses 53 acres (0.08 mi^2; 213,112 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 0.6 miles (0.961 km), encompassing about 0.6% of California’s coastline. Del Mar ASBS is entirely overlapped by and Del Mar MPA.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. to preserve land, or land and water areas in a natural condition and to protect the aquatic organisms and wildlife found here for public observation and study.

The designation was recommended by the Regional Water Quality Control Board (RWQCB) and supported by the Department of Fish and Game (DFG). No opposition to this designation was submitted. The area is an ecological reserve. The primary purposes of an ecological preserve are to preserve land, or land and water areas, and protect the aquatic organisms and wildlife present.

Gerstle Cove

The Gerstle Cove ASBS is located in Sonoma County at about 39°33’57” north latitude and 123°19’45” west longitude. The nearest towns are Gualala, located about 20 miles (32 km) north on Highway 1, and Jenner, located about 23 miles (37 km) south on Highway 1 (SWRCB 1979). The ASBS encompasses 10 acres (39,754 mi^2; 0.02 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 0.6 miles (0.886 km), encompassing about 0.04% of California’s coastline.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. it is a relatively pristine cove that is representative of the natural marine environment of Sonoma County.

The designation was recommended by the Regional Water Quality Control Board (RWQCB) and the Department of Fish and Game (DFG). This is inclusive of a reserve and underwater park for the use of divers and nature observers.

Point Reyes Headlands

The Point Reyes Headland ASBS is located in Marin County, California. The area is situated entirely within the boundary of the Point Reyes National Seashore Park. The Headland site is 11 miles (17.6 km) from the nearest town which is Inverness (SWRCB 1980). The ASBS encompasses 1,047 acres (1.64 mi^2; 4,237,491 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 4.8 miles (7.720 km), encompassing about 0.31% of California’s coastline.

Since 1972, the Point Reyes Headlands has had the reserve status protection and all marine life has been protected from human collecting and fishing activities. Point Reyes MPA is entirely overlapped by Point Reyes ASBS. The MPA and ASBS share the same boundary along the coastline. The oceanic boundaries are parallel to the shore and to each other, though the MPA boundary extends about ¼ mile off the coast and the ASBS and the ASBS boundary extends about ½ mile off the coast.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. the subtidal community at the ASBS is one of the most diverse in the San Francisco Bay region; 3. the intertidal zone has great species diversity including California mussel, gooseneck barnacles, acorn barnacles and red abalone.

The designation was recommended by the Regional Water Quality Control Board (RWQCB) and supported by the Point Reyes Bird Observatory. No opposition to this designation was submitted.

In 1972, the California Department of Fish and Game declared the Point Reyes Headlands as a Marine Life Reserve. Therefore, Article 1.57 of Title 14 states:

"Point Reyes Headlands Reserve (Marin County). No form of marine life may be taken from the ocean area within 1000 feet of the high tide mark in the Point Reyes Headlands bounded on the west by a line extending due west (true) from Point Reyes Lighthouse and on the east by a line extending due east (true) from Chimney Rock, without a written permit from the department. (Register 72, No. 1--1-1-72)."

Duxbury Reef

The Duxbury Reef ASBS is located near the town of Bolinas in Marin County, approximately 14 nautical miles (26 km) northwest of San Francisco. The ASBS is located within 37°53' to 37°56' north latitude, 122°44’ west longitude. The center of the municipality of Bolinas is located approximately ¾ mi. (1.2 km) from the Agate Beach entrance to Duxbury Reef. Subdivisions extend much closer, with some homes actually overlooking the reef from the surrounding mesa. The reef lies at the base of a high headland, called the Bolinas Mesa. According to contours shown in the most recent geologic map of the Point Reyes Peninsula, there are at least 8,320 acres (3,367 ha) of watershed providing drainage to the ASBS (SWRCB 1979). The ASBS encompasses 876 acres (1.37 mi^2; 3,543,446 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 3.4 miles (5.0 km), encompassing about 0.22% of California’s coastline.

Duxbury ASBS is almost entirely overlapped by Duxbury MPA. The MPA and ASBS share most of their boundaries along the coastline, but the northern boundary of the ASBS extends about 1/16 miles north of the MPA boundary. The south-eastern coastal boundary of the MPA extends about 1/8 mile beyond the ASBS boundary. Oceanic boundaries are parallel to the shore and to each other, though the MPA boundary extends about ¼ mile off the coast and the ASBS and the ASBS boundary extends about ½ mile off the coast.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. it contains a rich intertidal biota which has several unique components of sea slugs, rock inhabiting clams and worms, a rare burrowing anemone and a unique acorn worm; 3. it is the largest shale reef in California.

The designation was recommended by the Regional Water Quality Control Board (RWQCB) and supported by the Department of Fish and Game (DFG) and Dr. Gordon Chang. No opposition to this designation was submitted.

James V. Fitzgerald

The James V. Fitzgerald ASBS is a strip of exposed coastline with adjacent intertidal reefs, extending from the westerly extension of the centerline of Fourth Street in Montara in the north to Pillar Point breakwater in the south (SWRCB 1979). The ASBS encompasses 518 acres (0.81 mi^2; 2,097,013 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 5.5 miles (8.784 km), encompassing about 0.35% of California’s coastline.

The James V. Fitzgerald ASBS is entirely overlapped by James V. Fitzgerald MPA, though the Southern ASBS boundary extends around Pillar Point, whereas the MPA boundary ends at the point.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. dense stands of bull kelp are found along with red algae; 3. there is a diverse array of invertebrates that inhabit the broad reefs such as sea stars, starfish, crabs, chitons and purple urchins; 4. there are three types of subtital habitat.

The designation was recommended by the Regional Water Quality Control Board (RWQCB) and supported by the Department of Fish and Game (DFG), Department of Parks and Recreation (DPR), and the Sierra Club. No opposition to this designation was submitted.

Año Nuevo

The Año Nuevo Area of Special Biological Significance is situated along the central California coast in San Mateo County (approximately 37°06’ north latitude, 122°20’ west longitude) near the San Mateo-Santa Cruz County Line. The nearest town, Davenport, is 9.7 miles (15.5 km) to the south of the ASBS. Pescadero is 14.4 miles (23 km) north of the ASBS. Other towns near the ASBS are Half Moon Bay, 35 miles (56 km) to the north and Santa Cruz, 25 miles (40 km) to the south. Within the ASBS boundary is the Año Nuevo State Reserve (SWRCB 1981). The ASBS encompasses 13,560 acres (21.19 mi^2; 54,875,399 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 4.9 miles (7.847 km), encompassing about 0.31% of California’s coastline.

Approximately half of the Año Nuevo Invertebrate Area (MPA) overlaps with the Año Nuevo ASBS. The ASBS, which extends about 3-½ miles offshore, is overlapped along ¾ of coastal boundary by the MPA, which extends about ¼ mile offshore.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages, with large and highly diverse marine invertebrate populations that are very unique and not present at any other mainland ASBS site; 2. thousands of marine birds and mammals utilize the site as a breeding and feeding habitat.

Pacific Grove

The Pacific Grove ASBS is oriented in a northwest-southeast direction, adjacent to the town of Pacific Grove in Monterey County. For purposes of description, the ASBS is considered to lie along an east-west axis. The western seaward boundary of the ASBS is at 36°38'36" north latitude, 121°55'42" west longitude and is a seaward extension of Asilomar Avenue. The eastern seaward boundary is at 36°37'24" north latitude, 121°53'54" west longitude and is a seaward extension of Eardley Avenue. Land areas are only south of the ASBS, and offshore bay waters are north of the ASBS (SWRCB 1979). The ASBS encompasses 469 acres (0.73 mi^2; 1,898,526 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 3.2 miles (5.120 km), encompassing about 0.20% of California's coastline.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. it has dense beds of giant kelp *Macrocystis pyrifera*; 3. surf grass dominates large areas; 4. endangered sea otters forage in this area.

Carmel Bay

The Carmel Bay ASBS is located in Monterey County, immediately adjacent to the town of Carmel. The ASBS is south of the Monterey Peninsula, just north of the Santa Lucia mountain range, and west of the Carmel Valley. Pescadero Point, the northern boundary of the ASBS, is located at 36°34' north latitude, 121°57' west longitude; Granite Point, the southern boundary, is located just north of Point Lobos at 36°31' north latitude, 121°56' west longitude. The seaward boundary of the ASBS is formed by a straight line drawn between Pescadero and Granite Points; the landward boundary is the mean high tide line (SWRCB 1979). The ASBS encompasses 1,584 acres (2.48 mi^2; 6,411,404 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 6.7 miles (10.756 km), encompassing about 0.43% of California's coastline.

The Carmel Bay ASBS is entirely overlapped by Carmel Bay MPA.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. the intertidal zone is a valuable educational resource, due to the high biodiversity and excellent access.

Point Lobos

The Point Lobos ASBS is located at about 30°10' north latitude, 121°45' west longitude, within Monterey County, California. The closest town is Carmel, located about 35 miles upcoast on California State Highway 1 (SWRCB 1979). The Point Lobos ASBS is entirely overlapped by Point Lobos MPA. The ASBS encompasses 691 acres (1.08 mi^2; 2,795,439 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 9.4 miles (15.131 km), encompassing about 0.60% of California's coastline.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. a variety of marine mammals are present within the ASBS throughout the year, including the threatened Stellar Sea Lion, (*Eumetopias jubatus)*.

Julia Pfeiffer Burns

The Julia Pfeiffer Burns ASBS is located at about 30°10' north latitude, 121°45' west longitude, within Monterey County, California. The closest town is Carmel, located about 35 miles up the coast on California State Highway 1 (SWRCB 1980). The ASBS encompasses 1,743 acres (2.72 mi^2; 7,052,623 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 3.7 miles (6.020 km), encompassing about 0.24% of California's coastline.

Julia Pfeiffer Burns ASBS is entirely overlapped by Julia Pfeiffer Burns MPA.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. it is the most biologically rich portions of the California coast.

Salmon Creek Coast

The Salmon Creek ASBS is location adjacent to the Los Padres National Forest, which encompasses approximately 1.75 million acres of central California's scenic Coast and Transverse Ranges. The forest stretches across almost 220 miles from north to south (http://www.fs.fed.us/r5/lospadres/about/). The ASBS encompasses 1,458 acres (5,898,623 mi^2; 2.28 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 3.4 miles (5.533 km), encompassing about 0.22% of California's coastline.

The ASBS is included in this designation because it has a diversity of habitat and biological assemblages.

Laguna Point to Latigo Point

The eastern boundary of the Laguna Point to Latigo Point ASBS is Latigo Point (34°01'34" north latitude, 118 °45'20" west longitude) in Los Angeles County and the western boundary is Laguna Point (34°05'40" north latitude, 119°6'30" west longitude) in Ventura County. The ASBS lies in an approximate east-west orientation. Fifty-five (55) percent of the shoreline (and area) lies in Los Angeles County and 45 percent lies in Ventura County. The eastern boundary is about 16.4 miles (26.4km) from the City of Santa Monica and 4.1 miles (6.6 km) from Malibu Beach. The western boundary is about 6.5 miles (10.5 km) from Port Hueneme-Oxnard and 15 miles (24 km) from Ventura (SWRCB 1979). The ASBS encompasses 11,842 acres (18.50 mi^2; 47,923,090 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 24.0 miles (38.603 km), encompassing about 1.54% of California's coastline.

Laguna Point to Latigo Point ASBS is overlapped by Big Sycamore Canyon MPA in about 1/8 of the ASBS area.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. it has a healthy assemblage of giant kelp, (*Macrocystic pyrifera*).

Santa Catalina Island

Santa Catalina Island is located at 33°22’ north latitude, 118°25’ west longitude and lies approximately 20 miles offshore of the Palos Verdes Peninsula. The Island is 22 miles (35.4 km) long, 8 miles (12.9 km) across at its widest point and is oriented in a general northwest to southeast direction. Santa Catalina Island is part of Los Angeles County. Avalon is the only city on the Island. There is a community located between Catalina Harbor and Isthmus Cove, known as Two Harbors. Approximately 100 permanent residents of Two Harbors maintain the local recreational facility utilized by vacationers, the area’s primary industry (SWRCB 1979).

The Northwest Santa Catalina Island ASBS is located at the western end of the Island (33°27’ north latitude, 118°33’ west longitude). It includes most of the area west of Two Harbors (known locally as the Isthmus) (SWRCB 1979). The ASBS encompasses 13,235 acres (20.68 mi^2; 53,561,672 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 20.9 miles (33.599 km), encompassing about 1.34% of California’s coastline. A small portion of Northwest Catalina Island ASBS overlaps all of Arrow Point to Lion Head Point Invertebrate Area (MPA).

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. it is possibly a transitional zone between subtidal area containing predominantly northern and southern species; 3. due to the proximity to USC’s Catalina Marine Science Center, many scientific studies have yielded valuable information about the area.

The Southeast Santa Catalina Island ASBS extends from Jewfish Point to Binnacle Rock on the east end of Santa Catalina Island. Its seaward boundary follows the 300-foot isobath or a line one nautical mile offshore, whichever is more distant. Approximate coordinates of the center of the area are 33°18’30” north latitude, 118°18’ west longitude (SWRCB 1979). The ASBS encompasses 2,756 acres (4.31 mi^2; 11,151,303 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 2.9 miles (4.628 km), encompassing about 0.18% of California’s coastline.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. it represents the warmest water region of the Channel Islands, therefore the physical and biological conditions are a marked contrast to the reset of the Islands.

Robert E. Badham

The Robert E. Badham ASBS extends along the coast of Corona del Mar in Orange County. The Area is contained within the approximate map coordinates 33°34'50" to 33°35'25" north latitude, 117°51'10" to 117°52'20" west longitude (SWRCB 1979). The ASBS encompasses 220 acres (0.34 mi^2; 888,804 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 0.7 miles (1.113 km), encompassing about 0.04% of California's coastline.

A small portion of Robert E. Badham ASBS overlaps all of Robert E. Badham MPA. The MPA and ASBS share the same coastal boundary, though the MPA extends a very short distance from shore (less than ¼ mile). The northwestern corners of both Irvine Coast MPA and Crystal Cove MPA also overlap with the ASBS.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. offshore reefs provide abundant habitat for a variety of species.

Irvine Coast

The Irvine Coast Marine Life Refuge ASBS encompasses the nearshore waters between the southern border of Corona del Mar and Abalone Point in Orange County. Boundaries of the ASBS are contained within the approximate map coordinates 33°33'20" to 33°35'05" north latitude, 117°49' to 117°51'55" west longitude (SWRCB 1979). The ASBS encompasses 941 acres (1.47 mi^2; 3,806,657 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 3.4 miles (5.461 km), encompassing about 0.22% of California's coastline.

The entire Irvine ASBS is overlapped by MPAs. Irvine Coast MPA and ASBS share coastal boundaries, and the MPA extends about ¼ mile oceanward, into the ASBS, the oceanic boundary parallel to the coastal boundary. The Crystal Cove MPA northeast boundary is shared with the oceanic boundary of Irvine Coast MPA. The Crystal Cove MPA extends about ¼ mile beyond the oceanic boundary of the ASBS.

The ASBS is included in this designation because it has a diversity of habitat and biological assemblages.

Heisler Park

The Heisler Park ASBS comprises the nearshore waters near the town of Laguna Beach, Orange County. The approximate map coordinates for the area's boundaries are 33°32'25" to 33°32'45" north latitude, 117°47'15" to 117°47'55" west longitude. Beyond the immediate coastal bluffs of the Reserve, a public park and a public beach access are located. The landward side beyond the park is fully developed with private residences and businesses. Access on foot to the Reserve is provided by paved paths and steps, and signs announcing the Reserve are posted on all of these accesses (SWRCB 1979). The ASBS encompasses 32 acres (0.05 mi^2; 129,456 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 0.5 miles (0.781 km), encompassing about 0.03% of California's coastline.

Heisler Park ASBS is entirely overlapped by Heisler Park MPA and Laguna Beach MPA. Heisler Park MPA and Laguna Beach MPA overlap each other.

The ASBS is included in this designation because it has a diversity of habitat and biological assemblages.

La Jolla

The La Jolla ASBS is located at 32°51’52" north latitude, 117°15’15” to 117°16’15” west longitude, in La Jolla Bay, adjacent to the town of La Jolla, in San Diego County. The shoreward boundary line is the mean high tide line from the south end of Scripps Institution of Oceanography to Goldfish Point. It is the south one-sixth of the San Diego-La Jolla Underwater Park, which was created by City Ordinance 10363 on August 13, 1970. The Park itself extends from Point La Jolla westward, then northerly to the San Diego City limits, a north-south distance of approximately seven (7) miles along a line about one mile out from the shoreline for a total surface area 5977 acres. The seaward boundaries are designated by a series of five orange-red marker buoys which are clearly identified, and the on-land accesses at Goldfish Point, the La Jolla Beach and Tennis Club, and the south end of Kellogg Park are visibly marked as entrances to the Ecological Reserve.

The northern shore is a fine sandy beach whereas the southern shore is composed of rough boulders or ledges at the base of cliffs with one pebble beach in the Devil’s Slide area. The northern three-fourths of the shoreline face westward while the southernmost one-fourth faces northward (SWRCB 1979).

The ASBS encompasses 453 acres (0.71 mi^2; 1,832,543 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 1.7 miles (2.714 km), encompassing about 0.11% of California’s coastline.

La Jolla ASBS is completely overlapped by La Jolla MPA, which extends beyond the ASBS in the southwest corner.

The ASBS is included in this designation for the following reasons: 1. it has a diversity of habitat and biological assemblages; 2. it is in close proximity to Scripps Institute of Oceanography and is a desirable scientific study locale.

San Nicolas Island & Begg Rock

The ASBS encompasses 63,658 acres (99.47 mi^2; 257,615,348 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 26.9 miles (43.318 km), encompassing about 1.73% of California’s coastline.

The ASBS is included in this designation because it has a diversity of habitat and biological assemblages.

San Clemente Island

San Clemente Island (SCI) is the southernmost of California's Channel Islands, located 68 nautical miles west of San Diego and 55 nautical miles south of Long Beach. It is the primary maritime training area for the U.S. Department of the Navy Pacific Fleet, and the Navy Sea, Air and Land (SEALS), and also supports the U.S. Marine Corps, the U.S. Air Force and other users. It is also home to a variety of unique and rare ecological resources on land, and some of the richest marine communities in the world in adjacent waters. The island is approximately 21 nm long and is 4-1/2 nm across at its widest point (www.scisland.org). The ASBS encompasses 49,162 acres (76.82 mi^2; 198,952,668 m^2) of various coastal marine habitats. The length of coastline included in the ASBS is 58.5 miles (94.089 km), encompassing about 3.76% of California's coastline.

The ASBS is included in this designation because it has a diversity of habitat and biological assemblages.

GEOLOGICAL SETTING

Terrestrial Geological Setting

Redwoods National Park

The coastal geology of the ASBS is a mixture of three major components: the Franciscan assemblage, Quaternary deposits, and modern beach sands. The Franciscan assemblage occur a variety of sedimentary formations, including sandstones, siltstones, and conglomerates. Most of the intertidal rocks and sea stacks are derived from Franciscan rock types. At a few points volcanic greenstones and cherts can be found. Continental drift and plate movements have extensively sheared, faulted, and metamorphosed these geocynclinal deposits (National Park Service 1979, cited in SWRCB 1980).

Along Gold Bluffs Beach, a fluvial deposit was laid down in an ancient delta fan of the Klamath River. In the 1850's Gold Bluffs Beach had only a narrow beach between the base of the cliffs and the surf zone. Erosion of the cliffs by wave action resulted in erosion of the old fluvial deposits and a concentration of fine gold flakes in intertidal beach sands. Several commercial ventures were mounted to recover these gold deposits, without notable success. The beach is, today, wider than it was during the 19th Century and includes dunes that are a result of sand deposition along the shoreline. The beach extending southward from Crescent City to Nickel Creek is composed entirely of modern beach sands and is intermixed with boulders and rocks near White Knob at the south end of the beach. These sands at this beach, as at other beaches within the ASBS, are indicative of erosion of nearby coastal formations, or have their source in erosion within the major drainage basins of the Park and adjacent areas (SWRCB 1980).

Trinidad Head

Three geological components are in evidence in the Trinidad ASBS: the complex Franciscan Formation, Quaternary marine deposits, and modern beach sands. The present day geological picture is a result of differential weathering and erosion of the major components.

The blue clays the cliff bases in both the north and south portions of the ASBS are called "Franciscan mélange," shales that have been ground and smashed to small fragments by shearing through the ages. These are highly erodible sediments present numerous problems in road building and construction throughout the northern California coastal area. More recent overlying Quaternary deposits often "slump" following exposure and erosion of the under lying Franciscan mélange. Following winter storms, erosion of the Franciscan blue clays is particularly evident and results in increased turbidity of the nearshore zone. Local planners and agencies have recognized the danger in placing structures near the present edge of the bluffs because of erosion potential. The bluffs are currently designated as open space to lessen the possibility of increased erosion and damage to property. Most of the more resistant intertidal rocks and stacks are recognized as "graywacke," a mineralized sandstone, by geologists. Scattered throughout the area are other resistant rocks, mainly greenstone, a metavolcanic rock, found around the base of Trinidad Pier and in the southern portion of the ASBS. Another resistant Franciscan rock type, chert, is found in the cobble field on the upper beach of the southern part of the ASBS. The chert gravels and small boulders have apparently been eroded from the Franciscan melange at the base of the cliffs.

Trinidad Head is a metavolcanic intrusion which apparently was formed at about the same time as Franciscan deposits were being laid down. The rocks of the Head (mainly hornblende and diorite) are more resistant to erosion than the surrounding Franciscan formation, with the resultant appearance of a promontory (SWRCB 1979).

King Range

A high ridge runs parallel to the coast through the entire area, and elevations along the coastal ridge vary from 2,596 feet (787 m) at Chemise Mountain, near the southern border, to 4,087 feet (1,238 m) at Kings Peak, and 2,350 feet (712 m) at Oat Hill near the northern border. The slopes of this ridge drop precipitously into the intertidal zone along the coastline, and are cut by numerous small streams. The entire coastline is undergoing active uplifting as the Eastern Pacific Plate is moving under the Continental Plate.

Only three areas of relatively flat ground are found along the coast: Shelter Cove, where the adjacent ridge line drops to gently rolling hills about 1/2 mile (0.8 km) from the coast, Big Flat, an alluvial fan at the mouth of Big Flat Creek; and Spanish Flat, a narrow terrace extending for 2 miles (3.2 km) from Randall Creek to Spanish Creek. Slopes bordering the coast average grades of 50-60%, and approach 90% in some drainages (e.g. Cooskie Creek, Spanish Creek, and Kaluna Cliff). Huge rock slides and talus slopes fall directly into the intertidal zone at several points.

The main fault in the area, the Point Delgada Fault, is apparently a main branch of the San Andreas Fault, or may be the main fault itself. At Shelter Cove, several surface breaks opened during the 1906 earthquake. Nowhere are the effects of local seismicity on intertidal substrates more evident than at the huge Kaluna Slide, just north of Shelter Cove. Fractured, broken rock extends from Kaluna Cliff directly into the intertidal zone. The main break of the Point Delgada Fault is exposed near the top of the cliff; movement along the fault apparently triggered the slide in 1906.

Although the occurrence of minor faults along the coast has not been investigated, it seems clear that numerous faults cut across the coastal slopes. Barren areas, devoid of vegetation, are common along the coastline. These barren areas probably do not support appreciable vegetation because land slides accompanying earthquakes are a frequent occurrence. About one mile (1.6 km) south of the mouth of Cooskie Creek, a massive slide extends from the intertidal zone to approximately one mile inland. Although the date of the slide is unknown, the presence of uprooted trees in the slide debris and still-living Douglas Firs overhanging the upper cliffs suggest that the slide occurred within very recent times. It can be anticipated that local geological events and subsequent massive erosion will continue to have a major effect on the character of the ASBS intertidal zone and nearshore waters.

King Range has been mapped as part of the California Coast Range Geological Province, which elsewhere in northern California is mainly composed of rocks in the ubiquitous Franciscan formation, along with various metavolcanic intrusives or metamorphic rocks. Throughout the King Range, however, greenstones and cherts characteristic of the Franciscan formation are lacking for the most part. Metavolcanic intrusives, sometimes evident as pillow structures (indicating their origin underwater) are also found at Shelter Cove in the coastal bluffs. The over lying rocks of the King Range shows evidence of intermittent and persistent crustal deformation. Numerous folds, thrust faults, reverse faults, and strike-slip faults apparently developed during the Tertiary period and have continued to develop into present times because of tectonic processes. The San Andreas Fault meets the Mendocino Fracture Zone just north of the ASBS; severe seismic hazard will continue to exist along this section of the coast (SWRCB 1979).

Jughandle Cove

The ASBS lies within the coastal belt of the Franciscan Formation, which reaches along the coast from Cape Mendocino to Point Arena. This section of the Franciscan Formation averages fifteen miles (24 km) wide and consists primarily of greywacke. Subsequent and irregular uplifting in this portion of the Franciscan Formation resulted in the series of wave cut marine terraces that form the Pygmy Forest Ecological Staircase. Possibly, another terrace is still being formed subtidally (SWRCB 1981).

Saunders Reef

The Saunders Reef area is part of the Gualala Block which comprises all the rocks west of the San Block (Weaver, 1944), Andreas Fault between Fort Ross and Point Arena. The block consists of over 3.8 mi. (6 km) of Upper Cretaceous to Recent marine sediments that are highly faulted and folded (Boyle, 1967). Geologically, the Saunders

Reef area is complex. Sandstones and basalts are well exposed along the sea cliffs and sea stacks in the area. These rocks are, in turn, overlain by a series of Pleistocene marine terraces (SWRCB 1980).

There are four major geological units in the area: (1) the German Rancho Formation; (2) the Iverson Basalt; (3) the Gallaway Formation; and (4) marine terrace deposits.

The German Rancho Formation is over 1.9 mi. (3 km) thick in the Gualala Block (Wentworth 1966, cited in SWRCB 1980). However, it is found only in the southern portion of the area near Iverson Point, where it underlies the marine terrace deposits, and consists of with mudstones and conglomerates. The sandstones consist of medium to very coarse sand that is normally graded with sharp or erosional bases. Deposition of these marine sandstone beds occurred via turbidity currents in quite deep waters. The sands are angular and poorly sorted and are mainly comprised of quartz and kfeldspar with muscovite and carbonaceous material. The mudstones in this formation contain muscovite, montmorillonite, kaolinite, feldspar and quartz (Boyle 1967, cited in SWRCB 1980).

The Iversen Basalt unit, stratigraphically, overlies the German Rancho Formation and underlies the Gallaway Formation. The Iversen Basalt comprises all of the sea stacks found in the southern part of the ASBS, and along most of the seacliffs.

The early-Miocene Gallaway Formation consists of cemented mudstones and occasional porcelanite, as well as some dolomite concretions and benitonite beds. The mudstones consist of quartz, feldspar, calcite, montmorillonite, pyrite, glauconite and organic matter. The sandstones consist predominately of quartz and feldspar. The sandstones commonly occur as units 3 to 6 ft. (1 to 2 m) thick, but beds up to about 26 ft. (8 m) thick have been reported (Boyle 1967, cited in SWRCB 1980). This formation is exposed in the intertidal only in the northern-most part of the ASBS study area. The broad, intertidal terrace in the northern portion of the ASBS study area is underlain by the Gallaway Formation. On land, there are at least three marine terrace levels immediately adjacent to the Saunders Reef area. These Pleistocene terraces lie at elevations of up to 197 ft. (60 m), providing evidence of the relatively recent tectonic uplifting which has occurred in this area.

Beaches along the Saunders Reef ASBS are cobble-boulder beaches with little sand. The only sandy beaches are found in protected "pockets" where small streams provide a supply of sand, such as at Saunders Landing. The sea cliffs at the northern-most part of the study area are of the Gallaway Formation. Massive sandstones form the face of the cliffs and due to the massive nature of the sandstones and the precipitous cliffs, rock falls are very common. The remainder of the sea cliffs in the ASBS are composed of the massive Iversen Basalt. Consequently, the cliffs are steeper than they are to the north and, in some places, are actually overhanging. Due to rock falls and fresh water runoff, the sea cliffs in the area appear to be retreating rapidly landward. In fact, along some old faults or joints, headward erosion has undermined Highway 1, which, in some places in the study area, is perilously close to the sea cliffs (SWRCB 1980).

Gerstle Cove

The ASBS consists of bedrock, slump blocks, and giant boulders; North Gerstle Cove consists of moderately coarse sandstone bedrock; coarse sand, and sand, gravel, and fine sediment below the coarse sand layer. Western Gerstle Cove consists of medium sized coarse sandstone boulders. The adjacent landmass consists of terraces made of Eocene sediments, which consist of primarily sandstone, mudstone, and conglomerate.

The adjacent land mass is emergent coast, featuring a series of wave-cut marine terraces produced by relatively higher sea levels. The youngest marine terrace, bordering the ASBS, begins at the bluff, is about 25 to 50 ft. (8 to 15 m) high and extends northeastward several hundred feet. Heavy foot traffic along the northwestern side of the ASBS is resulting in deterioration of the edge of the bluff. The next older terrace is about 250 to 300 ft. (75 to 90 m) high and is at the level of Highway 1. This terrace is overlain by coastal terrace deposits, with Eocene sediments underneath consisting primarily of sandstone, mudstone, and conglomerate (SWRCB 1979).

Point Reyes Headlands

The basic geomorphology of the Point Reyes National Seashore Park revolves around the famous San Andreas Fault on its eastern boundary and the Pacific Ocean on the western boundary. Galloway (1977) refers to the Point Reyes Peninsula as a "little geological island" of granitic-based rock, while the mainland section east of the Peninsula consists of "Franciscan” rock. The discontinuity of these two large rock masses has led Galloway to postulate that in the past 25 million years the land west of the San Andreas fault, the Point Reyes Peninsula, has been moving northward at an average rate of 1/2 inch (1.3 cm) per year, and has traversed northward hundreds of miles (Galloway 1977, cited in SWRCB 1980).

The Point Reyes Headlands ASBS is a rugged rock promontory composed basically of granitic rocks, referred to as “Point Reyes granodiorite." Core samples have revealed that the granitic rocks extend 1,370 feet (417 m) below sea level. These rocks range in composition from quartz diorite to adamellite, containing more quartz and potash feldspar. Most of the granitic rocks of the Point Reyes Peninsula are deeply weathered. Overlying parts of the granite on the Point Reyes Headland are large patches of conglomerate, a hard sedimentary rock composed of large and small-size pebbles and cobbles, all cemented together. From the Lighthouse area of the Headland to the intertidal zone, there are large blocks of conglomerate. Giant sea caves have been etched into the conglomerates at the surf zone. These conglomerates are not found anywhere else on the Point Reyes Peninsula. The conglomerates are overlayed in an unconformed manner by basal glauconitic sand of the Drakes Bay Formation.

The Point Reyes Headland is virtually in an east-west alignment with the massive cliff facing south. The highest point of the Headland is at the western end, rising up to 612 feet (186 m), while at the Chimney Rock area of the east side, the cliff is approximately 173 feet (52 m). Galloway (1977) suggests that this massive cliff is an eroded fault-line scarp, down thrusted to the south. The submarine drop-off, known as "The Wall,” probably resulted from this downward fault-line scarp movement.

To the north of the Point Reyes granitic promontory are alignments of ridges and valleys which run approximately east-west. The ridges are harder layers of the Drakes Bay Formation and are folded into an anti-cline-syncline pattern. The valleys are remains of tributaries which drain into the drowned-valleys of Drakes Estero and Estero de Limantour (Galloway 1977, cited in SWRCB 1980).

Duxbury Reef

This location is the southernmost point of the Monterey Shale formation, which consists of chert, porcelanites, organic shales, and thin hard sandstones in considerable variation. The headlands are composed of sandstones that are undergoing continuous erosion by winds (SWRCB 1979).

Except for a small area of unconsolidated terrace deposits at the northern boundary of the ASBS, the whole of the area consists of Monterey shales. These shales cover most of the area from Duxbury Point to Double Point in the Point Reyes National Seashore, and extend as far north as some areas in the Tomales Quadrangle. The surfaces of outcrops are normally smooth and covered with vegetation, but where the shale is chert, a crag or pinnacle may be formed by differential erosion.

The headlands (Bolinas Mesa) overlooking the Duxbury Point area are composed of sandstones which are undergoing continuous erosion by winds. The reef is composed of harder organic shales and some cherts. These harder rocks are continually being exposed by rapid erosion of the mesa. Since 1859, Duxbury Point has eroded about 200 ft. (60 m), Bolinas Point about 160 ft. (50 m) and an unnamed point about 4,000 ft. (1200 m) north of Bolinas Point has eroded about 200 ft. (60 m). These measurements by the U.S. Coast and Geodetic Survey indicate an average erosional rate of about 2 1/2 ft. (0.76 m) per year. Along the stretch of coast adjacent to the ASBS, the Monterey sandstones and mudstones are well bedded and dip at an angle of about 45° seaward. Thus when bedding planes are lubricated with rainwater or drainage, landslides are apt to occur at the sea cliff. Waves during high tides quickly remove the material at beach level, with the slide gradually being eroded back to reach a stable angle of repose (Galloway 1977, cited in SWRCB 1979).

Duxbury Reef is the largest exposed shale reef in California. Its prominences extend up to 1 mi. (1.6 km) out to sea at Duxbury Point, and from 1/4 to 1/2 mi. (0.4 to 0.8 km) from the high tide line in other areas. Wave action has carved channels and depressions in the rocks, but more resistant ridges have remained as high protusions, resembling small islands. Most of these islands or prominences can be reached by foot at very low tides, but intervening channels are often deep and treacherous. Presumably, as the waves erode the outer reef rocks, new areas are continuously being exposed at the base of the cliffs. The reef then is slowly moving in a northeasterly direction as new rocks are exposed by wind erosion and old rocks are eroded down by waves. The rocks making up the reef itself contain calcium carbonate. Boring organisms such as clams and worms also contribute to the destruction of the reef as do humans who chip away the rocks to extract the clams (SWRCB 1979).

James V. Fitzgerald

Fitzgerald Marine Reserve straddles the geologically active Seal Cove Fault, which extends northward to connect with the San Andreas Fault near Bolinas Lagoon in Marin County. The San Andreas Fault runs across California from the Gulf of California to the San Francisco Bay area and is described as the boundary between two of the earth's great crustal plates, the continental American plate and the oceanic Pacific plate (Thurman 1975, cited in SWRCB 1979). The San Andreas Fault is probably responsible for the seismic activity of the Seal Cove Fault and secondary faults which diagonally transect the ASBS. Seismic activity at either the Seal Cove or Bay Area faults could result in surface rupture along the faults, high levels of ground shaking, ground failure (such as land sliding), and tsunami inundation (San Mateo County 1976, cited in SWRCB 1979).

The trace of the Seal Cove Fault is exposed in the sea cliff just north of the reserve headquarters. The mouth of San Vicente Creek, which drains the San Vicente watershed, is located just south of the headquarters. South along the west side of Seal Cove Fault, bedrock and overlying marine terrace deposits are vertically lifted about 150 ft. (45 m) to form the Pillar Point headland and ridge. It is the west face of this ridge which forms the sea cliffs south of the headquarters. The bedrock cliffs are composed of consolidated sandstone, siltstone and mudstone, much of it embedded in clay, which together form the Tertiary (Pliocene) Purisima Formation. The overlying marine terrace deposits which cap the Purisima bedrock consist of weakly consolidated, slightly weathered sands and gravels of more recent (Pleistocene) origin. The cliffs gradually increase in height in the southerly direction to a height of 134 ft. (40.7 m) above Frenchman's Reef and remain at about that height south to Pillar Point. They are being actively eroded over most of the length of the reserve. With little or no beach present, the most resistant subtidal and intertidal reefs offer only local resistance to wave action; erosional rates as high as 1-4 ft. (0.3-1.2 m) per year have been recorded at some places. This rapid cliff retreat aggravates land-sliding along much of the length of this section of the ASBS (San Mateo County 1976, cited in SWRCB 1979).

To the north of the marine reserve headquarters, the shoreline of Fitzgerald ASBS changes abruptly. This section of coastline is characterized by rugged rock outcrops and smaller reefs of granodiorite of Mesozoic origin (Geologic Map of California 1963). Elevation of these cliffs ranges from 25 to 50 ft. (7.6 to 15 m) in most places. Occasional sandy or cobble beaches are present between rock outcrops (San Mateo County 1976, cited in SWRCB 1979).

Año Nuevo

This area occurs in the Pliocene Purisima Formation. It consists of crushed and pervasively sheared sandstones and siltstones. Alluvial deposits are also present and consist of interbedded clays, peats, silts, and poorly sorted sand and gravel composed primarily of clasts of Santa Cruz Mudstone. Point Año Nuevo is covered by active dune fields. Between here and Franklin Point lies the only significant coastal dune fields between San Francisco and the mouth of the Salinas River in Monterey Bay. These dune fields consist of fine to medium grained sand.

The ASBS consists of a small rocky island lying about 0.5 miles (600 m) offshore from a low headland which juts about 1.5 miles (2 km) out into the Pacific from the general north-northwest trend of the coastline in San Mateo County. The surface of an emergent marine terrace forms the broad, nearly horizontal plain of Point Ana Nuevo. The wave-cut platforms mantled with terrace deposits truncate folded beds of the Purisima (Pliocene) and Monterey Formations (Miocene) (Tinsley 1972, cited in SWRCB 1979). With the exception of the south shore of Point Año Nuevo where near vertical sea cliffs of 60 to 90 ft (20 to 30 m) are present, the coastline either lacks cliffs or has small cliffs, usually less than 6 to 10 ft (2 to 3 m) high. South of the Point, three major fault strands within the San Gregorio fault zone intersect the coastline and the rather continuous Santa Cruz terrace sequence comes to an abrupt end. Lateral discontinuities and tilting of well-preserved marine terraces help define major structural blocks within the fault zone and document significant differential movement among these blocks from Point Año Nuevo north to San Gregorio Creek (LaJoie et al 1979, cited in SWRCB 1981).

Along the south shore of Point Año Nuevo, five faults exposed in the sea cliff clearly offset the 100,000 year-old marine terrace. The Frijoles fault consists of a 300 foot wide zone of crushed and pervasively sheared sandstones and siltstones of the Pliocene Purisima Formation and is exposed in the sea cliff on the south shore of Point Año Nuevo. The competent rock of the Purisima Formation dips gently northeast and forms high vertical seacliffs capped by the first marine terrace west of the fault zone. Lower cliff height and greater instability due to numerous landslides off the cliff face characterize the sea cliff in the fault zone. The beach is narrow during the winter within the crushed rocks of months and wave the fault shear erosion is extremely rapid zone.

Alluvial deposits consisting of interbedded clays, peats, silts, and poorly sorted sand and gravel composed primarily of clasts of Santa Cruz Mudstone are found east of the fault juxtaposed against the crushed Purisima Formation (Weber and LaJoie 1979, cited in SWRCB 1981).

Año Nuevo Island lies directly off the southern point and is connected by a rocky reef which is almost exposed at low tide. The area immediately adjacent, to the north of the reef between the island and mainland, is about 20 ft (7 m) deep and has a sandy bottom with a scattering of rocks. It is also highly probable that at least one fault which offsets the first marine terrace lies between Point Año Nuevo and Año Nuevo Island.

The elevation of the marine terrace platform on the island is about 15 ft (4.5 m) higher than on the point (Lajoie et al 1979, cited in SWRCB 1981). Point Año Nuevo and Franklin Point, directly north, are rather unusual as both are covered by active dune fields. These two points preserve the only significant coastal dune fields between San Francisco and the mouth of the Salinas River in Monterey Bay. The 300 to 350 acre dune field at Point Año Nuevo consists of fine-to-medium grained sand derived from a windward beach. Along the north shore of Point Año Nuevo, beach sands are winnowed by the prevailing northwesterly winds and the finer grained sands are carried up onto the low terrace above the beach. The dunes then march slowly to the southeast across the point and cascade off the cliff along the south shore, returning the sand once again to the littoral zone (Weber 1979a, cited in SWRCB 1981).

At present the dune field is almost entirely stabilized and very few areas of active dune movement are present. The moving dunes consist of small irregularly shaped masses of sand; the original barchoid dunes have either blown off the cliff or have been partially stabilized by the increase in dune vegetation. Two large barchan dunes were largely destroyed by quarrying operations in the 1950’s. Longitudinal dunes largely stabilized by beach strawberry, sea rocket, bush lupine, and ice plant are common on the northwest half of the point (Weber 1979b, cited in SWRCB 1981).

The landscape along the coast north of Santa Cruz consists of broad marine terraces separated by distinctly steeper slopes, the risers between the individual terraces. High vertical sea cliffs are present along the entire coast except at the mouths of recent stream valleys. The cliffs become progressively higher to the north, rising from about 15 to 20 feet (5 to 7 m) near Santa Cruz to greater than 120 feet (35 m) near Greyhound Rock and up to 360 feet (110 m) on the bluffs north of Waddell Creek. At Año Nuevo the landscape changes and maintains its regional character as far north as the mouth of Pescadero Creek. The broad marine terraces are no longer well defined and the area has a gentle rolling appearance. Risers between terraces are indistinct and the height of the present sea cliff, with the exception of the south shore of Point Año Nuevo, does not exceed 20 feet (6 to 7 m). Año Nuevo is the approximate dividing line between these two physiographic provinces which are separated by the San Gregorio Fault Zone. The variations in rock type and deformational history are responsible for the major differences in physiography and vegetation found on opposite sides of the fault (SWRCB 1981).

Pacific Grove

The coastline is characterized by numerous granite outcroppings and interspersed sandy coves. Lovers Point is the most extensive outcropping and lies midway between the eastern and western boundaries of the ASBS. Pt. Cabrillo is a large promontory of land near the eastern boundary of the ASBS and is the location of Hopkins Marine Station. Otter Point (0.8 miles or 1.3 km from the western boundary) and Lucas Point (0.4 miles or 0.6 km from the western boundary) also lie adjacent to the ASBS.

The coastline becomes more exposed to coastal waters as it proceeds from east to west along the ASBS. Pt. Pinos, only 0.3 miles (0.5 km) west of the ASBS, marks the southern end of Monterey Bay. This long, low-relief granite point continues subtidally as a shallow rocky reef, which is an extreme navigational hazard. Both the point and the reef offer considerable protection to the western half of the ASBS, which would otherwise be completely exposed to the open ocean.

The ASBS is located at the northern end of the Santa Lucia Mountains, where these mountains descend beneath Monterey Bay. The geology of the shoreline and nearshore waters of the ASBS is relatively simple, consisting only of Santa Lucia granodiorite. The rock is highly fractured and therefore weathers easily to sand size particles. The rock mass is cut by dikes, which are somewhat more resistant to weathering than the granodiorite. The rocks are extensively jointed in several directions, the most persistent being parallel to the shoreline. Jointing frequently occurs perpendicular to this, thus producing a blocky pattern in the exposed outcrops best seen at Lucas Point and Otter Point.

The sandy beaches within and adjacent to the ASBS are derived entirely from the granodiorite. Arnal et al. (1973) noted that Monterey Bay is a closed system with no sediment being transported into or out of the bay to the north and south. Also, the shoreline at Pacific Grove is situated such that longshore transport into the area from south bay beaches is highly unlikely.

The cliffs above the ASBS consist of finer grained marine terrace deposits, which may contribute sediment to the ASBS during periods of runoff and in areas of erosion. However, throughout the survey area, portions of the terrace are protected by a granite rock seawall. The seawall appears to be well-constructed and in good condition. Stairways and steps built into the seawall also mitigate erosion by providing a safer, easier means of reaching the intertidal zone. Paths are less common, and cliff erosion generally less severe in areas where seawall and stairways have facilitated access. It is important in maintaining water clarity in the ASBS and in preventing excessive siltation which could cover and smother sessile organisms (SWRCB 1979).

Carmel Bay

Carmel Bay is oriented in a north-south direction and has a wide opening to the sea. With the exception of Stillwater Cove, the coastline is exposed to open ocean; this accounts for the coarse sand and the steepness of the beaches. Rocky promontories here receive strong wave action and, therefore, have a weathered appearance.

The ASBS coastline is characterized by alternating rocky points and extensive granitic sand beaches. A high rocky cliff extends northeastward from Pescadero Point, forming partial protection for Stillwater Cove and Pebble Beach. Arrowhead Point, just south of Stillwater Cove, is oriented in a southwesterly direction and partially protects both the cove and Carmel City Beach to the south from wave action. Carmel City Beach extends south to Carmel Point (also known as Mission Point), which marks the midpoint of the Bay’s coastline.

The Carmel River drains into the ASBS just south of Carmel Point. The coastline just north of the river and a few miles south consists of the steep Carmel River Beach, interspersed with a few granite outcroppings. The Carmel Sanitary District outfall extends offshore, just south of the river mouth, from a rocky intertidal area.

San Jose Creek drains into the south end of Carmel River State Beach, a steep sandy cove which encloses the Carmel submarine canyon. This beach is known as San Jose Beach or Monastery Beach. The rocky, steep cliffs southwest of Monastery Beach extend westward to Granite Point, the southern boundary of the ASBS. A large rocky cove located just northeast of Granite Point is generally referred to as Hudson Cove.

Several distinct formations are found at different locations along the shoreline. The granite outcroppings represent the northwestern-most extension of the Santa Lucia mountain range, for which granodiorite is the basement rock. Granodiorite is an extremely coarse-grained, easily weathered rock containing quartz and large dark crystals of orthoclase feldspar. Subtidally, most of the floor and walls of the Carmel submarine canyon consist of granodiorite, which accounts for the unusually high visibility here. Intertidally, granodiorite occurs as promontories, boulders and cobble at Pescadero Point, Carmel Point, in the vicinity of the buried sewer outfall, and at the north end of Hudson Cove. Inland of the ASBS, granite outcrops occur north of Stillwater Cove, in the Carmel Valley, and along San Jose Creek, extending south to Pt. Lobos (Simpson 1972, cited in SWRCB 1979).

The Carmelo series, also common in and adjacent to the ASBS, can consist of four distinct rock types: sandstone, siltstone, conglomerate and shale. The predominate rock type in the ASBS is a conglomerate, consisting of igneous pebbles embedded in a coarse-grained, well-cemented matrix. Subtidally, the Carmelo formation consists of all four rock types and underlies Stillwater Cove; from here it continues southward to a point 300 yards (274 m) seaward of Ocean Avenue at the north end of Carmel City Beach. In the intertidal zone, this formation is visible adjacent to Stillwater Cove, in the promontory just north of Monastery Beach, and adjacent to Hudson Cove. Inland, the Carmelo formation occurs north of the Carmel Mission (northeast of the Carmel River mouth).

The Tremblor formation, consisting of a white to brownish sandstone intermixed with conglomerate, occurs at several shoreline locations between the volcanics at Arrowhead Point and amongst the Carmelo formation at Pebble Beach and Stillwater Cove. Inland, this formation occurs northeast of the Carmel Mission. Lava outcrops or extrusions occur both subtidally and intertidally at Arrowhead Point.

Quaternary rocks identified as Aromas Red Sandstone occur in cliffsides and along the beach from Arrowhead Point south to Carmel (Mission) Point. The winter storms of 1977 scoured Carmel City Beach and dramatically revealed the underlying sandstone slabs to an extreme, particularly towards the south end of the beach. Recent unconsolidated sediments form terraces which underlie the Pebble Beach Golf Course and are visible adjacent to the intertidal area. Submerged terraces of this composition also occur at depths of 210 feet (35 fathoms) throughout Carmel Bay. Sand beaches occur frequently along the ASBS. Possibly, this sediment results from the weathering of grandiosity rock. Sand transport has not been studied in Carmel Bay, and the origin of sediments there has not been determined (SWRCB 1979).

Julia Pfeiffer Burns

The area is within the Coast Range Geomorphic Province and is classified as Mesozoic granitic rock. The coastline is very steep resulting in restricted watersheds that are drained by canyons.

San Clemente

The island consists of granitic rock and intruding older metamorphic rocks (http://www.usgs.gov/).

Santa Catalina Island

The major exposed rock on Catalina Island is Catalina schist, a low-grade layered metamorphic rock. Landslides commonly occur where it forms steep slopes (Association of Engineering Geologists 1967, cited in SWRCB 1979).

Northwest Santa Catalina Island: The land adjacent to the ASBS is extremely rugged, consisting primarily of mountains with steep drop-offs to the ocean. The area is frequently intersected by narrow ravines (Catalina Head to West End) and by relatively wide stream valleys (West End to Blue Cavern Point). The highest peak adjacent to the ASBS is Silver Peak, reaching an elevation of 1,804 feet. The Isthmus is the land area with the lowest elevation (less than 20 feet) and also has the narrowest width of any portion of the island (0.25 miles). The Isthmus area is geologically very active, as indicated by frequent landslides (SWRCB 1979).

Southeast Santa Catalina Island: This area is characterized by steep, rocky cliffs. Occasional pocket beaches are narrow and steeply sloping and consist of sand and gravel, with scattered rubble and boulders (SWRCB 1979).

Laguna Point to Latigo Point

There are three principal coastal divisions that border the ASBS: the Ventura-Oxnard alluvial plain, the Santa Monica Mountain escarpment, and the central Malibu bluff coast.

The western eighth of the ASBS between Laguna Point and Point Mugu is bounded by the eastern margin of the Ventura-Oxnard plain. This plain is a large alluvial deposit from the Ventura River, Santa Clara River and Calleguas Creek drainages. Calleguas Creek drains into the ASBS through Mugu lagoon. It has a flow volume of about 3.4 million cubic meters per year, which is significant but relatively small, and drains an area of about 340 square miles. At the end of this extensive Calleguas Creek drainage, Mugu lagoon is formed. Mugu Lagoon is an example of lagoons which were once quite common in southern California. Although about one-half of the original wet lands have been filled in, the remaining 1500 acres probably represent the least disturbed lagoon in southern California (MacDonald 1976 and Warme 1971, cited in SWRCB 1979). A barrier bar with a single tidal opening bounds the seaward side of the lagoon. Within the lagoon itself, there is a subtidal core bounded by tidal creeks and ponds, intertidal sand and mud flats, a well-developed pickleweed, Salicornia, marsh and salt pans. In the fall the entrance is usually blocked as currents shift off the barrier beach. Within a few days of closure the U.S. Navy bulldozes an opening in the bar. The most common opening to the lagoon is about $1^1/_3$ miles east of Laguna Point (western ASBS boundary). However, the opening of the lagoon is not a static feature but migrates from time to time, usually in an easterly direction.

The Santa Monica Mountains rise steeply to the east of the Ventura Oxnard plain. These complex mountains are part of the east-west Transverse Ranges which lie mainly inland between the San Bernardino and Santa Ynez Mountains. The Northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz, and Anacapa Islands) represent a western extension of the Santa Monica Mountains. Geological formations within these mountains are primarily sedimentary rocks. The western end of the Santa Monica Mountains forms a steep escarpment along about one-quarter of the ASBS from Point Mugu to Little Sycamore Canyon in Ventura County. This region is characterized by steep mountain slopes (usually greater than 20%) and few offshore reefs. The coastal area here is susceptible to landslides. Point Mugu is an outcrop of resistant black shale. Further to the east, more easily weathered formations of sandstone and shale can be seen as white stratified outcrops in the roadcuts along Pacific Coast Highway. These are the Big Sycamore and Nicholas Formations.

The Malibu bluff coast is triangular with its widest point at Point Dume. This region is structurally the most complex within the ASBS. The rocks are highly folded and steeply dipping so that very different rock types lie next to one Another. The western part of this bluff coast from little Sycamore Canyon to Trancas Beach is made up of older Tertiary (Miocene) erosion resistant rocks of the Trancas Formation. The white cliffs of Paradise Cove are outcrops of the Miocene age Modelo Formation which forms steep inclined bids from Zuma Beach Eastward to Corral Beach (beyond the ASBS boundary). This formation is predominantly a siliceous shale and was probably formed in the deep sea. The headland at Point Dume is a highly resistant igneous breccia which has protected the softer sedimentary shale behind it from erosion. In addition to the Miocene deposits, there is an irregular veneer of Pleistocene marine terrace deposits on the bluff between the ocean and the mountains adjacent to the eastern section of the ASBS. This is a reddish, poorly stratified and sorted material, which is soft and easily dissected. It tends to form steep-sided stream gullies and sea cliffs.

A major east-west low angle thrust fault, the relatively young Malibu Coast Fault, separates the Santa Monica Mountain escarpment from the central Malibu bluff coast. The fault generally can be traced in the central and eastern part of the land adjacent to the ASBS by the distinct change in slope between the terrace of the Malibu bluff and the rapidly rising Santa Monica Mountains behind. High angle faults tend to run north from this fault into the Santa Monica Mountains. The Malibu Coast Fault runs inland from offshore at Las Flores Canyon to the east of the ASBS, and re-enters the sea at Little Sycamore Canyon within the ASBS. Many smaller faults run roughly north-south in the Santa Monica Mountains and often provide the basis of the steep-sided canyons in the area. The largest of these faults is the Sycamore Canyon Fault. Additional faults may separate the Trancas and Modele Formations at the western end of Zuma Beach and Another fault may exist offshore of Point Dume, separating the Point from the Modele Formation. Seismic activity within the ASBS has been relatively infrequent. Epicenters of 6 earthquakes between 1934 and 1958 occurred either within or offshore of the ASBS (Emery 1960, cited in SWRCB 1979). No major earthquakes are known to have occurred in the area within historic times.

Between Point Mugu and Deer Canyon the shallow water areas off the headlands are regularly bordered by bedrock outcroppings and boulder fields. These rocky substrates quickly give way to sand beyond a depth of no more than 10-15 feet. The more protected shallow water areas between the headlands are bordered by clean white sand beaches (La Jolla Beach and Big Sycamore Beach.

In some areas of the ASBS, man has altered the topography. Where the roadbed of the Pacific Coast Highway lies immediately adjacent to the sea, the shoreline has frequently been augmented by riprap. Old decaying groins also occur at regular intervals between Bass Rock and Little Sycamore Canyon. The U.S. Navy has constructed a jetty and placed riprap at the head of the west branch of Mugu Canyon. Three manmade piers exist within the ASBS. Two occur at the head of Mugu Canyon where the U.S. Navy has one in a state of good repair and one that is neglected. The third is a private fishing pier and boat launch at Paradise Cove (SWRCB 1979).

Robert E. Badham

The ASBS is fronted by sandstone bluffs that slough rubble at their base (SWRCB 1979).

Irvine Coast

The Abalone Point region is composed of a siltstone bench that is easily accessible from the adjacent beach only at times of low spring tides. The benchwork is part of a several hundred foot high cliff that also helps to limit access to the area. Just north of Abalone Point is a broad sand beach that stretches the entire length of the reserve. This sandy beach, over three miles long, is interrupted by small rocky outcroppings only twice, at Reef Point and at a small rocky bight just south of Crystal Cove. Sandstone bluffs line the entire beach. Erosion of these bluffs is particularly noticeable in the Scotchman's Cove region. The bluffs appear less eroded in the area around Pelican Point, where fossil-bearing rocks are found (SWRCB 1979).

La Jolla

The La Jolla ASBS is a small alluvial basin bounded on the south by the westward-trending sides of the Soledad Mountain, which reach the sea at Devil's Slide to Point La Jolla (commonly called Alligator Head). To the east and north the basin is bordered by a high ridge which forms the cliffs north of Scripps Institution of Oceanography. The alluvial fill of this basin rests on a seaward sloping basement Eocene sandstone and shale with a thickness of 30 to 40 ft. (10 to 12 m) (SWRCB 1979).

Submarine Topography and Substrate

King Range

The submarine topography off the coastline is complex and varied. Tidally emergent rocks are common within a quarter of a mile (400 m) of the shore, usually surrounded by coarse sand bottoms. The continental shelf (200 m depth) is apparently quite near the shoreline, within 4 to 5 miles (6.5 to 8.0 km), at several points. Three submarine canyons approach the shore along the coast: the Delgada Canyon just north of Point Delgada, the Spanish Canyon off Spanish Flat, and the Mattole Canyon just north of Punta Gorda.

Flat, shelf-like intertidal rock formations are absent along the coast except at two points. The first, about 1.1 miles (1.8 km) north of Punta Gorda, is a sedimentary (probably Franciscan) formation extending into the intertidal zone for approximately 40 yards (38 m) perpendicular to the sand beach. The second, at Pt. Delgada, is a well developed series of bench formations (clearly Franciscan) extending 80-90 yards (70-80 m) from the coastal bluffs to a drop-off into the subtidal zone. The intertidal rock formations at Pt. Delgada are extensive, with evidence of weathering by surge channels and wave action. Boulders 0.5-2 meters in diameter are scattered through the intertidal zone and have fine to medium grain sands around their bases. The stable substrate and modest protection from predominantly northwest waves have resulted in the establishment of a geologically amenable intertidal habitat (SWRCB 1979).

Jughandle Cove

Areas to ten feet (3 m) deep within the small northern cove consist of boulders and interspersed sand. Beyond this depth, the bottom is bedrock, boulder and some localized cobble and gravel patches. A series of offshore rocks extend northwesterly from the southern border of the cove. Their faces are roughly vertical and descend ten to thirty-five feet (3 to 11 m) to the bottom (SWRCB 1981).

The headlands north of Jug Handle Creek Cove drop vertically, as an irregular and often overhanging wall, to about fifteen feet (5 m) deep, where the bottom is dominated by large boulders and submerged pinnacles. The bottom of Jug Handle Creek Cove is filled with clean medium-grained sand which continues offshore to beyond sixty feet (18 km) deep. Boulders emerge from the sand on the borders of the cove (SWRCB 1981).

A series of rocks extend northwestward from the southern border of Jug Handle Creek Cove. From ten to thirty feet (3 to 9 m) emergent rocks rise from the sand to the surface. Further offshore, to forty-five feet (14 m) deep, the series continues as isolated submerged rocks rising out of the sand (SWRCB 1981).

The extreme southern cove within the ASBS has a gently sloping bedrock and boulder bottom. Nearshore emergent rocks in the northerly portion of this cove are in places surrounded by sand and cobble bottoms. Bedrock dominates deeper areas within the cove and offshore the bottom is similar to that off the northern headlands (SWRCB 1981).

Saunders Reef

Rock samples obtained by SCUBA divers indicate Saunders Reef is part of the Gallaway Formation. The reef is actually a complex of low parallel ridges and outcrops from 1.5 to 39 ft. (0.5 to 12 m) high. Some of these are exposed at low tide. The bottom between the ridges and outcrops is composed of rock, cobble and coarse sand. Large ripple marks were found in this area indicating very high surge velocities (SWRCB 1980).

Gerstle Cove

The submarine topography within the ASBS is extremely irregular, probably owing to exposure of the coastline to wave action, and concomitant erosion of the shoreline. The hardness of the sedimentary rock is highly variable, resulting in differential erosion producing a wave-cut and indented coastline. Thus, large slump blocks and boulders are continually being supplied to the marine environment. Large to small boulders dominate most of the gently sloping subtidal terrain. Slump blocks, wash rocks and emergent sea stacks also occur immediately offshore and constitute the only other topographic features in and adjacent to the ASBS (SWRCB 1979).

Point Reyes Headlands

The Point Reyes Headland ASBS extends from the intertidal zone out to 2,000 feet (609 m). At the south face of this 2,000 foot line, the depth is about 100 feet (30 m). However, at the western boundary of the ASBS zone, the depth probably is greater than 150 ft. (45 m), while at the eastern boundary, at the Chimney Rock area, the depth is less than 60 ft. (18 m) (SWRCB 1980).

The submarine topography consists of large granitic boulders throughout the shallow water zones with large amounts of sand interspersed between the boulders. At the west end, almost directly below the lighthouse, is “The Wall" - a vertical granitic face which drops 60 feet (18 m) to the sloping sandy bottom at 85 feet (26 m) (SWRCB 1980).

In contrast to “The Wall" of the western side of the ASBS, the submarine topography at Chimney Rock consists of large boulders 3 to 8 feet (1 to 2.4 m) in diameter. Sand surrounds these boulders and gently slopes out to the 60-foot isobath line. Large, vertical intertidal sea caves are also located amidst the conglomerate rocks about 150 feet east of the Lighthouse (SWRCB 1980).

Chimney Rock: At the east end of the ASBS is a large granitic sea stack with a single 50 foot (15 m) pinnacle that resembles an isolated chimney. This stack was a part of the main cliff during the past; erosion divided the section from the eastern promontory. Surrounding Chimney Rock are large boulders which make up the intertidal and subtidal configuration. Sand surrounds these granitic rocks, and continues in a gentle slope out beyond the 60 foot (18 m) isobath. Since the refractory waves sweep around the Chimney Rock area, there is movement of sand throughout the year (SWRCB 1980).

Pelican Arch: This unique granitic rock is 30 feet (9 m) in height and is a sea arch that is a frequent habitat of the Brown Pelican, Pelecanus occidentalis. The birds often perch on the arch while resting from their feeding activities within the area (SWRCB 1980).

Saddle Cove: The cliffs between Chimney Rock and Saddle Cove are nearly vertical, rising from sea level to about 190 feet (58 m). A small beach at the base of a sloping grade illustrates much erosion (SWRCB 1980).

Selit Rock: Massive granitic rocks which have split off from the south cliffs provide the name of this area as Split Rock Cove. The waters of this cove are much deeper than that of the major' coves within these southern-facing cliffs. The 30 foot (9 m) isobath bends deeply into Split Rock Cove. The deep water enables large waves to come very close to the area which gives Boulder Beach a steep profile with rounded cobbles and boulders (SWRCB 1980).

Sea Lion Cove: Granitic rocks, large and small, are scattered through the area west of Split Rock Cove. The smooth surfaces of these rocks enable many sea lions to haul out in this area. Coarse sand surrounds these granitic stacks. Sea Lion Cove is the major area for the California Sea Lions. Two sandy beaches in Sea Lion Cove enable hundreds of these mammals to haul out (SWRCB 1980).

Sea Caves: The conglomerates of the Point Reyes Headland ASBS extend from the highest point of the cliff at 612 feet (186 m) to the surf zone where the depth is 30 feet (9 m). The waves erode these conglomerates, etching out giant sea caves. Large conglomerate boulders and coarse sand make up the benthic substrate at the base of these cliffs, which are a favorite niche for the Common Murre, Uria aalge (SWRCB 1980).

“The Wall”: It is a 60 foot submarine cliff just below the Lighthouse at the western edge of the ASBS. The base of “The Wall" is 85 feet (26 m) below sea level with sand and rocks sloping out beyond 100 feet (30 m). This unique vertical wall is probably a result of faulting action of the Headland (SWRCB 1980).

Ideal diving conditions are almost impossible to realize as giant waves smash across this western promontory the year-round. The underwater surge from the refractory wave trains are severe, preventing divers from maintaining a fixed position on the wall. Moreover, the water visibility is extremely poor, at best about 30 inches (76 cm), both from the sediments stirred up by the wave-surge and by the darkness of these depths (SWRCB 1980).

Murre Rock: Just west of the Lighthouse, outside of the ASBS boundary, are two large granitic sea-stacks which are the main nesting sites for thousands of Common Murre, Uria aalge. These birds reside at the rock year-round (SWRCB 1980).

Duxbury Reef

Duxbury Reef is also the largest exposed shale reef in California. The bottom topography immediately offshore from the ASBS consists of eroded reef remnants interspersed with sand bottoms. Depth increases to 30 ft. (9.1 m) about ½ mi. (0.8 km) from shore and to 60 ft. (18 m) at a distance of 1 mi. (1.6 km). The bottom types in this outer area beyond the ASBS were not investigated, but probably consist of sand (SWRCB 1979).

Duxbury Reef itself is the largest exposed shale reef in California. Its prominences extend up to 1 mi. (1.6 km) out to sea at Duxbury Point, and from ¼ to ½ mi. (0.4 to 0.8 km) from the high tide line in other areas. Wave action has carved channels and depressions in the rocks, but more resistant ridges have remained as high protrusions, resembling small islands. Most of these islands or prominences can be reached by foot at very low tides, but intervening channels are often deep and treacherous. Presumably, as the waves erode the outer reef rocks, new areas are continuously being exposed at the base of the cliffs. The reef then is slowly moving in a northeasterly direction as new rocks are exposed by wind erosion and old rocks are eroded down by waves. The rocks making up the reef itself contain calcium carbonate. Boring organisms such as clams and worms also contribute to the destruction of carbonate the reef as do humans who chip away the rocks to extract the clams (SWRCB 1979).

James V. Fitzgerald

The overlying marine terrace deposits consist of weakly consolidated, slightly weathered sands and gravels of more recent origin. The reefs in the southern section are comprised of Pliocene shale or mudstone. These flat shale beds form a discontinuous rocky intertidal area (SWRCB 1979).

The flat shale beds in the southern section of the ASBS form a discontinuous rocky intertidal area almost 3 mi. (4.8 km) long. During low tides (below mean lower low water at OJ tidal level) much of the outer edge of the reefs, 500 to 1,000 ft. (150 to 300 m) offshore, may be reached from shore. The reefs are broken up by numerous tidal channels with steep or overhanging sides which run perpendicular to the shoreline, and by protected lagoons with rock/cobble bottoms, as at Seal Cove where a sand beach also occurs. Most of the reefs are fairly flat, but often exhibit greater relief toward the inner edge next to the cliffs. Tidepools of varying size and at varying tidal heights are abundant throughout the reefs. South of Frenchman's Reef and Whaleman Harbor, intertidal reefs are largely replaced by a wider sandy beach. Another extensive intertidal reef occurs south of Pillar Point. The southernmost edge of the Pillar Point Reef is marked by Sail Rock, which rises 32 ft. (9.7 m) out of the water (SWRCB 1979).

Approximately 1,000 ft. (300 m) offshore to the south of Frenchman's Reef and 650 ft. (200 m) southwest of the Pillar Point there are extensive subtidal reefs adjacent to the intertidal reefs, at depths of 20 to 35 ft. (6 to 11 m). Due south from Sail Rock (on the Pillar Point Reef) the intertidal and subtidal reefs are continuous with one Another at least for a distance of 250 ft. (80 m) offshore. The subtidal reefs at Pillar Point occur as a series of urchin-pitted shelves extending into gradually deepening water. The reefs here, as at the dive site off Frenchman's Reef, exhibit great relief, rising as high as 10 to 15 ft. (3 to 4.5 m) from the bottom. The reefs are frequently broken by narrow surge channels which run roughly perpendicular to the shore (SWRCB 1979).

Seaward of the exposed rock to the northwest of Frenchman's Reef, similar subtidal reefs and outcrops occur which are of lower relief (5 to 10 ft. or 1.5 to 3 m) than those south of Frenchman's Reef and the Pillar Point Reef. Large boulders protruding from the base of the reefs and outcrops are common. Away from the rock, the reef drops off to what appears to be the end of the reef system in that immediate vicinity. Approximately 300 ft. (100 m) from the rocks is a broad, flat sandstone bottom at a depth of approximately 35 ft. (11 m). Very little sand was present. The sandstone was devoid of macroscopic organisms (SWRCB 1979).

About 300 ft. (100 m) off the southern tip of Seal Cove, for at least 150 ft. (50 m) to the north, the bottom consists of small reefs, large outcrops and associated boulders at an average depth of 20 ft. (6 m). Large sandy areas were not encountered; increasing surge indicated the presence of shallower reefs to the north (SWRCB 1979).

Further evidence of continuity between the intertidal and sub-tidal reef systems was indicated by the presence of broad 30 to 50 ft. (10 to15 m) flat reefs about 1,000 ft). Moss Beach has similar flat (350 m) offshore of Moss Beach. In this area, the subtidal reefs are at a depth of about 30 ft. (9 m) and typically rise 3 to 7 ft. (1 to 2 m) off the bottom (SWRCB 1979).

Extensive subtidal reefs were not found in the northern end of the ASBS, though small reefs and rock outcrops appeared to be prevalent close to shore. Deeper water occurs closer to shore in the northern section of the ASBS than in the south. A dive was made approximately 1,300 ft. (400 m) offshore of the Montara sewage outfall line. At a depth reading of 70 ft. (21 m), the bottom had not yet been reached, so the dive was terminated. About 500 ft. (150 m) offshore, small reefs and outcrops were located at a depth of about 40 ft. (12 m). These were similar in size and relief (5 to 10 ft [2 to 3 m] high) to those found northwest of Frenchman's Reef. Similarly, large boulders were often found at the base of the outcrops. At this northern site, proportionately more of the bottom is comprised of wider sandy surge channels at the base of the rocky areas (SWRCB 1979).

Año Nuevo

The region of Año Nuevo Island to Año Nuevo Creek is characterized by a very irregular bottom topography with shoals and stacks rising vertically from the ocean floor (Arnal et al, 1978). An average depth of approximately 29 feet (10 m) was found for the submarine plateau (SWRCB 1981).

Beach sediments are coarser in the winter than in the summer. Beach sediments found at Waddell Creek, Greyhound Rock, and Elliott Creek are coarser than those of the Año Nuevo area. Very coarse sediments are present only in the winter and are probably due to the high energy of the storm waves. Waddell Creek and Greyhound Rock receive the direct impact of wave energy as the prevailing direction of waves is from the northwest and the Año Nuevo area has a southern shore exposure. For Point Año Nuevo, the coastal erosion due to wave energy from 1603 to 1970 was found to be 25,000 cubic yards/year (SWRCB 1981).

Pacific Grove

The ASBS is located in Monterey Bay, a wide-mouthed, deep bay which is bisected by an extensive submarine canyon. The canyon, as delineated by the 100-fathom curve, occupies 19 percent of the Bay's area. It drops off most steeply near shore and is 100 fathoms deep only 1½ miles (2.4 km) offshore. At the mouth of the bay the canyon is about 450 fathoms deep and 5 miles (8.0 km) wide (SWRCB 1979).

The canyon is aligned in a northeast-southwest direction, so at the mouth of the Bay the canyon is much closer to the southern headlands (4.1 miles, 6.5 km) than it is to Santa Cruz, at the north end of the Bay. The south canyon wall is also steeper, dropping from 100 to 900 fathoms in 1½ miles (2.4 km) off Pt. Pinos (SWRCB 1979).

The ASBS lies within the southern "shallows" of the bay, a water area enclosed by the Monterey Peninsula on the west side. Within the ASBS, depth contours are more compressed than in the rest of the southern shallows. The 40 fathom curve is one mile (1.6 km) offshore at Pacific Grove, but 3 miles (4.8 km) offshore at Monterey (SWRCB 1979).

The subtidal topography of the ASBS consists of shallow water reefs, interspersed with fields of coarse-grained sand. Kelp beds generally mark the location of reefs during the summer. There are also numerous shallow submerged rocks in the ASBS near Pt. Pinos, Lucas Point (Aumentos Rock), Lovers Point and Point Cabrillo (SWRCB 1979).

Carmel Bay

The submarine topography of the ASBS is dominated by the Carmel canyon, a major tributary of the Monterey submarine canyon. The Monterey canyon, one of the largest in the world, originates just offshore from Moss Landing, and extends into the center of Monterey Bay. The Carmel canyon originates about 1/4 mile offshore from the mouth of San Jose Creek in the ASBS. It extends offshore in a westerly direction for about 3 miles (6 km), then turns abruptly and continues to the northwest for 12 miles (19 km) before joining the Monterey canyon. The Carmel Canyon drops off steeply, reaching a depth of 1,200 ft. about 1 mile (200 fathoms, 1.6 km) offshore and a depth of 3,000 feet about 6 miles (500 fathoms, 9.7 km) offshore. The 120 foot (20 fathom) contour generally separates the canyon from shallower regions of the bay. In most locations the 120 foot (20 fathom) curve is less than 1/2 mile offshore; the canyon widens quickly so that it includes most of southern Carmel Bay. (SWRCB 1979)

It is thought that fault lines determined the orientation of Carmel canyon (Martin and Emery, 1967). The nearshore 3 mile portion of the canyon is aligned with the westward trending Carmel Valley fault; the offshore 12 mile portion is aligned with the northwesterly feeding Carmel Canyon fault (a seaward extension of the Sur and Palo Colorado faults) (Moritz, 1968) (SWRCB 1979).

Point Lobos

Vertical rocky walls are associated with coastal cliffs, promontories, offshore rocks and submerged reefs with overhangs, crevices and seams as additional features. Boulders ranging up to 10 ft. (3m) or more in diameter are common. Reefs occurred to at least 60 ft (l8m) deep and rose 30 ft. (9m) from the bottom. Reef tops are of low relief. Gravel and sand are found at all depths on horizontal surfaces, and playa role in scouring rock and, therefore, changing topography. No bathymetric information is available for the ASBS or surrounding areas (SWRCB 1979).

Julia Pfeiffer Burns

Vertical rocky walls are associated with coastal cliffs, promontories, overhangs, crevices and seams offshore rocks and submerged reefs with as additional features. Boulders ranging up to 10 ft. (3m) or more in diameter are common. Reefs occurred to at least 60 ft (18m) deep and rose 30 ft. (9m) from the bottom. Reef tops are of low relief. Gravel and sand are found at all depths on horizontal surfaces, and playa role in scouring rock and, therefore, changing topography. No bathymetric information is available for the ASBS or surrounding areas (SWRCB 1979).

Laguna Point to Latigo Point

The Mugu-Latigo ASBS extends from the intertidal zone seaward to the 100 foot contour line except at the head of Mugu Canyon, where it includes depths of at most, 125 feet. Except near the canyons, the bottom slopes off gently with a gradient of about 1.7% to 3% and consists primarily of medium to very fine, well sorted sand, especially below 60 ft. depths (SWRCB 1979).

Nearshore areas, particularly between Bass Rock, just west of Deer Canyon, Lechuza Point, and between Point Dume and Latigo Point, have a variable relief where the sand is replaced by extensive rock reefs. These reefs show a high degree of variability, ranging from cobble fields on a sand base to towering and precipitous bedrock ridges and gigantic boulders up to 30 to 40 ft. in diameter. The soaring reefs and ridges between Bass Rock and Lechuza Point generally lie parallel to shore and consist primarily of an erosion resistant brecciated rock. The more inclined reefs between Point Dume and Latigo Point generally run perpendicular to or at an angle away from the shore and consist of a more erosive sandstone. A few small reefs of this latter type run parallel to shore off Zuma Beach. Point Dume itself is of a mixed igneous brecciated rock origin. Just off the point a few sea stacks terminate in sand (SWRCB 1979).

The generally gentle sand slope of the ASBS is interrupted at two locations by submarine canyons: Mugu Canyon to the west and Dume Canyon to the east. Both are steep walled canyons of very fine sand to mud. These canyons are primarily offshore from the ASBS. They begin at about 50 to 60 foot depths, 500 to 800 feet offshore, and rapidly descend with a slope of 8 to 33%. In the deeper parts of both canyons (beyond the ASBS) poorly described rock outcrops apparently occur (Shepard and Dill, 1966) (SWRCB 1979).

Beyond the boundary of the ASBS, the ocean floor continues to slope off gradually as the continental shelf. Below a depth of about 300 feet (ca. 2 to 3 miles offshore) the bottom drops off more steeply as the continental slope. The slope terminates in the enclosed Santa Monica Basin at a depth of about 1500 feet. There is a large submarine ridge about 5 miles offshore due south of La Jolla Beach which projects out from the shelf. It rises to within 250 feet of the surface (SWRCB 1979).

There are two old artificial reefs within the ASBS. The one off Paradise Cove was installed by Fish and Game in 1959. It is in 60 feet of water, is composed of old autos, and covers an area of about one-tenth of an acre. This reef has largely deteriorated. The second reef, at about a 45 foot depth, is off the County Lifeguard Headquarters at

Zuma Beach. It is small and composed of old toilets, bathtubs, etc. Both reefs are surrounded by sand (SWRCB 1979).

Santa Catalina Island

Northeast Santa Catalina Island: Sand and mud comprise the majority of the subtidal substrate from the outer boundary of the ASBS to within approximately 500 yards (457 m) offshore. Nearshore, the main subtidal substrates in the ASBS are boulder slopes and sandy slopes, with a few rocky reefs. Cliffs are rare (SWRCB 1979).

In general, the subtidal area of the ASBS is rimmed with boulder slopes to a depth of 50 to 100 feet (30 m). Boulder size varies with depth. Shallow sloped areas often have a narrow band of medium-sized boulders (1 m diameter) interspersed with coarse sand closer to shore. Cactus Bay exemplifies this type of substrate. Larger boulders (4 - 8 m diameter), also interspersed with sand, are found from 10 to 50-foot (15 m) depths. With increased depth, the number and size of boulders decreases and the percentage of sand increases. In most areas surveyed, sand comprised nearly 100% of the substrate beyond 100-foot (30 m) depths (SWRCB 1979).

Sandy substrate is rare in water shallower than 40 feet (12 m) between Catalina Head and Arrow Point, with the exception of Starlight Beach and Parson's Landing. However, from Arrow Point to Blue Cavern Point there are many coves, such as Emerald Bay, Howland's Landing, and Isthmus Cove, with sandy subtidal substrate. These coves are enclosed by rock outcroppings and boulders extending to a depth of approximately 40 feet (12 m) (SWRCB 1979).

There are three types of nearshore sediments: 1) Lithic sediment composed of rock particles; 2) organic sediment composed of biological fragments such as shells and sea urchin tests; and 3) calcareous sediment composed of $CaCO_3$ primarily from corralline algae (SWRCB 1979).

Areas with heavy runoff, such as Parson's Landing and Cactus Bay, have lithic sediments, usually grading from coarse to fine sands as depth increases. Catalina Head and West End areas, which have large populations of mollusks and relatively heavy wave action, have organic sediments. Sediments found in some of the coves from Emerald Bay to Big Fisherman Cove contain a large percentage of calcareous debris (SWRCB 1979).

The intertidal area of the ASBS is not extensive. The shoreline is extremely rugged, with the main landmass rising steeply out of the ocean. Consequently, intertidal habitats are quite restricted in vertical range. The southwest (windward) side of the island is exposed to wave action and, in certain areas, minimal intertidal areas exist (for example, Catalina Head). However, the leeward side does not benefit from wave activity, and the combination of steep slopes and low wave action results in poor intertidal habitats. Relatively good intertidal habitat, characterized by gently sloping solid substrate, can be found only at Ship Rock, Bird Rock and Big Fisherman Cove Point (SWRCB 1979).

Approximately 40% of the ASBS intertidal area consists of solid rock walls, and about 45% consists of various-sized boulders. The majority of these habitats are extremely steep in profile. The remaining 15% of the intertidal area consists of sandy or cobbly beaches. Virtually no beaches exist from Catalina Head to the West End, with the exception of Sandy Beach. Between Catalina Head and Arrow Point, most of the intertidal habitat is occupied by boulders. Many small coves and sandy beaches occur along the northeast (leeward) coast from Arrow Point to Blue Cavern Point, although cliffs and boulder areas predominate in this region also (SWRCB 1979).

Southeast Santa Catalina Island: The above shore cliffs and talus slopes continue subtidally, and deep water occurs relatively close to shore. As a result, kelp beds generally form a narrow fringe around the island; however, a more extensive kelp bed exists between Binnacle rock and the shoreline. The ASBS is fully exposed to south swell. Steep, rocky cliffs limit the extent of the intertidal area. Binnancle and Church Rock are the most exposed; Jewfish Point is somewhat protected. This exposure plus the strong winds at the east end of the island make nearshore waters rough, and less frequently dived than other areas around the island (SWRCB 1979).

La Jolla

The general submarine topography in the La Jolla Basin area can be described as a narrow (about 2 miles) continental shelf, traversed submarine canyon that approaches to within about 300 m of the shore. The canyon empties into the broad San Diego Trough, which is a part the irregular submarine region of deep basins and intervening ridge termed the Continental Borderland (SWRCB 1979).

The substrate in the northern half of the Reserve is fine sand mixed with varying amounts of silt and/or mud. Surveys on sandy substrates, both on the northern sand shelf and inshore of the head of Jolla Canyon, describe this sand as fine and white, interspersed with occasional patches of mud. Presumably, this mud is derived from storm water runoff. The mud is never so abundant that the sand appears a thing other than clean, white sand on superficial glance. The fine is well sorted, with median grain diameters of: 0.20 mm in samples the beach; 0.12 mm in samples from 5 to 10 meters depth; and 0.09 mm in samples from 30 meters depth. The sand grains are fairly uniform in size, with 90% of the 5 to 10 meter samples in the 0.08 to 0.19 mm size. The sand is mainly quartz, although 5% is heavy minerals, 3% micaceous materials, and less than 3% silt (Fager, 1968). According to Fager this silt/mud content from storm runoff is insignificant, but his s area was close to the end of Scripps Institution of Oceanography pier. The silt/mud concentration or deposition is probably considerably 9 as one moves southward, approaching the offshore area of the largest storm drain located at the foot of Avenida de la Playa (SWRCB 1979).

The sandy bottom in the northern third of the Reserve slopes evenly and gently seaward down to depths of 100 ft. (30 m.) at a distance 1200 to 1300 ft. (365 to 396 m.) from shore. The slope steepens somewhat so that depths of 400 to 500 ft. (122 to 152 m) are reached in the next 500 m. this broad sandy shelf is bordered on the north and south by the two branched of the La Jolla branch of the La Jolla Submarine Canyon. The shoremost 300 m consist of a fine, white sandy substrate that is similar to the sandy shelf immediately north. At a depth of ca. 30 ft. (9 m), however, the slope steepens noticeably and there is a 4 to 5 ft. (1 to 2 m) clay bank that distinguishes the canyon at a depth of 50 ft. (15 m). The canyon head itself is characterized as a wide bowl-like structure, rimmed by a basement of Eocene sandstone/shale. The sides are extremely steep (nearly vertical) in some areas, whereas other areas lave a gradual sloping side. There are occasional small rock outcropings, but these are rare and this branch of the canyon is much less spectacular in its steepness and undercut ledges than the head of the more northern Scripps branch. The biota reflects the difference between the physical structures of these two heads (SWRCB 1979).

The southern third of the ASBS is much more diverse in substrate than the others. The area immediately inshore of the southern wall of the canyon is sandy, at least to depths of 35 ft. (10 m). Flat sandstone ledges are exposed in much of the Devil's Slide corner of the Ecological Reserve, extending as far northward as the southern end of the La Jolla Beach and Tennis Club. These ledges are found from shore to depths of at least 25 to 30 ft. (7.5 to 9 m.). In the subtidal areas offshore from the westward-facing section of shoreline, these flat ledges are a reflection of the intertidal and cliff strata, being tipped up some 20 to 30° northward. This allows for undercutting along the northern e, of these reefs, and it is along these northern, undercut ledges of t larger reef formations that many of the marine animals concentrate. Offshore from the northward-facing shoreline, this pronounced tipping becomes less and less distinguishable, especially with the shallow substrate along this section of the shoreline. At depths between 20 35 ft., there is a series of more or less parallel ridges made up of mudstone boulders. These ridges point shoreward toward the corner between Devil's Slide and La Jolla Caves and trend seaward on a north westerly direction where they cross the Ecological Reserve boundary depths of 35-50 ft. (10-15 m) (SWRCB 1979).

There is a small deposit of cobbles offshore from the La Jolla Beach and Tennis Club that becomes exposed during the winter months some years after a period of heavy surf; this patch extends for about 100 meters along a front parallel to the shoreline and at depths of 40 ft. (3 to 12 m) (SWRCB 1979).

San Clemente Island

There are several submerged platforms (Tanner and Cortes Banks) and deep basins (East Cortes and San Nicholas Basins), which measure up to 1.8 km deep, off of the southern coast of the island. There is submarine debris flow associated with the submarine canyon on the northwest end of San Clemente Island (http://highered.mcgraw-hill.com/sites/0070908214/student_view0/chapter2/virtual_vistas.html).

METEOROLOGICAL AND OCEANOGRAPHIC CONDITIONS

Climate

Northern Coast

The northern California climate is characterized by a mild maritime climate. In the summer months, a region of high pressure lies off the coast, generating the prevailing northwesterly winds and coastal fog. In winter, this high pressure zone moves southward and is replaced by a low pressure zone off the coast. Storms are common in the fall and winter. Cool, moist air masses move toward the coast during winter months and on contacting the coastal hills, are uplifted, cool, and drop their moisture as rain. The highest average monthly temperatures occur in late summer and fall, and the lowest in December and January. During the day, cool ocean air moves onshore as air heated over the land rises; at night, air tends to move from the cooler land masses toward the warmer ocean. In general the seaward nighttime flow is best developed in January (winter months) and least developed in July (summer). This seaward nighttime flow is primarily from the northeast and flows down the canyon slopes to the ocean (SWRCB 1979) (Felton 1965, cited in SWRCB 1980).

Redwoods National Park

There are 60 to 100 days with rainfall each year at the Redwoods National Park ASBS. Summer months are cool with frequent fog along the coast. The maritime climate is influenced significantly by the cool California current offshore. During May, June, and July, tides of maximum variation ("spring tides") occur during morning hours. These are months of maximum solar insolation. Air temperatures along the coast rarely exceed 75°F (24°C) in summer or drop below 45°F (7.7°C) in winter (SWRCB 1981).

Trinidad Head

There are no rain gauge records for the immediate Trinidad area, but records of rainfall have been kept at Patrick's Point State Park, 5.7 miles (9.1 km) north of the ASBS, and Arcata Airport, 5.7 miles (9.1 km) to the south. Arcata Airport averages 121 rainy days per year and a rainfall of 46.6 inches per year (118.4 cm/yr). Patrick's Point has 116 rainy days per year and a rainfall of 70.5 inches per year (179.1 cm/yr) (SWRCB 1979).

The mean annual air temperature at the Trinidad Marine Laboratory from 1973-1977 is 55.1°F (12.8°C) with lowest air temperatures recorded in January of each year and the highest air temperatures recorded in July (SWRCB 1979).

King Range

The rainfall at Shelter Cove, which is located within the King Range ASBS, is about 60% greater than the rainfall at Eureka, 48 miles (77.2 km) to the north, during the same period. Slightly inland, rainfall is considerably higher than along the coast. At Honeydew, just northeast of the ASBS, the average annual rainfall is approximately 110 inches (279 cm), making it one of the wettest places in the continental U.S. (SWRCB 1979).

Jughandle Cove

The average annual precipitation for the years 1959 to 1979 was 39.7 inches (101 cm). However, variation in annual precipitation in California is high; at Fort Bragg rainfall ranged from 21 to 61 inches annually (53 to 155 cm) for the years 1931 through 1960. Ninety-five percent of annual precipitation occurs from October through April. The remainder of the year is relatively rain-free though fog is common throughout the summer months and averages 30 days annually (SWRCB 1981).

Air temperature extremes are minimal along the Fort Bragg coast, with little temperature variation year-round. The average annual air temperature for the years 1959 through 1979 was 52.7°F (11.5°C), with an average fluctuation of only 10°F (5.6°C) on the coastal terraces (SWRCB 1981).

Saunders Reef

Although rainfall from 1975 to 1979 varied between 21 and 43 inches (53 and 109 cm), the highest values are more typical as 1976 and 1977 were drought years. Highest rainfall occurs from January through March and lowest from June through October. Information on wind velocities indicate that small craft warnings are typical and gale and storm force winds are common, especially during the late fall and winter storm season (SWRCB 1980).

Gerstle Cove

The annual rainfall averages about 47 inches (120 cm). The summer air temperature averages 64°F (18°C) and the winter air temperature is 42°F (6°C) (SWRCB 1979).

Point Reyes Peninsula and the Entrance to San Francisco Bay

The area of the Point Reyes Peninsula and the entrance to San Francisco Bay are characterized by cool, dry, foggy summers and cool, rainy winters. This coastal climate keeps summer temperatures well below those found a few miles inland. The Pacific Ocean tends to reduce the seasonal temperature range. Wind patterns reflect seasons. During winter storms, winds originate from the south, while high pressure systems generally bring brisk northwesterly winds in the spring and summer. Offshore breezes are warmer (SWRCB 1979).

Point Reyes Headlands

The general climate of the Point Reyes National Seashore Park is known as Mediterranean. Characteristics of this climate are moderate summers and cool, wet winters. The annual rainfall is about 19.5 inches (49.5 cm) per year. There is very little rainfall during the summer months. Most of the precipitation occurs in the winter months of November to March (SWRCB 1980).

Since the Point Reyes ASBS is exposed to the influences of the Pacific Ocean, the area is buffeted by strong winds, with maximum velocities in the range of 40 to 50 mph (64 to 80 km/hr) in the winter, while the summer average velocities range about 10 to 13 mph (16 to 20 km/hr). The maximum average temperatures ranged from 68° to 86°F (20° to 30°C) while the minimum average temperatures were 41° to 48°F (5° to 9°C). During the winter months, the skies are generally clear while during summer to fall months (July to October) more than half the days are foggy. Rainfall in the area is sparse, occurring mostly during months of December through March. The annual rainfall for the area is about 19.5 inches (49.5 cm) per year, producing an annual runoff of approximately 6 inches (15 cm) (Biswell and Agee, 1973) (SWRCB 1980).

Duxbury Reef

Measurements taken at the Point Reyes Lighthouse indicate that the daily mean temperatures fluctuate less than 7°F (3.9°C) from January to September (52 year average). The lowest mean average for a month is for January, 49.8°F (9.9°C) and the highest is 56.5°F (13.8°C) for September. Although there is no weather station in Bolinas or otherwise close to Duxbury Reef, these values from Point Reyes should approximate conditions at Duxbury Reef. Yearly rainfall averages from Point Reyes Station inland are 29.90 in. (760 mm) for a 13 year period and 19.55 in. (497 mm) at the Point Reyes Lighthouse (64 year average). The rainy season is from November to March (SWRCB 1979).

Central California

In general, the climate of the central California coast is characterized throughout the year as having moderate temperatures controlled by the circulation patterns of the North Pacific Ocean (SWRCB 1981). Wind direction varies seasonally with the location of the Pacific High pressure cell. When this cell is centered over the North Pacific, generally between April and September, the coast catches the eastern edge of the gyre, and prevailing winds are from the northwest. These winds are deflected down the coast by the coastal mountain ranges. Upwelling begins and the cooler water brought to the surface creates a cold zone near the coast. The interior valleys begin to heat up and the rising air creates a thermal low pressure area which draws cold air in from the ocean. Water vapor then condenses to produce the fog and low cloud-cover. In the late summer and early fall, the Pacific high-pressure system moves offshore and the interior valleys cool down (SWRCB 1979).

James V. Fitzgerald

Average monthly temperatures in the spring and summer range from 55° to 59°F (13° to 15°C). Highs may occasionally reach the mid 70's. During the spring and summer, fog and low-cloud cover is common in the ASBS. The months of October through April have the least fog (SWRCB 1979).

In the winter, storm winds blow from the southwest. Whereas the average wind velocity at Half Moon Bay is 12 to 15 knots (San Mateo 1976), strong winds are especially common in the winter. Winds of storm force (43 to 63 knots) are usually reported at least a few times a year. During the winter, temperatures are a few degrees cooler with monthly averages from 50° to 52°F (10° to 11°C) (SWRCB 1979).

As is typical of most maritime climates, James V. Fitzgerald ASBS receives abundant rainfall, most of which falls between October and April. Annual rainfall may vary greatly; from 1975 to 1977, it ranged from 13.13 to 24.6 in. (33.3 to 62.4 cm). Monthly rainfall can also show considerable variation; January rainfall ranged from 0.52 in. (1.32 cm) in 1976 to 9.01 in. (22.9 cm) in 1978 (SWRCB 1979).

Año Nuevo

The climate at Año Nuevo is generally milder than at the northerly San Mateo communities. The fog is less present than in nearby coastal areas. This is possibly because of the high coastal mountains to the north and south. Weather data (fog, sun, and rain) at Año Nuevo Point and Island are similar to data gathered at Half Moon Bay. The recorded mean temperature at Half Moon Bay is 54.5°F (12.5°C). The warmest period occurs during the summer months. The mean rainfall is 23.46 inches (59.6 cm). The microclimate at Año Nuevo is similar to Santa Cruz. The average annual rainfall at Año Nuevo as about 20 inches (50.8 cm) (SWRCB 1981).

Pacific Grove

Rainfall is moderate within the ASBS and highly seasonal. Between 1972 and 1975, average rainfall was 16.3 in. (41 cm) at Pacific Grove and 86% of the total occurred between November and April. The "rainy season" occurs as early as September, or as late as January. The length of the rainy season is also highly variable, such that March and April can experience the heaviest rains, or no rain at all (SWRCB 1979).

In Monterey, prevailing winds are from the north or northwest over 58% of the time in the spring and summer. The strongest northwest winds usually occur in March and April. Prevailing winds are still from the northwest, north-northwest or north more than 47% of the time, (Scott 1973) but are generally weaker than in spring and summer (SWRCB 1979).

Air temperatures in the ASBS are moderate and show little diurnal or seasonal variation. The average annual maximum temperature is 71.1°F (21.7°C); the average annual minimum temperature is 48.6°F (9.2°C). The proximity of both the bay and the ocean serves to moderate fluctuations in nearby land temperatures. The afternoon sea breeze keeps maximum temperatures down, whereas the evening fog traps heat radiated off the land and prevents early morning temperatures from dropping further (SWRCB 1979).

Carmel Bay

The climate of the Carmel Bay ASBS is characterized by mild air temperatures and cool ocean breezes. Fog persists (until early afternoon) in late spring and summer. Typically 90% of the rainfall occurs between November and April, and summers are dry (SWRCB 1979).

Air temperature and rainfall data were collected from two stations adjacent to the ASBS at the Carmel sewage treatment plant and at Pebble Beach. At the treatment plant, temperatures ranged between 43°F (6°C) and 68°F (20°C) during 1974-1979; rainfall averaged 19.6 inches/year (49.8 cm/yr.). Data taken at Pebble Beach over a longer period of time show an average low air temperature of 50°F (10°C) in the winter and an average high air temperature of 58°F (14.4°C) in summer. Yearly rainfall here averaged 17.3 inches (43.9 cm) (SWRCB 1979).

According to Ranger Culbertson at Pt. Lobos State Reserve, prevailing winds are from the north and northwest, with southerly winds accompanying storms. The proximity of land and water creates a diurnal pattern of onshore-offshore breezes, rarely absent. Winds are generally less than 10 to 15 miles per hour, (16 to 24 km/hr) except during storm conditions (SWRCB 1979).

During the spring, prevailing winds are from the northwest. In autumn, the Pacific High moves southward, making way for winter storm fronts. The first winter storms usually occur in September or October (SWRCB 1979).

Julia Pfeiffer Burns

Total precipitation varies annually along the Big Sur coast ranging from about 40 in (102 cm) in the north to about 30 in. (76 cm) in the south. Average annual precipitation is about 48 in. (122 cm). Less than 2% of the average annual precipitation falls from the beginning of June to the end of September (Elford 1970, cited in SWRCB 1979).

Air Temperatures are typically moderate within the ASBS, and tend to increase moving inland as well as decrease with elevation. The mean minimum temperature for January is 40°F (4.4°C) and the mean maximum temperature for July is 10°F (21°C) (Elford 1970). Since the coastline of the ASBS has a strong northwest-southeast direction, northerly winds apparently are not too intense nearshore (SWRCB 1979).

The area is often tempered by fog and marine air masses resulting in very moderate, year round temperatures (http://www.fs.fed.us/r5/lospadres/about/).

Southern California

Southern California is characterized by a Mediterranean climate with mild temperatures and seasonal winter rainfall. Weather in this area is largely controlled by the Eastern Pacific high which is located off the coast of Northern California during the spring and summer months; this high pressure cell prevents low pressure systems from moving down the coast into southern California. The summers are warm and without precipitation but moderated by prevailing westerly winds from the ocean and typical summer coastal fogs (SWRCB 1979).

Santa Catalina Island

Skies are generally clear; however, fog does occur during the cooler months. The mountainous land mass often limits the fog to the windward side of the island. The Isthmus is a break in this terrain and permits fog and wind to reach the leeward side (SWRCB 1979).

The average daily temperature ranges from the high 70's (°F) in late summer and the low 50's (°F) in winter. Rainfall occurs primarily between October and April; average annual precipitation is 11.4 inches, based on data from 1945 through 1967. The northeast side of Catalina experiences greater rainfall than the southwest side. The northeastfacing slopes (toward the mainland) are protected from the drying effect of the prevailing westerly winds and hot afternoon sun (SWRCB 1979).

Prevailing winds are from the west-northwest. However, during the summer and early fall, warm drying Santa Ana winds occasionally blow from the mainland (Thorne 1967) (SWRCB 1979).

Laguna Point to Latigo Point

The temperature, humidity, precipitation, and wind characteristics for the vicinity of the Laguna Point to Latigo Point ASBS are monitored by the Pacific Missile Test Center at Pt. Mugu and are published periodically (de Violin 1975). The average summer temperatures are a maximum of 62° to 72°F (19.5° to 21°C) and a minimum of 54° to 58°F (12° to 14.5°C) (SWRCB 1979).

In the late fall the East Pacific high weakens and moves south, allowing storm systems to move down the coast. During the winter months, winds are predominately northeasterly at Point Mugu. This area receives 95% of its yearly rainfall during the winter. The average relative humidity is actually lower in the winter than in the spring and summer. The average winter temperatures are a maximum of 62° to 64°F (17° to 18°C) and a minimum of 44° to 45°F (6.5° to 7.5°C) (SWRCB 1979).

The average annual precipitation is lower in the vicinity of the Laguna Point to Latigo Point ASBS (11 to 13 inches) than in the adjacent coastal mountains (up to an average of about 24 inches). However, there is a very large variation in precipitation from year to year. Between 1946 and 1973 the annual rainfall varied between 4.8 inches and 22 inches at Point Mugu (SWRCB 1979).

La Jolla

The monthly median temperatures for the minimum daily temperatures range from 8° to 9°C (46° to 48°F) in the winter months to ca. 17° to 18°C (62° to 64°F) in the summer months and those for the maximum daily temperatures range from 14° to 15°C (57° to 59°F) in the winter and/or spring months to 20-22°C (68-72°F) in the 1 ate summer and/or early fall months. The rainfall is largely concentrated in the winter months, although infrequent tropical squalls deposit significant rain during the summer months (SWRCB 1979).

Oceanographic Conditions and Historical Water Quality

Seasonal changes in wind direction commonly create seasonal patterns for the currents off of the California Coastline. For much of the year, the California Current brings colder northern waters southward along the shore as far as southern California (MLPA 2006). The California current is the eastern leg of the North Pacific Gyre, a massive, clockwise-moving current system which encompasses the entire North Pacific ocean (SWRCB 1979). The California Current is a wide, slowmoving south-eastward flow between 48°N and a southern limit of 23°N. The western limit of the California Current is the boundary region between subarctic water and eastern north Pacific central water, which at 32°N is about 700km from the coast. The western edge is often set at 1000km offshore. The majority of the water movement to the south occurs between 200 and 500km offshore, maximum water speeds are shallower than 200m. The upper waters of the transistion area are more influenced by subarctic water than the waters below 100m (Allen et al 2006).

The flow off of the northern California coast is strongest nearshore during the spring and early summer and offshore during the late summer and early fall (Allen et al. 2006). The seasonal presence of the California Current corresponds with that of the Pacific high-pressure cell, which is responsible for prevailing northwest winds (SWRCB 1979). Most of the California coast north of Point Conception is dominated by the southward flowing California Current (SWRCB 1980).

The Southern California Countercurrent occurs in the upper half of the Southern California Bight throughout the year except during April. It occurs in the southern half of the bight from April to December. Around Point Conception, The Southern California Countercurrent meets with the California Current, creating a rich transition zone. Counterflow north of Point Conception occurs during the fall and winter months (Allen et al 2006).

The seasonal presence of the California Current corresponds with that of the Pacific high-pressure cell, which is responsible for prevailing northwest winds. Beginning in March, as the California Current travels south along the coast, surface waters are driven to the right, or offshore, by the combination of northwestly winds and the Coriolis force. This triggers the upwelling of cold, nutrient-rich water from the depths along the coast, causing this oceanographic season to be termed the Upwelling Period. By September, as the northwesterly winds die down, the cold water sinks again and warmer waters return to the coast making way for the Oceanic Period (SWRCB 1979).

The Oceanic Period lasts into October, when the predominant winds move to the southwesterly direction. Close to shore, the California Undercurrent carries equatorial water northward along the Baja California and California beneath the California Current, at depths greater than 655 ft. (200 m) (SWRCB 1979). North of Point Conception in late fall and winter, its core gradually rises from 200-300m to the surface and becomes known as the Davidson Current (MLPA 2006). This current reverses current direction intermittently even in surface waters during the winter (SWRCB 1979), and may be continuous with the California countercurrent during this period (Allen et al 2006). It carries equatorial Pacific water of higher salinity and temperature than generally exists at this latitude, and has an important moderating effect on winter ocean temperatures (SWRCB 1979).

The Southern California Bight is the 300 km of recessed coastline between Point Conception in Santa Barbara County and Cabo Colnett, south of Ensenada, Mexico. The dramatic change in the angle of the coastline creates a large backwater eddy in which equatorial waters flow north near shore and subartic waters flow south offshore. This unique oceanographic circulation pattern creates a biological transition zone between warm and cold waters that contains approximately 500 marine fish species and more than 5,000 invertebrate species (SWRCB 1979).

The water transport in Southern California Bight in is influenced by the California Current and the Southern California Counter Current (SWRCB 1980). The prevailing direction of swell in the California Bight is from the west (SWRCB 1979). The California

Current flows southward along the coast (Michaels 2005). The California Current is generally located at the surface over the seaward slope, well outside of San Clemente Island and several hundred km offshore of the mainland; it flows toward the equator. Nearer to shore a large scale eddy effect takes place and surface water is transported poleward by the Southern California Counter Current. Upwelling also takes place in the Southern California Bight, in which nutrient rich bottom water rises to the surface. Even closer to shore, the current over the coastal shelf, in depths up to 60 meters, flows toward the equator. (Dailey et al 1993). The longshore current has a net southward flow and deposits sand into the heads of the La Jolla submarine canyon and thence down into the San Diego Trough (SWRCB 1980).

When the California Current reaches Point Conception it continues south well off the coast of the Southern California Bight and even beyond the outer islands. However, some of the California Current is diverted eastward at San Miguel Island. This water flows along the north coast of the northern Channel Islands and then splits into three parts and becomes the Southern California Countercurrent. One segment continues eastward along the northern Channel Islands and escapes into the Santa Monica Basin off Anacapa Island. Another segment moves northward across the channel at about the level of Santa Barbara. As it nears the coast it divides into the other two parts: a westerly flowing current along the coast from Santa Barbara to Point Conception (thus forming a counterclockwise gyre in the Western Santa Barbara Basin) and an easterly flowing and weaker portion of the current moves along the coast from Santa Barbara to Port Hueneme where it also enters the Santa Monica Basin. The eastern arm of the Southern California Countercurrent forms a counterclockwise gyre in Santa Monica Bay which flows northerly and then westerly along the Malibu Coast from El Segundo all the way to Point Dume; here it rejoins the offshore eastward flowing current. The combined water mass moves primarily southward off the coast from Santa Monica Bay to well beyond the Mexican Border where it finally rejoins the California Current (SWRCB 1979).

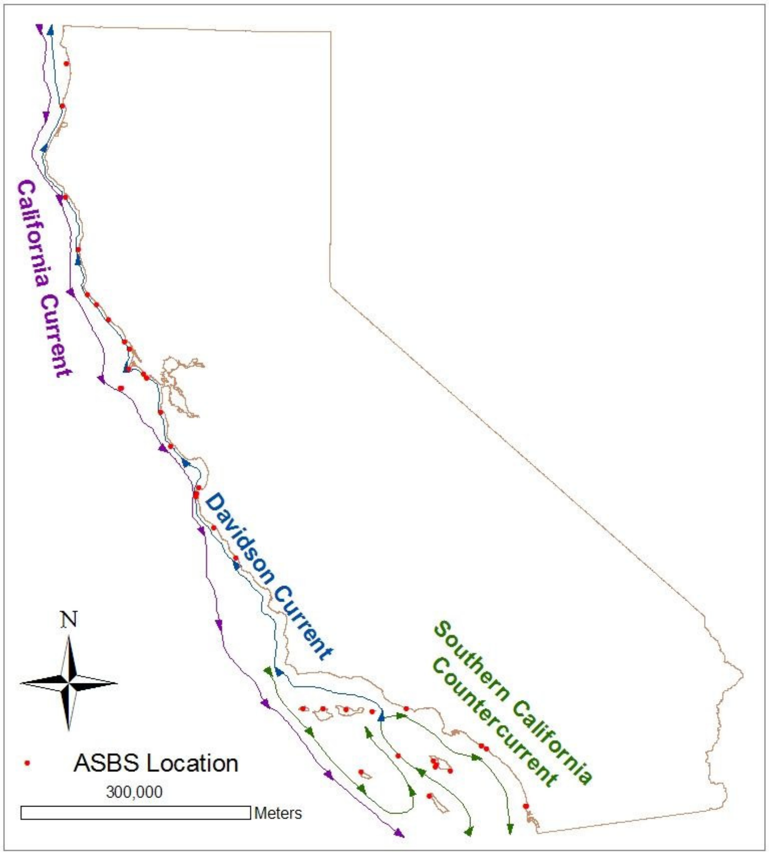

Figure 1. Generalized Major Surface Currents in California Coastal Waters.

Laid over this general pattern throughout California are both short-term and long-term changes. Local winds, topography, tidal motions, and discharge from rivers create their own currents in nearshore waters. Less frequently, a massive change in atmospheric pressure off Australia floods the eastern Pacific with warm water, which suppresses the normal pattern of upwelling. These short-term climatic changes, called El Niño, reduce the productivity of coastal waters, causing some fisheries and seabird and marine mammal populations to decline and others to increase. For instance, warm waters that flow north in an El Niño carry the larva of California sheephead and lobster from the heart of their geographical range in Mexico into the waters off California (MLPA 2006).

Other oceanographic changes last for a decade or more and these natural fluctuations can have significant impacts on the health and composition of marine life. In these regime shifts, water temperatures rise or fall significantly, causing dramatic changes in the distribution and abundance of marine life. The collapse of the California sardine fishery occurred when heavy commercial fishing continued on sardine populations that were greatly reduced by a cooling of offshore waters in the late 1940s and early 1950s. In response to the decline in sardines, California law severely curtailed the catch. In 1977, waters off California began warming and California Department of Fish and Game Master Plan for Marine Protected Areas April 13, 2007 (Page 6) remained relatively warm. The warmer water temperatures were favorable for sardines, whose abundance greatly increased. But the warmer waters also reduced the productivity of other fish, including many rockfishes, lingcod, sablefish, and those flatfishes that favor cold water for successful reproduction (MLPA 2006).

Currents and other bodies of water may differ dramatically in temperature and chemistry, as well as speed and direction. These factors all influence the kinds of marine life found in different bodies of water. In general terms, geography, oceanography, and biology combine to divide California marine fisheries and other marine life into two major regions north and south of Point Conception. Within each region, other differences emerge. Conservation and use of California's marine life depends partly upon recognizing these differences (MLPA 2006).

Redwoods National Park

From July to November the current moves southward at about 0.8 ft. (0.25 m) per second, but its general pattern of flow is interrupted by projecting headlands. Point St. George, just to the north of Redwood National Park ASBS, tends to push the southward flowing waters offshore, and a large gyre forms south of this headland. This gyre appears to extend about 24 miles (40 km) south, trapping within it much of the sedimentary material entering the ocean from the Klamath River and Redwood Creek. Some of the finer material entering the ocean at the mouth of the Smith River, north of Crescent City, is transported around Point St. George and deposited on Crescent Beach within the ASBS (Pirie et al 1975) (SWRCB 1981).

In the November to February period each year, nearshore current patterns are complex and are greatly affected by winter storms. Large volumes of fresh water are discharged into the nearshore waters with heavy silt loads. Small local gyres are evident when observing stream discharge plumes and fine particulate silts may move either north or south dependent on the local current pattern. Indirect evidence of an inshore, northward flowing current, perhaps an extension of the Davidson Current, is provided by annual differences in the settlement of some sand beach invertebrates. In 1974-76, the sand crab *Emerita analoga* was rare on sand beaches within the ASBS (SWRCB 1981).

An upwelling period is evident along the coast of the ASBS during March through August. Deeper, cooler, nutrient enriched nearshore waters are particularly evident south of capes or headlands, such as Point St. George. Pirie et al (1975) described an area of upwelling south of Crescent City; increased chlorophyll concentrations during the March to August period in 1974-76 support the existence of nutrient-rich waters in the nearshore zone of the ASBS (Boyd and DeMartini 1977) (SWRCB 1981).

During May, June, and July, tides of maximum variation ("spring tides") occur during morning hours (SWRCB 1981).

The nearshore environment of the Redwood National Park ASBS is influenced by a seasonally variable current pattern, by large amounts of fresh water entering the nearshore zone at the mouth of the Klamath River and at the mouth of Redwood Creek, and by seasonal changes in the temperature of nearshore waters.

The salinity of nearshore waters fluctuates markedly depending on patterns of local rainfall. Near major stream discharge points, surf zone waters are frequently below 1 ppt salinity (essentially fresh water). The extent of the fresh water influence is dependent on the volume of stream discharge and is difficult to pinpoint exactly. Surf zone waters were below 1 ppt for ¼ mile north and south of the mouth of Redwood Creek during periods of high stream flow in 1974-76, but beach waters at Gold Bluffs Beach, 4½ miles north were never below 30 ppt. It is likely that a similar pattern of low salinity during peak discharge periods (winter months) is also in existence near the mouth of the Klamath River. The only regular measurements of surface salinities along the Humboldt-Del Norte Counties coastline are made at the Telonicher Marine Laboratory operated by Humboldt State University at Trinidad. These data suggest a pattern of modest variation in the salinity of nearshore waters, except in areas where stream discharge may have a major influence.

Surface water temperatures fluctuate annually, with the lowest temperatures in late winter or early spring and the highest water temperatures in late summer or early fall. Water temperatures are recorded regularly at Crescent City and Trinidad Bay.

Redwood National Park lies within three major river basins. The inland, northern portion of the Park lies within the Smith River drainage basin, the middle portion within the Klamath River basin and the southern portion within the Redwood Creek drainage basin. Numerous small coastal streams drain directly into the ocean at several points. The high suspended sediment load of streams and rivers emptying into the coastal waters of the ASBS are a reflection of the unstable soils on the coast and inland combined with recent logging operations. Erosion within the Redwood Creek drainage basin is a serious problem that is being addressed by the National Park Service in its management plan.

Trinidad Head

The current patterns of the nearshore waters of the Trinidad Head ASBS are complex and variable. The two portions of the ASBS are affected quite differently by wave and wind conditions because of their differing exposure. Along the shorelines of both areas, sand and rock are intermixed and subjected to tidal variations of approximately 9.3 feet (2.8 m), dependent on the day and season (SWRCB 1979).

The nearshore circulation pattern is greatly influenced by the prevailing north to south longshore drift and the interruption of this longshore drift by Trinidad Head. Fluctuations in the temperature and salinity of the nearshore waters of the ASBS are relatively moderate. The lowest water temperatures 43° to 48°F (6° to 8^{o}C), are generally recorded in late winter or early spring each year, and the highest water temperatures 53.6° to 55.4°F (12° to 13°C), are recorded in the late summer or early fall. The mean annual water temperature is about 50°F (10°C). Salinity varies, depending upon rainfall and runoff from surrounding streams. During periods of high rainfall in the winter, surface water salinity may drop to 20 parts per thousand (ppt) for brief periods. The average annual salinity is approximately 34 ppt. Modest seasonal changes in water temperature and salinity are typical of the nearshore zone along the northern California coast (SWRCB 1979).

King Range

From approximately March to July, an "upwelling season" prevails in the nearshore waters in response to winds from the northwest. Upwelling is particularly intense just south of Cape Mendocino, greatly influencing the nearshore environment of the ASBS (SWRCB 1979).

The nearshore zone of the ASBS is considered one of the most hazardous to navigation in all of California. Waves 20 to 25 feet (6 to 7.5 m) in height have been observed at Point Delgada and Punta Gorda, even during summer months. Many ships have been lost along the coast since the late 1800’s because of the hazardous, unpredictable sea conditions, and because the coast lacks suitable protected anchorages. Only a small area southeast of Pt. Delgada (Shelter Cove) offers protection from northwesterly storms, and even there the anchorage is considered unsafe because of exposure to southwesterly winds and waves (SWRCB 1979).

No measurements of nearshore water temperatures or salinity have been taken on a regular basis in the ASBS. It seems likely that winter water temperatures are approximately 48 to 50°F (9 to 10°C), with annual high water temperatures around 55° to 58°F (13° to 14.5°C), based on water temperatures taken at Eureka and Trinidad to the north (SWRCB 1979).

The major source of freshwater entering the nearshore zone is the Mattole River, although numerous small streams empty into the ocean along the shoreline of the ASBS. Considering the coastline is fully exposed to the effects of winter waves, it seems unlikely that freshwater significantly dilutes seawater within the nearshore zone. Wave force would tend to rapidly mix freshwater with seawater in the surf zone. No estuarine plant or animal species were found anywhere within the ASBS except near the mouth of the Mattole River. Surface water salinities probably do not fall below 28 to 30 ppt except in the immediate vicinity of the Mattole River mouth (SWRCB 1979).

Erosion along the coastline, with transport of fine sediments into the nearshore zone, is a natural consequence of the active geological history of the coastline. Natural erosion processes have been greatly accelerated in the past fifty years by logging, grazing, and road building activities; however, the turbidity of nearshore waters is high at every season of the year. During the past five years, water visibility has not been observed to exceed five feet (1.9 km) within the ASBS. During the upwelling season (March-July), nearshore waters are frequently light to dark green in color, suggesting nutrient enrichment from upwelled waters. The coastline is considered dangerous for diving because of currents, heavy surf, and poor visibility (DeMartini, personal communication) (SWRCB 1979).

Jughandle Cove

Around the ASBS, the California Current is broad and meandering and averages 25 to 60 inches/sec (10-25 cm/sec). Though this current has no discreet western boundary, it extends 60 to 330 miles (100-600 km) offshore. This water mass is underlain by the deep (650 ft; 200 m) California Undercurrent which flows northward from Baja California to north of Cape Mendocino (SWRCB 1981).

During the Upwelling Period nearshore waters are turbid due to strong wave action and phytoplankton blooms. The Oceanic Period is typified by calm seas and relatively clear water. Wave action is strong and nearshore waters are generally well mixed and turbid during the Davidson Period (SWRCB 1981).

Water temperature information is based on data collected during the years 1975 through 1978 (6) from a beach near the mouth of the Albion River, located eight miles (14 km) south of the ASBS. Mean monthly temperatures in the winter are typically 48° to 51℉ (9° to 10.5℃) and mean monthly temperatures in the summer range from 52° to 54.5℉ (11° to 12.5℃). Maximum temperatures usually occur from April through August and range from 59° to 61℉ (15° to 16℃). Minimum temperatures occur from November through April and are typically near 46℉ (8℃). The greatest monthly temperature fluctuations, approximately 11℉ (6℃), are usually during April and May and probably correlate with periods of intermittent upwelling (SWRCB 1981).

Mean salinities along the central and northern California coast range from less than 33.0 ppt. near Cape Mendocino to 33.5 ppt. offshore of Point Conception. Ocean waters typically increase in salinity from north to south and are slightly more saline near shore. The mean seasonal salinity range is small along most of the Mendocino coast. The salinity of nearshore waters off Point Arena, about thirty miles (45 km) south of the ASBS, ranged from highs of 33.9 to 34.0 ppt. in the early summer to lows of 32.2 to 33.5 ppt. in early winter. Jug Handle Cove has lower salinity during the winter due to increased flow from Jug Handle Creek, though no data is available regarding the extent and degree of this influence (SWRCB 1981).

All creeks emptying into the ocean in areas adjacent to the ASBS are of possible concern regarding water pollution. The major problem is siltation during the winter. Erosion from past logging operations causes high levels of siltation within the Jug Handle Creek drainage. It is probable the effects of this pollution are of minor consequence to the marine biotas of the ASBS. Homes along the immediate coastline adjacent to the ASBS are suspected sources of water quality reduction. Most of these homes have septic systems which may leach along the bluffs during winter (SWRCB 1981).

The ASBS is probably unaffected by the water quality problems of Noyo Harbor at Fort Bragg. The problems of Noyo Harbor include fish processing, boat docking and logging in the upper reaches of the Noyo River. The Caspar Development, located one mile south at Caspar Cove, poses no problem to water quality within the ASBS. However, the trailer park at Caspar Cove has been identified as a local pollution problem within that cove (SWRCB 1981).

Saunders Reef

The California Current is most important in nearshore waters during summer and early fall. Highest velocities occur in winter; at that time the current is located over 125 mi. (200 km) offshore at Cape Mendocino, north of the ASBS (Hickey, 1979) (SWRCB 1980).

Upwelling dominates the nearshore waters in spring and early summer, and may also occur at other times under favorable wind conditions. Upwelling, common along most of the California coast, brings cold, nutrient-rich water inshore which is an important stimulus to phytoplankton and, probably, macroalgal growth (SWRCB 1980).

The northern location combined with cold currents and upwelling produces relatively low nearshore water temperatures. In 1978, the highest monthly mean surface temperature measured near Salt Point (south of the ASBS) was 57.2℉ (13.8℃) in March and the lowest was 48.5℉ (9.6℃) in December. Although only partial records are available, temperatures at Point Arena are lower. Records for 1975 and 1976 at Salt Point indicate that consistently low water temperatures are typical of this region (SWRCB 1980).

In addition to current patterns, upwelling, and low temperatures, the shallow water around the ASBS is also strongly influenced by exposure to the large seas and swells characteristic of the northern California coast. The bottom around the reef, the cobble and boulder beaches, and the presence of the intertidal kelp, *lessoniopsis littoralis,* all indicate this is an area of extreme surge and surf. Because of the high water motion, the reef and intertidal areas are accessible by small boat only a few days per year. In addition, the high water motion keeps the shallow water well mixed, maintaining high nutrient levels and low water clarity. High turbidity may be caused by both the re-suspension of bottom sediments by seas and swells and by plankton blooms. Visibility during the winter may be reduced by sediment runoff from the gulches bordering the ASBS (SWRCB 1980).

Gerstle Cove

North Gerstle Cove is protected from the prevailing northwesterly swell during the summer, as evidenced by the presence of numerous jellyfish, and by the deposition of fine particulate matter there. During the winter, when southerly gales are common, the general water flow is northward, associated with the Davidson Current (SWRCB 1979).

The fine particulate matter which settles in North Gerstle Cove during the summer appears to become resuspended later in the year. During a southerly gale in September, 1977, an increase in turbidity was observed while visibility was reduced virtually to zero. In January, during a period of westerly seas, turbidity levels similar to summer conditions were observed. The material suspended in September had probably been removed to deeper water in January (SWRCB 1979).

Surface temperatures have been monitored at Salt Point State Park since January, 1973, by State park staff for Scripps Institution of Oceanography. For the years 1973 through 1976, the months of August through November ranked as those having the four highest seasonal mean temperatures. The four greatest ranges in temperature occurred in June, July, August and January. During summer, the development of a shallow thermocline occurs, especially on very calm days (SWRCB 1979).

During the ASBS Reconnaissance Survey (SWRCB 1979) pit-type toilets were found adjacent to the parking area on the northwest side of the ASBS. Furthermore the Reconnaissance Survey also found a source of water pollution due to the filleting of fish in the launching area by sportsmen. During the summer, numerous carcasses had been found in the intertidal and subtidal zones. Mouldering fish did generate a smell and the site was aesthetically unpleasing during the survey. Since then the Department of Parks and Recreation has remedied that situation with a fish cleaning station draining to a septic system.

The salinity regime appears to be characteristic of the surrounding coastline. Runoff sources are from the adjacent cliffs and two small rivulets which probably supply freshwater from late fall through early summer during normal rain years. Because the freshwater supply is relatively small and mixing is generally great, steep, localized salinity gradients are probably rare (SWRCB 1979).

Point Reyes Headlands

Waves which are generated by northwest winds strike the Point Reyes Headland and refract around the Point towards the inner beaches of Drakes Bay (Cherry, 1965). There is constant erosion of the Point Reyes Headland from the action of these waves which carry much sediment from the Headlands to Drakes Bay where the sediments are sorted along the beach front (SWRCB 1980).

The waves which affect the littoral zone vary according to the patterns and influences of winds and other weather conditions which occur in this locality. In some areas of the ASBS, the waves strike the intertidal zone with variable intensity. At Sea Lion Cove, the offshore sea stacks break up the velocity of the waves; therefore, the beaches in the cove are made up of well-mixed, medium particle size sands. The sea lions find this area suitable habitat for hauling out. In contrast to Sea Lion Cove, the beach at Split Rock Cove consists of 4 to 16 inch (10 to 40 cm) cobbles. This beach does not have any sea stacks to break up the waves; therefore, the velocity of waves striking the beach is intense. The term "boulder beach" aptly describes the characteristics of this cove. The influence of upwelling at the Point Reyes Headland ASBS is unknown (SWRCB 1980).

The water clarity at the ASBS ranges from 3 feet in the nearshore area to about 15 feet at the 30 foot (9 m) contour line. Water clarity and visibilities are fairly good for Marin County waters, averaging about 7.4 feet (2.3 m) during the underwater dives. Due to the intense wave action of the area, there are many sediments which become suspended in the water column close to shore and during summer months the plankton blooms are the highest, thus contributing to the poor visibilities of the water column.

During winter when plankton blooms are lowest, the visibility in the near shore waters reaches a maximum of about 10 feet (3.0 m) (SWRCB 1980).

Surface salinities (total dissolved solids) averaged 32.1 ppt. This figure is slightly higher than the average salinities in the coastal waters near the Golden Gate Bridge. Water temperatures averaged about 50.9°F (10.5°C) over a period of 24 years of observations at Point Reyes Headland. Dissolved oxygen levels averaged about 8.9 mg/l. Nitrates and phosphates were at levels less than 0.01 parts per million (ppm) when measured in 1979 (SWRCB 1980).

Duxbury Reef

The reef is subjected to unbroken Pacific Ocean swells. During times of winter storms, enormous waves crash onto the outermost rocks; the inner areas are protected except at the highest tides. The California Current system provides a general southerly movement of water along the northern coast of California. This movement becomes very complex in the vicinity of San Francisco Bay, where large volumes of water are continually being exchanged by the tides. Upwelling is most intense during the summer months, resulting in very cold sea temperatures during the summer. During winter and spring, a northward flowing surface current develops, bringing warmer waters near to shore. The complexities of these current systems and the tidal exchange with San Francisco Bay create a highly complex picture with regard to water movement in and around Duxbury Reef. Probably the water washing the reef varies seasonally in its origin. Nevertheless, there is a general northwesterly eddy which carries water from San Francisco Bay towards Duxbury Reef on ebb tides (SWRCB 1979).

Strong currents are produced by wave backwash and treacherous rip currents are fairly obvious in some areas. Strong currents are also noted in the larger tidal channels which separate wave-swept outer rocks from more protected terrace areas (SWRCB 1979).

Water temperatures from the Golden Gate show an average (40 years) of 55.8°F (13.1°C) with a maximum of 68°F (20°C) and minimum of 41°F (5.7°C). The warmest months are July-October and the coldest are December-February (SWRCB 1979).

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There have been no studies conducted on local current patterns around the ASBS. A one day release experiment at the Montara Sanitary District sewage treatment plant outfall indicated water movement to the north and northwest (Gustafson, 1972). No conclusions can be drawn from this, however, because local current patterns may be highly variable, influenced by the weather, tidal factors, and amount of fresh water runoff entering the system (SWRCB 1979).

Fitzgerald Marine Reserve ASBS is typical of other stretches of open central California coastline in that it is fully exposed to the force of especially strong winter swells. Ten-foot swells are not uncommon during the winter. The existence of extensive subtidal reefs, to depths of about 30 ft. (9 m) throughout much of the reserve, probably affords some protection to organisms of the intertidal zone by dissipating some of the wave shock further from shore. However, any organism that is to survive at the outer edge of the reserve must be extremely well adapted to withstand high wave action and strong surge (SWRCB 1979).

Average surface temperatures offshore range from 52° to 53°F (11° to 12°C) in the winter to 59° to 61°F (15° to 16°C) in late summer. Inshore, salinity may be lower at the mouth of San Vicente Creek (SWRCB 1979).

High turbidity is also characteristic of the ASBS nearshore waters during periods of large swells. Much of the non-reef bottom in the reserve is sand, which is carried up into the water column by wave action. The reef-dwelling organisms, then, must either be short-lived species which mature and reproduce during the calmer part of the year, or must be well adapted to withstand scour and possible burial by sand (Daly and Mathieson, 1977) (SWRCB 1979).

Año Nuevo

Surface water temperatures for Año Nuevo were determined from a comparison of the records from Pigeon Point Shellfish Hatchery and Pacific Grove. Daily water temperatures are taken from the water intake at Pigeon Point Shellfish Hatchery. The temperature ranges from 53.6^{o} to 57.2^{o}F (12^{o} to 14^{o}C) for the months of November and December (Anon, 1980). The water temperature in the ASBS probably never gets below 50^{o}F (10^{o}C) during the coldest periods (January and February) or above 62.6^{o}F (17^{o}C) during the warmest months (May through October) (SWRCB 1981).

During any time of the year, turbidity increases from the surface to the bottom. It is higher in the winter than in the summer. Even when surface waters are clear, observations by divers indicate very turbid waters on the bottom in winter and early spring. Bottom waters at Año Nuevo have a turbidity of 1.39 (JTU) with 0.096 g/L of suspended sediments. Greyhound Rock had 1.21 (JTU) and 0.060 g/L of suspended sediment on the bottom. Since light is an important factor for plant growth, the high turbidity of the water (which most likely occurs year-round at Año Nuevo) may be responsible for the lack of kelp at depths greater than 30 feet (10 m) (SWRCB 1981).

Pacific Grove

Currents within the ASBS are weak and variable. Because this is a nearshore area, winds, bottom topography and the tidal cycle exert considerable influence on the speed and direction of currents at any particular time. However, the ASBS is also located in close proximity to the open coast, and current patterns are also influenced by prevailing offshore currents.

The influence of the California Current on circulation patterns in the bay depends largely on its speed, which varies seasonally. When it first appears in surface waters, in February, the California Current has an average speed of about .04 knots. Current speed increases rapidly to 0.21 knots in March, and reaches a maximum of 0.28 knots in July. Subsequently, the speed decreases to about 0.07 knots in September and October (Lammars, 1971) (SWRCB 1979).

As with the California Current, the influence of the Davidson Current on Monterey Bay circulation patterns depends somewhat on its speed. Current speed increases from about 0.04 knots in November to a maximum of 0.14 knots in December and January, and current direction shifts from the south to the southeast. The onset of the Davidson Period corresponds with the advance of atmospheric low pressure cells, and often begins abruptly with the year's first winter storm. The northward flowing current is deflected onshore by the Coriolis force, and downwelling results. Particularly during storms, downwelling is evidenced by large nearshore swells and causes vertical mixing to depths of up to 163 to 330 ft. (50 to 100 m). The Davidson Current is more sluggish than the California Current, and thus its effect on bay circulation is more easily counteracted by prevailing winds. Blaskovich (1973) estimated that the Davidson Current determined surface circulation patterns in the bay only when wind speeds were less than one meter per second (about 2.2 miles per hour) (SWRCB 1979).

Upwelled waters enter Monterey Bay near Pt. Pinos, following the contours of the submarine canyon, and exit near Santa Cruz to the north. As the canyon is oriented in a southwest-northeast direction, the entrance of upwelled water imparts a general counter-clockwise current pattern in the Bay. However, a portion of the entering water sometimes splits off at Pt. Pinos and forms a clockwise eddy near the ASBS (SWRCB 1979).

Oceanic waters generally reach the ASBS during a portion of the Oceanic Period, as the ASBS is located at the outer edge of the bay. The blue, warmer oceanic water is easily distinguished from the bay’s typical cold, greener water. Currents are probably weaker and more variable than during the Upwelling Period. There is evidence that a clockwise gyre, or at least eastward currents, persist in the south bay through September (Stoddard in Lammars 1971) (ESI 1970). However, surface currents are directed more towards the north. By October, south bay circulation patterns appear to be absorbed into the larger, counterclockwise gyre of the north and central bay. Reise (1973) found that nearshore currents off Cannery Row tended to be directed offshore, such that drift bottles were recovered often near Santa Cruz. When water movement was onshore, recoveries were made at a more westerly position than during the Upwelling Period. This could be attributed to a lessening of northwest winds and/or disappearance of a clockwise gyre in the south bay (SWRCB 1979).

Wind has a major effect on surface water currents in the ASBS. Since the direction and magnitude of both local and larger scale winds is continually in a state of flux, surface currents tend to be erratic and rarely attain much velocity in any particular direction. To a certain extent, surface current speed varies directly with that of the wind. The wind factor in surface currents has been estimated at between 2.2 to 4 per cent (Blaskovich; Broenkow), thus inducing currents of between 0.04 to 0.4 knots, depending on wind speed. As indicated previously, the velocity of offshore currents ranges between about 0.04 to 0.28 knots. Thus, the effect of winds on local currents is at least comparable to that of offshore currents; maximum current speeds could be expected when the two forces act together. The afternoon sea breeze appears to cause onshore water movement, particularly during the Upwelling Period. Winds are generally weaker during the remainder of the day, and surface current direction may be dictated by the prevailing offshore current (Reise, 1973) (SWRCB 1979).

Monterey Bay has a diurnal tidal cycle, with two high and two low tides of unequal height. The tidal cycle has little influence on bay circulation because the mouth of the bay is wide and the nearshore is narrow. Thus, tidal flows are not accelerated by constriction as occurs at the Golden Gate; Skogsberg (1936) noted that tidal streams were usually less than one knot in velocity. Water entering the bay on an incoming tide is generally denser than nearshore water, so it enters along the bottom. This causes a seaward displacement of both surface waters. As the tide ebbs, surface waters are again moved onshore. Skogsberg (1936) noted that surface water moved offshore at 0.3 knots on a flood tide, and back onshore with the ebb tide at a speed of 0.36 knots. The Association of Monterey Bay Area Governments reported onshore surface currents of 0.39 to 0.46 knots in the south bay on an outgoing tide in September. The onshore water movement generated by the tides is probably augmented by the effect of onshore winds, and therefore the current velocity is greater than on a flood tide (SWRCB 1979).

In other studies of surface currents, Blaskovich (1973) and Stevenson (1964) were unable to relate changes in current speed and direction specifically to the tidal cycle. Most likely wind is the dominant force affecting surface currents; tides may be instrumental in causing wind induced changes to occur over a longer or shorter period of time (SWRCB 1979).

Coastal upwelling is particularly strong offshore from Pt. Pinos and discourages thermocline formation by inducing vertical mixing in at least the western half of the ASBS. The dominant influence of coastal upwelling is indicated by a weaker thermocline at Pt. Pinos as compared with areas to the east (SWRCB 1979).

Canyon upwelling generally acts to steepen the thermocline in shallow areas of the bay, such as the ASBS. In the Monterey canyon, cold water begins to upwell towards the surface as early as February (Skogsberg 1936). However, upwelled water does not affect the thermocline in the shallows until much later, when it starts to sink and is deflected horizontally and shoreward by canyon walls. As the southern canyon wall is steeper, horizontal deflection of upwelled water is also greater, allowing intrusion of cold water along the bottom into more nearshore areas. Canyon upwelling probably contributes more towards thermocline formation in the eastern portion of the ASBS and is responsible for the lower temperature at 20 meter depths and greater thermocline stability. At Pt. Pinos, any influence of canyon upwelling on thermocline formation is apparently obscured by vertical mixing in this more exposed area, at least during the Upwelling Period (SWRCB 1979).

The average sea surface temperature along the shoreline of the ASBS is 13.14℃ (56℉), as determined by measurements taken at Hopkins Marine Station over the 25-year period from 1938 to 1963. Sea surface temperatures are considerably colder than most other ocean temperatures at this latitude; this is due to the proximity of the Monterey Submarine Canyon, which allows deep, colder oceanic water access to the bay. Persistent summer fog also depresses surface temperatures by reducing incident radiation (SWRCB 1979).

Sea surface temperatures at shore exhibit little seasonal variation. Temperatures generally range from a minimum of 11.04℃ (52℉) in January to a maximum of 15.82℃ (61℉) in September. The average annual range in monthly temperatures is only 2.58°C (5°F), between 11.83° to 14.40°C (53° to 58°F). The moderate seasonal fluctuations are due to the fact that upwelling depresses sea temperatures in the spring and summer, when insolation is greatest, whereas winter and fall surface temperatures are elevated by the presence of southerly offshore currents and possible freshwater runoff (SWRCB 1979).

As in much of Monterey Bay, shore temperature fluctuations within a week or month commonly equal or exceed seasonal variations in the ASBS. Basically, short-term fluctuations are greatest during the summer and early fall, when maximum thermoclines exist. In nearshore waters, the thermocline is easily disrupted by causing vertical mixing and abrupt local winds, decreases in surf or surface tidal water changes, temperatures (SWRCB 1979).

At both nearshore and offshore stations, winter temperatures in the ASBS are slightly lower than for Monterey Bay as a whole (mean temperature of 12.5°C (54.5°F). Skogsberg attributes these colder nearshore temperatures to the formation of eddies which prevent the intrusion of warmer oceanic or Davidson Current waters (SWRCB 1979).

The ASBS is a shallow water area inside Monterey Bay, yet in close proximity to the open coast. Thermocline characteristics are therefore influenced by (1) coastal upwelling, (2) Monterey Submarine Canyon upwelling, (3) diurnal wind and tidal patterns, and (4) submarine topography. Basically, thermocline formation in the ASBS is weak and unstable due to the predominance of upwelling in the seasonal and localized oceanographic regime (SWRCB 1979).

Offshore winds weaken thermocline formation by inducing upwelling or downwelling. In the south bay, the sequence of strong offshore winds, upwelling, and thermocline reappearance can all occur within a week's time. Weekly oscillations in temperature gradients can therefore exceed monthly changes and be of the magnitude of annual changes in monthly averages (Lasley 1977). The afternoon sea breeze probably weakens any thermocline which may have formed during morning hours, by causing a mixing of surface layers (SWRCB 1979).

Although tides have a minimal influence on patterns in Monterey Bay, they probably promote large-scale circulation vertical mixing in the ASBS and thereby weaken existing thermoclines. Bottom topography has a disruptive influence on thermocline where it causes wave formation or any other type of turbulence. Rocky reefs thus tend to interrupt thermocline existence, but in shallower water, the attached kelp probably has a stabilizing influence during the summer. The only measurements of a thermocline within the ASBS were taken in Hopkins Marine Life Refuge by DF&G between 1968 and 1970. The average thermocline during the entire study period was 7.3°C/50m, much higher than that at the offshore stations or the average maximum of 3.5°C/50m recorded by Skogsberg for Monterey Bay. The steeper thermocline could be due to greater surface insolation, plus the intrusion of upwelled canyon water to an even shallower bottom depth (46 ft. or 13.9 m average at the two DF&G stations). The average thermocline was 0.1°C higher in the kelp beds and only noticeably higher in August. A minimum gradient of 0.4°C/50m occurred in January in the kelp bed; a maximum gradient of 19°C/50m occurred in August, also at the kelp bed station.

Surface temperatures are higher earlier in the year possibly because upwelling is not as great here and insolation can therefore heat surface waters more effectively (SWRCB 1979).

The salinity characteristics of the ASBS resemble those of the open ocean. Because of the wide opening of Monterey Bay and the presence of the Monterey Submarine Canyon, ocean water has good access to nearshore areas and is the major factor which determines salinity and halocline features. Discharge from the Salinas River into Monterey Bay is of relatively low volume, highly seasonal, and occurs a good distance from the ASBS. During the winter months, when river flow is high, the Davidson Current tends to direct the discharge north rather than south (SWRCB 1979).

The average surface salinity in nearshore waters of the ASBS is 33.5 parts per thousand (ppt), based on a 25 year average of daily measurements at Hopkins Marine Station. This approaches the salinity of the open ocean, which is about 34 ppt at this latitude. The average minimum salinity is 33.19 ppt. The relative stability of surface salinity is an indication of the low volume of freshwater inflow (SWRCB 1979).

The halocline, or salinity gradient, has not been measured within the ASBS. Undoubtedly, the steepest halocline exists during the rainy season, when low salinity water is superimposed upon bay water of average salinity. Close to shore, wave action probably prevents a halocline from forming. The halocline becomes well formed beyond the surf line, then disappears where offshore waters are beyond the influence of the freshwater inflow. Therefore, the offshore extent of the halocline depends upon the severity and duration of a particular storm, as well as tidal and surf conditions. A halocline may be more pronounced in nearshore waters adjacent to large storm drain discharges. Kelp beds may also enhance halocline formation by reducing surge; however, large beds are generally absent during the season of heaviest rainfall (SWRCB 1979).

Bigelow (1928) noted that pools of lower salinity water sometimes get trapped below the surface during the winter. In the spring, upwelling forces these pools to the surface and acts thereby to reduce rather than increase surface salinity. The more offshore waters of the ASBS are generally beyond the influence of freshwater inflows and, therefore, the surface salinity and halocline do not vary much with the seasonal pattern of rainfall. Salinity characteristics are quite stable and uniform throughout the top 65 ft. (20 m) of the water column. The limited variation appears to be caused by localized and seasonal upwelling activity and predominance of different offshore currents (SWRCB 1979).

A reverse halocline is not uncommon during the late summer and early fall. The Oceanic Period brings into the bay water which is more saline, but also warmer, so it tends to enter the bay along the surface. Evaporation also increases surface salinity during this period. Both factors can cause a slight negative salinity gradient to exist until winds cool the surface waters or cause vertical mixing. A reverse halocline is probably less common in upwelling areas, where subsurface salinity is higher and surface evaporation is reduced. A slight negative halocline existed in September in the vicinity of the ASBS (Engineering-Science Inc.) (SWRCB 1979).

Dissolved oxygen (DO) concentration in the ASBS is limited primarily by physical and chemical features of the marine environment. Salinity is typically high, reducing the solubility of atmospheric oxygen in surface waters. Thus, dissolved oxygen values can be quite low, as compared with other bays, and still be close to air-saturation levels. For example, during the 1971-72 AMBAG survey year, the average DO at the Hopkins and Pt. Pinos stations was only 5.9 mg/1 throughout the top 65 ft. (20 m) of the water column. However, the average percent saturation was close to 100%, based on seawater density at the time samples were taken. Surface DO is particularly low during the Oceanic Period, when warmer sea surface temperatures further depress the air saturation point (SWRCB 1979).

Upwelling causes colder, oxygen deficient water to continually be brought to the surface, thereby lowering surface DO values and obliterating any vertical gradient which may have developed. The variability of upwelling activity in the ASBS probably affects DO values, as well as other water column characteristics. The surface water DO at Pt. Pinos is much lower during March, May and June, (e.g., months associated with persistent upwelling). However, the surface DO was higher at Pt. Pinos in August, September and October, possibly reflecting the presence of oceanic water of higher oxygen content (SWRCB 1979).

The average DO differential from 0 to 65 ft. (0 to 20 m) at both stations was about -1.5 mg/1 (range of +0.96 to -4.75 mg/l) during the 1971-72 AMBAG survey. Photosynthesis probably contributed to the high surface DO value, and the low value at 65 ft. (20 m) could be attributed to the intrusion of upwelled canyon waters. At Pt. Pinos, maximum stratification occurred in September and October. Intrusion of oceanic water is probably responsible for the higher surface values, whereas lack of vertical mixing caused dissolved oxygen in deeper waters to drop (SWRCB 1979).

A 1968-69 DF&G kelp bed study contains the only data on DO concentration from within the ASBS. Measurements were taken at a kelp bed station and in a sandy bottom area about 1000 ft. (305 m) offshore. The average DO throughout the water column was 6 mg/1 at both stations, with no significant differences noted between the two stations during any sampling period (Miller, unpublished data). The vertical gradient was highest in April and May, at which time the DO at 65 ft. (20 m) dropped as low as 2.8 mg/1. The maximum gradient appears to occur when upwelled canyon water intrudes along the bottom and is not immediately mixed with shallower, oxygen rich water (SWRCB 1979).

Although upwelling initially depresses surface water DO values, it also brings nutrient-rich waters to the surface and thereby creates phytoplankton blooms. In shallow water areas, the increased photosynthetic activity may partially offset the initial decrease in surface water 00 caused by upwelling. Thus, upwelling periods are often followed by a horizontal stratification of surface DO in the bay, with the shallows having the highest values. Because of the high productivity in the ASBS and the continual mixing of surface waters, there is probably little long range variation in DO values. However, wide fluctuations from long term averages are common and reflect the dynamic nature of the water column (SWRCB 1979).

Turbidity levels within the ASBS vary spatially, seasonally, and often diurnally. Spatial variations are caused by differences in bottom topography, substrate type, and sediment size. Turbidity generally decreases towards the west end of the ASBS, as the coarser sand here settles out more quickly if disturbed (K. Casson, personal communication). There is less turbidity above the rocky reef west of Otter Point than at the Lovers Point reef because the reef contains less interspersed sand. Turbidity increases shoreward, as wave action increases. During the 1968-69 kelp bed study (Miller, unpublished data) the average secchi disk reading was 20 ft. (6 m) in the nearshore kelp beds, and 22 ft. (6.8 m) 1000 ft. (305 m) offshore. Over a similar time period (1 year), the average secchi disk reading was 29.7 ft. (9 m), about ¼ mile offshore from DF&G stations (SWRCB 1979)..

Seasonal variation in turbidity is caused by biological as well as physical features of the area. Freshwater runoff causes turbidity in nearshore waters during and after storms, particularly at storm drain discharge points. Upwelling increases turbidity by inducing vertical mixing and plankton blooms, to the extent that visibility is often at a minimum during the spring. The DF&G kelp study (Miller, unpublished data) recorded minimum secchi disk readings of 5½ to 6 ft. (1.67 to 1.88 m) in March. Maximum visibility often occurs during the Oceanic Period, as the influx of oceanic water is clearer than typical bay water. The DF&G study recorded a maximum secchi disk reading of 31 ft. (11.3 m) in November; a maximum secchi disk reading of 48 ft. (17.6 m) was also recorded in November during the AMBAG study. Local winds probably cause diurnal variations in turbidity close to shore. Winds are generally greater at Pt. Pinos than at Pt. Cabrillo and may cause an increase in turbidity (SWRCB 1979).

The sources of nutrients in shallow portions of Monterey Bay were first studied by Bigelow in 1928. Bigelow found that the greatest concentrations of silicate, phosphates and nutrients were found at great depths (≥1967 ft. or 600 m), and concluded that upwelling was an important means of making such nutrients available to phytoplankton in the photic zone. However, he also noted that the concentration of silicate and phosphate showed the greatest increase at 0 to 164 ft. (0 to 50 m) and that values increased shoreward. This indicated that the shoal bottom is itself an important local source of these nutrients, as it is the repository for diatoms and other organisms which die and sink to the bottom (SWRCB 1979).

Nutrient concentrations were not available for waters within the ASBS. However, nutrient measurements have been taken offshore at stations that are about 1/4 mile seaward of the ASBS, and values there probably reflect nutrient concentrations, gradients, and trends within the ASBS. Average values for all nutrients are high, as compared with other areas in Monterey Bay (SWRCB 1979).

Ammonia is excreted by marine organisms at all levels of the food chain, from zooplankton to marine mammals. It is also a by-product of decomposition and is used as a food source by some plankton. Within the ASBS, ammonia concentrations and fluctuations appear to be the result of such biological activity. Upwelling causes an increase in surface ammonia values by fostering the growth of phytoplankton populations, which in turn leads to increased zooplankton activity. Therefore, increases in nutrient concentration should be followed by a similar elevation in ammonia concentration, allowing for a time lag and some horizontal displacement. Lasley (1977) found that ammonia values in the south bay remained low during the first few days after upwelling ceased, then increased to 7.8 mg-at/L with highest values towards Pt. Pinos. The entire gradient moved eastward, then subsided, undoubtedly indicating the movement of a greater surface population of zooplankton (SWRCB 1979).

The average ammonia concentration about ¼ mile offshore from the ASBS, was 1.67 mg-at/L between 1972 and 1976. The higher values were probably the result of greater zooplankton activity in an area where upwelled water had slowed down and warmed somewhat. The higher values could be attributed to the bird and marine mammal populations which are prevalent on inshore rocks. The sharp, usually negative gradient in concentrations also suggests that differences are related to biological activity (SWRCB 1979).

Carmel Bay

Current patterns in Carmel Bay are influenced primarily by the offshore oceanographic regime, the Monterey and Carmel submarine canyons, and local winds. Northwest winds and other factors cause surface waters to move seaward. Colder, nutrient rich water upwells to the surface. Upwelling is usually very pronounced in the ASBS, partially because the Carmel canyon allows cold, deep oceanic waters access to the bay (SWRCB 1979).

The Davidson current brings warm, southern water to the area. From November to February, local winds modify or counteract large-scale current patterns in surface waters of the ASBS. Drift cards that were released between the months of March and August in the bay were blown shoreward by predominant northwest winds. In January, cards released off Pt. Lobos were found at various points along the Monterey Peninsula. The predominant influence at this time could have been the northward flowing Davidson current, and/or southwest winds (SWRCB 1979).

Subsurface currents flow both up and down the Carmel canyon, approximating the period of the diurnal tidal cycle. Net flow appears to be down canyon or offshore. Surface currents in the south bay move southward toward Pt. Lobos. The predominance of a nearshore, southward moving current has been substantiated by dye release studies by Lee (Wong 1970) and observations by SCUBA divers at Monastery Beach and Carmel River State Beach (SWRCB 1979).

Carmel Bay is a relatively wide-mouthed bay with little freshwater inflow; water column characteristics would therefore be expected to resemble those of the open ocean. However, very few measurements of the physical and chemical parameters of the bay have been made, and these do not provide a comprehensive description of water quality. (SWRCB 1979).

Spring upwelling and the resulting plankton bloom decrease visibility drastically. Visibility is particularly good at Monastery Beach; hence divers are attracted to the area. High visibility is largely due to the submarine canyon, which consists primarily of resistant granodiorite and contains very little sediment. In addition, the steep drop-off of the canyon close to shore prevents the formation of surf until almost the shoreline; thus preventing bottom sediment from being stirred up. (SWRCB 1979).

Water temperature measurements in the bay range between 48° and 63°F (9° and 17°C), and these limited data correspond well with the long-range averages and seasonal variations documented by Skogsberg (1936) for Monterey Bay. Both surface and 66 foot (20 m) temperatures show a decline between February and July, as upwelling causes colder, subsurface water to rise from depths. During late summer and early fall, temperatures throughout the water column increase. None of the monitoring studies detected a distinct thermocline, probably due to the shallow depths of the transects and their proximity to the surf zone. Temperature data from 1976-77 are somewhat higher than that from previous years, possibly because upwelling was less pronounced that year (Kinnetics 1977). Subsurface temperatures showed a decline between 1973 and 1975 (SWRCB 1979).

Data collected between 1973 and 1977 show that salinity in the south bay varied only slightly with depth and transect location at anyone time. Average salinity increased rather dramatically during this period, probably due to the much reduced runoff from the Carmel River and other sources during those drought years. Relatively low salinities were recorded between February and October of 1973, with a definite low in April which coincided with maximum discharge from the Carmel River. Between June 1974 and March 1977, the south bay's average salinity approached that of the North Pacific Ocean (34.1 ppt), as might be expected with almost no freshwater inflow. However, the apparent increase might be due in part to differences in analytical methods and technique (SWRCB 1979).

Dissolved oxygen measurements ranged between 6 and 10 mg/L with little variation among transect stations. In general, values are consistent at these shallow depths through the year and are similar to average concentrations recorded for Monterey Bay. Data were collected by various surveyors and some variation could be attributed to a difference in analytical techniques (SWRCB 1979).

Information on nutrient levels in the ASBS was not available. Extensive California Cooperative Fisheries Investigations (CALCOFI) work in Monterey Bay indicates that nitrate, nitrite and phosphate levels are elevated in surface waters during periods of upwelling (Engineering-Science 1977) (SWRCB 1979).

Monitoring studies indicate that turbidity in the south bay is highly variable. However, turbidity was measured using a variety of techniques, so direct comparison of data is not possible. Undoubtedly, turbidity increases in sand or mud bottom areas, in areas close to shore, and during periods of wind and/or storm (SWRCB 1979).

Point Lobos

Turbidity levels vary throughout the year. In the winter, nearshore waters are well-mixed and turbidity levels generally increase although fairly clean water has been noted during the winter. During the spring and summer, phytoplankton blooms probably account for most water turbidity. Turbidity levels are usually lowest in the fall when coastal waters are calm. Due to a lack of fine sediments within the ASBS, water clarity can be high. However, due to a landslide that occurred near McWay Rock during the winter of 1977, there has been a persistent, localized, turbid water mass of an acre or more in extent (SWRCB 1979).

Water temperature data are unavailable for the ASBS. The nearest temperature recording station until March 1978 was at the southern end of Point Lobos State Reserve located approximately 30 miles (40 km) upcoast. In March 1978, Another recording station was established at Granite Canyon approximately 5 miles (8 km) downcoast of Point Lobos. Temperature regimes of both Granite Canyon and South Point Lobos are similar, with the former being slightly lower. Bimonthly isotherms for waters adjacent to Point Lobos usually include the nearshore waters of the ASBS and of Monterey Bay. Thus, surface water temperatures inside the ASBS are probably within the normal variation occurring around Point Lobos. Water temperatures at the southern end of Point Lobos for the years 1974-78 ranged from a minimum of 46°F (8°C) in January, February and March to a maximum of 62°F (16.7°C) in August. During the winter, mean monthly water temperatures are usually around 50° to 54°F (10° to 12°C). Summer mean monthly water temperatures generally vary from 52° to 57°F (11° to 14°C). In the spring and summer, periods of colder water (48° to 52°F or go to 11°C) associated with upwelling commonly occur along the central California coast. Water temperatures recorded within the ASBS during subtidal surveys in July and August averaged around 50° to 52°F (10° to 11°C), corresponding to a period of upwelling (SWRCB 1979).

Salinity data are unavailable for the ASBS. Salinity levels throughout most of the ASSS probably approach those of the north Pacific Ocean since very little freshwater enters ASBS waters. However, lower ocean salinities occur in the vicinity surrounding the mouths of both Partington and McWay Creeks. The discharge from these two creeks is relatively small and has at most a very localized effect on the biota occurring near their mouths (SWRCB 1979).

Julia Pfeiffer Burns

During the upwelling period, strong wave action, plankton blooms and concomitant turbid waters occur within the ASBS (SWRCB 1980).

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Laguna Point to Latigo Point

Two aspects of current patterns within the ASBS warrant consideration: 1) the influence of oceanic currents which carry large masses of water along with concomitant plankton, larvae and possibly pollutants, and 2) the influence of more localized phenomena on current patterns.

An easterly flowing and weaker portion of the California Current moves along the coast from Santa Barbara to Port Hueneme where it also enters the Santa Monica Basin in the vicinity the ASBS. The ASBS, especially east of Point Dume, is sometimes influenced by westerly moving waters from Santa Monica Bay, due to the flow of the California Countercurrent. The strength of this counter clockwise current is determined by local conditions. The degree to which these currents affect the ASBS can vary considerably depending on the prevailing local wind and weather patterns. However, the offshore waters which have a dominant impact on the ASBS ultimately come from the eastern Santa Barbara Basin and the Santa Cruz Basin. Thus, the net movement of shallow, nearshore waters is eastward along the ASBS. Turnover times of the inshore waters in the Southern California Bight are estimated to be 1 to 2 times per year. During periods of upwelling (mainly in April-June), surface waters are driven south away from the ASBS. The effect is to bring deeper, cold, nutrient rich waters to the surface (SWRCB 1979).

The movements of subsurface waters in the vicinity of the ASBS are not well understood at this time. The major flow at 200 m depth appears to be northward and is termed the California Undercurrent (SWRCB 1979).

Local currents in the nearshore waters vary considerably from day to day and season to season. They are integrally associated with the local weather patterns and are influenced by winds, swell and tides. Local surface current patterns are often determined primarily by wind direction. Thus westerly winds induce an easterly flow, easterly or southerly winds induce a westerly flow, and northerly or northeasterly winds

(Santa Ana's) induce an offshore flow. These latter periods are times of rapid local upwelling of deeper waters which move in to replace the surface waters as they are blown offshore. In general, the major wind direction over the ASBS is westerly throughout the year. Thus, wind patterns reinforce the general eastward flow induced by offshore currents and swell (SWRCB 1979).

The ocean swell also has a major influence on local currents. Most of the time the swell and the wind lie roughly parallel and travel in the same direction, from the west, and, hence, have an additive effect. However, where the two conflict, current direction cannot always be predicted and can vary from place to place and time to time. The dominant swell pattern is westerly, especially during most of the winter and spring months. During the summer and fall, however, large southerly swells generated from storms in the southern hemisphere frequently strike the shores of the ASBS. The swells tend to create more westerly moving nearshore currents (SWRCB 1979).

An important shallow water current is the longshore current. Where ocean swells strike the beach at an angle, a current develops in the shallowest waters (usually to depths of no more than 20 or 30 ft.) directed away from striking waves. In the ASBS, the dominant winter and spring westerly swells usually produce an eastward moving longshore current. During times of more southerly swells the longshore currents tend to move westward. These currents can be extremely swift, moving at rates approaching 30 to 40 meters per minute. Such currents usually do not persist for more than a day or two, and can reverse their flow rapidly, over a period of minutes. At Point Dume, in the vicinity of the stacks just offshore, the easterly moving offshore currents coupled with dominant easterly nearshore currents create a very strong current directed toward Santa Monica Bay. Longshore drift carries large quantities of sediments in a predominately southerly direction. The quantity of material transported has been estimated to be about 900 yd^3/day at Point Mugu and Sequit Point and about 800 yd^3/day at Point Dume (Fay 1972) (Ingle, 1966) (SWRCB 1979).

Ripcurrents are particularly prominent off the exposed beach at Zuma, but they can occur off all of the other sand beaches along the ASBS. Sea conditions within the ASBS generally consist of a 2 to 4 foot swell, but can vary from flat calm to seas in excess of 15 to 20 feet on rare occasions (SWRCB 1979).

Water clarity within the Laguna Point to Latigo Point ASBS varies from zero to over one hundred feet. However, these extremes are both relatively rare and occur at most a few days a year. Visibility averages between 10 and 20 feet throughout most of the year. Maximum turbidity can be expected during the spring and early summer plankton blooms, and during winter and early spring storms. Maximum visibility tends to occur in the late summer and fall. Visibility almost always improves away from the shoreline; it is usually 0 to 10 ft. to a water depth of about 20 feet, and then steadily improves with increasing depth to a maximum at about 35 foot depths and beyond. Seaward of the ASBS, water clarity usually exceeds 40 ft. (SWRCB 1979).

The average surface temperatures within the ASBS range between 56.5 and 65.5°F (14 and 19°C) with a minimum of 48°F (9°C) recorded in May and a maximum of 72°F (22.5°C) recorded in August. There is a distinct thermocline (ca. 2-3°F) which varied in depth between 20 to 35 feet. The depth of this thermocline varied from location to location and with time. Often the thermocline breaks down and major stratification disappears during the winter and spring months as a result of mixing by storms and upwelling. In Mugu Canyon in September, three distinct thermoclines between the surface and 100 ft. were detected. These occurred at 20, 40 and 80 foot depths and each thermocline had a temperature differential of about 2°F (SWRCB 1979).

Salinity within the AS8S remains relatively constant throughout the year. The maximum of about 33.7 ppt occurs in the fall and the minimum (33.5 ppt or less) occurs during the rainy season of winter and early spring. As there are no major drainages into the ASBS except Calleguas Creek, salinities do not drop sharply in most locations throughout the year. Calleguas Creek discharges large quantities of low salinity water into the ASBS during the rainy season. This influence is localized around the mouth of Mugu lagoon. Temperature and salinity gradients produce an increase in sea water density with depth (SWRCB 1979).

Dissolved oxygen levels within the ASBS are adequate to support marine life. The minimum concentration reported is about 4 mg O_2/L, which is about 50% air-saturation. In the surface waters, dissolved oxygen concentrations usually vary between 100 and 140% air-saturation as a result of aeration caused by the swell and wind chop. Values are highest in the fall and winter (USEPA 1977) (SWRCB 1979).

Nitrate levels within the ASBS surface waters range between 0.01 and 0.16 mg/L and increase with depth. Concentrations are highest in the spring when deeper nutrient rich waters are brought to the surface by upwelling (Allan Hancock Foundation 1965) (SWRCB 1979).

Trace metals probably vary considerably within the ASBS from place to place and with time as their concentrations are affected by storm runoff, lateral currents, upwelling, and plankton concentrations. These metals can occur in ionic form, absorbed on particulates, bound to organics or as complexes. Lead and mercury levels appear to be increasing in the sediments of the Southern California Bight (SCCWRP 1975) (SWRCB 1979).

Santa Catalina Island

The ASBS is located in the Southern California Bight. The principal geostrophic current in this area is the California Current, which flows southward from Point Conception to Baja California. Santa Catalina Island is surrounded by the Southern California Countercurrent. Ocean waters flow northwest along the southwest side of the island and seem to flow southeast along the northeast side. Temperature and salinity indicate that the waters found on either side of the island are very similar, suggesting that the same water mass may set up a kind of local gyre and circulate around the island. Very little is known about the current patterns within this ASBS (SWRCB 1979).

Upwelling is thought to occur in the ASBS but is not documented. Westerly winds blowing down northeast-facing canyons may cause upwelling from Arrow Point to Blue Cavern Point. It is likely that significant upwelling occurs at the extreme west end of the Island, possibly being at least partly responsible for the tremendous biomass of plankton found there (SWRCB 1979).

The prevailing direction of swell in the Southern California Bight is from the west. Consequently, intertidal areas on the southwest (windward) side of this ASBS are exposed to the most wave action. The swell bends around the west end and strikes north-facing beaches on the leeward side at an angle, reducing wave energy. Northeast-facing habitats on the leeward shore are the most protected. Only during northeast wind conditions (Santa Anas) are these areas exposed to wave action (SWRCB 1979).

Studies indicate that water movement is due primarily to wind stress and tidal currents. Water moves from southeast to northwest as the tide flows in and in the opposite direction as the tide flows out. This flow pattern can be confused at the surface by northwest winds (SWRCB 1979).

Tides at Catalina are mixed semi diurnal with a maximum range of nine feet (3 m). The range is from approximately +7.1 feet to -1.7 feet MLLW (NOAA 1977). The normal fluctuation is between four and five feet (1. 2m and 1.5m) (SWRCB 1979).

Northwest Santa Catalina Island: Water clarity and temperature data (surface and twenty meter depths) have been taken approximately daily by personnel at CMSC since 1970. The sampling station is located near Bird Rock, Isthmus Cove, on the leeward side of the Island. Clarity is usually greatest between October and January (about 25 m) and poorest between April and July (about 8 m) when plankton blooms occur (SWRCB 1979).

Surface water temperatures at the CMSC sampling station range from 11°C in winter to 20°C in September and October. A thermocline was found between 60 to 80-foot (24 m) depths, with the lower temperatures averaging 17.8°C (SWRCB 1979).

During the summer of 1971, SCCWRP studied trace metal concentrations in the mussel *Mytilus californianus* at 17 sites within the Bight, 11 along the mainland coast and six adjacent to the Channel Islands, including one at Bird Rock. In general, the highest metal concentrations were measured in the digestive glands. The data indicate that the distribution of lead is related to diffuse inputs, while the distribution of copper, chromium and silver are related more to urban point sources. No distinct pattern was observed for nickel or zinc (Alexander and Young 1976). The soft tissues from these mussels were also analyzed for DOT (Young and McDermott 1976). Mussels from Bird Rock contained 0.31 mg/dry kg DOT, while mussels from Palos Verdes contained about 180 mg/dry kg DOT. Mussels from the other mainland study sites contained levels ranging from 0.17 to 3.0 mg/dry kg (SWRCB 1979).

Southeast Santa Catalina Island: Mean monthly temperatures (1950-1959) recorded southeast of Catalina Island were lowest in February (14.10°C) and highest in September (19.87°C) (Dykzeul and Given 1978) (SWRCB 1979).

Robert E. Badham

The ASBS is fairly well protected from northwest swells by the breakwater extending from Newport Bay. It is, however, exposed to southwesterly swells, with little protection except in some of the small coves surrounded by the large offshore rocks. Tidal surge and a consistent 2 to 3 foot surf make boat and diver entry from shore difficult throughout most of the year, under even moderate conditions. Velocities of 5 to 10 cm/second have been recorded during the Davidson Current period, and appear to be highly variable (SWRCB 1979).

Turbidity is generally high and is largely due to surf and surge, which constantly churn the shallow areas. Visibility ranged from a maximum of about 30 ft (9 m) to only a few inches, during the course of a 9-month study. A seasonal cycle of winter and spring nutrient enrichment and resultant increased phytoplankton productivity also contribute to decreased water clarity. During the course of a recent survey, a winter (late February) diatom bloom occurred, drastically increasing turbidity. Also, the lack of hydrogen sulfide stains on surface sediments is a further indication of strong mixing and oxygenation of the entire water column (SWRCB 1979).

Water temperatures in the vicinity vary seasonally. In the summer, surf temperatures approach 70°F; winter temperatures rarely drop below 60°F. Subtidally, the water is generally several degrees cooler, ranging from 55°F in the winter to 65°F in the summer and early autumn. In the summer, a shallow thermocline usually exists. Its actual location is variable and dependent upon storm mixings, turbidity, convective stirring during cooling periods, and convergence and divergence caused by wind patterns (Cairns and LaFond 1966). The thermocline is usually eliminated by October to mid-November (SWRCB 1979).

Several small drainages enter the northern portion of the ASBS forming marshy areas. Commercial day cruise fishing boats (party boats) and private boats utilize the Newport Beach Refuge extensively. In addition, considerable shore fishing and spearfishing have been observed within the limits of the reserve. Several commercial lobster fishermen' buoys were noted through the course of the study. There's often heavy boat traffic traversing the reserve from the adjacent Newport Bay area, and on weekends the offshore areas often congested with sailboats. The accessibility of the ASBS and its proximity to Newport Bay results in a considerable amount of activity within the reserve, particularly on weekends and holidays, including SCUBA diving, snorkeling, swimming, boating, fishing, water skiing, sunbathing and tidepool exploring. Many persons have been observed turning over rocks within the intertidal area, and removing organisms from the region, despite the numerous “protected area” signs posted along the beach. Additionally, it is impossible for anyone approaching from the sea to observe these notices. The large conspicuous offshore rocks and arches also are not too far removed from the activities of climbers and tidepool explorers (SWRCB 1979).

Irvine Coast

The entire coastline is unprotected from the southwesterly swells that are, at times quite heavy. There is consistent 2 to 3 foot surf that makes launching of boats and entry by divers difficult at best and extremely hazardous on days of very heavy surf. Current velocities, on the order of 5 to 10 cm/sec, are highly variable (SWRCB 1979).
Water temperatures vary seasonally. In the summer surf temperatures usually approach 70°F; winter temperatures rarely drop below 60°F. Subtidally, the water is generally several degrees colder, ranging from a low of 55°F in the winter to 65°F in summer and early autumn. A shallow summer thermocline usually exists. The actual location of the thermocline in the water column is highly variable and is a function of (1) storm mixing, (2) turbidity, (3) convective stirring during cooling periods, and (4) convergence and divergence caused by wind patterns (Cairns and LaFond 1966). The depth of the thermoci1ne is generally less than 30 feet (9 m); it is usually abolished by October or mid-November (SWRCB 1979).

The lack of hydrogen sulfide stains in this region indicates that the water mass is well mixed and well oxygenated. This is probably a result of the open exposure and chronic moderate to heavy surf conditions that prevail. Turbidity of the water is primarily a action, although it does follow a seasonal winter and spring as a result of increased (due in part to the upwelling of nutrient the year) (SWRCB 1979).

Heisler Park

The clarity and degree of surge and wave action of the nearshore waters vary considerably from day to day. When visibility is poor, the water column is typically full of suspended particulate matter. This material has not been examined to determine whether it is silt or phytoplankton, but the color and light refraction properties suggest it is the former. In waters of less than 33 foot depth, hydrogen sulfide stains can be found on surface sediment under rocks (SWRCB 1979).

La Jolla

Elements of the California Current and the Southern California Counter Current influence the ocean waters in the La Jolla area; additionally, late summer and winter Santa Ana winds or the prevailing north/northwest winds during the spring promote varying periods of upwelling. The Oceanside Cell of sand transport movement flows southward and empties an estimated 260,000 yds^3 of sand annually into Scripps branch of the La Jolla Submarine Canyon. A small amount of bypasses this branch of the canyon and is deposited on La Jolla Shore Beach (Keen 1976). Sand flowing further south is virtually all emptied into the La Jolla branch of the canyon (Shepard and Inman 1951) (ani Inman 1953) (SWRCB 1979).

The sea state of the La Jolla Basin waters is generally calm, and it is rare that the ocean waters of the ASBS approach sea state 4 (moderate, with wind waves of 4 to 8 feet). The monthly medians are 1 to 2 (calm or smooth, with wind waves of less than 2 feet). The direction of swells at the pier usually come from a magnetic bearing of 270° to 290° (W to WNW), although winter storm swells swing in from a slightly more southern direction. The waves have an average height of only 1 to 2 feet (although there are winter storms that produce waves of 8 feet or so in the vicinity of the Scripps Institution of Oceanography pier), with an average period of 7 to 8 seconds, ranging from extremely short period waves of 2 seconds to long period waves of 15 seconds (SWRCB 1979).

Water column visibility at La Jolla is generally very clear, with vertical visibility at times being as deep as 50 feet (15 meters). Visibilities of 20 to 30 feet (6 to 9 meters) are not uncommon in the vicinity of Dike Rock on the northern end of the San Diego Marine Life Refuge (SWRCB 1980). Visibility at times may be drastically reduced by the occurrence of red tides (blooms of phytoplankton), turbidity due to large waves, and storm runoff. Oil globules are known to be deposited on the beach at La Jolla. These oil globules may be a result of vessel discharges and/or natural oil seepage (SWRCB 1980). The shoreline in the San Diego Marine Life Refuge ASBS, as well as in the contiguous San Diego-La Jolla Ecological Reserve ASBS, exceeds water quality standards for bacterial indicators due to nonpoint and point sources (SWRCB 2003). Based on records during the period 1961-1990 the annual rainfall for the La Jolla area is about 10–15 inches (National Weather Service 2004).

Over the more than 50 yeas of observations from the Scripps pier, which is located less than 500m from the northern boundary of the ASBS, surface water temperatures have exhibited annual ranges of 8.3° to 14.5℃, with minimum temperatures ranging from 10.1° to 14.5℃ and maxima from 21.1° to 24.6℃. Surface water temperatures taken from various sites within the ASBS compared with those taken at Scripps pie indicate that surface waters are consistently warmer in the ASBS. Of the 85 days in 1976-1978 for which comparative data are available, the temperatures at the were warmer only 17 days (mean +0.62 ± 0.46℃, range 0.1 to 1.5℃); and the temperatures were colder 66 days (mean -0.91 ± 0.75℃, range -0.1 to 4.1℃); and the temperatures were the same on only two days. It appears that the waters in the ASBS, at least in the southern half, are about 0.5℃ warmer at the surface than the water at the end of the Scripps pier. However, this relationship may not be consistent for 11 areas of the ASBS; the majority of temperature observations in he Reserve were made over the boulder reef complex area (about 30 to 35 ft., or 10 m). The two sets of temperature data are otherwise more or less correlated positively; the water warms or cools at both areas in synchrony (43 out of 58 instances). The annual variation of surface and bottom water temperatures demonstrates the expected seasonal cycles (SWRCB 1979). According to more recent data inclusive of the period August 1916 to June 2001, surface water temperatures ranged from 10.1° C (50.2° F) to 25.8° C (78.4° F); the mean temperature during that period was 17.0℃ (62.6° F) (calculated from raw data provided by Teresa Kacena, SIO 2003).

The salinity of surface waters has annual ranges (between maxima and minima) of 0.38 to 1.50 ppt (there is actually a range of 4.52 ppt in 1967, but this is due to a suspiciously low reading of 29.64 ppt on September 27), with minimum salinities varying between 32.34 and 3.47 ppt (except for the anomalous 29.64 ppt just mentioned) and maxim between 33.68 and 34.65 ppt. The variation in salinities exhibits an annual cycle similar to that for temperatures except that he peak occurs a month earlier in the summer (SWRCB 1979). According to more recent data for the period 1993 to 1996, salinity ranged from 31.3 to 33.9 ppt, with a mean annual average of 33.4ppt (calculated from raw data, SIO 2004).

No turbidity measurements were available, although visual estimates of horizontal and vertical water visibilities were taken on observation dives and by a group observing lobsters in the boulder reef complex area. The La Jolla Shores sandy areas are generally the clearest among San Diego nearshore waters, and interviews with veteran divers indicate vertical visibilities ranging from nearly zero to 50 ft. (15 m) at the surface, although there is frequently greater visibility at depths. Horizontal visibilities have a similar range, but those estimates are reported by untrained divers and are subjective. The rocky reef areas n the axis of the Devil's Slide corner are generally dirty, although the visibility noticeably improves with depth. At the outer edge of these reefs, at depths of 30 to 40 ft. (9 to 12 m), the water is often clear enough to see the bottom, and visibilities of 20 to 30 ft. (6-9 m) are not uncommon. Blooms of phytoplankton, commonly called Red Tides, affect both vertical and horizontal visibilities. Concentration of dinoflagellates have been reported by Holmes, Williams, and Eppley (1967) of up to 20x106 cells/L. These blooms consist of unicellular microscopic dinoflagellates, such as *Gonyaulax polyedra (*changed to *Lingulodinium polyedra*, 1989*), Gymnodinium sp., Cochlodinium sp., and Prorocentrum micans* (SWRCB 1979)*.*

MARINE BIOLOGICAL RESOURCES OF THE ASBS

Marine Biota

Biological surveys were conducted and reported in the SWRCB's California Marine Waters, Areas of Biological Significance Reconnaissance Survey Reports (1979-1981). The results have been summarized in Table 2 (below) to display the number of flora (plant and algae), invertebrate, and fish species found in each ASBS.

Table 2. Number of flora (algae and marine vascular plants), invertebrate, and fish species found in each ASBS, as summarized from biological surveys conducted for the SWRCB's Reconnaissance Survey Reports (1979-1981).

ASBS Name	Number of Flora Species	Number of Invertebrate Species	Number of Fish Species
Redwoods National Park	35	433	29
Trinidad Head	24	407	0
King Range	28	181	11
Jughandle Cove	14	72	9
Saunders Reef	31	157	13
Del Mar Landing	No Survey Conducted		
Gerstle Cove	39	310	26
Point Reyes Headlands	31	299	16
Duxbury Reef	6	89	0
James V. Fitzgerald	33	159	12
Año Nuevo	35	634	14
Pacific Grove	87	521	17
Carmel Bay	30	125	78
Point Lobos	27	242	15

Julia Pfeiffer Burns	17	151	26
Salmon Creek Coast	No Survey Conducted		
Laguna Point to Latigo Point	43	613	86
Northwest Santa Catalina Island	38	254	38
Southeast Santa Catalina Island	44	260	27
Robert E. Badham	7	90	13
Irvine Coast	5	187	24
Heisler Park	15	160	28
La Jolla	20	151	36
San Nicolas Island & Begg Rock	No Survey Conducted		
San Clemente Island	No Survey Conducted		

Marine Wildlife

Marine Reptiles

Marine sea turtles occur in California waters. Four species of federally protected sea turtles may be along the California coast: green (*Chelonia mydas* FE), leatherback (*Dermochelys coriacea* FE), loggerhead (*Caretta caretta* FE), and olive ridley sea turtles (*Lepidochelys olivacea* FE). These marine turtles are circum-global in distribution but breeding colonies have not been observed in California (Coastal Conservancy 2005).

Marine Birds

Birds comprise the most conspicuous group of animals occurring along the California coast, in that many individuals are easily visible from land during all seasons and tidal conditions. Most marine bird populations are seasonal; heaviest use occurs during spring and fall migrations, and in winter. During the summer, most of the species are nesting elsewhere (SWRCB 1979).

Birds are important predators of many of the fish and invertebrates inhabiting the coast. In the rocky intertidal zone, several species of shorebirds (especially black turnstones, surfbirds, rock sandpipers, black oystercatchers, willets, and whimbrels) prey on water lice, salt water fleas, and other small crustaceans. Bristle worms, a variety of small mollusks, and occasionally representatives of other invertebrate taxa are also preyed upon. Gulls feed on crab, seastars, *Pisaster ochraceus*, and sea urchins. On the sandy beach, sanderlings and marbled godwits probe for water lice, *Excirolana*, salt water fleas, *Orchestoidea* and *Paraphoxus*, the sandcrab, *Emerita analoga*, and adult and larval insects. Seabirds that capture food near the water surface (pelicans, phlaropes, terns, and gulls) or dive beneath the surface (loons, grebes, cormorants, sea ducks, and alcids) forage on zooplankton, squid and fish, as well as mollusks and crustaceans taken from the seafloor (SWRCB 1979).

Seabirds found in the southern California Bight include Xantu's murrelet (*Synthliboramphus hypoleucus*), California gull (*Larus californicus*), Heermann's gull (*Larus heermanni*), western gull (*Larus occidentalis*), Royal tern (*Sterna maxima*), California brown pelican (*Pelecanus occidentalis*), ashy storm-petrel (*Oceanodroma homochroa*), Brandt's cormorant (*Phalacrocorax penicillatus*), and double-crested cormorant (*Phalacrocorax auritus*) (SWRCB 1979) (PRBO 2005). The California least tern (*Sterna antillarum*) and elegant tern (*Thalasseus elegans*) forage and nest along the California coast. The bald eagle (*Haliaeetus leucocephalus*) is also present along the coast and in the Channel Islands. They were listed as an endangered species in 1967 when their population drastically diminished from exposure to the chemical pesticide DDT. Recovery efforts were made to repopulate this species and, after successful attempts, they were downgraded to threatened in 1995. As of July 6, 1999, they were recommended for delisting by the United States Fish and Wildlife Services due to the increase in numbers found to exist (DFG 2001).

Along the northern and central coast, several species nest close to the intertidal zone, and are present as year-round residents. The black oystercatcher nests on rocks just above the reach of the waves. A smaller shorebird, the snowy plover, is a nests on the upper areas of beaches. Among seabirds, pelagic cormorants nest in scattered colonies along sea cliffs. This species builds nests on rock shelves along the cliff faces above the surf. Brandt's cormorant, a larger species which typically selects flat areas on islands for colony sites, is also present in large numbers along the northern and central coast. Gulls and black oystercatcher also nest along the coast (SWRCB 1979).

Of the 100+ other species occurring somewhat regularly along the California coast, the great majority nest outside of California, with many species migrating annually to the Arctic to breed. Small numbers of some of theses species, often immature birds, remain here throughout the summer (SWRCB 1979).

Marine Mammals

All marine mammals are protected under federal law (Marine Mammal Protection Act). Members of this group are predominantly carnivorous and represent the upper end of the marine food chain in the coastal waters. The three orders of marine mammals found along the California coast are the seals and sea lions (*Pinnipedia*), the sea otters (*Carnivora*) and the dolphins, porpoises and whales (*Cetacea*); the seals and sea lions are the most easily observed and abundant (SWRCB 1979).

WATERSHED AND LAND USE CHARACTERIZATIONS

Watersheds adjacent to ASBSs were analyzed by State Water Board staff for impermeability (impervious surfaces) based on land use data in Calwater2.2 Planning Watersheds and The National Land Cover Characterization NLCD 2001 Impervious Surfaces (Independent per-pixel estimates of Imperviousness) USGS/USEPA. The results are presented in Table 3. Impervious surface greater than 50% was found in watersheds draining to the Pacific Grove, La Jolla, Robert Badham, and Irvine Coast ASBS.

Table 3. Percent Impervious Surfaces adjacent to ASBS.

ASBS Name	%
Jughandle Cove	28.04
Del Mar Landing	29.69
Gerstle Cove	8.69
Saunders Reef	10.59
Trinidad Head	8.55
Kings Range	2.46
Redwoods National Park	7.61
James V Fitzgerald	24.73
Duxbury Reef	5.37
Point Reyes Headlands	4.03
Ano Nuevo	4.86
Point Lobos	11.05
Julia Pfeiffer Burns	5.62
Pacific Grove	64.52
Salmon Creek Coast	4.77
San Nicholas Island and Begg Rock	6.24
San Clemente Island	5.15
Laguna Point to Latigo Point	18.05
North West Santa Catalina Island	4.05
Southeast Santa Catalina Island	4.05
La Jolla	91.64
Heisler Park	28.19
Robert E. Badham	72.50
Irvine Coast	53.73
Carmel Bay	25.57

Redwoods National Park

Department of Transportation (CalTrans)

The Department of Transportation (CalTrans) classified and mapped the land use and summarized population density within ASBS tributary drainage areas (TAS). 69.9% of the TAS is open space public land, 17.5% is agricultural land, and 7.8% is very low density residential. The remaining land use type is less than 2% each of medium and low density residential, water, and urban reserve. Population density in the TAS is less than 100 people per squared-mile.

Trinidad Head ASBS

Trinidad Rancheria and City of Trinidad

Trinidad Rancheria has maintained a status quo since 1978 due to the lack of development. The city has very few available empty lots for future development and the City does not have industry or agriculture usage. The overall patterns of land and water use suggest that there have not been significant changes in the patterns over the past 28 years. It is likely there will not be significant changes in the near future.

King Range ASBS

Humboldt County Dept. of Public Works, Shelter Cove

The Community of Shelter Cove is located at the western end of Shelter Cove Road, approximately three miles northwest of the Humboldt-Mendocino county line. Shelter Cove is primarily residential, with some commercial development to support the local tourism industry, a nine-hole golf course, and a paved airstrip.

Saunders Reef

Department of Transportation (CalTrans)

The Department of Transportation (CalTrans) classified and mapped the land use and summarized population density within ASBS tributary drainage areas (TAS). 57.7% of the TAS is open space public land and 41.5% is low density residential. The remaining land use is undetermined. Population density in most of the TAS is less than 100 people per squared-mile.

Del Mar Landing ASBS

Sea Ranch Association

At The Sea Ranch nearly 60% of land use is common area, of which the primary use is open space dedicated to the preservation of the natural environment. A small percentage of commons at The Sea Ranch is used for roads, recreation facilities, and community facilities. Remaining land use consists of residential and commercial areas. The County of Sonoma limits lot coverage (building footprint) to no more than 35% of the lot area. As a result, impervious surfaces are reduced by lot coverage limitations and by paving restrictions of TSRA's design review body. Of the 58 lots in the study area, most have gravel drives and only a few have paved drive surfaces.

Point Reyes ASBS and Duxbury Reef ASBS

The surrounding land mass of the Duxbury Reef ASBS has at least 8,320 acres (3,367 ha) of drainage leading into several streams. Most conspicuous in the Agate Beach area is a large pipe and stream which join at the access trail and flow across the intertidal zone to the channel between the outer rocks and inner terrace. This water comes from roadsides and land occupied by subdivisions on the mesa. The water mixes rapidly with seawater and its diluting effect is quickly minimized. A very large stream is located about 2/3 of the distance to Bolinas Point from Agate Beach. Two small waterfalls were observed in the Bolinas Point area. This water flows directly into tide pools on the reef. Another very large stream is located at the extreme northern end of the ASBS. At various points along the ASBS, ground water is observed seeping from the cliffs into the beaches or over the rocks (SWRCB 1979).

Point Reyes National Seashore

An outline is provided describing the work that will be done in the watersheds that drain to Duxbury Reef and Point Reyes Headlands ASBS units under Prop 50. It includes: a) making a drainage map of the Bolinas community that drains to Duxbury Reef; b) record and report the condition and performance of the municipal stormwater management facilities in the Duxbury Reef ASBS watershed in Bolinas; c)Identify and report land uses within the Duxbury Reef ASBS watershed and identify associated, potential water quality impacts and water pollution sources; d) Develop and implement a stormwater water quality monitoring plan that will effectively assess the quality of the stormwater discharging to the Duxbury Reef ASBS; e) Perform data analysis of stormwater monitoring results; f) Prepare an Assessment and Recommendation Report based on results of stormwater drainage facility assessment and on water quality monitoring results. This report will focus on ways to improve water quality that drains to the ASBS.

Marin County Dept. of Public works

The largest Bolinas Mesa drainage network includes Alder Creek and several tributary drainages to the north and south. The small tributary drainage to the south meets Alder Creek just before emptying into the ocean at Agate Beach. The discharge from the tributary through the culvert represents the ASBS discharge point that is being addressed.

Stormwater runoff flows overland or through groundwater seepage within a system of roadside ditches and culverts to the major drainages on the Mesa.
The majority of the land use draining to the discharge point and into Alder Creek is single family residential; however, there are several agricultural operations (commercial gardens); a variety of commercial sole proprietorships (Dentist offices, massage offices, etc.) and certain ranching/livestock operations—most notably a small portion of Niman Ranch (cattle) and the Vanishing Point Ranch (horses). Due to the rural nature of the area, many Bolinas Mesa residents have chickens, goats, horses and/or other livestock property.

Approximately 250 developed properties drain into the Alder Creek watershed.
An estimated 79% of the roads within the Alder Creek watershed are unpaved and are not maintained by Marin County. The remaining 21% of roads are County maintained, paved roads. The area of land that drains to Alder Creek and to the discharge point is 275 acres.

James V. Fitzgerald ASBS

Department of Transportation (CalTrans)

The Department of Transportation (CalTrans) classified and mapped the land use and summarized population density within ASBS tributary drainage areas (TAS). 72.6% of the TAS is low density residential, 17.8% is medium density residential, 8.7% is agricultural, and 0.8% is industrial. Population density varies from 100 to 5000 people per squared-mile.

Pillar Point (Air Force)

The storm water runoff discharge into the ASBS originates from Pillar Point AFS tracking station on the bluff. Storm water runoff at Pillar Point AFS either infiltrates into site soils, sheet flows over the cliff side into the ocean, or is channeled off-site through engineered drainages. Storm water runoff from the developed areas, approximately 8.3 acres of Pillar Point AFS collects in a small concrete drainage channel adjacent to the circular facility perimeter road and is directed towards a sump near the guardhouse. Runoff is then discharged to the north through a culvert and subsequently conveyed through an engineered concrete drainage channel down the cliff face to the beach below. The watershed draining to the ASBS is composed of approximately 36% impervious surface (includes pavement and building coverage) and the remaining 64% is composed of vegetated hillsides. The land use is primarily characterized by open space as well as administrative and industrial land uses. Approximately 10 to 15 site personnel work within the boundaries of the ASBS watershed.

County of San Mateo

The Fitzgerald ASBS watershed is approximately 4.5 square miles and is located in unincorporated San Mateo County. The dominant land uses are residential, park/open space, ranching and equestrian facilities, a military facility, small-scale agriculture, and light commercial/industrial. Three residential communities are located in the watershed, Montara, Moss Beach, and Seal Cove. The community of El Granada is also located in the vicinity, but drainage from the area flows to Pillar Point Harbor and is located outside of the ASBS boundary. As of 2000, the combined population of Montara and Moss Beach was less than 5,000. A municipal airport (Half Moon Bay Airport) is located in the vicinity. However, the majority of runoff from this facility flows to the Pillar Point Harbor, which is located outside of the ASBS boundary. The US Air Force has a small tracking station on the bluffs just north of Pillar Point (From the County of San Mateo exception application).

Año Nuevo ASBS

Department of Transportation (CalTrans)

The Department of Transportation (CalTrans) classified and mapped the land use and summarized population density within ASBS tributary drainage areas (TAS).60.9% of the TAS is low density residential, 24.4% is open space public lands, and 14.5% agricultural. Population density in the TAS is less than 100 people per squared-mile.

Pacific Grove ASBS

The only somewhat natural drainage into the Pacific Grove ASBS is from Greenwood Creek which runs through Greenwood Park. Upstream from the park, the creek again becomes part of the storm drain system. All other freshwater discharges to the ASBS are from storm drains (SWRCB 1979).

City of Pacific Grove

The watershed areas that drain to the ASBS comprise a total of approximately 940 acres and is predominately residential. The downtown retail sector comprises 30 acres. The Pacific Grove Golf Links contribution is approximately 43 acres in size. Parks, open space, and a recreational trail system border the entire length of the ASBS.

Carmel Bay ASBS

There are several watersheds adjacent to the Carmel Bay ASBS; however, all freshwater discharges are seasonal. Pescadero Canyon drains into the ASBS at the north end of Carmel City Beach and San Jose Creek drains into Monastery Beach. The principle drainage is the Carmel River Basin, which covers a total of about 225 square miles (585 km2) (Army Corps of Engineers, 1974) in a northwest-southwest direction. Carmel Valley, the lower portion of the watershed, extends eastward about 15 miles (24 km) from the river mouth.

The estimated 50-year mean annual run-off from the Carmel River is 142,300 acre-feet (176 hm^3). Flow is highly variable, both seasonally and from year to year. Between August 1962 and September 1967, mean annual flow was only 63.200 acre feet (78 hm^3) and no measurable flow occurred at the gauging station during the first three-quarters of 1977 (Sedway/Cooke 1977, cited in SWRCB 1979). Ninety percent of the river's flow occurs between February and August (SWRCB 1979).

Department of Transportation (CalTrans)

The Department of Transportation (CalTrans) classified and mapped the land use and summarized population density within ASBS tributary drainage areas (TAS). 29.1% of the TAS is low density residential, 28.5% is agricultural, 25.2% is open space public lands, and 14.6% is medium residential. The remaining land use type is less than 2.0% each of urban reserve, low density commercial, and high density residential. Population density of about half of the TAS is less than 100 people per squared mile. Population density in the remaining area of the TAS ranges from 100 to 10,000 people per squared-mile, though, it should be noted that density exceeds 5,000 people per squared-mile in the city of Carmel-by-the-Sea.

Point Lobos ASBS

Department of Transportation (CalTrans)

The Department of Transportation (CalTrans) classified and mapped the land use and summarized population density within ASBS tributary drainage areas (TAS). 82.9% of the TAS is open space public land, 13.8% is low density commercial, and 2.3% is medium density residential. Population density of the TAS is less than 100 people per squared-mile.

Julia Pfeiffer Burns ASBS

Within the Julia Pfeiffer Burns ASBS, two small watersheds occur, Partington Creek draining into Partington Cove and McWay Creek draining into Waterfall Cove (SWRCB 1980).

Department of Transportation (CalTrans)

The Department of Transportation (CalTrans) classified and mapped the land use and summarized population density within ASBS tributary drainage areas (TAS). 99.2% of the TAS is open space public lands and 0.7% is low density residential. Population density of the TAS is less than 100 people per squared-mile.

Salmon Creek Coast

Department of Transportation (CalTrans)

The Department of Transportation (CalTrans) classified and mapped the land use and summarized population density within ASBS tributary drainage areas (TAS). 99.7% of the TAS is open space public lands and the remaining land is agriculture. Population density of the TAS is less than 100 people per squared-mile.

Laguna Point to Latigo Point ASBS

City of Malibu Dept. of Public Works

The marine, canyon, and watershed environment westward of Malibu Canyon Road to the Ventura County line is in a relatively undisturbed state. The slopes and hillsides are dominated by coastal sage scrub and chaparral vegetation and large areas of riparian habitat in the canyons. Along the coast, kelp beds are found, providing habitat for many species of sea life. The natural environment from the Civic Center eastward has suffered some biological degradation. Grading and development eliminated some native hillside vegetation in some areas, portions of creeks have been channelized, and kelp beds have largely diminished or disappeared but reef and rock zones still provide habitat for many species of fish.

More than 15% of the total land in Malibu is public open space. 1869.9 acres of open space are used for public recreation, including regional parks, local parks, beach parks and general open space. Local and regional parks make up 743.7 acres of the open space in Malibu. Vacant, undeveloped private land comprises 60.4% of all land in the City (7578.3 acres), most of which is in its natural state containing tree, brush, shrub and grassland vegetation. With a majority of the land in Malibu still sitting as undeveloped open space, it is evident that the general character of the land has changed little since 1974, when the Area of Special Biological Significance was first designated.

Los Angeles County Dept. of Public Works

Eight small watersheds totaling 33,000 acres drain into the ASBS along the County of Los Angeles coastline. This area consists of the unincorporated County of Los Angeles, City of Malibu, State Parks, National Parks, and California Department of Transportation roadways. The County of Los Angeles has jurisdiction over approximately 12,300 acres of the total drainage area. The land use is almost entirely natural open space. Small portions of the drainage area also include low density residential developments, small agriculture plots, and beach parking areas. The impervious surfaces are estimated to account for three percent of the watershed.

Department of Parks and Recreation

Point Dume is comprised of 31 acres of parkland. There are 2972 lineal feet of beach associated with this unit. About half of that is isolated from the unit with a parking area that is administered by the County of LA.

Department of Transportation (CalTrans)

The Department of Transportation (CalTrans) classified and mapped the land use and summarized population density within ASBS tributary drainage areas (TAS). 86.1% of the TAS is open space public lands, 4.9% is low density residential, 4.8% is very low density residential, and 2.6% is medium density residential. The remaining land use type is less than 1.0% each of low density commercial, industrial, high density residential, planned development, high density commercial, water, urban reserve, and mixed use. Population density of the TAS varies from less than 100 to 10,000 people per squared-mile, and in a few relatively small areas, reaches 20,000 people per squared-mile.

Northwest and Western Santa Catalina Island ASBS

Santa Catalina Island Company

The majority of the land adjacent to the ASBS is Open Space Easement and Conservancy Area. The Two Harbors area and Little Geiger Cove to Howland's Landing are the Non-Easement, Non-Conservancy areas owned by the SCICO. The land use is dominated by residential areas, view corridors/public uses, campgrounds/hostels, and lodges/Inns. The SCICO has two secondary stage wastewater treatment plants within the ASBS. Additionally, SCICO has removed the underground fuel storage tanks previously located at the vehicle fueling facility located adjacent to the beach.

The high use visitor period runs roughly from Memorial Day in May through Labor Day in September. During that time, the City of Avalon, as well as other recreation areas and summer camps on the island are generally filled to capacity. During the remaining months the population drops to a fairly constant level of permanent residents while other areas retain a minimum number of more-or-less permanent, maintenance-type personnel (Los Angeles County, Department of Regional Planning. 1983. Local Coastal Plan, Santa Catalina Island).

Southeast Santa Catalina Island ASBS

Connolly Pacific Company

The Connolly facility is located in the Pebbly Beach Extractive Use Zone in the Santa Catalina Island Local Coastal Plan. Connolly leases the property from SCICO. There is a quarry located 0.8 miles off shore. Connolly must maintain the natural shoreline contours, meaning some rocks are added periodically to areas where storms have caused slippage. Connolly is also required to reconstruct a "natural" hillside topography upon reclamation. The facility is approximately 248 acres and is completely pervious (i.e. No paved roads or parking areas).

San Clemente Island ASBS

U.S. Navy

There are 214 watersheds on the island. The revised universal soil loss erosion occurs on most of the island at a rate of les than 4 tons per acre per year, though the northeast coast of the island erodes at 12 to 23 tons per acre per year. Most of the island is less than 1.5% impervious, and reaches up to 12.3% imperviousness in a few, relatively small areas.

Robert E. Badham ASBS

The land immediately behind the coastal bluffs of the Robert E. Badham ASBS is nearly completely developed, and private homes line most of the cliff edge. Public access to the Refuge is provided by a large, partially paved walkway at Poppy Avenue and by climbing over the rocks along shore from the north (from the Corona del Mar area (SWRCB 1979).

City of Newport Beach

Population: 38,394 housing units and a population of 70,032 in 2000. Within the watershed drainage are of the ASBS, there was a total population of 4,523.

Impervious Surface Area: The drainage area for the ASBS has an average impervious surface percentage of 44.5%. Along the coast, where the majority of the population resides, the impervious surface area is close to 85%.

Land Use: Of the approximately 32,000 acres that make up the City of Newport Beach, the drainage area of the Newport Beach Marine Life Refuge consists of 1659.32 acres. The majority of the drainage area is either residential, 733.27 acres, or vacant land, 729.06 acres. The rest of the watershed is open land and recreation (100.22 acres), mixed use or under construction (82.74 acres), commercial and public (10.44 acres), and transportation and utilities (3.61 acres). There are no industrial areas within the watershed. The vacant land is located on either side of Buck Gully and Morning Canyon Creek and is bordered by residences and open parks.

Irvine Coast ASBS

Department of Transportation (CalTrans)

The Department of Transportation (CalTrans) classified and mapped the land use and summarized population density within ASBS tributary drainage areas (TAS). 56.2% of the TAS is open space public lands and 43.8% is medium density residential. Population density in about 65% of the TAS is less than 100 people per squared-mile. Population density of a relatively small area of the TAS ranges from 5,000 to 10,000 people per squared-mile. The remaining are of the TAS has a population density of 100 to 500 people per squared-mile.

Department of Parks and Recreation

Crystal Cove: Crystal Cove State Beach is comprised of 2791 acres of land. There are 16800 lineal feet of beach associated with this park. The park has approximately 8 miles of trails. The park is bisected by State Highway 1. There are 174,120 square feet of parking lot at the Pelican Point facility. Developed area in the park amounts to about 0.5% of the total area. Caltrans has developed collection infrastructure to accumulate all roadway drainage and eliminate any direct runoff from the Highway 1 section over most of the area that has the potential to impact the ASBS. About 50% of the park is bordered by urban development and golf course with the remainder undeveloped back country to the top of the coastal drainage ridgeline.

Heisler Park ASBS

The most popular activities at the Reserve are exploring tidepools, picnicking, sunbathing, and SCUBA diving (several large dive classes utilize the area nearly every weekend from February through November). Other activities observed included fishing from boats and snorkeling (SWRCB 1979).

City of Laguna Beach
Population: 1,225 property lots, 26,000 residents, and the current resident watershed population of approximately 2,500 to 3,000 people. It is estimated that about 3,000,000 people visit the city each year.
Impervious Surface Area: The watershed impervious surface area is estimated to be about 70 percent. Because the watershed is built out, it is anticipated that the existing percentage of impervious surface will not significantly change in the future.
Land Use: Land use of the watershed area is predominantly residential and a small percentage of commercial use along the Pacific Coast Highway. The reserve watershed area consists primarily of residential development from the beach cliff area extending inland to the narrow coastal plain and up on the hillsides. There are no industrial businesses or facilities within the watershed. There are five City parks and recreation areas which amount to 61 acres, and there is one City facility, the City Park Division operations yard.

La Jolla ASBS

City of San Diego
General: The La Jolla is a hillside coastal community of the City of San Diego. The community has warm summers and mild winters. Nearly all the annual precipitation occurs between the months of October and April. Summer rains can occur, but are infrequent. The La Jolla receives an average of about 11 inches of rainfall per year.

Population: Within the ASBS watershed area, there are approximately 1,640 households based on the 2000 consensus. It is estimated that the current resident population is 6,060 people in the watershed. During the summer months, visitors and tourists significantly increase the amount of people in the community.

Impervious Surface Area: The La Jolla Ecological Reserve drainage area impervious surface percentage is estimated to be about 43%. Because the watershed is built out, it is anticipated that the existing percentage of impervious surface will not significantly change in the future.

Land Use: The ASBS #29 watershed is fully developed and has been for several decades; land uses and, assumedly storm water quality, have remained fairly static during this time. There are approximately 1452 acres in the ASBS drainage area. Of this total, 80% is urbanized area and 20% is undeveloped or dedicated open space. There are no industrial businesses or facilities within the watershed.

EXISTING DISCHARGES

The Southern California Coastal Water Research Project (SCCWRP) 2003 Final Report on Discharges into State Water Quality Protection Areas found 391 municipal or industrial storm drains, 1012 small storm drains, 224 nonpoint sources, and 66 seeps or springs that may have been influenced by nonpoint source wastes. SCCWRP also found 637 intermittent (gullies) or perennial streams. Since the SCCWRP survey SWRCB staff has identified another 96 drainages, most of which are storm water or nonpoint source discharge sites.

There are 473 runoff discharges into ASBSs exceeding 18 inches in diameter or width. 315 of those discharges exceeded 36 inches in diameter or width.

Caltrans did a study of 186 discharges to ASBS. Of those 186, 83 discharges were directly into an ASBS and 103 were indirect, meaning that they were either attenuated through natural vegetation (65) or discharged to streams (38) along the coast just prior to draining into an ASBS.

Waste Discharge Treatment

The following are summaries of Best Management Practices (BMPs) or other controls or treatment that responsible parties have done or are doing to address waste discharges.

Department of Transportation (CalTrans)

Non-structural maintenance BMPs from Caltrans Storm Water Quality Handbook, Maintenance Staff Guide (CTSW-RT-02-057[1]), May 2003

Non-structural BMPs implemented in the ASBS' covered by the Coast Highway Management Plan (Highway 1, from San Carpoforo Creek in San Luis Obispo County to the Carmel River in Monterey County)
Treatment BMPs (Source: Table 2-5 of Caltrans Storm Water Quality Handbooks, Project Planning and Design Guide (CTSW-RT-02-077[1]), September 2002, April 2003 Printing).

Approved Treatment BMPs: Biofiltration: strips/Swales, Infiltration Devices, Detention Devices, Traction Sand Traps, Dry Weather Flow Diversion, Gross Solids Removal Devices (GSRDs), Media Filters, Multi-Chamber Treatment Train, Wet Basins
See the CAL TRANS exception application for more details.

Department of Parks and Recreation

Crystal Cove State Park Water Quality Action Plan
They are working under requirements of a Cease and Desist Order (CDO 00-87) in the area adjacent to the Crystal Cove ASBS Unit. This order involved septic systems associated with the Historic District and Reef Point parking lot management in Crystal Cove State Park as well as the operation of the Newport Coast Development and the Pacific Coast Highway Drainage tributary to the park. The Reef Point Parking lot plan includes the following:

Vacuuming program: Twice per month (June-October); Once per month (November-May).

Trash Removal: Litter removal from all parking areas daily, Inspect and remove litter from culverts, drainages and other areas.

Vegetation Management: Continue to implement coastal sage scrub revegetation program both within natural drainages and on the bluff top.

Showers: Continue to maintain shower fixtures to prevent unnecessary use of fresh water

Additionally, the Crystal Cove Park is working on fulfilling requirements of the El Morro CDO: R9-2003-0285. This process has eliminated all septic systems associated with these facilities.

Salt Point/Gerstle Cove

A fish cleaning facility is located at the Salt Point unit and is located adjacent to the restroom facilities. There is no discharge to surface waters from the Fish Cleaning Station.

Other Parks, Current treatment processes, pollution control/BMPs

Toilet facilities are provided, both permanent and portable, throughout the park units at convenient locations to provide sanitations facilities for visitors. Trash receptacles and scheduled trash pick up are a part of each units operation. Department wide educational activities are continual. Public presentations at park units continue to attempt to get the word out about damage that can occur if litter is not disposed of correctly. Other issues are discussed such as chemical impacts such as oil and grease from normal life activities in our society. The use of pesticides in park unites is supervised by licensed applicators. Recycling programs and collection facilities are located in most park units.

Humboldt County Dept. of Public Works, Shelter Cove

New homes and businesses in lower Shelter Cove are required to connect to the existing sewer system. This requirement is being implemented through the Coastal Development Permit process administered by the Humboldt County Planning division

Construction BMPs for erosion and sediment control are required for construction in Shelter Cove. This is also implemented through the Coastal Development Permits issued by the Humboldt County Planning Division. Inspections during construction are performed by the Humboldt County Planning and Building Division.

Development in Shelter Cove is regulated by the Local Coastal Program land use designations and zoning ordinances, and the Coastal Development Permit process. The land use designations, zoning, and permitting processes regulate parcel size, allowable uses, housing density, commercial development, and sewer and septic development in Shelter Cove.

Land along the ocean buffs has been acquired by the Bureau of Land Management to be kept relatively undeveloped, as was recommended in the 1979 Reconnaissance Study.

Sanitary wastewater is being treated and recycled to irrigate the golf course.

Humboldt County will coordinate with the Shelter Cove Resort Improvement District to develop policies and projects to protect and improve local water quality, such as drainage improvements, storm water treatment BMPs, and water quality testing. See the Humboldt County Dept. of Public Works exception application for more details.

Pillar Point (Air Force)

Current BMPs: Spill prevention Control and Countermeasure Plan; Integrated Natural Resources Management Plan; Annual Wastewater Inventory; Wet Weather Preparedness Plan (scheduled for 2006 implementation); and Parking lot, building, and drainage system repair and maintenance.

Structural BMPs: Double-walled aboveground storage tanks; and Storm water runoff energy dissipaters.

Sea Ranch Association

At present there are no treatment processes, pollution controls, or management practices for waters entering the two storm drains. Dry weather flows into the storm drain system are effectively non existent since natural drainage patterns were minimally disrupted and private lots do not drain to a comprehensive storm water collection system as found in most modern subdivisions. The opportunity for pollutants or toxic substances to enter the drainages to the ASBS is limited by several factors including the above drainage practices and storm drain system. Another factor is land use in the watershed area draining to the ASBS which is limited to residential and natural common areas.

Marin County Dept. of Public Works

Marin County municipalities have been actively managing stormwater runoff since the early 1990s through MCSTOPPP. This stormwater management plan details the BMPs being implemented to reduce the impact of road maintenance activities on watercourses in the County including drainages to the ASBS. The performance standards outline BMPs for the following Phase II stormwater program elements: Municipal maintenance, Illicit discharge controls, New Development and Construction controls, Industrial and Commercial Discharges, and Public Information and Participation.

Street sweeping occurs on a semi-annual basis on County maintained roads. The County Parks department is exploring an agreement with County road maintenance staff to sweep the Agate Beach Parking lot in the fall. Ditch cleaning occurs in the summer and ruing the winter on an as-needed basis to maintain flow. See the Marin County exception application for more details.

Trinidad Rancheria

A fish cleaning station with a counter, sink, and faucet is no longer in use and has been removed. Divers have noted fish carcasses and odor. The Rancheria has purchased refrigerated trailer to allow holding and recycling of offal. By the year 2007 the Rancheria is willing to provide user education and signing to ensure that all offal is deposited in the recycle bags and no chemicals are discharged.

The mooring field is occupied by commercial and recreational fishing boats from May through October. No live-in occupation of boats is known to occur. SWRCB is concerned that release of metals by corrosion-protective “zincs” and bottom paint could damage the kelp beds. SWRCB additionally speculates that fishermen defecate from boat rails. The Rancheria has sampled for petrochemical pollution in the harbor near the mooring field twice a year for each of the past two years as part of its EPA Section 106 Water Quality grant. The purpose of this sampling was to detect water quality threats from land- or water-based petrochemical pollution. No threats were found. The Rancheria is committed to continuing this sampling program.

The Rancheria has committed to ceasing the use of bleach. Although the discharge of chlorine has been eliminated, the discharge of wash water and runoff from the surface of the ramp may constitute a discharge.

<u>City of Trinidad</u>

The City of Trinidad is in the process of implementing an On-site Wastewater Treatment System (OWTS) management program. The program is supported by grants from the EPA and SWRCG. The overall goal of this program is to eliminate the potential contamination of ground and surface waters by maintaining the proper function of all the septic systems and avoiding any septic failure in the City.

<u>Point Reyes National Seashore</u>

The Point Reyes National Seashore General Management Plan: the ASBS areas fall within one of three subzones within the Special Protection Zone:
Special Protection: Wilderness Subzone: Bird Rock ASBS, Double Point ASBS
Special Protection: Marine Reserve Subzone: Point Reyes Headlands Reserve
Special Protection: Biotic Sensitivity Subzone: Duxbury Reef Reserve and Extension

Point Reyes National Seashore Water Resources Stewardship Report (WRSR): intended to support park staff in identifying strategies to meet park desired conditions, and to develop indicators that may be used to measure success.

Coastal Watershed Assessment: The CWA will document available information and highlight to park managers where more monitoring or implementation to improve conditions are necessary. The final report will be provided to the Seashore during summer 2006, but we anticipate incorporating findings of the ASBS investigation into this report.

Inventory and Monitoring Program (I&M): Through the I&M programs, there are now protocols for implementation of a broad scale water quality monitoring program, fisheries monitoring (including salmonids), pinniped monitoring, etc. The I&M program has also been instrumental in providing initial funding for many of the coastal inventory efforts described as part of this program, including Coastal biophysical inventory, Seabird monitoring, and the high-resolution coastal habitat mapping programs.

City of San Diego

Current treatment processes, pollution controls, and/or best management practices used City-wide can be found in the FY 205 Annual Report. City-wide practices such as street sweeping, storm drain cleaning, and education/outreach efforts are implemented in the ASBS watershed. Five of the 17 ASBS discharge points are currently outfitted with low-flow diversion devices, and additional diversions are planned as indicated in the Planning Report Memo. The city is currently planning specific ASBS water quality strategies in conjunction with Coastkeeper and the Scripps Institute of Oceanography as shown in the Prop 50 and "Consolidated Grant" grant applications.

City of Newport Beach

The city is employing three tactics to reduce the discharge of pollutants to the ASBS:

a) Avoid transport of pollutants (transport prevention)
b) Minimize sources of pollutants (source control), and
c) Mitigate (treatment control)

City of Laguna Beach

Current Pollution Prevention Measures: Increased Infiltration and Water Quality Management Plans- The City of Laguna Beach will increase infiltration of stormwater through land development requirements and implementation of Municipal Stormwater Permit Standard Urban Stormwater Mitigation Plan (SUSMP) requirements etc.

Additional Pollution Prevention Programs: ban on smoking at public beaches as well as trash and grease control.

Implementation of Water Conservation Methods: The Laguna Beach County Water District will continue its general conservation message to encourage residents and visitors to reduce usage of water in daily activities.

Increased retention and Sewer System Capacity: The City of Laguna Beach has completed improvements to the sewer system by cleaning and televising the lines, and repairing defects to the lines in all high priority areas. The improvement project will be completed in 2007.
Implementation of Effective Enforcement Management Measures: The City has made water conservation mandatory within the reserve drainage area and is enforcing over irrigation issues within the watershed.

Current Source Control Measures: Street sweeping, pet waste management, pesticide management, illicit discharges and commercial inspections, additional source controls

Current Treatment Control Management Measures: Dry Weather Diversion of Municipal Storm Drains that Discharge Directly to the ASBS, Stormwater Filtering of

Municipal Storm Drains that Discharge Directly to the ASBS, Implementation of BMPs under the NPDES MS4 Permit Programs.

Malibu City Dept. of Public Works

Numerous activities including, but not limited to: city ordinances, onsite wastewater treatment systems, illicit connection/illicit discharge elimination program, planning and construction of new development and redevelopment projects, street maintenance, public information through Malibu Current Quarterly Environmental News and other sources, and Ocean Friendly Garden Program.

Pesticide Applications in ASBS

Table 4 provides information taken from exception applications related to pesticide applications.

Table 4. Pesticides applied by applicants.

ASBS	Responsible Party	Pesticide/Herbicide Use
2	Sea Ranch Association	Pesticides and Herbicides not used within the drainage study area
6	Trinidad Rancheria,	None used
	Trinidad City	None used
	Dept. of Parks and Rec.	Use of pesticides in park units is supervised by licensed applicators.
7	Humboldt County- Public Works Dept.	no information provided
	Dept. of Parks and Rec.	Use of pesticides in park units is supervised by licensed applicators.
8	U.S. Dept. of the Interior- redwood National State Parks	no information provided
	Dept. of Parks and Rec.	Use of pesticides in park units is supervised by licensed applicators.
	Dept. of Transportation (Del Norte County)	Garlon 4: 32 oz/acre; Pathfinder: 32 oz/acre; Roundup Pro: 64 oz/acre
9	Dept. of the Air Force	Stopped use in 2002
	Dept. of Parks and Rec	Use of pesticides in park units is supervised by licensed applicators.
	County of San Mateo	None used on land that drains into the ASBS
11	Marin County- Dept. of Public Works	unknown, personal/private property use only
11,12	Point Reyes National Seashore	Integrated Pest Management (IPM)
19	Pacific Grove City- Public Works Dept.	Pesticides and Herbicides used: Fusalade II; 0.4 to 0.6 ounce/1000 sq. ft
		Roundup.pro; 1.6 % sol'n, spot spray 1.6 gallon/100 gal water
		Pendulum; 40 lb bag per 1/5 acre, 100 to 200 lb/ acre
		Turflon Ester; 1/2 to 1 quart/acre
		Garlon 4; 1 to 8 quarts/acre
		Surflan; 1.5 to 8 quarts/acre
ASBS	**Responsible Party**	**Pesticide/Herbicide Use**
		Rodeo; 3/4 to 1.5 % sol'n, spot spray

		Pro Spreader Activator; Non-ionic surfactant, 2-8 ounces/100 gal water
21	U.S. Dept. of the Navy	Herbicides and pesticides used /year at SNI (in gallons)
		Roundup: 8 gallons Garlon: 6 gallons
		Termador: 0.5 (diluted) Suspend: 0.75 (diluted)
23	U.S. Dept. of the Navy	Herbicides used in 2005 (gallons): Roundup, 45; Garlon, 15
		Previously used herbicides: Rodeo, Pathfinder
24	Los Angeles County- Dept. of Public Works	no information provided
	Malibu City-Public Works	no information provided
	Dept. of Transportation	Endurance: 32 oz/acre
		Manage: 1 oz/acre
		Oust: 2 oz/acre
		Pathfinder: 128 oz/acre
		Pro-Spreader: 4 oz/acre
		Reward: 64 oz/acre
		Roundup Pro: 96 oz/acre; 128 oz/acre
		Telar: 1 oz/acre
		Transline: 8 oz/acre
		Fusilade II T&O: 24 oz/acre
		Gallery 75DF: 16 oz/acre
		Embark 2-S: 64 oz/acre
		Dimension Ultra 40WP: 24 oz/acre
		Montar: 224 oz/acre
	Dept. of Parks and Rec.	Use of pesticides in park units is supervised by licensed applicators.
25	Santa Catalina Island Company	None used
28	Connolly Pacific Company	no information provided
29	San Diego City	Rodeo and Roundup applied on an as-needed, ad hoc basis
		Rodeo Roundup applied prior to street resurfacing
30	Laguna Beach City	Fertilizers: Turf Supreme, Gro Power Plus, Grow More
		Pesticides/Herbicides: Round-up Pro, Fusilade II, Metaldyhyde 7.5,

Water Chemistry

Dischargers applying for the general exception to the California Ocean Plan supplied sampling data from various waterbody types. Data for Ammonia N and metals, including Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni), Selenium (Se), Silver (Ag), and Zinc (Zn), are provided in Appendices B and C for discharges and receiving water respectively. The data may be compared to the instantaneous maximum objectives for metals and ammonia in the California Ocean Plan Table B, shown in Table 5 (below).

Table 5. California Ocean Plan Table B Instantaneous Maximum Objectives.

Arsenic	80 µg/L
Cadmium	10 µg/L
Chromium	20 µg/L
Copper	30 µg/L
Lead	20 µg/L
Mercury	0.4 µg/L
Nickel	50 µg/L
Selenium	150 µg/L
Silver	7 µg/L
Zinc	200 µg/L
NH_3N	6,000 µg/L

A very preliminary review of the ammonia data was performed. Ammonia N in the receiving water at Pacific Grove, Heisler Park and San Clemente Island ASBS was found to be above the instantaneous maximum of 6,000 µg/L. Figure 2 is a graph of ammonia concentrations in ocean receiving water. More work should be done by staff, in conjunction with the applicants, to evaluate the quality of this ammonia data.

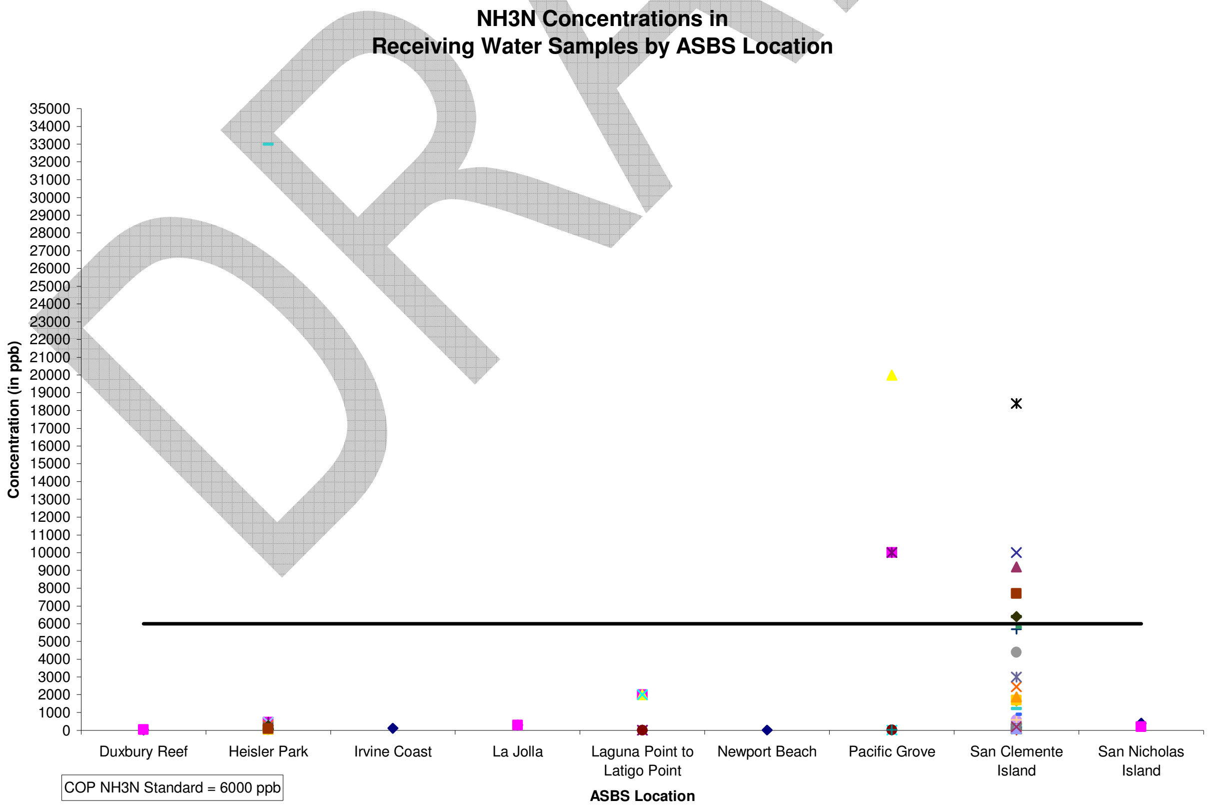


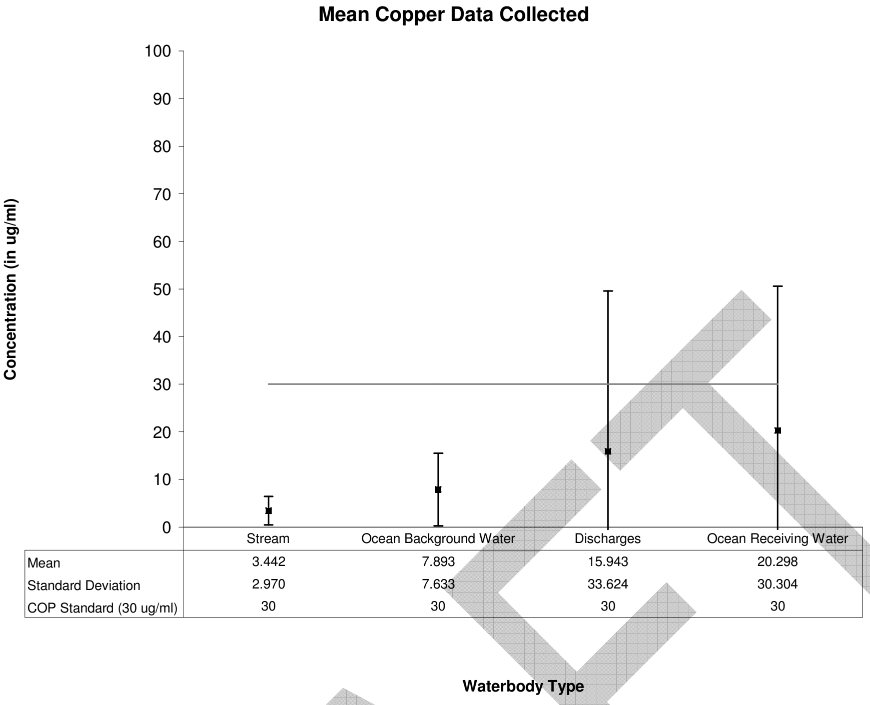
Figure 2. NH3N Concentrations in Receiving Water Samples by ASBS Location.

For selected metals (copper, silver, zinc, lead, and nickel) and PAHs, a further assessment was performed. For these constituents data was further categorized as follows: ocean water near a discharge, storm water or nonpoint source runoff discharges, naturally occurring streams, and background ocean water. Data from several ASBS were lumped together. Table 6 provides the number of samples for each constituent and category.

Table 6. Sample Numbers and Standard Deviations of Each Waterbody.

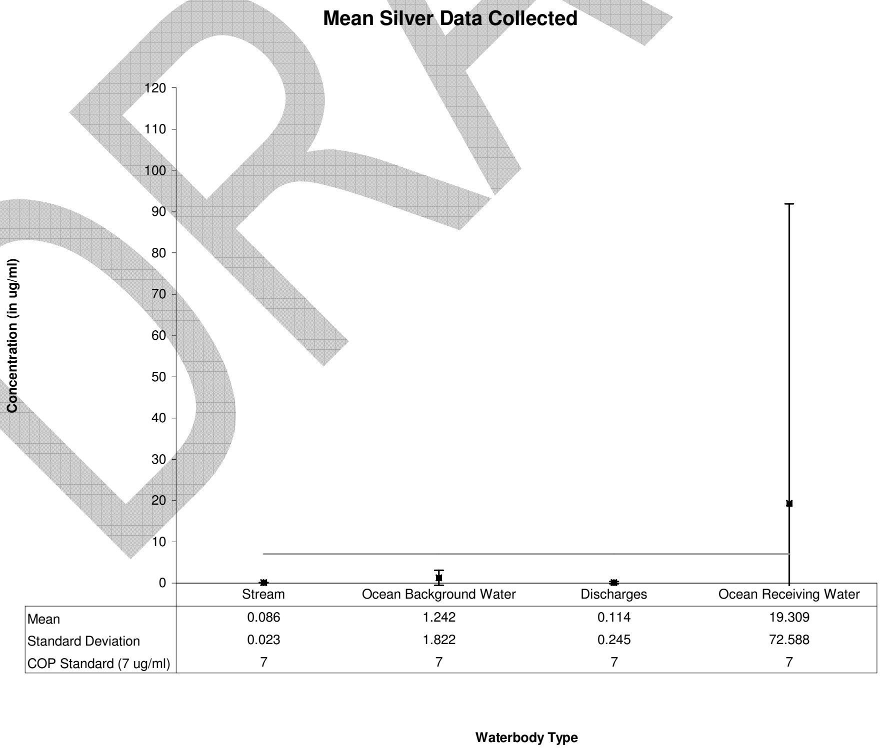
Constituent	Waterbody Category	Number (n)
Copper	*Stream*	15
	Ocean Background Water	13
	Discharges	151
	Ocean Receiving Water	139
Lead	*Stream*	11
	Ocean Background Water	12
	Discharges	125
	Ocean Receiving Water	96
Nickel	*Stream*	11
	Ocean Background Water	13
	Discharges	116
	Ocean Receiving Water	95
Silver	*Stream*	11
	Ocean Background Water	9
	Discharges	96
	Ocean Receiving Water	83
Zinc	*Stream*	11
	Ocean Background Water	13
	Discharges	131
	Ocean Receiving Water	92
PAH	*Stream*	4
	Ocean Background Water	3
	Discharges	37
	Ocean Receiving Water	12

Results (mean and standard deviation) for copper, silver, zinc, lead, nickel and PAHs are graphed for each category in Figures 3 though 8. For the metals the COP instantaneous maximums are shown on the graphs. The PAH 30 day average objective of 0.0088 µg/L is a human health objective (bioaccumulation/seafood consumption) and is not used here for comparison purposes. It is also important to note that while most of the data represented grab samples, a few data points represent composite sampling.



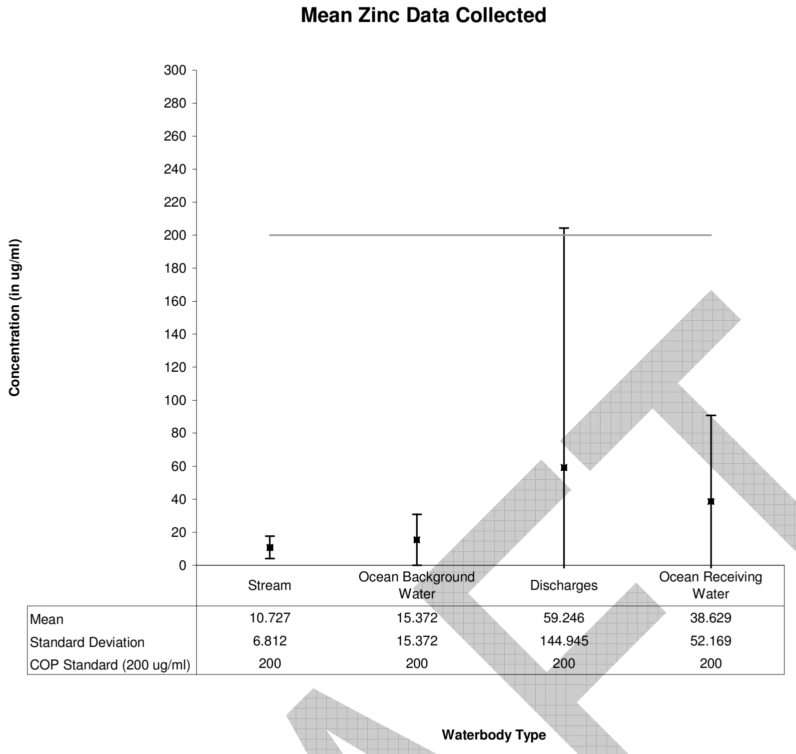
	Stream	Ocean Background Water	Discharges	Ocean Receiving Water
Mean	3.442	7.893	15.943	20.298
Standard Deviation	2.970	7.633	33.624	30.304
COP Standard (30 ug/ml)	30	30	30	30

Figure 3. Mean Copper Data.



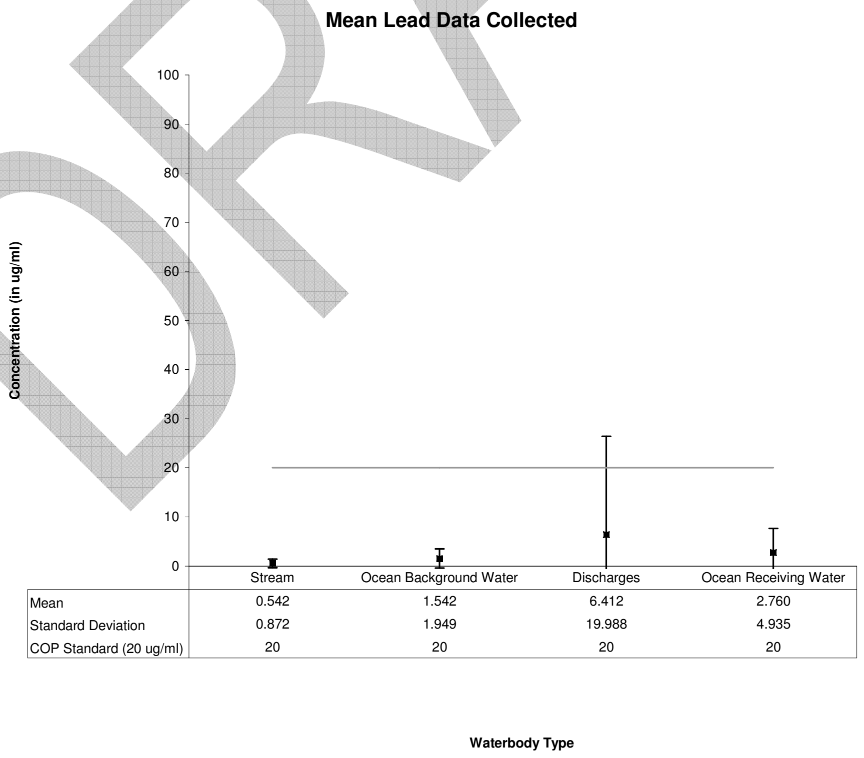
	Stream	Ocean Background Water	Discharges	Ocean Receiving Water
Mean	0.086	1.242	0.114	19.309
Standard Deviation	0.023	1.822	0.245	72.588
COP Standard (7 ug/ml)	7	7	7	7

Figure 4. Mean Silver Data.



	Stream	Ocean Background Water	Discharges	Ocean Receiving Water
Mean	10.727	15.372	59.246	38.629
Standard Deviation	6.812	15.372	144.945	52.169
COP Standard (200 ug/ml)	200	200	200	200

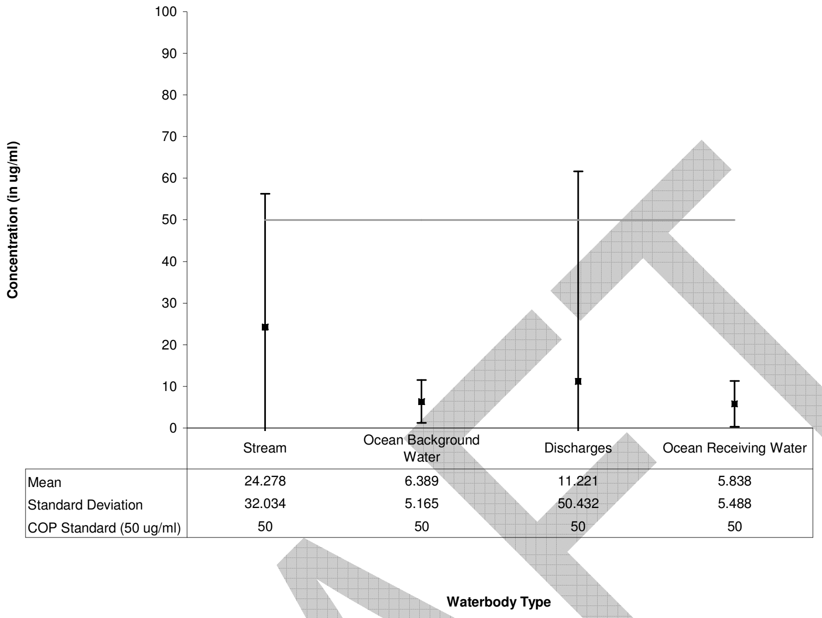
Figure 5. Mean Zinc Data.



	Stream	Ocean Background Water	Discharges	Ocean Receiving Water
Mean	0.542	1.542	6.412	2.760
Standard Deviation	0.872	1.949	19.988	4.935
COP Standard (20 ug/ml)	20	20	20	20

Figure 6. Mean Lead Data.

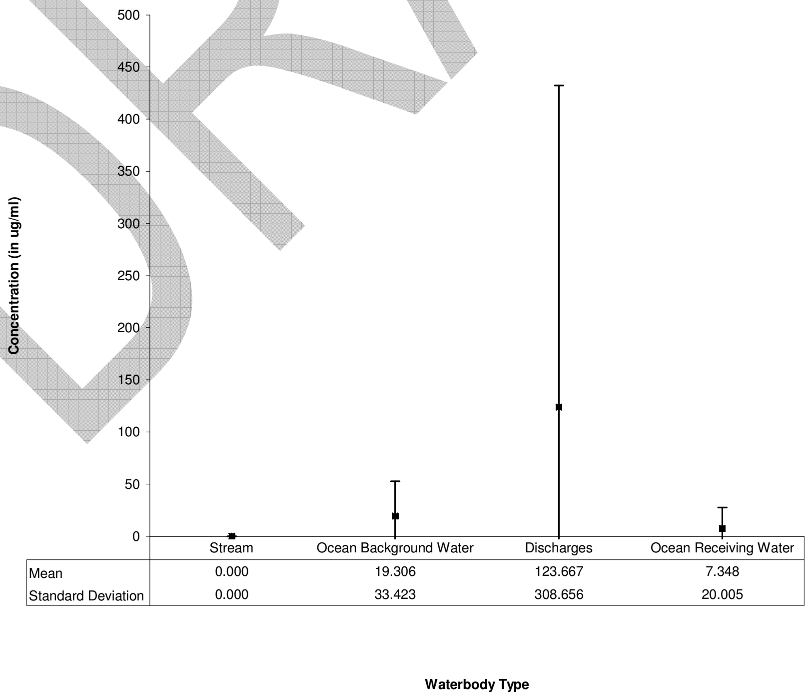
Mean Nickel Data Collected



	Stream	Ocean Background Water	Discharges	Ocean Receiving Water
Mean	24.278	6.389	11.221	5.838
Standard Deviation	32.034	5.165	50.432	5.488
COP Standard (50 ug/ml)	50	50	50	50

Figure 7. Mean Nickel Data.

Mean Total COP PAH Data Collected



	Stream	Ocean Background Water	Discharges	Ocean Receiving Water
Mean	0.000	19.306	123.667	7.348
Standard Deviation	0.000	33.423	308.656	20.005

Figure 8. Mean Total COP PAH Data.

Most of the data exhibited high variability. Copper, zinc and lead generally are known constituents in urban runoff. For copper, zinc and lead the means for discharges and ocean receiving water were substantially higher than for streams and background ocean levels.

For nickel, discharges were substantially elevated, but naturally occurring streams had an even higher mean. Therefore some component of the nickel in the discharges may be from natural geologic sources. The mean silver in ocean receiving water was high, but that was mostly due to one very elevated data point. Runoff samples for silver were relatively low.

PAHs are also known constituents in storm water discharges and the mean PAH discharge levels were elevated compared to streams. Receiving water mean PAHs were actually lower than background ocean levels away from the discharge sites.

The following are summaries of data for specific ASBS. Only measurements above the Table B instantaneous maximum are mentioned. It should be noted that while mercury was sometimes elevated, the sampling procedures might not have been adequate to avoid sample contamination. Therefore the mercury results may or may not be relevant, but are reported below anyway.

Heisler Park: The City of Laguna Beach reported elevated levels of zinc at one location (high reading of 300 µg/ml) and copper at two locations (high reading of 110 µg/ml) in storm drain samples taken. In receiving water, elevated levels of mercury at one location (high reading of 1.9 µg/ml), zinc at two locations (high reading of 360 µg/ml), copper at sixteen locations (high reading of 150 µg/ml), silver at seven locations (high reading of 560 µg/ml) and ammonia expressed as nitrogen at one location (high reading of 33,000 ppb) were also noted.

Irvine Coast: In receiving water samples taken, CalTrans reported elevated levels of mercury at one location (high reading of 100 µg/ml).

La Jolla: The City of San Diego reported elevated levels of copper at two locations (high reading of 36.6 µg/ml) in storm drain samples taken.

Laguna Point to Latigo Point: The County of Los Angeles reported elevated levels of chromium at six locations (high reading of 97 µg/ml) and copper at seven locations (high reading of 81.2 µg/ml) in storm drain samples taken.

Newport Beach: The City of Newport Beach reported elevated levels of cadmium at one location (high reading of 10.2 µg/ml) in storm drain samples taken. In receiving water samples taken, they reported elevated levels of cadmium at one location (high reading of 10.2 µg/ml) and copper at one location (high reading of 31.4 µg/ml).

Pacific Grove: The City of Pacific Grove and Hopkins Marine Laboratory reported elevated levels of cadmium at one location (high reading of 40 µg/ml), lead at one location (high reading of 31.5 µg/ml), zinc at two locations (high reading of 209.5 µg/ml), copper at six locations (high reading of 69.2 µg/ml), ammonia expressed as nitrogen at twelve locations (high reading of 470,000 µg/ml), and mercury at two locations (high reading of 0.72 µg/ml) in storm drain samples taken. In receiving water samples, there were elevated levels of ammonia expressed as nitrogen at three locations (high reading of 20,000 µg/ml).

San Clemente Island: The Department of Defense, US Navy, reported elevated levels of arsenic at one location (high reading of 87 µg/ml), mercury at one location (high reading of 0.6 µg/ml), chromium at seven locations (high reading of 1,010 µg/ml), copper at fourteen locations (high reading of 309 µg/ml), lead at seven locations (high reading of 169 µg/ml), nickel at five locations (high reading of 520 µg/ml), and zinc at six locations (high reading of 1150 µg/ml) in storm drain samples taken. In receiving water samples taken, the Navy reported elevated levels of copper at ten discharge locations (high reading of 50 µg/ml) and ammonia expressed as nitrogen at seven locations (high reading of 21,600 µg/ml) in receiving water samples taken.

Santa Catalina Island: The Santa Catalina Island Company reported elevated levels of copper at two locations (high reading of 40.50 µg/ml), chromium at two locations (high reading of 43.8 µg/ml), mercury at one location (high reading of 1.89 µg/ml), and nickel at one location (high reading of 54 µg/ml) in storm drain samples taken. Connelly-Pacific reported elevated levels of copper at one location (high reading of 30.80 µg/ml), mercury at one location (high reading of 1.89 µg/ml), and nickel at one location (high reading of 54.00 µg/ml) in storm drain samples taken.

Trinidad Head: In receiving water samples taken, Trinidad Rancheria reported elevated levels of copper at one discharge point (high reading of 41.2 µg/ml) and zinc at one discharge point (high reading of 206 µg/ml).

Toxicity

The COP daily maximum toxicity objectives are 0.3 TUa for acute toxicity and 1.0 TUc for chronic toxicity (critical life stages).

For stormwater runoff acute toxicity, two samples were elevated (0.5 TUa in ASBS 24 and 0.6 TUa in ASBS 33) for fish, one sample was elevated (1.0 TUa in ASBS 30) for sea urchins, and four samples were elevated for mysids (<1.0 TUa in ASBS 19, 1.4 TUa in ASBS 29, 1.5 TUa in ASBS 30, and 0.4 TUa in ASBS 32). Samples at various ASBS were also tested high for chronic toxicity in stormwater runoff. For runoff the highest chronic toxicity (16 TUc) for kelp was at ASBS 29. For runoff the highest chronic toxicity (8 TUc) for mysids was at ASBS 33. For runoff the highest chronic toxicity (32.26 TUc) for sea urchins was at ASBS 6.

For ocean receiving water acute toxicity, one samples was elevated (0.65 TUa in ASBS 30) for fish, two samples were elevated for mysids (1.3 TUa in ASBS 29 and 0.6 TUa in ASBS 30) and one sample was elevated for kelp (0.6TUa in ASBS 30). Samples at various ASBS were also tested high for chronic toxicity in ocean receiving water. For ocean receiving water the highest chronic toxicity (4 TUc) for kelp was at ASBS 32. For ocean receiving water the highest chronic toxicity (1.8 TUc) for mysids was also at ASBS 32. For ocean receiving water the highest chronic toxicity (16 TUc) for sea urchins was at ASBS 25.

The toxicity data is shown in Appendix D.

MUSSEL WATCH DATA

Mussel Watch Monitoring is an important tool in assessing bioaccumulation and water quality. Data collected by the National Ocean and Atmospheric Administration (NOAA) National Status and Trends (NS&T) and by the State Water Board Mussel Watch Program (SMWP) are provided below to assess spatial distributions and temporal trends in chemical contamination in or near certain ASBS.

NOAA NS&T Mussel Watch Program Data

To characterize the spatial distributions and trends in contaminant levels in the coastal ocean, NOAA NS&T Program was formed in 1986. The NOAA NS&T Mussel Watch Program measures the presence of concentrations of a broad suite of trace metals and organic chemicals in surface waters. The NS&T Mussel Watch Program is national in scale and the sampling sites are representative of a large area. The sites were not knowingly selected near waste discharges points.

The NOAA NS&T Program analyzes bivalve tissue samples from the mussels *M. edulis and M. californianus* for trace metals, synthetic organic constituents, and histopathology. The NOAA N&ST sampling is conducted every two years. Additional information on the NOAA NS&T Mussel Watch Program can be found at http://ccma.nos.gov/stressors/pollution/nsandt/

Six sites in the NOAA NS&T data base that were in or near ASBS were assessed:

- Redwood National Park ASBS/Klamath River/Flint Rock Head (1989)
- King Range ASBS/Point Delgada/Shelter Cove (1999-2005)
- Farallon Island ASBS/East Landing (1988)
- Pacific Grove ASBS/Lovers Point(1999-2005)
- Laguna Point to Latigo Point ASBS/Point Dume (1999-2005)
- SE Santa Catalina Island ASBS/S.Santa Catalina Island Bird Rock (1998-2004)

All PAH measurements (nationally) for all bivalve species across all the years for the NS&T Mussel Watch Program were used to determine the 85 percentile. For trace metals only *Mytilus* species across all the years for the NS&T Mussel Watch Program nationally were used to determine the 85 percentile. The ASBS sites were evaluated against these national 85 percentiles for polynuclear aromatic hydrocarbons (PAHs) and trace elements.

The PAHs were less than the 85th percentile in all ASBS sampling sites except at Point Dume; Naphthalene, 1-methylnaphthalene, and 1-methylphenanthrene exceeded the 85th percentile at Point Dume. Similar levels were found at another site (Las Tunas) outside of the ASBS and further east in Santa Monica Bay.

At Flint Rock Head in the Redwood National Park ASBS there no exceedances of the 85th percentile for trace metals. arsenic, cadmium, copper, nickel, zinc, aluminum, iron and tin were greater than the 85th percentile at Point Delgada in Shelter Cove. Pacific Grove had exceedance of the 85th percentile for cadmium, lead and tin. At Point Dume trace elements including chromium and tin exceeded the 85th percentile. Cadmium, chromium, nickel, and silver exceeded the 85th percentile at South Catalina Island.

Appendix E presents the NOAA Mussel Watch data for the ASBS listed.

State Mussel Watch Program Data

The SMWP was initiated in 1977 by the State Water Board to provide a uniform statewide approach to the detection and evaluation of toxic substances in California coastal waters, bays, harbors, and estuaries. The SMWP conducted a monitoring program using transplanted bivalve (*Mytilus californianus*) for trace elements and organic contaminants. The tissue samples were analyzed for the presence of trace elements and legacy pesticides. Additional information on the SMWP can be found at http://www.waterboards.ca.gov/swamp/musel_watch.html .

An Elevated Data Level (EDL) is defined for the purposes of the SMWP as that concentration of a toxic substance in mussels or clams that equals or exceeds a specified percentile (such as 85 or 95 percent) of all measurements of the toxic substance in the same species and exposure condition (resident or transplant between 1977 and 1997).

SMWP Data From 1977-1999

Historically, 621 sampling sites have been assessed in California as part of the SMWP from 1977 to 1999. In the August 2006 ASBS Status Report, mussel sample results located in or near ASBS were summarized for the period 1977-1999. Sampling sites included 15 ASBS during 1977 to 1999. It is difficult to generalize which ASBS has the highest concentration and which one has the lowest because the results are constituent-dependent. However, Trinidad in Humboldt County showed a larger number of samples results with elevated concentration of EDL 85 and some with EDL 95 during 1986 to 1999 when comparing to other ASBS. Anacapa Island had a smaller number of samples with elevated concentration during 1977 to 1980 sampling period. Pacific Grove had a large number of samples with lead above the EDL 85 during 1977 to 1982. La Jolla and Corona Del Mar had a large number of samples with silver and lead above EDL 85 during 1977 to 1990, Carmel had a large number of samples with cadmium above EDL 85 during 1984 to 1989. Organic compounds were present at a higher concentration in Trinidad Head, Bodega Head, and J. Fitzgerald during the sampling period of 1977 to 1989. Appendix F provides SMWP data from 1977 to 1999 as it was presented in the August 2006 ASBS Status Report.

SMWP Data from 2001- 2005

The SMWP program has suffered from a lack of funding since 2000. The Department of Fish and Game at Moss Landing Laboratories collected and analyzed mussel samples since 2001 from a limited list of sites. Only 18 sites are currently being monitored for the Water Boards by the California Department of Fish and Game.

SMWP primary targets areas with known or suspected impaired water quality. For this report, data from the following sites in or near ASBS have been reviewed:

- Pacific Grove
- James V. Fitzgerald
- Bodega Head (near but not within the ASBS)
- Trinidad Head.

The available data for trace elements and organic constituents from 2001 to 2005 were reviewed and compared to the EDL 85 and EDL 95. The data for 2006 and 2007 are currently being reviewed and will be available in the near future.

Most of the trace elements except silver were present at low concentration in all ASBS. However none of the elements exceeded the EDL 85 or EDL 95 in any of the ASBS during 2001-2005 sampling periods.

Pesticides compounds including cis-chlordane, trans-chlordane, total chlordane, heptachlor epoxide, and dieldrine exceeded the EDL 85 in Trinidad Head, Bodega Head, J. Fitzgerald and Pacific Grove ASBS during one or more sampling events in 2001 to 2004. Data from J.Fitzgerald and Pacific Grove ASBS also show exceedance of EDL 85 and 95 for DDD, DDE, cis and trans-chlordane and PCB 1254.

Appendix G provides a summary of the State Mussel Watch data from 2001 to 2005.

RECENT BIOLOGICAL SURVEYS – MARINE BIOTIC COMMUNITY

Redwoods National Park ASBS

Marine Resources of Redwood National and State Parks (Cox et al. 2005)

Redwoods National and State Park submitted a report entitled Marine Resources of Redwood National and State Parks (Cox et al. 2005). In this Marine Resources Report, two rocky intertidal research efforts were performed. They were; 1) a rocky intertidal inventory to determine the diversity of invertebrate and algal species present and 2) a rocky intertidal monitoring survey to record the abundance and change of certain key sessile and mobile species over time.

Diversity Study: Rocky intertidal sites include False Klamath Cove, Enderts Beach, and Damnation Creek. Sandy intertidal sites include: Crescent Beach, Gold Bluffs Beach, and Redwood Creek Beach. The Marine Resources Report also provides key data for study locations that were positioned near discharge sites previously identified in the SCCWRP 2003 Report. The study site at False Klamath Cove is located near the highest concentration of discharge points associated with Hwy 101 roadway runoff. The other study sites are positioned near natural outlets of varying sizes and generally were considered “reference” sites. The Marine Resources Report re-inventoried the identical sites as that of the 1982 Reconnaissance Survey Report, and attempted to replicate the methods used by the scientists (Boyd and DeMartini in 1977), but did not replicate the data analysis. Cox et al reinventoried Enderts Beach and False Klamath Cove. Enderts Beach was considered a “reference site” and False Klamath Cove was considered as the “discharge site.”

In July 2005, multiple teams of two to three people spread out over the study sites with a check-list of species. Phycology experts, Dr, Frank Shaughnessy and Ginger Tennent, assisted with collection and identification of algae. Voucher specimens were collected for all possible invertebrate and algal species. Some species were photographed in lieu of collection due to preservation difficulties, Algae were identified using Abbott and Hollenberg (1976) and Gabrielson et al. (2004). Invertebrates were identified using Morris et al. (1980) Kozloff (1993), and Kozloff (1966). Measurement of the algal and invertebrate species of the July 2005 survey were recorded as five abundance categories; abundant, common, present, uncommon or rare.

The 1977 Boyd and DeMartini inventory of False Klamath Cove (FKC) and Enderts Beach (END) site recorded their findings differently than the Cox 2005 survey, The Boyd and DeMartini inventory data was collected during four sampling periods (late summer and late winter) from July 1975 to June 1976. The number of square meter plots examined at each site was 40 at FKC and 35 at END.

A total of 114 algal taxa were recorded in inventories of FKC and END. Thirty eight algal species were found at these sites in 2005 that were not listed by Boyd and DeMartini (1977 and 1981). Invertebrate inventories at False Klamath Cove and Enderts Beach recorded a total of 176 invertebrates. Of these, 77 were not previously recorded.

The June 2004 to November 2005 surveys of five species provide valuable baseline data on the conditions at three sites. However, these surveys may not provide enough data to assess a response to the effects of storm water runoff or possible constituents in the ocean water. The 5 selected species by the researchers are generally known for their tolerance to a variety of physical and chemical environmental conditions, and were not chosen by the researchers as selected species with known tolerances or sensitivity to anthropogenic contaminants occurring from storm water runoff or in the ocean receiving waters.

According to Cox et al, invertebrate species inventoried at the False Klamath Cove discharge site and the Enderts Beach reference site showed no clear pattern in species presences or absence. Also according to Cox et al, when comparing the algal species found during the 2005 and 1977 rocky intertidal inventory surveys, no clear patterns emerged to assess potential impacts from storm water runoff or ocean water conditions. Three species of algae (*Haplogloia andersonnii, Pterygophora californica and Pikea robusta*) were found at Enderts Beach in 2005 and 1977 and the False Klamath Cove discharge site in 1977, but was absent from the False Klamath Cove discharge site in the 2005 survey. One species (*Odonthalia washingtoniensis*) was only found at the False Klamath Cove discharge site in 2005 and 1977. The two species found at only the reference sites in 2005 and 1977 were *Calliiarthron tuberculosum* and seersucker kelp *Grateloupia setchellii*.

Community Dynamics Surveys: Using the Marine protocols, permanent photo-plots were set up at False Klamath Cove, Damnation Creek, and Enderts Beach. All plots were sampled and photographed every two to three months from June 2004 though November 2005. Sampling was done for all three sites within six days during lowest tides. Each site required a full day of sampling employing a team of six scientists. The monitoring that has occurred constitutes a thorough representation of seasonal data for the year. The photo plots were established to record changes in the cover of certain populations including: mussels (*Mytilus californianu*s), barnacles (*Chthamalus dalli and Balanus glandula*), and three species of algae (*Endocladia muricata*, *Pelvetiopsus limitata*, and *Fucus gardneri*). These five sessile populations were chosen for monitoring because they are conspicuous, bed-forming, abundant, and ecologically important. *Fucus gardneri* was not dense and continuous enough at Enderts Beach, nor was there dense enough *P. limitata* at Damnation Creek when the study was initiated, to merit plot establishment for those species at those sites. At Damnation Creek, five additional mussel plots were sampled. These plots were located in the outflow of Damnation Creek where salinity is often much lower than in the other mussel plots. Otherwise, each species type was monitored in five replicate plots at each site.

Photo plots (of 75 x 50 cm) were marked by three permanent bolts which were digitally photographed every other month (Figure 13). Plots were photographed with an Olympus 560 digital camera mounted on a 50 x 75 cm PVC photo framer to ensure equal scale among plots. Photo plots were scored for percent cover of sessile species using a rectangular grid (10 x 10 units) of one-hundred evenly-spaced points created on an LCD computer monitor using Adobe Photoshop. This grid was overlaid on the digital photos, and was switched on and off to determine what taxon was below each point. Different layers of algae were not scored separately, so the total percent cover was constrained to 100%. The top-most layer that was attached to the substrate was always scored. Limpets, chitons, and sea stars were scored as such. For other mobile invertebrates, whatever was beneath the organism was scored if possible. Otherwise, the point was scored as “unidentified”. This photo plot scoring technique was adopted from the MARINe monitoring group (Engle 2005).

In addition to percent cover measurements; mobile invertebrates were counted within each photo plot area. With the exception of burrowing organisms and amphipods, all mobile invertebrates were counted in the field within the 50 x 75 cm PVC quadrat. The quadrat was aligned with three plot marker bolts to ensure accurate replication. Algal over-story was gently moved so that hidden invertebrates could be located. For select species, such as *Tegula funebralis* and *Nucella ostrina*, the length of the shell (measured at its longest axis) was recorded to determine the size distribution of individuals present. This was done for the first 10 individuals recovered from each plot, unless fewer were present. In mussel beds, forceps were used to remove *N. ostrina*, *T. funebralis*, and other species that were partially hidden in between mussels. Extremely abundant mobile invertebrates, such as limpets (smaller than 15 mm) and littorines (*Littorina* spp.), were sub-sampled using a smaller quadrat. Limpets larger than 15 mm were counted in the entire 50 x 75 cm plot. Small (0-15cm) limpets were counted in two size categories (< 5 mm and 5-15 cm) within three 20 x 20cm quadrats laid diagonally through the larger quadrat. Limpets occurring on rocky or other substrata (including barnacle tests) were recorded separately from those occurring on mussel valves. Littorines were counted in three 10 x 10 cm quadrats placed diagonally through the larger quadrat.

Chthamalus dalli and *Balanus glandula* (Barnacles)

Barnacle cover varied substantially over time and among sites, which may be due to their relatively short lifespan. At Damnation Creek, barnacle cover decreased steadily in summer and fall of 2004, but remained relatively stable throughout the rest of the study (Figure 15A) Percent cover of *Endocladia* and non-coralline crusts increased in 2005. These species may continue to increase in percent cover due to the high amount of free space (rock cover). At Enderts Beach, barnacle percent cover reached a maximum in October of 2004, and declined slightly after that (Figure 15B). Similar to trends at Damnation Creek, cover of *Endocladia* and non-coralline crusts has increased slightly in barnacle plots throughout 2005. There was also a spring-time pulse of *Porphyr*a cover in barnacle plots. At False Klamath Cove, barnacle cover underwent periodic spring-time declines followed by recovery.

Trends in the abundance of mobile invertebrates associated with barnacle plots were similar at Damnation Creek and Enderts Beach. *Nucella ostrina,* a predatory gastropod that feeds on mussels and barnacles, occurred at highest densities (15-25 per plot on average) in barnacle plots in summer and fall of both sampling years. *Tegula funebralis*, a herbivorous snail, reached a mean abundance of 5 per plot in winter of 2004/2005 at Damnation Creek. However, this snail was generally absent in warmer months and did not reach a mean density higher than 2 per plot in any month at Enderts Beach. Littorine abundance increased in spring then peaked in June sampling events of both years at Damnation Creek and Enderts Beach. Limpets were most abundant in fall and winter for both of these sites . At False Klamath Cove, *Nucella* abundance remained at a mean of 3 snails per plot or less. Low *Nucella* populations may be due to strong fluctuations in the percent cover of these barnacle plots. A decrease in mean abundance of *Nucella* in April 2005 corresponds to a drastic decrease in the percent cover of barnacles occurring in the same month. Littorine abundance generally increased through April 2005 as well, but decreased thereafter. Limpet abundance remained low throughout the study period.

Endocladia muricata (Turfweed)

The percent cover of *Endocladia muricata* varied seasonally at all three sites with cover generally reaching maximum in spring and summer, and minimum in winter. When percent cover of *Endocladia* was low, cover of non-coralline crust and *Fucus* tended to be higher. Non-coralline crust (usually the sporophyte stage of *Mastocarpus* spp) is a common under story cover, so it was difficult to tell if crust percent cover is actually 36 increasing or only being exposed in the absence of *Endocladia* over storey. Increased *Fucus* cover may be a result of recruitment facilitation by *Endocladia. Endocladia* is known to facilitate the recruitment of *Silvetia,* a southern California rockweed, similar to *Fucus* .

Mobile invertebrate abundance in *Endocladia* plots was highly variable among sites. *Nucella* abundance peaked in winter of 2004/2005 at all three sites but actual mean abundance was less than 12 snails per plot. At Damnation Creek, where *Nucella* abundance in *Endocladia* plots was generally highest, an additional peak in abundance occurred in August, 2004. *Tegula* occurred at up to an average of 25 individuals per plot in the autumn of 2004, but this snail occurred at very low density in *Endocladia* plots at the other two sites. Littorine abundance remained low in *Endocladia* plots at

Damnation Creek until April, 2005. In June of 2005 mean littorine density increased drastically to approximately 800 per plot. This increase does not appear to correspond to any change in algal cover, however. At Enderts Beach, littorines density reached an average of over 2000 individuals per plot in October, 2004, but littorines populations remained low in *Endocladia* plots for all other sampling events. This peak corresponds to a peak in *Endocladia* cover in the same month. Littorine abundance remained between 200 and 1200 snails per plot throughout the study period, with peaks in August, 2004 (800 littorines per plot) and January, 2005 (1200 littorines per plot 0. Limpet populations undulated between 200 and 500 individuals per plot at both Damnation Creek and Enderts Beach. Whereas mean limpet populations were between 50 and 200 individuals per plot at False Klamath Cove.

Fucus gardneri (Rockweed)
Percent cover of *Fucus* did not vary seasonally. At Damnation Creek, percent cover declined to 70 percent in winter of 2004/2005, but recovered to above 80 percent the following fall. Percent cover of rock indicated an opposite trend indicating this change in percent cover of *Fucus* was not due to a species replacement, although percent cover of *Endocladia* did increase slightly throughout the study. At False Klamath Cove, percent cover of *Fucus* declined steadily throughout the study, while percent cover of noncoralline crust, an understorey species, increased proportionately.

In *Fucus* plots at Damnation Creek, *Nucella* reached a mean abundance of 9 individuals per plot in October, 2004. Mean abundance remained between 1 and 4 individuals per plot in all other sampling periods. Limpet counts undulated between 30 and 115 in *Fucus* plots at both Damnation Creek and False Klamath Cove, reaching maximum abundance in August 2004 at 43 both sites. Littorines density generally increased over the study period in *Fucus* plots at Damnation Creek, reaching a maximum of 2060 individuals per plot in June 2005. At False Klamath Cove, littorines were more variable. Abundance was highest in August 2004 at 480 individuals per plot, and lowest in January 2005 at 41 individuals per plot. These trends do not seem to correspond to changes in percent cover, however. Variation in mobile invertebrate abundance in mussel plots was seasonally similar among sites, but the magnitude of these fluctuations varied by site.

Tegula counts were 0-2 individuals per plot in *Fucus* plots at Damnation Creek until June 2005, when mean abundance reached 6 snails per plot. *Nucella* abundance was generally higher at False Klamath Cove, remaining between 10 and 15 individuals per plot for all months except August, 2004, when mean abundance dropped to 4 individuals per plot . At False Klamath Cove, abundance of *Tegula funebralis* remained between 13 and 22 individuals per plot throughout the study, with the maximum density occurring in January 2005. *Tegula* were generally smaller and more abundant in *Fucus* plots at False Klamath Cove than at Damnation Creek. At Damnation Creek, *Fucus* plots contained fewer individuals, but many of these were of larger size. A pulse of small individuals occurred in January, 2005 at both sites, followed by a spike in the abundance of *Tegula* over 10 mm in summer and fall.

Mytilus californianus (Mussel)

Mussel cover remained high and stable throughout the course of this study. At Damnation Creek and Enderts Beach, decreases in mussel cover corresponded to increases in the percent cover of the barnacle *Polycipes polymerus.* At False Klamath Cove, percent cover of mussels was slightly more variable and generally corresponded to changes in percent cover of rock.

Mean *Tegula* abundance remained low in mussel plots at all sites. Limpet counts were highest in August 2004 at Damnation Creek (270 per plot) and Enderts Beach (510 per plot), and in October 2004 at False Klamath Cove (520 per plot).

Nucella abundance peaked again in June 2005 at Damnation Creek (15 snails per plot) and Enderts Beach (62 snails per plot). *Nucella* were generally more abundant at Enderts Beach and False Klamath Cove. Abundance peaked in October at Damnation Creek (5 snails per plot) and False Klamath Cove (43 snails per plot), and in August at Enderts Beach (75 snails per plot). Mussel plots at Enderts Beach contained a high proportion of large *Nucella ostrina* especially in summer and fall months. While individuals at the other two sites were more evenly distributed among size classes, there is a prevalence of larger individuals in summer and fall as well. Small individuals were present throughout the year at all sites, but are most common in August and October, 2004. *Nucella* in mussel plots at the mouth of Damnation Creek show a more distinct seasonal shift in size distribution than the population living in the mussel plots with more stable salinity. Small *Nucella* were present in January of 2005, but decreased in abundance in April, 2005 and in both June surveys. Larger individuals are present in nearly every survey, but reach maximum abundance in August and October.

Pelvetiopsis limitata (Rockweed)

At Enderts Beach, *Pelvetiopsis* cover was lowest in October 2004, but remained relatively stable throughout the remainder of the monitoring period. Decreases in *Pelvetiopsis* cover corresponded to increases in the percent cover of rock and barnacles. At False Klamath Cove, *Pelvetiopsis* cover remained between 70 and 80 percent throughout the study period. Rock and barnacles accounted for most of the remaining 20-30 percent cover.

Abundance of *Nucella* and *Tegula* remained low in *Pelvetiopsis limitata* plots at Enderts Beach. Limpet abundance was lowest in April 2005 at all three sites. *Nucella* counts were highly variable at False Klamath Cove, with peaks occurring in October 2004 (12 snails per plot) and April 2005 (19 snails per plot). Littorines reached a mean density of 750 snails per plot in October 2004 at Enderts Beach, but littorine abundance remained low through spring 2005 at the other two sites. Littorines reached a mean density of 110 snails per plot in April 2005 at Damnation Creek, and 820 snails per plot at False Klamath Cove in June 2005. Limpet counts remained fairly stable, between 135 and 240, at Enderts Beach. Limpet abundance was also stable but slightly lower (60-210) at False Klamath Cove.

PISCO/MARINe (Raimondi 2006)

Peter Raimondi of the University of California at Santa Cruz Center for Ocean Health, performed a data assessment for eight of the ten ASBS within the influence of Caltrans discharges. In his report (Data assessment for ASBS/ Ocean Plan for Caltrans March 12, 2006) Dr. Raimondi summarizes site characteristics and provides a brief ecological community analysis of established rocky intertidal monitoring stations. These established stations are either a PISCO or MARINe site and provides a continuum of data collected using either Community Dynamics Survey or Biodiversity Protocol. PISCO/MARINe monitors three sites in this ASBS at Enderts, False Klamath Cove and Damnation Creek. All three are sites monitored using Community Dynamics Surveys, but only since 2004, and Damnation Creek was also monitored using the Biodiversity Protocols.

Enderts Reef is comprised of a gently sloping (5°) bench of intermediate width and moderate relief. The surrounding coast is made up of boulders, bedrock, and pebbles beaches. No biodiversity data were collected here but the species trends seem typical for this sort of site. One species of special interest was recorded here, the surfgrass, Phyllospadix spp. No invasive species were recorded at this site.

False Klamath Cove reef is comprised of bedrock and boulders. The reef is a gently sloping, long reef of moderate relief. The surrounding coast is made up of bedrock, boulders and sand. No biodiversity data have been collected here but species trends have been collected (since 2004) and seem typical to this point. Two species of special interest were found here, the surfgrass, *Phyllospadix* spp. and the sea palm, *Postelsia palmiformes*. No invasive species have been found here.

Damnation Creek reef is comprised of pebbles, boulders and bedrock. The reef is a gently sloping, long reef of moderate relief. The surrounding coast is similar to the sample site. One species of special interest was recorded here, the surfgrass, *Phyllospadix* spp. No invasive species were recorded at this site. Raimondi compared the ecological communities in a series of reference sites in Northern California. Species richness at Damnation Creek was 111 species, whereas species richness at reference sites ranged between 98 and 113. Damnation creek differed significantly from all other sites. This was not the result of the site being more impacted than other sites; instead it was due to differences in species composition that seems most likely due to the site being remote, pristine and of different geomorphology than the reference sites.

Trinidad Head ASBS

One report was available, Sean Craig's 2006 Humboldt State University Study (HSU) intertidal survey prepared for the City of Trinidad, and the Trinidad Rancheria Ocean Plan exception application, which provides a quantitative comparison of marine species at one of the discharge sites and at a site distant from this discharge

Craig's survey provides a quantitative assessment of the marine life species in the intertidal zone near waste discharges identified in the SCCWRP 2003 survey, and at a reference location approximately 100 meters to the northeast of Trinidad Head. The selected waste discharge location is a site where the City of Trinidad's primary storm water outfall is located. Directly adjacent to this pipe is the outfall pipe of Humboldt State University's Telonicher Marine Lab, and the location is also influenced by the pier's parking lot runoff and certain boat cleaning operations. The second rocky intertidal sampling site was located approximately 100 meters northeasterly along the shoreline away from the first site, as the "undisturbed site," a reasonable distance from the main outfall and comparable in substrate. Both sampling stations were examined for vertical and horizontal zonation of the marine life.

Both sampling sites were similar in appearance consisting of boulders partially submerged in sand and appeared to be generally unmoved throughout time. Species abundance, composition and the general pattern of zonation of the intertidal algae and invertebrate were examined. Boulders were randomly selected along a single axis within four distinct shore regions from the high shore to the low shore. These regions were labeled High, Mid-High, Mid and Low. A 0.25 square meter quadrat was placed at each sampling point measuring both the vertical and horizontal arrangement of organisms on each boulder. Surveys were conducted during low tide on three consecutive days, May 25, 26, and 27, 2006. Thirty quadrat samples were collected on 10 boulders at the outfall site, and 36 quadrat samples were collected from 12 boulders at the undisturbed site. Each randomly selected boulder was measured for species abundance, composition and general pattern of zonation of the intertidal algae and invertebrates. Measuring the vertical and horizontal arrangement of organisms allowed for the examination of changes in species composition at the outfall site as compared to the control site.

The log-normal model of abundance and diversity was used to compare the discharge site with the control site. Sessile and mobile invertebrates were measured for abundance using a count and then the log was taken. Anenomes and algae were counted as percent cover. When considered together, the diversity and abundance of biologically similar organisms within a community are more powerful in assessing the effects of disruption than when taken separately. A Log-normal model of abundance and diversity is one tool in applied ecology for use to test ecosystem integrity, disruption, and health.

The Craig reported the same species present at both the outfall site, and the "undisturbed" reference location; a total of 23 species were recorded, 10 macrophyte and 13 invertebrate species. The researchers stated that the outfall site and the "undisturbed" site show a similar pattern in both vertical and horizontal zonation of species. Fucoid algae, including *Fucus gardneri* and *Pelvetiopsis limitata* were found restricted to the higher regions of boulders generally below the barnacle line across the shore. Also found in the highest zone were a group of red algae species *Mastocarpus papillatus*, *M. jardinii*, *Cryptosiphonia woodii*, *Endocladia muricata* and *Neorhodomela larix.* All four shore zones included barnacles *Chthamalus dalli* and *Balanus glandula,* abundant at the upper reaches of the boulders. The anemone *Anthopleura elegantissima* was present in all but the high zone at both locations.

Abundance between the two sites were not the same. Craig provided the explanation that the difference in organismal abundances between the two sites may be due to the physical positioning and slope of the shore line, and describe the outfall site as a long gentle slope more protected from heavy wave action as compare to the undisturbed site and filling in more slowly during the incoming tide. The undisturbed site was described as being less protected with the potential to be more rapidly immersed with an incoming tide. The raw data was provided to SWRCB staff; further analysis of this raw data using a multivariate approach may be appropriate.

Del Mar Landing ASBS

There was one report available, a Baseline Inventory of the Rocky Intertidal Zone at the Del Mar Landing Ecological Reserve May 2006 by Jacqueline Sones et al. This inventory was prepared for The Sea Ranch Association (TSRA) Ocean Plan exception application and provides a quantitative comparison of marine species at two of TSRA's discharge sites and at two control sites.

Recent rocky intertidal surveys such as the 2006 Sones report provide relevant quantitative information at four selected points along the 1 km of rocky shoreline of the ASBS. Prior to this work, very little rocky intertidal community inventory work has been done at the Del Mar Landing ASBS. Steve Obreski conducted some work at Sea Ranch in 1972 but the exact locations of his study sites are unknown and the data in his report was considered too preliminary and too narrow to use for this initial study (Sones et.al 2006). John Pearse wrote a site description for a rocky intertidal area near Walk-On Beach, a location approximately 3 km south of the Del Mar Landing ASBS. This report did not represent a complete inventory effort of the rocky intertidal biotic community, but did provide an informative overview of the area (Sones et al 2006).

Also near Walk-On Beach and part of TSRA, the University of California at Santa Cruz's Coastal Biodiversity Survey team (Raimondi, SWAT) conducted surveys of the rocky intertidal community in 2001 and 2005. Though the topography at Walk – On Beach is slightly different than at Del Mar Landing, that inventory provides a quantitative measure of diversity and abundance of the rocky intertidal algal and invertebrate community in the vicinity.

During April 2006 a baseline biological inventory of the rocky intertidal communities was conducted at the Del Mar Landing ASBS. The ASBS is located off Helm Road at the northern end of TSRA community. It covers approximately 1 km of rocky shoreline. Four rocky intertidal sites were sampled during the inventory, two discharge sites and two control sites. Two discharges (storm water conveyances) drain into the ASBS near the "discharge" sites, one at Helm Road, and another approximately 185 meters further east. "Control" sites were selected by the survey team in areas distant from discharge sites approximately 80 meters away, and most likely free from potential influence of the discharges. Transects were set up and surveyed near both discharge sites and at two control sites located a reasonable distance away from the direct influence of the storm water outfalls. The control sites were also chosen based on similarities in substrate, slope, aspect, and wave exposure.

Surveys were conducted on two consecutive days, April 21 and 22, 2006. At each site, single 5-meter long transects were laid out in each of four zones representative of the dominant intertidal community types. These community types included high, upper middle, lower middle and low zones. Transects were set up parallel to the shoreline running from east to west at approximately the same tidal height for each zone.

Photographs were taken of each transect as well as selected algae and invertebrates encountered during the surveys. Five 20cm x 20cm quadrats were randomly placed along each transect. The sampling design was 5 quadrats per zone x 4 zones per site x 4 sites for a total of 80 quadrats. The entire survey comprised 40 quadrats in discharge sites and 40 in control sites.

All species in each quadrat were identified and the percent cover of sessile invertebrates and algae or number in individuals for mobile invertebrates were calculated. Mussels were not destructively sampled so the algae and invertebrate counts represent the topmost layer of the mussel bed most notable in the lower middle zone. Sessile invertebrate cover, sessile invertebrate diversity, mobile invertebrate abundance, mobile invertebrate diversity, algal cover, algal diversity, and total cover were analyzed using a general linear model (Analysis of Variance). Models evaluated the measures of interest as a function of location (west vs. east) and outfall (discharge vs. control). Thus the results reflect overall impacts of the discharge after accounting for differences in the two locations. Measures of diversity were calculated using the Shannon Diversity Index (H). Dr. Matt Bracken (Bodega Marine Laboratory) performed the data analysis.

Fifty-eight (58) species of marine algae and invertebrates were recorded in all the quadrats and pooled across discharge and control sites. Of these, there were 26 species of algae and 32 species of invertebrates. Of the 32 invertebrates, 13 were sessile species and 10 were mobile species. Twenty-two species of algae were found at the discharge sites versus 25 species of algae at the control sites. Twenty-nine species of invertebrates were found at the discharge sites versus 22 species of invertebrates. Approximately 70% (n=40) of all species were shared between the discharge and control sites, indicating a high degree of similarity.

When Sones compared the discharge sites with the control sites in the eight biological measures of species richness, sessile invertebrate cover, sessile invertebrate diversity, mobile invertebrate abundance, mobile invertebrate diversity, algal cover, algal diversity, and total cover, no significant differences were found between these two sites. Invertebrate richness was slightly higher at the discharge sites and algal richness was slightly higher at the control sites. The only measure that was close to being significantly different was the mobile invertebrate abundance driven by one species the Checkered Periwinkle (*Littorina plena/scutulata).* Sones concluded that these trends were insignificant and probably due to sampling artifacts and the high variability of rocky intertidal communities. However, Sones pooled the raw data prior to statistical analysis. It is recommended that an independent analysis of the data set be performed to evaluate possible storm water runoff effects on individual species within each biological zone and at each location.

James V. Fitzgerald ASBS

PISCO/MARINe (Raimondi 2006)

Peter Raimondi of the University of California at Santa Cruz Center for Ocean Health, performed a data assessment for eight of the ten ASBS within the influence of Caltrans discharges. In his report (Data assessment for ASBS/ Ocean Plan for Caltrans March

12, 2006) Dr. Raimondi summarizes site characteristics and provides a brief ecological community analysis of established rocky intertidal monitoring stations. These established stations are either a PISCO or MARINe site and provides a continuum of data collected using either Community Dynamics Survey or Biodiversity Protocol. PISCO has also carried out Biodiversity surveys at Fitzgerald Marine Reserve. James V. Fitzgerald is a gently sloping, long, bedrock reef of very low relief. The biodiversity survey (2002) found 96 species at this site, which is high for this region. Two species of special interest, owl limpets and surfgrass were found and according to Raimondi it is likely that abalone may also occur here. No invasive species were found in their surveys. The result of the community analysis showed that Fitzgerald Marine Reserve clustered out with a series of central coast sites, including Pigeon Point, Andrew Molera, Mill Creek and Rancho Marino. The latter three sites are either reserves or de-facto reserves because of physical isolation. The species present gave no evidence of degradation. There are not extensive long-term data that could be used to detect change.

Pillar Point Storm Water Outfall in the James V. Fitzgerald ASBS (Tenera 2007).

In 2007 Tenera studied the rocky intertidal community at the US Air Force Pillar Point storm water outfall This outfall at Pillar point is in the southern section of the ASBS.

This report examined the Pillar Point watershed, land use, storm water discharge volumes and the potential for water quality effect on the biota. Impacts from the main storm water outfall to the rocky intertidal habitat were quantitatively evaluated using a gradient transect method. Additionally, investigations of other relevant marine life habitats were qualitatively surveyed for potential storm water impacts. A previous study performed by Tenera in 2004 in the northern sector of the ASBS near San Vicente Creek was also evaluated in its potential relevance to storm water impacts on the intertidal life. Tenera also examined the previous State Water Board's Reconnaissance Survey performed in the 1970's (SWRCB 1979) comparing the qualitative findings of that report with the current data.

A quantitative marine survey was performed in July 2007 where the Air Force storm water outfall discharges into the James V. Fitzgerald ASBS. The immediate discharge area is a 55 m (60 yd) wide sand beach. The closest rocky habitat to the outfall is a low-lying intertidal bench rock platform that is approximately 45 degrees lateral to the initial trajectory line of outfall discharges, and is separated from the outfall by the sand beach. Quadrats positioned along transects were sampled on the bench rock platform nearest the outfall using standard intertidal sampling methods. Sampling was done at increasing distances (sites) from the outfall and beach. This method obtains data on the patterns of spatial variation among species on rocky habitat with increasing distances from the outfall. A nearby low-lying bench rock platform in a reference area with a sand beach backing the platform was sampled in the same fashion for comparison.

One limitation of the Tenera 2007 study are that the study was performed during the dry season, and it is possible that species may have recovered since the prior rain events of the previous wet season. The assessment of storm water discharge effects is limited from the study being a one-time survey of only two areas, and due to naturally occurring variation between sites. It is possible that a larger, more intensive sampling effort over a longer duration may detect possible storm water discharge effects. However, effects may still not be detected with additional studies without further investigation of species and their sensitivity to various constituents found in the runoff and ocean water.

Another limitation was related to the limited period covered by the survey. A one-time survey assumes that the reference area adequately represents baseline conditions and the species and patterns of abundances that would be present near the storm water outfall if the outfall were absent. While every effort was made to locate a reference area that was similar in habitat characteristics to the area sampled along the outfall transect, differences in community composition were still expected, due to the number of natural factors that can vary unpredictably over time and space and therefore affect the composition and spatial patterns of species abundances. Factors include wave impacts, microhabitat differences, sand scour, pre-emption of space by sand, sand burial, predation, grazing, competition for space, to name a few.

The storm water outfall and reference transects were densely populated with a variety of species, characterized mainly by the algae and surfgrass. Invertebrates were less common. The relative scarcity of invertebrates was likely due to the abundant layer of sand covering the rocks. The influence of sand is likely year-round in the study area. The sand likely prevents many motile invertebrates from remaining firmly attached to rocks and the sand tends to smother rock boring and tube-dwelling invertebrates.

The bench rock platform nearest the Pillar point storm water outfall and the reference platform are low-intertidal elevation platforms, and thus lack the higher elevations supporting species more characteristic of the upper-intertidal zone (e.g. rockweed communities). Species characterizing the bench rock platforms were surfgrass (*Phyllospadix torreyi*), oar kelp (*Laminaria sinclairii*), split kelp (*L. dentigera*), hollow-branch seaweed (*Gastroclonium subarticulatum,* previously *G. coulteri*), and iridescent seaweed (*Mazzaella splendens,* previously *Iridaea cordata*). All are obligate low-intertidal or low-intertidal/shallow-subtidal occurring species.

In general, Tenera found most of the species sampled to be more abundant on the storm water outfall transect that the reference transect. Multivariate analysis of the community data did reveal that many of the differences in species abundances between transects were statistically significant. According to Tenera the storm water outfall and reference areas were both densely populated with species indicative of a healthy marine community and characteristic of rocky habitats exposed to high wave action. There were no indications of stress to the marine community near the Pillar Point storm water outfall based on the presence of unusual species patterns.

While the sand beach was a large habitat type in the area, large amounts of sand also covered the bench rock platforms, entrapped at the bases of the algal branches and fronds. The algae emerging from the sand provides direct evidence that the rocks were at one time not covered by sand. The shifting sand in the area probably has a large effect in constantly altering species abundances and their distributions in the area. Any changes resulting from sand effects such as scour and burial, could easily mask any potential effects from storm water discharges.

Tenera's multivariate analysis revealed various species that were significantly different in abundance between transects. A variable abundance pattern was seen in the distribution and abundance of surfgrass (*Phyllospadix torreyi*) and oar kelp (*Laminaria sinclairii*). These two species can be common along sandy shores, and were abundant on both transects. However, where they were most abundant along the transects was different between transects. On the storm water outfall transect, surfgrass had low abundance in the sand beach-bench rock interface zone but abundant at distances further away from the outfall and sand beach. In contrast, surfgrass on the reference transect was most abundant in the sand beach-bench rock interface zone. While this may indicate that storm water can limit the abundance of surfgrass near the outfall, other factors may account for the relative lower abundance of surfgrass in the sand beach-bench rock interface zone near the outfall. Feather-boa kelp (*Egregia menziesii*) and oar kelp were relatively abundant in this zone near the outfall. Feather boa kelp and oar kelp may have limited the potential amount of surfgrass that could have otherwise grown in that area. The differences in species abundances may have also been due to different spore and seed settlement opportunities between species and whether sand cover was a factor during the times of settlement.

A qualitative survey was also performed by Tenera in 2007 at the Pillar Point sector of the ASBS. The purpose of this survey was to supplement the findings of the gradient transect study performed on the bench rock platform near the main storm water outfall. This qualitative study includes the other marine life habitats in this area including rock walls and outcroppings. Shore walk surveys were done to further characterize the marine community in the overall study region. It is important to note that the during the Tenera 2007 qualitative assessment, storm water was not discharging from the main outfall. The shore walk surveys of the Pillar Point storm water outfall area covered a shoreline distance of approximately 450 m (492 yds) and documented a variety of species in habitats not sampled by the gradient transects. Observations were recorded and assessed for unusual patterns in species distributions in other areas that were readily apparent and could possibly be attributed to effects from storm water discharges.

All areas observed in the qualitative survey were populated by a variety of species indicative of a healthy, rocky intertidal marine community. Most of the differences between the general area of the storm water outfall transect and general area of the reference transect were in the zone where the sand beach transitions into rocky habitat. Various habitat areas other than where the gradient transects were located were specifically searched for sea lettuce (*Ulva* spp.) as an indication of freshwater and constituent influence. There were no areas of algal blooms that would possibly be indicative of a pollution or high nutrient influence.

Tenera stated that a discharge response can be found in the northern sector of the ASBS at the perennially flowing San Vicente Creek, sea lettuce is found to be quite abundant, while none is found near the Pillar Point storm water outfall. The watershed of San Vicente Creek is also larger that that of the Pillar Point, with multiple land uses. The abundant sea lettuce at San Vicente Creek indicates that prolonged drainages from relatively large watersheds with multiple land uses are needed to elicit and sustain a discharge response. Discharges from the Pillar Point headland are much smaller and less frequent, and the areas drained are not used for ranching, farming, or residential living, as what occurs in the San Vicente Creek watershed. There may be a smaller likelihood that discharges from the Pillar Point storm water outfall would cause the same type of change seen at San Vicente Creek. Should such changes occur, however, they would be expected to be smaller in spatial scale and more temporary in nature.

Año Nuevo ASBS

PISCO/MARINe (Raimondi 2006)

Peter Raimondi of the University of California at Santa Cruz Center for Ocean Health, performed a data assessment for eight of the ten ASBS within the influence of Caltrans discharges. In his report (Data assessment for ASBS/ Ocean Plan for Caltrans March 12, 2006) Dr. Raimondi summarizes site characteristics and provides a brief ecological community analysis of established rocky intertidal monitoring stations. These established stations are either a PISCO or MARINe site and provides a continuum of data collected using either Community Dynamics Survey or Biodiversity Protocol.

Año Nuevo is a long gently sloping reef of moderate relief. It is comprised of sedimentary rock and sand. Año Nuevo is a UC Marine Reserve site co-administered by the State. The biodiversity surveys (2002) found 92 species at the site. In these surveys one species of special interest was found, surfgrass, but both owl limpets and black abalone have been found in other surveys. Invasive species were not found at this site. Cluster analysis of the ASBS sites relative to a suite of reference sites in the central coast indicates some interesting patterns. Año Nuevo differs from all other sites in the region. Evaluation of the species lists and the site characteristics suggests that this is mainly due to geomorphology (mixed rock and sand). It is also possible that the site is affected directly and indirectly by the impacts of the large population of elephant seals that resides at Año Nuevo.

Pacific Grove ASBS

Tenera performed “A Comparative Intertidal Study and User Survey, Point Pinos, California” (July 2003) which was submitted as part of the City of Pacific Grove’s exception application. The purpose of the Point Pinos Survey was to investigate the effects of visitor use on the Point Pinos rocky shoreline located on the Monterey Peninsula, and just outside the western boundary of the Pacific Grove ASBS, and was not designed to survey the biological community at outfall locations. In this report, site descriptions were compared to the Point Pinos, which receives high levels of visitor use because of its scenic values and easy accessibility from roads, adjoining parking lots, and trails. One of the main attractions of Point Pinos is the rich, diverse marine life along the rocky shore. Tidepools are common in the area, and small sandy beaches also occur along the upper shore.

Five sites surveyed in the SWRCB 1979 Reconnaissance Survey Report (SWRCB 1979) were revisited in July 2002. One of the five sites was located at Point Pinos and the other four sites were situated along shoreline between Point Pinos and Hopkins Marine Station. A species list was developed for each site by walking the area and noting all species encountered. All identifications were made in the field. In contrast, it was not clear in the original study if samples had been collected for laboratory identification. The tide level was slightly above MLLW (above the surfgrass zone) during the 2002 survey. Two biologists worked separately in the search effort at each site and created a combined species list for each site. The combined search effort at each site was between 1-2 hr.

The Points Pinos report found it difficult to use the data from the State Water Board 1979 Reconnaissance Report (field survey in 1977) and current data to make direct comparisons over time, as the species list appeared to be affected by differences in the intensity of search effort, time spent at each site, tidal levels during the surveys, and detail to adequately characterize the sampling sites. It was found that the most common species were still present in all areas in both surveys, but there was uncertainty concerning the continued or past occurrences of less common species. Without the same sampling effort in both surveys, there was no assurance in whether a species was not present or simply overlooked.

The total number of algal and invertebrate species found at the Point Pinos site was similar between the 1977 and 2002 surveys. In contrast, more species were found at each of the four other sites in the 2002 survey compared to the 1977 survey, but all of the sites also had species that were unique to one or the other survey.

The appendices in the 1979 SWRCB Report contain other species lists. Tenera found that those lists could not be used for comparison with the current survey. The list of intertidal invertebrates for several areas in the State Board report is based on the cumulative listings from 27 literature and museum references dating in the 1940s-1960s. The species were tabulated for large general areas (Point Pinos, Monterey Peninsula, Pacific Grove, Hopkins Marine Station). Because the collecting locations were not specified, the data were of limited use in comparing changes in faunal composition over time. Also the number of species found in each area probably reflects the number of times each area was sampled. Tenera found, however, that Point Pinos was a popular study area between the 1940s and 1960s, as the species list for Point Pinos is the longest. Tenera concludes that from their observations that overall diversity has not changed at the Point Pinos site since the survey in 1977.

Tenera found one conclusive difference, however, between the 1977 and 2002 surveys. This was a lack of sea palms (*Postelsia palmaeformis*) in the present survey although there were not able to conclude whether its absence was due to visitor impacts or to natural causes. Although not listed as a species of special concern or of rare, endangered, or threatened status by the CDF&G or the U.S. Fish and Wildlife Service, California Code of Regulations prohibit cutting or disturbing this species. Regardless, this species is illegally collected for consumption.

Carmel Bay ASBS

PISCO/MARINe (Raimondi 2006)

Two MARINe/PISCO sites within the Carmel Bay ASBS are adjacent to Caltrans roadway drainages, Carmel Point and Stillwater Cove. Carmel Point is long gently sloping reef made up of bedrock and boulders. It is a high relief reef surrounded by bedrock, boulders and sand. Raimondi has been following black abalone for the last two years at this site because it has a healthy abalone population, which is increasingly uncommon with the progression of withering disease. Raimondi does not do biodiversity or community dynamics surveys at this site.

Stillwater Cove is a gently sloping bedrock reef of intermediate length. It is a high relief reef surrounded by other bedrock reefs and sandy coves. Raimondi conducts Biodiversity surveys (2001, 2005), abalone surveys (since 2001) and community dynamics surveys (since 2000) at this site. 90 species were found at this site and species trends and abalone populations appear healthy. Three species of special interest have been found at this site: abalone, owl limpets and surfgrass. Sea palms are not found here because the site is protected from high wave energy. No invasive species have been found at this site. Based on cluster analysis Stillwater Cove is similar to a site to the south, Point Sierra Nevada. These two sites are then most similar to Point Lobos, which makes sense give the proximity of Stillwater Cove to Point Lobos.

Point Lobos ASBS

Peter Raimondi (UC Santa Cruz Center for Ocean Health) performed a data assessment for eight of the ten ASBS within the influence of Caltrans discharges. In his report (Data assessment for ASBS/ Ocean Plan for Caltrans March 12, 2006) Dr. Raimondi summarizes site characteristics and provides a brief ecological community analysis of established rocky intertidal monitoring stations. These established stations are either a PISCO or MARINe site and provides a continuum of data collected using either Community Dynamics Survey or Biodiversity Protocol.

Point Lobos is a marine reserve and one of the most protected sites along the central coast. Point Lobos is gently sloping, long, bedrock reef that has high relief and which is topographically complex. The biodiversity surveys (2001, 2005) found 90 species at this site. In addition, community dynamic and abalone surveys have been performed at Point Lobos since 1999. Community trends and abalone populations appear healthy at this site. Three species of special interest have been found at Point Lobos: abalone, owl limpets and surfgrass. According to Raimondi it is very likely that sea palms may occur at this site at the more exposed locations. Based on cluster analysis, Point Lobos differs from all other sites along the central coast. Looking at the species list and site characteristics the separation of Point Lobos seems due to its topographic complexity and high relief. Also the species composition of this site is not suggestive of a degraded state.

Julia Pfeiffer Burns ASBS

Peter Raimondi (UC Santa Cruz Center for Ocean Health) performed a data assessment for eight of the ten ASBS within the influence of Caltrans discharges. In his report (Data assessment for ASBS/ Ocean Plan for Caltrans March 12, 2006) Dr. Raimondi summarizes site characteristics and provides a brief ecological community analysis of established rocky intertidal monitoring stations. These established stations are either a PISCO or MARINe site and provides a continuum of data collected using either Community Dynamics Survey or Biodiversity Protocol.

Partington Point (also called Pardington Point) is a short, steep, bedrock reef of moderate relief. This reef is one of the characteristic steep reefs of the Big Sur coast that are unlike most other central California reefs (more like the reefs of the Farallones). Two species of special interest: abalone and owl limpets are found at Partington Point. No invasive species have been found at this site. Species richness of the ASBS sites in the central coast region (Ano Nuevo, Point Lobos, Julia Pfeiffer Burns at Partington Point and Carmel Bay) range from 75-92 species. The lowest value, 75, was found at Partington Point, which is a very small reef. Still, this site is not atypical when compared to a suite of reference sites in the central coast. Based on cluster analysis, Partington Point is similar to another Big Sur site, Lucia, which has similar geomorphology.

Laguna Point to Latigo Point ASBS

PISCO/MARINe (Raimondi 2006)

Peter Raimondi (UC Santa Cruz Center for Ocean Health) performed a data assessment for eight of the ten ASBS within the influence of Caltrans discharges. In his report (Data assessment for ASBS/ Ocean Plan for Caltrans March 12, 2006) Dr. Raimondi summarizes site characteristics and provides a brief ecological community analysis of established rocky intertidal monitoring stations. These established stations are either a PISCO or MARINe site and provides a continuum of data collected using either Community Dynamics Survey or Biodiversity Protocol.

Old Stairs is a reef composed of bedrock, boulders and sand. It is a relatively long, gently sloping reef of moderate relief. It is surrounded by sand and a few other bedrock reefs. Raimondi found 54 species at Old Stairs in their biodiversity survey (2001). Old Stairs is also a site that has been monitored using Community Dynamics surveys since 1994. One species of special interest, the owl limpet, is found at Old Stairs. Abalone has long been absent from this region. Surfgrass is found nearby. No invasive species have been found at Old Stairs. In the community analysis with other nearby sites Old Stairs groups out with Mussel Shoals in a group distinct from other southern California reefs. Species diversity and trends are typical for southern California and suggest anthropogenic impact (collection, trampling, and other more indirect effects). Number and size distributions of key species (like seastars and owl limpets) are lower than would be expected in a protected area.

Summary of Biological Resources of the ASBS (Ambrose & Lee 2007)

The Ambrose & Lee 2007 report was performed for the City of Malibu and summarizes information from previous field studies conducted at the Laguna Point to Latigo Point ASBS, and presents a summary of a collection of recent data from 1994 through 2006.

The biological community at Paradise Cove was selected by Ambrose and Lee as the place most representative of relatively undisturbed conditions within the ASBS. Paradise Cove can be compared to other southern California study sites using a statistical clustering technique. Pete Raimondi had performed such comparisons among a set of MARINe sites sampled in southern California. In his analysis, the rocky intertidal near community at Paradise Cove was reported to be most similar to the community at Alegria, a site in Santa Barbara County south of Point Conception that has little human disturbance. However, possible disturbance from storm water or other anthropogenic discharges effects are not part of the MARINe study site design or analysis. Other sites that clustered with Paradise Cove were Arroyo Hondo and Coal Oil Point in Santa Barbara County, and Mussel Shoals and Old Stairs in Ventura County. General observations by Ambrose and Lee suggest that Paradise Cove historically supported and continues to support a relatively rich rocky intertidal community compared to other intertidal reefs in the ASBS.

Ambrose and Lee concluded that the lack of consistent, quantitative data for sandy beach communities makes it difficult to compare Paradise Cove (the selected "reference" site) to other areas within the ASBS. Most notably, there are considerable differences among different beaches. For example, in the 1970's, Morin and Harrington (SWRCB 1979) reported higher diversity of macroinvertebrates on sandy beaches around Paradise Cove compared to Zuma Beach, which is upcoast from (west of) Point Dume. Morin and Harrington attributed this to differences in physical factors such as exposure and influence of beach wrack. Dugan et al. (2003) also emphasized the influence of different physical factors and wrack. Since these differences still exist throughout the ASBS, Ambrose and Lee anticipated that there will still be significant differences in the sandy beach communities on the various beaches. When comparing Paradise Cove as a reference area with few discharge sites, the potential for impacts to the marine life, and the other selected research areas within the ASBS, Ambrose and Lee conclude that there is insufficient data to determine if there has been general degradation in the ASBS over the past 30 years, or whether certain sites have changed more than others. In addition, there is insufficient data to link discharges to the condition of the sandy beaches presented in this report.

Ambrose and Lee recommended that an intertidal marine life study be designed to encompass gradient transect sampling at the two representative storm water discharge sites (MUG 232 and MUG 430, SCCWRP discharge data ID points) and at the selected reference location. These discharge sites were selected to be representative of the City of Malibu's storm water flows. In addition, the reference location was selected at a site between MUG 375 and MUG 386. A transect survey would provide data which can then be analyzed for differences in species composition and abundance between sites and further analyzed for differences in quadrats and their physical distance from the discharge source.

Irvine Coast ASBS

PISCO/MARINe (Raimondi 2006)

Peter Raimondi (UC Santa Cruz Center for Ocean Health) performed a data assessment for eight of the ten ASBS within the influence of Caltrans discharges. In his report (Data assessment for ASBS/ Ocean Plan for Caltrans March 12, 2006) Dr. Raimondi summarizes site characteristics and provides a brief ecological community analysis of established rocky intertidal monitoring stations. These established stations are either a PISCO or MARINe site and provides a continuum of data collected using either Community Dynamics Survey or Biodiversity Protocol.

This ASBS is co-located with Crystal Cove State Park. Other surveys have been done at this site including a number of projects from faculty and students at Cal State Fullerton. This ASBS, like most sites in Southern California, is heavily visited and there really is no expectation of areas not being impacted (Raimondi 2007).

Crystal Cove is a reef composed of bedrock and boulders. It is a relatively long gently sloping reef of low relief. It is surrounded by areas of bedrock, boulders and sand. Raimondi found 114 species at this site in their biodiversity surveys (2001, 2003, 2004), which is a high number for this region. Community dynamic surveys have been conducted at this site since 1995. Two species of special interest are found at this site, owl limpets and surf grass. Abalone has long been absent from this region. The invasive species *Sargassum muticum* and *Caulacanthus ustulatus* are both found at Crystal Cove. In the community analysis with other nearby sites Crystal Cove groups with Dana Point and Scripps (Dike Rock), suggesting its similarity to two relatively nearby sites. Species diversity suggest anthropogenic impact (extraction, trampling and other more indirect effects). Number and particularly size distributions of key species (like seastars and owl limpets) are lower than would be expected in a protected area.

MBC Applied Environmental Sciences (MBC 2004)

One report was by the Department of Parks and Recreation, for the Crystal Cove Park site within the Irvine Coast ASBS. This March 2004 report “Characterization of the Rocky Intertidal Crystal Cove State Park” was prepared for the State of California Department of Parks and Recreation by MBC Applied Environmental Sciences of Costa Mesa, CA (MBC 2004).

The study was designed to characterize two intertidal areas of Crystal Cove State Park, at Treasure Cove and Reef Point during the spring and fall of 2003. This study was designed to duplicate methods utilized previously in the area by Valencic in 1986. Like Valencic’s previous survey, this 2004 study was designed to assess seasonal variation in the intertidal community of Crystal Cove during one year. This report compares the results spring and fall 2003 intertidal surveys at two sites in Crystal Cove, and compares these results to those of the 1986 survey and other work in the area. Four tidal levels were examined at each reef: low, mid, and upper intertidal, and mussel zones (above the upper intertidal). Each tidal level was identified by characteristic species: the low zone was characterized by low algal turf and coralline algae, the mid zone by rockweed, the upper zone by barnacles and littorine snails, and the last by mussel communities. Attempts were made to find quadrat markers from the 1986 study; however, with the exception of four mussel plots at Treasure Cove, none of the original plots were found.

The study involved the use of rectangular quadrats sited along preestablished transect lines. The location of each quadrat was recorded as the transect line identification, the distance in meters along the transect, upcoast or downcoast direction, and perpendicular or parallel placement of the quadrat relative to the transect line. Quadrat locations were initially chosen in spring 2002 as representative of a tidal level in the area. Five replicate quadrats were selected for each tidal level at each reef site. In the fall, quadrat sites were located using the data recorded as part of the identification number. Photos from the spring survey were used as an aid for final placement to match the previous quadrat positions as closely as possible.

A PVC frame with an inside diameter of 50 x 75 cm was placed on the sample site. Station location and quadrat identification number were recorded on a plaque attached to the frame. At least two photographs were taken of each quadrat. Photographs were taken with a high-definition digital camera in JPEG format. In the laboratory, all electronic photo files were downloaded and renamed to include date of sampling, location and quadrat identification number. The digital format allowed the photoquadrats to be examined on a desktop computer monitor. Each photoquadrat picture was converted to Photoshop (PSD) file format, which allow an additional visual gridline layer to be added to each photo. The gridlines divided each photo into ten equal areas to facilitate determination of percent cover of intertidal organisms. The gridlines could be turned off to examine those organisms that fell below the lines. The digital formatting and high definition of the photos permitted significant magnification of the images, aiding the examination of details and facilitating species identification.

Percent coverage and species identification for each quadrat were determined from a single photo, with the additional photos reviewed to assist with identification and to ensure that all species were noted. In several cases, two photos of the same quadrat were examined and analyzed independently as a quality check of methods. Identification was made to the lowest possible taxonomic level, with the exception of two similar, coexisting red algae species, *Gelidium* and *Pterocladia*, which were collectively identified as algal turf. All species were enumerated as a percent cover of the photoquadrat. Presence of specific indicator species was used to define tidal levels: mussels, barnacles, rockweed and algal turf for mussel, upper, mid, and low levels, respectively.

Treasure Cove is located at the northern end of the park and has poor public access except during low tides. The upper rocky intertidal at Treasure Cove is characterized by relatively low-lying, flat bedrock which occasionally is covered or scoured by the coarse beach sands. The mid intertidal at Treasure Cove is characterized by bedrock which extends seaward as exposed craggy ridges with fairly sharp relief and numerous channels and pools to the downcoast side of the area, while more centrally, ridges are fewer and most of the mid-tidal-level fauna is found on bedrock and boulder outcroppings within numerous shallow pools. The low intertidal at Treasure Cove is typified by low relief, flat bedrock benches. Offshore of this area are large exposed and mussel covered bedrock outcrops that are accessible only on very low tides on calm days. The mussel sites at Treasure Cove are reoccupied plots established in 1986 on the flat top of the rocky point to the downcoast side of the area.

Reef Point is the southernmost rocky intertidal reef at Crystal Cove State Park. This area is near two pedestrian trails and is easily accessible to the public. The rocky intertidal at Reef Point is composed of three slightly separated rocky structures. The reef farthest downcoast is a narrow, high relief rock ridge that runs offshore of the beach. Slightly upcoast of this ridge is a relatively low relief flat, rocky bench. Continuing upcoast is the main Reef Point structure, where sampling for this project was undertaken. Attempts to relocate the 1986 plots were unsuccessful, so all quadrats were located along the new transect lines. Exposed ridges support the upper level and mussel communities examined in this study. Farther offshore, the mid and low levels are characterized by a relatively flat area with exposed bedrock and boulders interspersed by shallow pools, channels, and sandy areas. Slightly offshore of the lower intertidal areas are larger, high relief rock structures, including several large offshore rocks. The intertidal area at Reef Point is exposed to waves from both the south and northwest. Sand movement in the area is greater than at Treasure Cove, and parts of the low relief areas, particularly on the upcoast side of the reef, are subject to burial by sand.

Species richness generally increased in the Treasure Cove area between spring and fall 2003, except in the upper level plots, which had one fewer species in fall. Total percent cover at Treasure Cove was also higher in the fall, even though percent cover of the lower level plots in fall was nearly 20% less than in spring. In total, 20 species covered 54% of the area in spring, and 24 species covered 56% of the available substrate in fall. While a core group of dominant species was found in the area during both seasons, the contribution of those species differed notably between seasons. Algal turf, the dominant species in the low and mid level plots and present at all levels in spring, was reduced considerably in the area by fall. Coralline alga, present in low abundance at the low and mid levels in spring, replaced algal turf as the dominant species in the low and mid levels and was present at all levels in fall. Coralline alga and algal turf are generally found in very similar conditions at Crystal Cove, on fairly flat surfaces in the low intertidal or in areas with pooled water. The decline of algal turf throughout Treasure Cove, along with a reduction in total coverage by all species at the low-level plots, suggests that the algal turf decline was due to seasonal variations such as water and air temperature and day length, but not competition from other species. The increase in coralline alga in the Treasure Cove area in fall appears to be a result of increased availability of suitable habitat.

Species richness was slightly higher in spring than in fall at Reef Point, although the low and mussel-level plots had slightly more species in fall. Overall percent cover was very similar between seasons, with a slight increase at all but the mid-level plots in fall. In total, 24 species covered 68% of the area in spring, and 22 species covered 69% of the available substrate in fall. The contribution by the dominant core species was found to be fairly similar during both seasons. Algal turf was somewhat reduced in the area in fall, but not as noticeably as at Treasure Cove. At the low intertidal quadrats, increase in percent cover of coralline alga in fall was about the same as the reduction in algal turf, while in the mid levels, increases in coralline alga, rockweed, and bare substrate were similar to the reduction in percent cover of algal turf. This may suggest that a local, possibly seasonal, reduction of algal turf allowed the expansion of other species.

In fall, several of the intertidal quadrats at Reef Point were partly inundated by sand. Although sand was also present in some plots in spring, it was not as prevalent as in fall. Some organisms were covered to an extent that could impair their survival. For this reason, percent cover of sand was noted for the fall Reef Point surveys. The amount of sand was highly variable and sand was noted in some quadrats at low-, mid- and upper-intertidal levels. Mussel plots on the bedrock ridges were above the level of sand inundation, even during the fall sampling. Coverage by of sand ranged from relatively low at three low-intertidal plots to 100% cover at one upper intertidal photoquadrat. Excluding the mussel level, sand cover averaged about 20% at Reef Point in fall.

Seasonal totals from both sites at Crystal Cove State Park suggest that the intertidal remains fairly consistent between seasons, with 27 species covering 61% of the available substrate in spring and 26 species covering 63% of the substrate in fall. However, specific tidal levels show notable differences between spring and fall. Percent cover at low level plots in fall were reduced by about 10% from spring values, while species richness was higher. This is likely a result of the general reduction in algal turf with a resultant increase of availability of substrate as mentioned previously. At mid-level quadrats, a slight increase in percent cover in fall accompanied a slight decrease in species richness. Both cover and richness were very similar between seasons, making the mid intertidal the most seasonally consistent level. In upper intertidal quadrats, the level with the lowest total percent cover during both seasons, species richness decreased from 19 species in spring to 15 species in fall, while average percent cover increased by about 5% during that same period. The increase in percent cover at the upper level plots appears to be related to an increase in white acorn barnacles at Reef Point, and coralline alga at Treasure Cove. In the mussel-level plots, six more species were found in fall than in spring. On average, 10% more of the available substrate was covered in fall, with most of the additional cover accounted for by increases in California mussel. When results from both seasons are combined, Treasure Cove and Reef Point both were found to support 27 intertidal species, although cover of available substrate was about 13% higher at Reef Point. Cover at all levels was greater at Reef Point, particularly in the upper intertidal, with about 30% more substrate covered than at Treasure Cove. This difference is likely related to scouring by coarse sand noted in the upper intertidal at Treasure Cove. At Reef Point, the finer grained sand that inundates the site does not seem to scour the rock substrate clean as it does at Treasure Point.

These results seem counterintuitive to the impression one receives when visiting the sites. Large and relatively well-protected tidal pools at Treasure Cove support populations of conspicuous, and occasionally numerous, large intertidal invertebrate species, including sea urchins (*Strongylocentrotus* spp), giant keyhole limpets (*Megathura crenulata*), California sea hares (*Aplysia californica*), and sea cucumbers (*Parastichopus* spp), while hermit crabs and snails are common in the rocky pools. Difficult public access to the area helps protect these species from being harassed or taken by park visitors. However, the upper-intertidal level at Treasure Cove, the most depauperate of the quadrats surveyed during this study, are occasionally scoured by coarse sand, while the rocky substrate in the mid-tide level tends to be craggy with notable vertical relief. These physical characteristics differ from those found at the same tidal levels at Reef Point, and likely contribute to the differences between areas at those levels. The physical characteristics of the low- and mussel-levels plots at Treasure Cove are fairly similar to those at Reef Point, and, consequently, these levels are the most similar between the sites. At Reef Point, while the hard substrate is well populated, pools are generally sandy and smaller than at Treasure Cove, and with easy public access, large species are rare, giving the impression of a less profuse intertidal community in the Reef Point area.

In 2003, species richness appeared to be lower than had been noted in previous studies in the Crystal Cove area; however, species composition, and especially the dominant species, were similar to those in previous surveys in the area (MBC 1971, Valencic 1986). In comparison to the results of the 1971 study, which included surveys at Reef Point, species richness was notably lower. However, the earlier study conducted both in situ investigations and intertidal scrapings. Differences in sampling methods may account for the disparity in results. In the 1986 project, results were not well quantified for the intertidal survey, although Valencic's descriptions of the communities at both areas are similar to those found in this 2004 study. The low intertidal in the Valencic study seemed to be at a slightly lower tidal level than during the current study, judging by the presence of *Phyllospadix*, *Egregia*, and other fairly large plant species (MBC 2004). Although occasionally found in the current 2004 study, these species are much more common slightly lower in the intertidal than in areas surveyed in this survey, although observations outside of this study may suggest that presence of these larger plant species is seasonally variable at the low-tidal level.

Species Diversity. Overall Shannon-Wiener species diversity (H') for all surveys and tidal levels combined was 1.91, with the highest diversity (1.99) for results of the combined fall survey. Diversity was consistently lowest at the low-tidal level stations and tended to be highest at the upper tidal level on most transects, although not notably higher than at mid or mussel quadrats. Overall, diversity with all tidal levels combined was generally similar to values found at mid, upper or mussel zones.

Community Composition. The seven most abundant species (each of which covered 1% or more of the area during all surveys) together occupied 58% of the available intertidal substrate at Crystal Cove State Park. The remaining 25 species collectively occupied another 4% of available substrate. Algal turf (*Gelidium/Pterocladia* spp) was the most abundant species, covering an average of 26% of the available substrate during both seasons at the two sites. California mussel (*Mytilus californianus*) was the next most abundant species, accounting for about 11% of the total coverage in the quadrats, followed by the calcareous red coralline alga Corallina spp with 7% of the cover, the white acorn barnacle (*Balanus glandula*) and the tar-spot alga (*Ralfsia spp*) with about 5% each and the aggregating anemone (*Anthopleura elegantissima*) and rockweed (*Silvetia compressa*) each covering about 2% of the total available substrate.

Two species, algal turf and tar-spot alga, were the only species to occur in all tidal levels at both sites during spring and fall. Twelve additional species were found to occur at all four tidal levels, although not at both sites or during both surveys. Algal turf was most abundant at low-tide quadrats, where it averaged 62% cover, and was also dominant at the mid-tide level, covering 32% of the available surface. The California mussel was most abundant in mussel-level plots, where it averaged 38% cover. California mussels contributed slightly to coverage at the upper and mid levels, but did not occur at the low intertidal level. Like algal turf, coralline alga was most abundant in low tide quadrats, contributing 17% cover, but was also found commonly at mid-level plots where it accounted for 8% cover. White acorn barnacle was strongly associated with the upper intertidal, where it covered 17% of available area, while rockweed was most abundant, with 7% cover, at mid tide quadrats.

Algal turf was more abundant at all levels during the spring surveys, while most other species were similarly abundant between seasons or were slightly more abundant in fall. Coralline alga was much more abundant in fall than in spring, particularly at Treasure Cove where it replaced algal turf as the dominant species.

Of the 32 species recorded in photoquadrats, ten were plants, which are primary producers, nine were herbivores that graze on algae (most of the gastropod molluscs and the chiton), eight were filter feeders that filter large amounts of water through structures in the body (all the barnacles, mussels and the annelid worm), three were deposit feeders which gather suspended or fallen particles (anemones), and one (the emarginate dogwinkle, *Nucella emarginata*) was a predator.

Cluster Analysis. A dendrogram was constructed based on the percent cover for each species at each site. The 16 sites (two seasons, two locations, and four levels) fell into three groups based on community composition and abundance. Tidal level appeared to the most important determining factor, with all low intertidal sites found in Group III and all mussel sites falling into Group II. Site location was the next most important factor, with all Reef Point upper quadrats and spring mid-level quadrats grouping with the mussel level in Group II, and both Treasure Cove upper quadrats and spring mid level falling into Group III with the low- intertidal sites. Season appeared to be the least important factor. Group I, the most dissimilar from the other groups, contained only one site, the fall Treasure Cove mid level.

Site clustering was strongly related to relative percent cover of California mussels at each site. At Group II sites, California mussel covered at least 3.5% of the available substrate, while at Group I and III sites California mussel was absent, or occurred only in low abundance. Relative percent cover of the dominant alga species, algal turf and coralline alga, at the Group I site differed notably from that at any other site in the study area. (MBC 2004)

La Jolla ASBS

As part of their Exception Application, the City of San Diego’s Marine Life Exhibit A attachment included four recent reports that pertain to the La Jolla ASBS. Two of these reports are considered to be primary, the Ghost Forest in the Sea: The Use of Marine Protected Areas to Restore Biodiversity to Kelp Forest Ecosystems in Southern California (Parnell et. al. 2005a) and the Effectiveness of a Small Marine Reserve in Southern California (Parnell et. al. 2005b).

Recent subtidal habitat surveys such as the Effectiveness of a Small Marine Reserve (Parnell et. al. 2005b) provides new data not otherwise performed since the Kobayashi surveys (Kobayashi et. al. 1978) which surveys the conspicuous species in the kelp-forest, submarine canyon, and boulder-reef habitats of the San Diego-La Jolla Ecological Reserve. The Kobayashi surveys did not provide detailed baseline data necessary for a temporal comparison, but the Parnell (2005) report conducted inside/outside comparisons among similar microhabitats that were discriminated quantitatively. This ensured that inside/outside comparisons were conducted between similar habitats, increasing the likelihood that differences were due to the protection within the ASBS.

Extensive surveys of physical habitat, algae, fishes, and invertebrates were conducted within the kelp forest both inside and outside the reserve. The entire La Jolla kelp forest was divided into squares of 250 m on each side; surveys were conducted using band transects placed randomly within a grid. At least 2 transects were conducted within each square. Habitat parameters included depth measurements and estimates of sharp vertical relief within 1 m of the transect line at every 1 m interval mark, substrate type (sand, bedrock, rock cobble), and algae every 0.5 interval mark, and the presence/absence of major benthic features (ledges, crevices, overhangs) along 5 m sections.

For kelp habitat, inside/outside density comparisons revealed significantly higher densities of male and female sheephead, rock scallops and red urchins inside the reserve. Densities of lobsters were nearly significantly greater inside the reserve. Of the fishes, only male sheephead displayed size differences between the reserve habitat and similar habitat outside. Overall, Parnell found the results to indicate that the reserves provide protection only for species that are strictly residential or sessile.

Parnell found that historical comparisons of densities in the kelp habitat inside and outside the reserve indicate alarming declines in many fished species inside the reserve: lobsters, green abalone, pink abalone, octopus, kelp bass and sculpin Scorpaena guttata whose mean densities have sharply declined.

In the submarine canyon habitat, vermillion rockfish and male sheephead appear to be protected well. Both species were observed in significantly higher abundances in the La Jolla branch of the La Jolla underwater canyon located inside the reserve, than the Scripps branch of the canyon located outside. No size data are available, however, they are probably the only populations of large individuals of these species remaining in the La Jolla area.

Parnell's surveys in the boulder-reef habitat were specifically targeted at green abalone for logistical reasons. However, he commonly observed several very large lobsters in the northeastern shallows of the reserve. Individuals of this size outside the reserve are very rarely observed; therefore the reserve may be protecting some resident lobsters. Further evidence of this is the observation that lobster traps are still common at the western margin of the reserve late in the lobster season.

Parnell counted 33 species of invertebrates and 27 species of fish in the band transects. Of these, only the species currently or historically targeted for commercial or recreational harvest were included in the inside/outside comparison.

A total of 286 transects were conducted during the spring and summer of 2002; 16 of these were conducted within the single grid box located in the kelp habitat within the reserve. The kelp habitat in the reserve is characterized by reefs, sharp vertical relief, crevices and overhangs, and moderate levels of sand. The algal species that distinguished this habitat from other areas within the kelp bed were *Egregia menziesii, Eisenia arborea, Cystoseira osmundacea* and *Desmerestia spp*., and turf-forming red algae.

Inside/outside comparisons were only possible for 7 species of animals. These comprised kelp bass, barred sand bass, male and female sheephead, red urchins, spiny lobster *Panulirus interruptus*, rock scallop *Crassedoma giganteum* and pink abalone *Halliotis corrugata*. There were not enough individuals of other target species to conduct statistical comparisons. The results indicate that individual species' comparisons were significant (α = 0.05) for red urchins, rock scallops, and male and female sheephead, whose densities were all higher in the reserve.

Fish size frequencies for kelp bass were similar inside and outside the reserve. However, the size-frequency distributions of male and female sheephead inside and outside the reserve differed. A significantly (achieved significance level, ASL = 0.046) larger proportion of males .50 cm were observed inside the reserve. A larger but non-significant (ASL = 0.350) proportion of females .25 cm were also observed in the reserve. Too few barred sand bass were observed for size comparisons.

Adult sea urchin populations were significantly larger inside the reserve. Smoothed size-frequency distributions of red and purple urchins show differences that probably reflect fishing pressure on red urchins outside the reserve. The observed difference between the modes of red urchins inside and outside the reserve was 17 mm and the distributions as summarized by the large modal size were significantly different (ASL, 0.001). The observed difference for purple urchins was 1 mm and was not significant (ASL = 0.71). Approximate 95% confidence intervals for the large modal size for red urchins were 96 and 109 mm and 85 and 93 mm inside and outside the reserve, respectively. Therefore, the population of adult red urchins was significantly larger inside the reserve.

In general, the results of the inside/outside comparisons and the comparisons with historical data yielded 4 general conclusions: 1. The Reserve at the La Jolla ASBS appears to protect only a few harvested species, those that are sessile or highly residential, suggesting that the reserve is too small; 2. Comparisons with historical data indicate that most harvested species in the reserve, even some species for which reserve effects were observed, have declined seriously since 1979. Parnell concluded this indicates that the magnitude of any reserve effect is inadequate to protect most species from natural and anthropogenic perturbations, further supporting Parnell's contention that the reserve is too small; 3. The reserve may function as an enhancive reserve for green abalone in the boulder-reef habitat, red urchins in the kelp habitat, and vermillion rockfish and sheephead in the canyon habitat, since large individuals of these species were observed in higher densities inside the reserve than outside, including the entire area off La Jolla; 4. Historical data are important in determining reserve effectiveness when baseline date are lacking because they provide an historical perspective with which to gauge inside/outside comparisons. The reserve at the La Jolla ASBS protects only ~0.8% of the kelp forest habitat and ~11% of the boulder-reef habitat in the La Jolla area.

San Nicolas Island & Begg Rock ASBS

One report was available, the Biological Survey Report prepared by Merkel & Associates (April 2007) for the Navy's exception application for San Nicolas Island (SNI). Quantitative intertidal and subtidal biological surveys were performed at a representative discharge sites and at two reference locations. This report also includes biological survey work previously performed by other researchers; it provides a comprehensive assessment of the various subtidal and intertidal ecoregions of San

Nicolas Island and provides some insight into the scope and extent of biological survey efforts performed historically.

Sampling stations were determined by conducting a reconnaissance of each location and selected based on several criteria including representation of the general area, access, UXO avoidance, operational safety, proximity to observed or expected runoff, proximity to sensitive wildlife, and whether of not there is a habitat area of sufficient size to sample. At each sample station, marine biologists recorded the abundance and/or percent cover of organisms at each of three tidal elevations (+5, +3, and 0 ft MLLW) using a $0.25m^2$ quadrat following methods used for other surveys at San Clemente Island. For subtidal surveys, a diving biologist using SCUBA determined the distribution and abundance of subtidal invertebrates and algae at the -40 ft MLLW isobath.

Two metrics were derived from these surveys 1) number of taxa, and 2) abundance or percent cover. Since there were no benchmarks available for the metrics, comparisons were made to reference conditions within an associated ecoregion. Based on historical data, these community measurements are highly variable. Merkel and Associates considered differences of 50% in the number of taxa or abundance/cover between any two sites to be in the realm of natural variation. If a metric measured at a station was lower by 50% or more than the associated reference station, then that metric was flagged. When one or both metrics at a station were flagged, the biologist considered substrate data, historical data if available, looked at results of the receiving water and sediment measurements for causal relationships, and used best professional judgment to determine in intertidal or subtidal habitats required additional evaluation.

Graphs were prepared for species or taxonomic groups that were relatively abundant, and in some instances, species were placed into taxonomic groups for graphing purposes. Summary tables were prepared for species or taxonomic groups that were not relatively abundant or common. In addition, a species list was developed from this and previous surveys.

Results indicated a high degree of biological variability in the intertidal and subtidal zones around SNI, possibly due to differences in substrate type and coverage such as cobble, boulder, bedrock or sand. Generally, different substrata supported different assemblages of organisms and at some locations the presence of competitive dominants led to biological interactions. According to Merkel and Associates all marine habitats surveyed at SNI had diverse, healthy communities. Variability amongst communities was attributed to normal variability and there was no indication of direct impacts associated with Navy activities. The metrics used to determine potential impacts to beneficial uses further indicated biological variability within an ecoregion, supporting the need to have multiple reference locations. According to Merkel and Associates the biological data in combination with water and sediment chemistry, and toxicity, provided a weight of evidence that Navy discharges do not compromise protection of ocean waters for beneficial uses.

Long-term trends in giant kelp forest populations have been studied at SNI. For a National Park Service study, six benthic study sites (10 – 12 m deep) have been sampled semiannually since 1980, and they have concluded that at Dutch Harbor, giant kelp populations fluctuate on a cyclical pattern due to intraspecific competition since sea urchin grazing is not significant, but that on the west end of SNI, sea urchin grazing heavily influences giant kelp populations, which may lead to a higher turn over rate with more frequent recruitment pulses.

The metrics used to determine potential impacts to beneficial uses further indicated biological variability, supporting the need to have multiple reference locations. The selection of a single (as requested by the SWRCB) or several reference locations may not be suitable to determine causal relationships. Based on decades of sampling kelp forests within the Channel Islands, the National Park Service suggested annual sampling for Channel Island sites for a minimum of ten years, with an initial, consistent annual sampling program necessary to provide an adequate baseline to describe perturbations.

Subtidal Survey Methods: At each subtidal sample station, a diving biologist using SCUBA determined the distribution and abundance of subtidal invertebrates and algae at the –40 ft MLLW isobath. A 25-m long transect tape was established at each isobath. Kelp abundance was counted in ten, randomly placed five-meter-long by two-meter-wide bands transects (10m2). Observations included the number of kelp plants in each band transect, the number of stipes at a height of one meter above the bottom, and the size of the individual plants. Four size categories were measured; newly recruited kelp plants (minimum size 2-10 cm), juveniles (10-40 cm in length), subadult (between 40 cm and 2 m), and adults (greater than 2 m in length). The characteristic color and wavy pattern of the blades allowed biologists to readily identify even relatively small Macrocystis plants.

Biologists documented the abundance of key indicator plant and invertebrate species in ten, randomly placed one-meter by one-meter quadrats (1m^2). Biologists also quantified substrate type (sand, rock, cobble) and algal cover using a point contact method with 20 points sampled within the 1m^2 quadrat. Target species/assemblages were surveyed at each subtidal sampling location. These were common subtidal organisms present during previous Navy surveys performed in 1998. Other species of interest were also noted. Formal fish transects were not conducted, but all fish species observed were recorded to document presence and relative qualitative abundance (e.g., abundant, common, rare). Quality assurance was maintained by using experienced diving biologists, and by each biologist cross-checking for proper species identification, abundance estimate, and data recording for each quadrat.

Intertidal Spatial Assessment Methods: At each sample station, marine biologists recorded the abundance and/or percent cover of organisms at each of three tidal elevations (+5, +3, and 0 ft MLLW) using a 0.25m^2 quadrat following methods used for previous Navy surveys at SCI in 1998. A 10-m long transect tape was established at each tidal elevation, and four randomly placed quadrats along the transect line were sampled at each of the three tidal elevations. Two biologists were assigned to each quadrat to record abundance and/or percent cover (for invertebrates, algae, and substrate) for several target species that were determined to be key species in the previous Navy marine resources inventory in 1998. Abundance was quantified by counting total individuals within each 0.25m^2 quadrat and percent cover was measured using the point contact method at 20 points within each 0.25m^2 quadrat. Quality assurance was maintained by using experienced intertidal biologists, and by cross-checking for proper species identification, abundance estimate, and data recording for each quadrat.

Several algal species were grouped into taxonomic categories to allow efficient field sampling and comparison with past studies. All species in the genus *Corallina* were grouped into the group coralline algae, red turf included low-lying red algae (e.g., *Gelidium* spp.), red foliose was made up of leafy erect red algae (e.g., *Pterocladia* spp.), Ralfsiaceae included all encrusting brown algae in the Ralfsiaceae family (e.g., algae that resemble “black tar”), and other browns included brown algae such as *Dictyota* spp., *Dictyopterus* spp., *Zonaria* spp., *Halydris* spp., *Colpomenia* spp., *Leathesia* spp., *Scytosiphon* spp., *Fucus gardneri, Selvetia compressa,* and *Pelvetiopsis limitata.*

A total of six sites were chosen for sampling around San Nicolas Island. They include four sites that are representative of areas that receive storm water discharges associated with distinct Navy operational activities such as airfield, water desalination, and rocket launch operations. The total also included two locations chosen to represent areas that receive storm water runoff not associated with Navy activities, and thereby are considered a reference condition. Because there are insufficient historical data to assess how reference conditions might vary around the island, two reference locations were chosen to represent potential differences that might occur on either side of the island. The sampling locations are:

Corral Beach and **Dutch Harbor** were selected reference locations. Corral Beach is located between Blue Whale Cove and Tranquility Beach and was chosen as a reference location to account for potential spatial variability. The general area consists of rocky bluffs, with relatively small pocket beaches. The intertidal area ranged from vertical rocky bluffs to cobble, with surge channels. The intertidal sampling location was located in the vicinity of an ephemeral stream/drainage, and consisted of bedrock at all tidal levels. The subtidal zone consisted mostly of boulders and bedrock with moderate relief of up to 2.5 meters. Patches of sand were common in deeper areas or in pockets between rocky outcroppings. Water and sediment samples were collected outside the surf zone directly offshore of the drainage. Intertidal sampling was conducted on the rocky platform west of drainage, and subtidal sampling was conducted directly offshore of the drainage. Dutch Harbor is located on the south-central portion of SNI, consists of a rocky headlands separated by sandy beaches, and was chosen as a reference location to account for potential spatial variability. The intertidal area consists of rocky intertidal platforms separated by sandy beach, and the subtidal area consists of bedrock with moderate to high relief of up to 3 meters, separated by sand patches. Water and sediment samples were collected outside the surf zone directly offshore of the headland. Intertidal sampling was conducted on the rocky platform east of the headland, and subtidal sampling was conducted directly offshore of the headland. One notable observation included the presence of black abalone (Haliotis cracherodii) within some of the intertidal ledges.

Coast Guard Beach, an area of point source brine discharge from desalination operations. Coast Guard Beach is located on the eastern portion of the island, and was requested by the SWRCB to be sampled. The area is predominantly sandy beach habitat, with the exception of a rip-rap jetty that extends approximately 250 feet (ft) (77 meters [m]) into the ocean. The subtidal habitat is also primarily sandy substrate, although west of the jetty at an approximate depth of 25 ft (8m), scattered low-relief rocky substrate is present. The brine discharge area is located on the back beach, east of the jetty. Water and sediment samples were collected outside the surf zone directly offshore of the brine discharge area. Subtidal sampling was conducted west of the jetty in the area of low-relief rocky substrate. For a large portion of the year, the sandy beach serves as a nursery and breeding area for northern elephant seals and California sea lions. Strong southerly currents (i.e., running from north to south) are common in this area, and were experienced while sampling.

At Coast Guard Beach, nine species or taxonomic groups were flagged for the subtidal habitat for exceeding the 50% difference criteria, and included *Macrocystis, Pterygophora, Laminaria, Parastichopus, Pisaster*, urchins, sponges, ectoprocts, and ascidians. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, competitive interaction (biotic), substrate variability, exposure, and species mobility.

For the intertidal analysis, species abundance or percent cover and number of taxa from Coast Guard Beach were compared to Corral Beach and Dutch Harbor. Sixteen species or taxonomic groups were flagged for the intertidal habitat at Coast Guard Beach for exceeding the 50% difference criteria, and the total number of species also exceeded the 50% criteria, which was expected considering that the intertidal habitat at Coast Guard Beach consisted of sandy substrate and that all of the indicator organisms were primarily those found on firm or rocky substrate. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by substrate variability.

Daytona Beach, located in the southeast portion of the island, is representative of a storm water runoff area associated with barge landing operations. A large pier, used to load and unload barges, is located along a sandy stretch of beach. The intertidal area is sandy beach, as well as the habitat adjacent to the pier. However, mature giant kelp forests are located offshore, both east and west of the pier. Water and sediment samples were collected outside the surf zone adjacent to the pier, while subtidal sampling was conducted in the kelp forest east of the pier. For a large portion of the year, the sandy beach serves as a nursery and breeding area for northern elephant seals and California sea lions.

At Daytona Beach, four species or taxonomic groups were flagged for the subtidal habitat for exceeding the 50% difference criteria, and included *Pterygophora*, red turf algae, ectoprocts, and ascidians. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, competitive interaction (biotic), substrate variability, and exposure.

For the intertidal analysis, species abundance or percent cover and number of taxa from Daytona Beach were compared to Corral Beach and Dutch Harbor. Similar to Coast Guard Beach, sixteen species or taxonomic groups were flagged for the intertidal habitat at Daytona Beach for exceeding the 50% difference criteria, and the total number of species also exceeded the 50% criteria, which was expected considering that the intertidal habitat at Daytona Beach consisted of sandy substrate and that all of the indicator organisms were primarily those found on firm or rocky substrate. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by substrate variability.

Tranquility Beach is located on the northern portion of the island, and is representative of a storm water runoff area associated with the residential area (Nick Town). Nick Town is located on a mesa above Tranquility Beach, with a ravine that may potentially transport storm water from Nick Town to nearshore receiving waters. The majority of the intertidal area is comprised of sandy beach, with rocky intertidal platforms on the east and west ends of the beach. An expansive giant kelp forest is located offshore of Tranquility Beach, with the substrate consisting of a mixture of bedrock with high relief (4 meters in some places) and large boulders with interspersed patches of sand. Water and sediment samples were collected outside the surf zone directly offshore of the ravine. Intertidal sampling was conducted on the rocky platform west of ravine, and subtidal sampling was conducted directly offshore and to the north of the ravine.

At Tranquility Beach five taxonomic groups were flagged for the subtidal habitat for exceeding the 50% difference criteria, and included *Laminaria*, red turf algae, *Parastichopus, Pisaster*, and ectoprocts. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, competitive interaction (biotic), substrate variability, exposure, and species mobility.

For the intertidal analysis, species abundance or percent cover and number of taxa from Tranquility Beach were compared to Corral Beach and Dutch Harbor. Eight species or taxonomic groups were flagged for the intertidal habitat at Tranquility Beach for exceeding the 50% difference criteria, and included encrusting coralline algae, turf and geniculate coralline algae, *Sargassum*, littorine snails, mussels, chitons, turban snails, and urchins. The total number of species was within the 50% criteria of the reference locations. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, substrate variability, exposure, and species mobility.

Blue Whale Cove is located on the northern portion of SNI and is representative of storm water runoff associated with rocket launch operations. Rocket launch platforms are located on a mesa above Blue Whale Cove, with a ravine that may potentially transport storm water from the platforms to nearshore receiving waters. Similar to Tranquility Beach, the majority of the intertidal area in Blue Whale Cove is sandy beach, with rocky intertidal platforms on the east and west ends of the beach. An expansive giant kelp forest is located offshore of Blue Whale Cove, with the substrate consisting of a mixture of bedrock with high relief (4 meters in some places) and large boulders with interspersed patches of sand. Water and sediment samples were collected outside the surf zone directly offshore of the ravine. Intertidal sampling was conducted on the rocky platform west of ravine, and subtidal sampling was conducted directly offshore and to the north of the ravine.

At Blue Whale Cove eight species or taxonomic groups were flagged for the subtidal habitat for exceeding the 50% difference criteria, and included *Laminaria*, red turf algae, coralline turf, *Pisaster*, urchins, sponges, ectoprocts, and ascidians. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, competitive interaction (biotic), substrate variability, exposure, and species mobility.

For the intertidal analysis, species abundance or percent cover and number of taxa from Blue Whale Cove were compared to Corral Beach and Dutch Harbor. Ten species or taxonomic groups were flagged for the intertidal habitat at Blue Whale Cove for exceeding the 50% difference criteria, and included geniculate and encrusting coralline algae, *Sargassum*, green algae, limpets, littorine snails, mussels, chitons, turban urchins, and anemones. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, substrate variability, exposure, and species mobility.

San Clemente Island ASBS

One report was available, the Naval Auxiliary Landing Field, San Clemente Island Area of Special Biological Significance Biological Survey Report (Merkel & Associates February 2007). The report provides a comprehensive assessment of the various subtidal and intertidal ecoregions of San Clemente Island, including significant data of the status of surrounding kelp forests. Their report also includes previous biological surveys performed at San Clemente Island (SCI).

Several marine biological surveys have been conducted at SCI to either meet permit conditions (focused) or to assess the biological communities around the island. The focused surveys were aimed at documenting potential effects of the SCI wastewater treatment plant outfall on marine biota. These surveys included both intertidal and subtidal surveys in the vicinity of the Wilson Cove sewage point source outfall. According to Merkel and Associates results of the focused surveys suggested that very localized impacts to marine biota occurred in the intertidal zone directly in the vicinity of the outfall, but there were no apparent effects 15 m (50 ft) beyond the outfall or in the subtidal zone.

Island-wide surveys were conducted to document and compare the habitat around SCI with other Channel Islands. The island-wide surveys were all subtidal, kelp forest surveys, and results indicated that the subtidal communities at SCI were diverse and healthy in comparison to the other Southern Channel Islands (e.g., Catalina, Santa Barbara, Anacapa, and Santa Cruz Islands), and similar to San Nicholas Island. Fish, algae and invertebrates displayed a high degree of diversity and most noted species were observed from juveniles to aging adults. SCI's relative remoteness, limited anchorages, and unpredictable operational closures likely play a significant role is reducing fishing pressure and subsequent impacts to the associated marine communities. According to Merkel and Associates no visible impacts from Navy operations were observed on the underwater communities at visited sites.

The island-wide surveys delineated four ecoregions around the island. Although the number of sites sampled within each ecoregion was too low to describe significant differences between ecoregions, some notable trends in habitat classification were apparent. First, the only two sites classified as developing kelp forests were located on the east shore, where bottom substrate and oceanographic conditions possibly limited perennial kelp forests from forming. As expected, the north and west ecoregions were dominated by mature kelp forests and sand bottom with sub-canopy brown algae. These mature kelp forests supported dense stands of understory algae unlike the Pyramid and east ecoregions, which were dominated by encrusting invertebrates on the hard substrate. Dense understory algae were most typically present where high flow nutrient rich oceanic water was consistently available, as in the north and west shore ecoregions of SCI. The Pyramid ecoregion had a southeast aspect and typically experiences less wind and swell than other exposures throughout the island.

Methodologies from previous surveys were reviewed to assist in the development of methods to meet the State Water Board request. Due to logistical constraints, including access to portions of the island, potential weather concerns, diver safety and bottom time limitations, and the distance between potential sampling locations, the methods were developed to provide the best information to satisfy the request by the SWRCB and also to make comparisons with previous survey data.

Results indicated a high degree of biological variability in the intertidal and subtidal zones within an ecoregion, primarily due to differences in substrate type and coverage (e.g., cobble, boulder, bedrock, sand). Generally, different substrata supported different assemblages of organisms, and at some locations the presence of competitive dominants (e.g. mature giant kelp forest) led to biological interactions. According to Merkel and Associates all marine habitats surveyed at SCI had diverse, healthy communities. Variability amongst communities was attributed to normal variability and there was no indication of direct impacts associated with Navy activities. The metrics used to determine potential impacts to beneficial uses further indicated biological variability within an ecoregion, supporting the need to have multiple reference locations.

Two metrics were derived from these surveys: 1) number of taxa, and 2) abundance or percent cover. There were no benchmarks available for these metrics so they can only be compared to reference conditions. In the case of SCI, the comparisons were made to reference conditions within an associated ecoregion. Based on historical data, these community measurements are highly variable. According to Merkel and Associates differences of 50% in the number of taxa or abundance/cover between any two sites would be considered in the realm of natural variation. Therefore, if a metric measured at a station was lower by 50% or more than the associated reference station, then that metric was flagged. When one or both metrics at a station were flagged, the biologist considered substrate data, historical data if available, looked at results of the receiving water and sediment measurements for causal relationships, and used best professional judgment to determine if intertidal or subtidal habitats required additional evaluation.

Graphs were prepared for species or taxonomic groups that were relatively abundant, and in some instances, species were placed into taxonomic groups for graphing purposes (e.g., red turf and red foliose algae were grouped into a red turf algal taxonomic group). Summary tables were prepared for species or taxonomic groups that were not relatively abundant or common. In addition, a comprehensive species list was developed from this survey, and previous surveys.

Subtidal Survey Methods: At each sample station, a diving biologist using SCUBA determined the distribution and abundance of subtidal invertebrates and algae at two isobaths (-12 and –40 ft MLLW). A 25-m long transect tape was established at each isobath. Kelp (i.e., large brown algae) abundance was counted in ten, randomly placed five-meter-long by two-meter-wide bands transects (10m^2). Observations included the number of kelp plants in each band transect, the number of stipes at a height of one meter above the bottom, and the size of the individual plants. Four size categories were measured; newly recruited kelp plants (minimum size 2-10 cm), juveniles (10-40 cm in length), subadult (between 40 cm and 2 m), and adults (greater than 2 m in length). The characteristic color and wavy pattern of the blades allowed biologists to readily identify even relatively small *Macrocystis* plants.

Biologists documented the abundance of key indicator plant and invertebrate species in ten, randomly placed one-meter by one-meter quadrats (1m^2). Biologists also quantified substrate type (sand, rock, cobble) and algal cover using a point contact method with 20 points sampled within the 1m^2 quadrat. A list of target species/assemblages that were surveyed at each subtidal sampling location is provided. These were common subtidal organisms present during previous Navy surveys. Other species of interest were also noted. Formal fish transects were not conducted, but all fish species observed were recorded to document presence and relative qualitative abundance (e.g., abundant, common, rare). Quality assurance was maintained by using experienced diving biologists, and by each biologist cross-checking for proper species identification, abundance estimate, and data recording for each quadrat.

Intertidal Survey Methods: At each sample station, marine biologists recorded the abundance and/or percent cover of organisms at each of three tidal elevations (+5, +3, and 0 ft MLLW) using a 0.25m^2 quadrat following methods used for previous surveys at SCI. A 10-m long transect tape was established at each tidal elevation, and four randomly placed quadrats along the transect line were sampled at each of the three tidal elevations. Two biologists were assigned to each quadrat to record abundance and/or percent cover (for invertebrates, algae, and substrate) for several target species that were determined to be key species in the previous marine resources inventory. Abundance was quantified by counting total individuals within each 0.25m^2 quadrat and percent cover was measured using the point contact method at 20 points within each 0.25m^2 quadrat.

Quality assurance was maintained by using experienced intertidal biologists, and by cross-checking for proper species identification, abundance estimate, and data recording for each quadrat. A list of target intertidal species/assemblages that were surveyed at each intertidal sampling location. These species are common intertidal organisms and are considered to be representative organisms that were present during previous surveys. Other species of interest and substrate type (rock, cobble, sand) were also noted. Cobble was defined as small, moveable rock generally less than 12 inches in diameter.

Several algal species were grouped into taxonomic categories to allow efficient field sampling and comparison with past studies. All species in the genus *Corallina* were grouped into the group coralline algae, red turf included low-lying red algae (e.g., *Gelidium* spp.), red foliose was made up of leafy erect red algae (e.g., *Pterocladia* spp.), Ralfsiaceae included all encrusting brown algae in the Ralfsiaceae family (e.g., algae that resemble "black tar"), and other browns included brown algae such as *Dictyota* spp., *Dictyopterus* spp., *Zonaria* spp., *Halydris* spp., *Colpomenia* spp., *Leathesia* spp., and *Scytosiphon* spp.

A total of ten locations were chosen for biological sampling around SCI. These included five locations that were representative of areas that discharges associated with distinct Navy operational activities. The total also included five locations chosen to represent areas that receive storm natural runoff not associated with Navy activities, and thereby considered a reference condition. The five reference locations were chosen because historical data indicated that there are four ecoregions around the island that result in different reference conditions. The ten sampling locations, grouped by ecoregion, are:

Castle Rock (CR) was chosen as a reference location for the north ecoregion, and was located approximately 0.5 miles west of Bird Rock. A rocky bluff backed the intertidal area, with patches of cobble at higher tidal levels, leading to bed rock at lower tidal levels. An expansive kelp forest was present offshore with extensive surfgrass beds present near shore. The substrate in this area consisted of a mixture of bedrock with moderate relief (2 meters in some places) and large boulders with interspersed patches of sand.

Northwest Harbor (NW) is located in the north ecoregion, and was an area requested to be sampled by the SWRCB since in-water BUDS training occurs in nearshore waters. In-water detonation training occurs directly offshore of BUDS Camp on sandy subtidal habitat in water ranging from 10 to 15 feet deep. The area boasts a wide variety of different marine habitats, including sandy beach, rocky intertidal habitat composed of boulders and cobble, and also formational rock along the western shoreline, sandy subtidal habitat, and a diverse rocky subtidal habitat. The cove is somewhat protected by prevailing northwesterly winds and swell, by a small island (Bird Rock) located offshore that provides a roosting area for a variety of sea birds and marine mammals. An extensive giant kelp forest was present both within the cove and further offshore. The ASBS sampling location was situated east of the sandy beach, along the boulder and cobble intertidal area, on a rocky headland between BUDS Camp and Graduation Beach. The subtidal sampling locations were situated directly offshore of the intertidal locations.

Five species or taxonomic groups were flagged for the intertidal habitat at Northwest Harbor for exceeding the 50% difference criteria, and included coralline algae, *Sargassum*, green algae, barnacles, and mussels. The total number of species was within the 50% criteria, which was almost expected as the comparisons are among organisms or groups of organisms that were previously reported to be common species at SCI. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, competitive interaction (biotic), substrate variability (the substrate at Northwest Harbor was predominantly boulder, while Castle Rock was bedrock), and exposure (Northwest Harbor is more protected than Castle Rock).

Four species or taxonomic groups were flagged for the subtidal habitat at Northwest Harbor for exceeding the 50% difference criteria, and included *Cystoseira*, *Phyllospadix*, crustose coralline algae, and urchins. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, competitive interaction (biotic), substrate variability, exposure, and species mobility.

East Airfield (EA) is located in the north ecoregion and east of the runway, and is representative of a storm water runoff area associated with airfield operations. The site was situated below a steep rocky bluff, with two distinct geological formations, and a small pocket beach that extended into the subtidal zone. The intertidal area was heterogeneous with rocky outcroppings separated by sand at lower tidal levels, small benches with tidepools at mid-tidal levels, and irregular and steep upper tidal level. A very narrow band of rocky substrate that supported giant kelp was present near shore, with sandy subtidal habitat present further offshore. A more extensive kelp forest was present downcoast of this site.

Three species or taxonomic groups were flagged for the intertidal habitat at East Airfield for exceeding the 50% difference criteria, and included coralline algae, *Sargassum*, green algae, and limpets. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability (e.g., green algae tend to be ephemeral species), competitive interaction (biotic), and substrate variability (the substrate at East Airfield was predominantly bedrock outcropping with sand patches, while Castle Rock was bedrock).

Twelve species or taxonomic groups were flagged for the subtidal habitat at East Airfield for exceeding the 50% difference criteria, and included *Laminaria*, *Cystoseira*, *Sargassum*, *Phyllospadix*, *Dictyota*, red turf algae, crustose coralline algae, and all of the invertebrates. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, competitive interaction (biotic), substrate variability (the 40-ft isobath at East Airfield was all sand, while Castle Rock was bedrock with high relief), exposure (East Airfield is more protected than Castle Rock), and species mobility.

Eel Point is within the west ecoregion. This region tends to be characterized as having a wide shelf of mostly bedrock with expansive kelp forests. It is also exposed to large swell for the entire year. The Eel Point (EP) site was located within the cove south of Eel Point, and was chosen as a duplicate reference location for this ecoregion to account for potential spatial variability. The intertidal area within the cove ranged from vertical rocky bluffs to cobble. The sampling location was located south of the point in the vicinity of an ephemeral stream/drainage, with boulder and cobble present at higher tidal levels, and bedrock at lower tidal levels. The subtidal zone consisted mostly of bedrock with moderate relief of up to about 2.5 meters. Patches of sand were common in deeper areas or in pockets between rocky outcroppings.

Lost Point is within the west ecoregion, and was also chosen as a reference location for this ecoregion. The Lost Point (LP) site was located within the cove south of Lost Point. The intertidal area within the cove ranged from vertical rocky bluffs to cobble. The sampling location was located south of the point in the vicinity of an ephemeral stream/drainage, with boulder and cobble present at higher tidal levels, and bedrock at lower tidal levels. The subtidal zone consisted mostly of bedrock with moderate and high relief of up to 4 meters. Small patches of sand were common in deeper areas or in pockets between rocky outcroppings.

West Airfield (WA) is located on the very north section of the west ecoregion. This site is located in West Cove, and is representative of a storm water runoff area associated with airfield operations. West Cove is a protected cove relative to the other sites within this region, with a small sandy beach bordered by a steep rocky intertidal area to the north, and relatively flatter intertidal bench to the south, where intertidal sampling was conducted. Sand extends into the subtidal zone providing a clear path for entrance into West Cove. Mid- to high-relief rock and bedrock were present to the north and south, which supported a dense giant kelp forest.

Twelve species or taxonomic groups were flagged for the subtidal habitat at Northwest Harbor for exceeding the 50% difference criteria, and included *Laminaria*, *Cystoseira*, *Sargassum*, *Phyllospadix*, *Dictyota*, red turf algae, crustose coralline algae, and all of the invertebrates. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, competitive interaction (biotic), substrate variability (the 40-ft isobath at East Airfield was all sand, while Castle Rock was bedrock with high relief), exposure (East Airfield is more protected than Castle Rock), and species mobility.

One taxonomic group was flagged for the subtidal habitat at West Airfield for exceeding the 50% difference criteria, and included crustose coralline algae. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, competitive interaction (biotic), substrate variability (the 40-ft isobath at East Airfield was all sand, while Castle Rock was bedrock with high relief), exposure (East Airfield is more protected than Castle Rock), and species mobility.

Stone Station or East Reference (REF) is located in the east ecoregion, and was chosen as a reference location for this ecoregion. Similar to other locations within this region, the island drops off very rapidly with steep depth contours in the subtidal zone. The sampling area was located in the vicinity of an ephemeral stream/drainage, with large boulders and cobble present in the intertidal and subtidal zones. A narrow, but dense stand of giant kelp was present in the subtidal zone.

NOTS Pier (NT) is located in the east ecoregion, and was an area requested to be sampled by the SWRCB since the area is used to stage testing operations and is a potential source of runoff. The east side of the island drops off very rapidly and as a result there are not large expansive stands of giant kelp as along the west shore, but rather relatively narrow bands that parallel the coast. The intertidal zone was predominantly cobble and boulder, which also extended into the subtidal zone. The subtidal zone consisted mostly of very large (often several meters in size) boulders with small patches of sand. Adjacent to the boulder habitat, were large expanses of sandy subtidal habitat that supported isolated beds of eelgrass.

Five subtidal species or taxonomic groups were flagged for the subtidal habitat at NOTS Pier for exceeding the 50% difference criteria, and included *Pterygophora*, *Laminaria*, *Cystoseira*, *Dictyota*, and red turf algae. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability (e.g., *Pterygophora* was relatively uncommon at SCI), competitive interaction (biotic), and substrate variability (the 40-ft isobath at reference location had a high percentage of sand compared to the NOTS location).

Intertidal species abundance or percent cover and number of taxa were compared to a reference location (Stone Station). Three species or taxonomic groups were flagged for the intertidal habitat at NOTS Pier for exceeding the 50% difference criteria, and included encrusting coralline algae, *Eisenia*, and littorine snails. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, competitive interaction (biotic), and substrate variability (the substrate at the reference location was predominantly cobble), and species mobility.

Sun Point (SP) was chosen as a reference location for the Pyramid Ecoregion. Unlike many of the other locations, Sun Point area has a large sandy beach, with large expanses of sandy subtidal habitat offshore. Relatively small, but dense stands of giant kelp were only present on patch reefs located offshore. The intertidal and shallow subtidal sampling locations were located east of an ephemeral stream/drainage. The intertidal zone consisted of a relatively low relief bedrock bench, while the shallow subtidal zone consisted of moderate to high-relief bedrock with sand. The deeper subtidal sampling location was located further offshore, and consisted of bedrock and cobble with moderate amounts of sand.

Horse Beach Cove (HB), in SHOBA is representative of an area that has an active bombing range, and is within the Pyramid ecoregion. The sampling location was along western shore of Horse Beach Cove, an area that was predominantly irregular bedrock in the intertidal and shallow subtidal zones. Deeper subtidal areas consisted of lower relief bedrock and boulder interspersed with sand. Sandy habitat was more common in the deeper depths, towards the center of the bay.

The location sampled in the Pyramid ecoregion included Horse Beach. Species abundance or percent cover and number of taxa were compared to a reference location (Sun Point). Four species or taxonomic groups were flagged for the intertidal habitat at Horse Beach for exceeding the 50% difference criteria, and included barnacles, *Serpulorbis*, littorine snails, and mussels. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by competitive interaction (the intertidal zone at Horse Beach had a high cover of turf algal species which may affect the distribution of invertebrates), and substrate variability (the substrate at the reference location was predominantly a bedrock bench compared to a irregular bedrock platform with tidepools), and species mobility.

Six subtidal species or taxonomic groups were flagged for the subtidal habitat at Horse Beach for exceeding the 50% difference criteria, and included *Phyllospadix*, *Dictyota*, red turf algae, sponges, ectoprocts, and ascidians page. The total number of species was within the 50% criteria. According to Merkel and Associates there was no apparent impact to beneficial use based on these metrics as they can be explained by natural variability, competitive interaction (biotic), and substrate variability (the 40-ft isobath at Horse Beach location had a high percentage of sand compared to the Sun Point [reference] location).

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APPENDICIES

Appendix A. Water Quality Threats for ASBS.

ASBS No.	ASBS Name	Regional Water Board	Approximate Number of Higher Threat Discharges	Priority Direct Discharge Sources	Direct Discharges, Potential Constituents of Concern	Other Watershed sources	303d listings
1	Jughandle Cove	1	1 (Caltrans bridge)	highway runoff	metals, trash, indicator bacteria	logging, lumber processing, septics	---
2	Del Mar Landing	1	3 storm drains	residential and road runoff;	pesticides, PAHs, metals, indicator bacteria	septics, golf courses, highway runoff	---
3	Gerstle Cove	1	1 storm drain, and boat ramp area	recreational facility, parking lot and boat ramp runoff	indicator bacteria, PAHs, metals	septics	---
4	Bodega	1	1 point source, plus discharge and runoff via wetland	waste seawater point source	metals, chlorine	runoff from nearby watersheds	---
5	Saunders Reef	1	6 storm drains	highway and parking runoff	PAH's, bacteria, metals, trash	homes, septics	---
6	Trinidad Head	1	5 storm drainages and nonpoint sources, 1 waste seawater outfall, plus seeps	septics and contaminated seeps, pier and mooring field; boat cleaning; urban runoff	pesticides, metals, chlorine, PAH's, indicator bacteria		Trinidad Beach: indicator bacteria

ASBS No.	**ASBS Name**	**Regional Water Board**	**Approximate Number of Higher Threat Discharges**	**Priority Direct Discharge Sources**	Direct Discharges, Potential Constituents of Concern	Other Watershed sources	303d listings
7	King Range, specifically in the immediate vicinity of Shelter Cove	1	9 storm drainages, 1 sewage outfall, 1 fish cleaning station, 1 boat ramp	fish cleaning point source; launch ramp and marine operations; residential and road runoff, sewage treatment plant point source	pesticides, PAHs, indicator bacteria	septics?	Mattole River approx 2 miles north of the ASBS was listed for sediment and temperature, TMDL adopted in 2003
8	Redwood National Park	1	39 storm drainages and 1 sewage outfall	highway parking lot and campground runoff; sewage treatment	metals, PAH's, trash	grazing, septics, logging	Klamath River: nutrients, organic enrichment, low oxygen, temperature, sediment; Redwood Creek: sediment and temperature
9	James V. Fitzgerald	2	19 municipal, military or transportation storm drains	sewage collection and pumping facility - sewage spills; residential, parking, and highway runoff	pesticides, PAHs, metals, indicator bacteria		Shoreline and San Vicente Creek: indicator bacteria; Pillar Point: mercury
10	Farallon Islands	2	0		---	runoff from San Francisco Bay	

ASBS No.	**ASBS Name**	**Regional Water Board**	**Approximate Number of Higher Threat Discharges**	**Priority Direct Discharge Sources**	Direct Discharges, Potential Constituents of Concern	Other Watershed sources	303d listings
11	Duxbury Reef	2	10 storm drains and nonpoint sources	residential parking lot and road runoff; septics/seeps;	pesticides, metals, PAH's, indicator bacteria	Alder Creek watershed, septics, grazing, agriculture; runoff from San Francisco Bay	Bolinas Beach: indicator bacteria
12	Point Reyes Headlands	2	7 storm drains and nonpoint sources	recreational facilities runoff	indicator bacteria	septics, grazing	---
13	Double Point ASBS	2	0	---	---	---	---
14	Bird Rock	2	0	---	---	Tidal flow from Tomales Bay and Bodega Bay---	---
15	Ano Nuevo	3	14 storm drainages and nonpoint sources	agriculture runoff, highway runoff	metals, PAHs, pesticides, trash	recreational facilities runoff	---
16	Point Lobos ASBS	3	16 storm drainages and nonpoint sources	parking lot and boat launch, recreational facility and road runoff	PAH's, metals	residential runoff	---
17	San Miguel, Santa Rosa, Santa Cruz Islands ASBS	3	0	grazing and roads	legacy sediment	runoff from mainland	---

ASBS No.	**ASBS Name**	**Regional Water Board**	**Approximate Number of Higher Threat Discharges**	**Priority Direct Discharge Sources**	Direct Discharges, Potential Constituents of Concern	Other Watershed sources	303d listings
18	Julia Pfeiffer Burns	3	38 storm drainages > 0.25m	highway runoff, legacy sedimentation	sediment, trash, metals, PAHs, indicator bacteria	recreational facility runoff, septics	---
19	Pacific Grove	3	44 municipal storm drains > 0.25m, plus marine lab and aquarium discharges	waste sea water point sources, urban runoff	pesticides, trash, metals, PAH's		---
20	Salmon Creek Coast	3	22 storm drainages > 0.25m	highway and rural residential runoff	metals, PAH's		---
21	San Nicolas Island & Begg Rock	4	10 storm drains and 1 brine discharge pt. source	military operations, industrial runoff, desal brine point source	metals, perchlorate, PAH's		---
22	Santa Barbara and Anacapa Islands	4	0	2 boat landings, only medium priority		runoff from mainland	---
23	San Clemente Island	4	16 storm drains and 1 sewage outfall	military operations, sewage treatment plant, industrial runoff	metals, ammonia, perchlorate, PAH's, indicator bacteria		---

ASBS No.	**ASBS Name**	**Regional Water Board**	**Approximate Number of Higher Threat Discharges**	**Priority Direct Discharge Sources**	Direct Discharges, Potential Constituents of Concern	Other Watershed sources	303d listings
24	Laguna Point to Latigo Point	4	120 municipal storms drains	residential runoff; highway runoff; recreational facilities, septic leach fields on beach	pesticides, metals, PAHs, trash, indicator bacteria	upstream septics; residential runoff and horse property runoff;	Santa Monica Bay and beaches (Escondido, Paradise Cove, Point Dume, Zuma, Trancas Meyer, Sea Level, Leo Carillo Nicholas Canyon): various pollutants
25	Northwest Santa Catalina Island ASBS	4	26 storm drains and nonpoint source discharges, plus marine lab discharges	residential commercial and road runoff; pier and mooring facilities;	metals, PAHs, trash, indicator bacteria	runoff from mainland; sewage treatment plant	---
26	Western Santa Catalina Island	4	3 nonpoint sources	boating; road runoff	metals, PAH's		---
27	Farnsworth Bank	4	0	----	---	----	---
28	Southeast Santa Catalina Island	4	2 storm drainages/ nonpoint sources	quarry operations; barge landing	metals, PAHs	runoff from mainland	---

ASBS No.	**ASBS Name**	**Regional Water Board**	**Approximate Number of Higher Threat Discharges**	**Priority Direct Discharge Sources**	Direct Discharges, Potential Constituents of Concern	Other Watershed sources	303d listings
29	La Jolla	9	14 storm drains >0.5 m, plus 156 storm drains 0.2 -0.5 m	urban runoff	pesticides, metals, PAHs, trash, indicator bacteria	runoff from nearby watersheds	Beaches: indicator bacteria
30	Heisler Park	9	3 storm drains >0.5 m, plus 2 other large storm drains of undetermined size	urban runoff	pesticides, metals, PAHs, trash, indicator bacteria	runoff from nearby watersheds; sewer spills	Beaches, Heisler Park N: indicator bacteria
31	San Diego-Scripps	9	22 storm drains >0.25 m, 10 storm drains 0.2 – 0.25 m, plus marine lab discharges	pier, waste seawater point source, urban runoff	pesticides, metals, PAHs, trash, indicator bacteria	runoff from nearby watersheds	Beaches: indicator bacteria
32	Robert E. Badham	8	3 storm drains ≥ 1.0 m, 3 storm drains 0.2 – 0.33 m	urban runoff	pesticides, metals, PAHs, trash, indicator bacteria	runoff from nearby watersheds	Buck Gully Creek: indicator bacteria
33	Irvine Coast	8 and 9	16 storm drains > 0.5 m, plus shallow ground water runoff from bluff	urban and highway runoff, golf course, recreational facilities	pesticides, metals, PAHs, trash, indicator bacteria	runoff from nearby watersheds	Los Trancos Creek: indicator bacteria

ASBS No.	**ASBS Name**	**Regional Water Board**	**Approximate Number of Higher Threat Discharges**	**Priority Direct Discharge Sources**	Direct Discharges, Potential Constituents of Concern	Other Watershed sources	303d listings
34	Carmel Bay	3	33 storm drains ≥ 0.5m, 135 storm drains 0.2 – 0.3m, 1 sewage outfall, plus golf course nonpoint source runoff	golf course runoff; sewage treatment plant; urban and highway runoff recreational facilities,	pesticides, metals, PAHs, trash, indicator bacteria	upstream sources on Carmel River	Stillwater Cove: indicator bacteria

Appendix B. Data from Runoff (Discharges) Samples Provided by Applicants.

ASBS	Responsible Party	Nearest Discharge	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	NH3N
Ano Nuevo Point	CalTrans	MUG 011	5	<0.2	4.7	10	5.4	<0.2	4.6	<2	<0.2	38	<100
Carmel Bay	City of Carmel	CAR 205											150
		CAR 205											160
Del Mar Landing	Sea Ranch	DEL 005	<0.0020	<0.0010	<0.0010	<0.050	<0.0050	ND	<0.010	<0.0050	ND	<0.050	200
		DEL 016	<0.0020	<0.0010	<0.0010	<0.050	<0.0050	ND	<0.010	<0.0050	ND	<0.050	200
Duxbury Reef	Marin County	DUX 016	0.76	0.58	1.99	3.93	0.23	ND	21.8	0.78	ND	15.1	40
		DUX 016	0.79	0.6	1.99	3.9	0.22	ND	22.2	0.72	ND	15.4	30
		DUX 021	1.16	<0.1	1.85	3.46	1.9	0.026	26.4	1.14	<0.1	10.5	
		DUX 021	1.16	<0.1	1.92	3.52	1.97	0.0252	26.3	1.25	<0.1	10.4	
Heisler Park	City of Laguna Beach	HSL 013	2	0.5	5.2	110	16	<0.10	15	0.88	<0.50	300	500
		HSL 013	1.5	<0.50	2.5	36	6.6	<0.10	6.2	1.4	<0.50	130	300
Irvine Coast	CalTrans	IRV 020	2.8	1.1	14	100	6.2	<0.2	16	<0.5	<0.5	41	1700
James. F. Fitzgerald	CalTrans	FIT 026	<0.5	<0.2	6.1	8.5	2.5	<0.2	7.8	<2	<0.2	23	110
La Jolla	City of San Diego	SDL 165											940
		SDL 165											890
		SDL 165											1100
		SDL 165	13.7	ND	8.3	31.3	10.2	ND	9.91	1.13	ND	95.6	60
		SDL 165	2.76	ND	1.91	36.6	6.9	ND	3.5	1.37	ND	77.7	600
		SDL062											2000
		SDL062											200
		SDL062											600.0
		SDL062											0
		SDL062											400
		SDL064											0
		SDL064											0
		SDL064											820
		SDL064											ND
		SDL165											1000
		SDL165											0
		SDL165											920
		SDL165											207
Laguna Point to Latigo Point	CalTrans	MUG 003	3.8	0.44	13	15	7.5	<0.2	10	2.2	<0.5	57	1000
		MUG 003	1.6	0.25	4	25	3.3	<0.2	6.8	0.55	<0.5	110	1200

ASBS	Responsible Party	Nearest Discharge	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	NH3N
Laguna Point to Latigo Point (cont.)	Los Angeles County	MUG 226	3.94	0.6	95.80	31.40	6.37	<0.05	49.10	2.13	0.16	88.30	NT
		MUG 226	3.98	0.59	97.00	31.50	6.18	<0.05	49.30	1.83	0.19	87.10	
		MUG 226	3.96	0.595	96.40	31.45	6.28	<0.05	49.20	1.98	0.18	87.70	
		MUG 371	7.69	0.52	31.70	60.60	3.20	<0.05	15.20	2.58	<0.1	148.00	500
		MUG 371	7.75	0.45	31.20	59.10	3.26	<0.05	14.90	2.42	<0.1	146.00	
		MUG 371	7.72	0.485	31.45	59.85	3.23	<0.05	15.05	2.50	<0.1	147.00	
		MUG122	5.32	0.38	7.01	3.36	0.88	0.07	7.38	0.76	0.21	4.08	
		MUG122											200.0
		SDL062	4.24	2.01	3.42	81.20	14.40	0.16	49.80	8.84	0.15	11.30	
Newport Beach	City of Newport Beach	NEW 013		36.7		17.2							10
		NEW 020		4.58		2.85							10
		NEW 020		3.58		9.52							
		NEW 020		3.92		9.48							
		NEW 020		5.47		7.47							
		NEW 020		0.96		5.69							
		NEW 020		0.34		3.41							
		NEW 020		0.61		3.62							
		NEW 020	4.3	10.2		29.3	2.85	0.0285	27.9	37.4	<0.1	47.8	
		NEW 020		7.96		11.4							
		NEW 020		8.01		10.5							
		NEW 020		3.35		3.59							
Pacific Grove	Hopkins Marine Laboratory	PCG 241	0.95	0.3	1.23	45.2	18.1	ND	2.44	ND	ND	201	<10
		PCG 249	1.33	<0.1	13.4	36.2	15.3	0.7	2.68	0.94	<0.1	102	60
		PCG 249	1.32	<0.1	12.4	36.2	15.3	0.72	2.63	0.55	<0.1	102	
		PCG 256	1.68	ND	0.47	11	4.69	0.0149	0.93	ND	ND	59.9	10000
		PCG 256	1.76	ND	0.46	11	4.63	0.0172	0.92	0.5	ND	59.4	
		PCG 257	1.17	0.3	1.49	19.1	31.5	0.0155	1.65	ND	ND	129	20000
		PCG 258	23.9	ND	0.22	7.52	3.53	ND	0.34	ND	ND	115	300000
		PCG 259	29.9	ND	0.18	7.65	2.12	ND	0.39	ND	ND	94	470000
	Monterey Bay Aquarium	PCG 260											<10
		PCG 260											50
		PCG 260											10
		PCG 260											<10
		PCG 260											10
		PCG 260											<10
		PCG 260											30
		PCG 260											10

ASBS	Responsible Party	Nearest Discharge	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	NH3N
Pacific Grove (cont)	Monterey Bay Aquarium	PCG 260											30
		PCG 260											30
		PCG 260											30
		PCG 260											70000
		PCG 260	12.6	<0.1	1.97	59.7	2.63	0.02	5.5	1	<0.1	209.5	50000
		PCG 260	1.37	0.026	0.82	0.97	0.109	0.02	0.354	0.021	<0.005	2.65	20000
		PCG 260	4.19	<0.2	0.81	33.3	4.62	<0.01	1.68	<0.2	<0.5	149.5	190000
		PCG 260	1.43	0.76	2.18	29.7	1.32	<0.01	0.64	3.5	<0.5	67.5	80000
		PCG 260											60000
		PCG 260											40000
		PCG 260											180000
		PCG 260											
	Hopkins Marine Laboratory	PCG 261		40									3000
		PCG 262	2.51	0.22	2.34	69.2	9.6	ND	0.88	0.84	ND	70.6	<100
Redwood National and State Park	CalTrans	RED 023	<0.5	<0.2	<1	1.2	<0.5	<0.2	1.9	<2	<0.2	14	590
San Clemente Island	Department of Defense, US Navy	SCI 001				70	120						
		SCI 007	ND	ND	ND	18	ND	ND	ND	ND	ND	44	
		SCI 019	6.6	0.4		36.6	5.5	<0.2	8.9	<2.3	<1.1	141	
		SCI 019	11.5	0.7		32.9	11.7	<0.2	18	3.7	<1.1	137	
		SCI 019	3.9	<0.29	8.1	16.3	2.9	0.12	4.6	ND	ND	65.1	
		SCI 019			ND	33						160	
		SCI 019	5.1	ND	ND	11	ND	ND	ND	ND	ND	11	
		SCI 019			15	45						320	
		SCI 019	ND	ND	ND	21	4.7	ND	ND	ND	ND	190	
		SCI 019				46						200	440
		SCI 020			19.6	62.2							320
		SCI 020			18.3	21.6							480
		SCI 020			5.9	10.7							
		SCI 020			ND	60							
		SCI 030	12	0.8	15.5	56.3	13.1	<0.2	11	2.7	<1.1	903	
		SCI 030	28	<0.29	125	73.1	47.2	0.4	69	5.9	<1.1	375	
		SCI 030	15	<0.29	108	58.4	28.2	0.2	58	<2.3	<0.11	200	
		SCI 030			ND	18	ND		ND			110	
		SCI 030			140	64	39		68			230	
		SCI 030			200	98	46		98			360	
		SCI 078	13	<0.29	37.2	24.7	9	0.25	25	4.5	<0.11	45.5	30
		SCI 078	87	<0.29	1010	309	169	0.6	520	17.9	<0.11	1150	

ASBS		Nearest Discharge	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	NH3N
San Clemente Island (cont.)	Department of Defense, US Navy	SCI 078	6.2	ND	33	22	8.9	0.32	21	2.2	ND	120	
		SCI 088					11						
		SCI 088					34						
		SCI 088					18						
San Nicholas Island	Department of Defense, US Navy	SNI006	<0.01	<0.005	<0.01	0.01	<0.01	<0.00001	<0.01	<0.01	<0.01	0.03	
		SNI006	ND	ND	ND	0.01	ND	ND	ND	ND	ND	0.03	
		SNI006	<0.01	<0.005	<0.01	0.02	<0.01	<0.00001	<0.01	<0.0.1	<0.01	0.03	
		SNI006	<0.01	<0.005	<0.01	0.02	<0.01	<0.00001	<0.01	<0.01	<0.01	0.03	
		SNI006	<0.01	<0.005	<0.01	0.01	<0.01	<0.00001	<0.01	<0.01	<0.01	0.06	
		SNI006	0.03	0.006	0.1	0.09	0.1	0.0001	0.07	<0.01	<0.01	0.5	
		SNI006	0.056	<0.01	<0.01	0.055	<0.05	<0.0002	<0.01	<0.1	<0.01	<0.05	
		SNI006	0.056	<0.01	<0.01	0.055	<0.05	<0.0002	<0.01	<0.1	<0.01	<0.05	
		SNI006	<0.05	<0.01	<0.01	0.061	<0.05	<0.0002	<0.01	<0.1	<0.01	<0.05	
		SNI006	<0.05	<0.01	<0.01	0.061	<0.05	<0.0002	<0.01	<0.1	<0.01	<0.05	
		SNI018	ND	ND	ND	0.1	ND	0.00002	ND	ND	ND	0.17	
		SNI018	ND	ND	ND	0.03	ND	0.00004	ND	ND	ND	0.07	
		SNI018	<0.01	<0.005	0.01	0.1	<0.01	0.00002	0.1	<0.01	<0.01	0.15	
		SNI018	<0.01	<0.005	0.01	0.12	0.01	0.00003	<0.01	<0.01	<0.01	0.11	
		SNI018	ND	ND	0.01	0.12	0.01	0.00003	ND	ND	ND	0.11	
		SNI018	<0.01	<0.005	<0.01	0.05	<0.01	0.00001	<0.01	<0.01	<0.01	0.08	
		SNI018	<0.01	<0.005	<0.01	0.05	<0.01	0.00001	<0.01	<0.01	<0.01	0.08	
		SNI018	<0.01	<0.005	0.01	0.09	<0.01	0.00005	<0.01	<0.01	<0.01	0.15	
		SNI018	<0.01	<0.005	0.01	0.09	<0.01	0.00005	<0.01	<0.01	<0.01	0.15	
		SNI018	0.01	<0.005	0.05	0.11	0.03	0.00007	0.03	<0.01	<0.01	0.25	
		SNI018	0.01	<0.005	0.05	0.11	0.03	0.00007	0.03	<0.01	<0.01	0.25	
		SNI018	<0.01	<0.005	0.01	0.06	<0.01	0.00003	<0.01	<0.01	<0.01	0.13	
		SNI018	<0.01	<0.005	0.01	0.06	<0.01	0.00003	<0.01	<0.01	<0.01	0.13	
		SNI018	<0.05	<0.01	0.069	0.12	<0.05	<0.0002	0.028	<0.1	<0.01	0.17	
		SNI018	<0.05	<0.01	0.069	0.12	<0.05	<0.0002	<0.028	<0.1	<0.01	0.17	
		SNI018	<0.05	<0.01	0.011	0.12	<0.05	<0.0002	<0.01	<0.1	<0.01	0.11	
		SNI018	<0.05	<0.01	0.011	0.12	<0.05	<0.0002	<0.01	<0.1	<0.01	0.11	
		SNI019	ND	ND	0.01	0.14	0.04	0.00003	0.01	ND	ND	0.15	
		SNI019	0.03	ND	0.11	0.18	0.12	0.00022	0.03	ND	ND	0.34	
		SNI019	ND	ND	0.03	0.09	0.03	0.00006	ND	ND	ND	0.14	
		SNI019	ND	ND	ND	0.09	0.01	0.0004	ND	ND	ND	0.11	
		SNI019	<0.01	<0.005	<0.01	0.06	<0.01	0.00002	<0.01	<0.01	<0.01	0.05	
		SNI019	<0.01	<0.005	<0.01	0.08	0.02	0.00013	<0.01	<0.01	<0.01	0.14	

ASBS	Responsible Party	Nearest Discharge	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	NH3N
San Nicholas Island (cont.)	Department of Defense, US Navy	SNI019	<0.01	<0.005	0.01	0.19	0.07	0.00004	0.02	<0.01	<0.01	0.18	
		SNI019	ND	ND	0.01	0.19	0.07	0.00004	0.02	ND	ND	0.18	
		SNI019	<0.01	<0.005	0.01	0.11	0.03	0.00008	0.01	<0.01	<0.01	0.09	
		SNI019	ND	ND	0.01	0.11	0.03	0.00008	0.01	ND	ND	0.09	
		SNI019	<0.01	<0.005	<0.01	0.13	<0.01	0.00002	<0.01	<0.01	<0.01	0.12	
		SNI019	<0.01	<0.005	<0.01	0.13	<0.01	0.00002	<0.01	<0.01	<0.01	0.12	
		SNI019	<0.01	<0.005	0.01	0.11	0.02	0.00003	<0.01	<0.01	<0.01	0.1	
		SNI019	<0.01	<0.005	<0.01	0.11	0.02	0.00003	<0.01	<0.01	<0.01	0.1	
		SNI019	<0.01	<0.005	<0.01	0.11	<0.01	0.00002	<0.01	<0.01	<0.01	0.11	
		SNI019	<0.01	<0.005	<0.01	0.11	<0.01	0.00002	<0.01	<0.01	<0.01	0.11	
		SNI019	<0.01	<0.005	0.02	0.12	0.05	0.00002	0.01	<0.01	<0.01	0.23	
		SNI019	<0.01	<0.005	0.02	0.12	0.05	0.00002	0.01	<0.01	<0.01	0.23	
		SNI019	<0.05	<0.01	0.012	0.31	<0.05	<0.0002	0.023	<.1	<0.01	0.27	
		SNI019	<0.05	<0.01	0.012	0.31	<0.05	<0.0002	0.023	<0.1	<0.01	0.27	
		SNI019	<0.05	<0.01	<0.01	0.1	<0.05	<0.0002	<0.01	<0.1	<0.01	0.088	
		SNI019	<0.05	<0.01	<0.01	0.1	<0.05	<0.0002	<0.01	<0.1	<0.01	0.088	
		SNI024	<0.01	<0.005	<0.01	0.02	<0.01	0.00002	0.03	<0.01	<0.01	0.09	
		SNI024	0.02	<0.005	0.02	0.03	0.01	0.00019	0.03	<0.01	<0.01	0.22	
		SNI024	1.2	<0.005	1.2	0.01	0.1	<0.00001	<0.01	<0.01	<0.01	0.44	
		SNI024	<0.01	<0.005	0.03	0.02	0.01	0.00004	0.02	<0.01	<0.01	0.38	
		SNI024	5.4	<0.005	5.4	0.03	0.46	0.00004	0.02	<0.01	<0.01	0.18	
		SNI024	ND	ND	0.01	0.03	0.46	0.00001	0.01	ND	ND	0.44	
		SNI024	<0.01	<0.005	<0.01	<0.01	<0.01	0.00002	<0.01	<0.01	<0.01	0.08	
		SNI024	0.4	<0.005	0.4	0.01	0.05	<0.00001	<0.01	<0.01	<0.01	0.06	
		SNI024	ND	ND	ND	ND	ND	0.00002	ND	ND	ND	0.08	
		SNI024	ND	ND	ND	0.01	0.05	ND	ND	ND	ND	0.06	
		SNI024	<0.01	<0.005	0.01	0.03	0.36	0.00001	0.11	<0.01	<0.01	0.22	
		SNI024	<0.01	<0.005	<0.01	0.02	<0.01	0.00004	0.01	<0.01	<0.01	0.54	
		SNI024	<0.01	<0.005	0.01	0.03	0.69	0.00001	0.11	<0.01	<0.01	0.22	
		SNI024	<0.01	<0.005	0.03	0.04	0.54	0.00001	0.03	<0.01	<0.01	0.11	
		SNI024	<0.01	<0.005	<0.01	0.01	<0.01	0.00002	<0.01	<0.01	<0.01	0.15	
		SNI024	<0.01	<0.005	0.03	0.04	0.54	0.00001	0.03	<0.01	<0.01	0.11	
		SNI024	<0.01	<0.005	<0.01	0.09	0.38	0.00001	0.17	<0.01	<0.01	0.1	
		SNI024	<0.01	<0.005	<0.01	0.02	<0.01	0.00003	0.01	<0.01	<0.01	0.39	
		SNI024	<0.01	<0.005	<0.01	0.02	<0.01	0.00003	0.01	<0.01	<0.01	0.9	
		SNI024	<0.01	<0.005	0.01	0.06	0.57	0.00002	0.08	<0.01	<0.01	0.18	
		SNI024	0.03	<0.005	0.15	0.1	0.07	0.0052	0.1	<0.01	<0.01	0.42	

ASBS	Responsible Party	Nearest Discharge	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	NH3N
San Nicholas Island (cont.)	Department of Defense, US Navy	SNI024	<0.01	<0.005	0.15	0.1	0.07	0.0052	0.1	<0.01	<0.01	0.42	
		SNI024	<0.05	<0.01	0.056	0.12	0.55	<0.0002	0.074	<0.1	<0.01	0.38	
		SNI024	<0.05	<0.01	0.056	0.12	0.55	<0.0002	0.074	<0.1	<0.01	0.38	
		SNI024	0.075	<0.01	0.16	0.19	0.098	0.00037	0.12	<0.1	<0.01	0.53	
		SNI024	0.075	<0.01	0.16	0.19	0.098	0.00037	0.12	<0.1	<0.01	0.53	
		SNI024	<0.05	<0.01	0.075	0.098	<0.05	0.0002	0.052	<0.1	<0.01	0.24	
		SNI024	<0.05	<0.01	<0.01	0.049	0.33	<0.0002	0.013	<0.1	<0.01	0.074	
		SNI024	<0.05	<0.01	0.075	0.098	<0.05	0.0002	0.052	<0.1	<0.01	0.24	
		SNI024	<0.05	<0.01	<0.01	0.049	0.33	<0.0002	0.013	<0.1	<0.01	0.074	
Santa Catalina Island	Santa Catalina Island Co.	CAT057	8.46	1.58	12.50	40.50	14.80	0.04	18.40	1.32	ND	141.00	200
		CAT057	8.11	1.21	12.10	37.70	15.10	0.04	18.00	1.00	ND	139.00	200
		CAT057	1.95	0.06	1.45	1.33	0.40	0.01	1.49	ND	ND	1.54	20
		CAT057	1.94	0.06	1.22	1.41	0.45		1.65	ND	ND	1.59	ND
		CAT057	1.51	3.40	4.16	9.62	0.23	ND	2.72	10.90	ND	22.80	450
		CAT057	0.95	4.19	4.38	9.91	0.18	1.89		9.78	ND	22.50	ND
		CAT057	1.69	0.04	0.31	0.16	0.03	0.01	0.19	ND	ND	0.05	ND
		CAT057	1.83	0.03	0.57	0.37	ND	ND	0.58	ND	ND	0.12	ND
		CAT057	2.80	1.62	43.40	19.10	10.00	0.07	50.70	6.15	ND	39.80	
		CAT057	3.03	1.58	43.80	18.70	9.90		50.00	5.88	ND	1.77	
	Connelly-Pacific	CAT002	3.26	0.62	7.36	30.80	6.52	0.08	54.00	0.16	ND	53.40	
		CAT002	1.64	0.07	0.32	0.33	0.06	ND	0.48	0.02	ND	0.36	
		CAT002	1.51	3.40	4.16	9.62	0.23	ND	2.72	10.90	ND	22.80	
		CAT002	0.95	4.19	4.38	9.91	0.18	1.89		9.78	ND	22.50	
		CAT002	1.69	0.04	0.31	0.16	0.03	0.01	0.19	ND	ND	0.05	
Trinidad Head	Trinidad Rancheria	TRI 030	1.1	0.3	3.5	41.2	1.98	ND	5.5	0.6	ND	206	

<u>Note</u>: A bold number indicates that readings exceeded the California Ocean Plan Table B Objective.

Appendix C. Data from Receiving Water Samples Provided by Applicants.

ASBS	Responsible Party	Nearest Discharge	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	NH3N
Duxbury Reef	Marin County	DUX 016	0.76	0.58	1.99	3.93	0.23	ND	21.8	0.78	ND	15.1	30
		DUX 016	0.79	0.6	1.99	3.9	0.22	ND	22.2	0.72	ND	15.4	40
Heisler Park	City of Laguna Beach	HSL 002	3.5	<1.0	16	23	2.3		12	5.6	<2	67	122
		HSL 002	<2.0	<1.0	9.2	98	14		13	2	<2	250	448
		HSL 002		<1.0	<8	<2	<2		4.3		<2	<10	<50
		HSL 002											100
		HSL 002		<1.0	<8	<2	<2		6.8		<2	<10	
		HSL 002	1.52	0.049	0.395	0.219	0.067		0.325	<0.015	<0.01	2.86	
		HSL 002	2.5	<1.0	<8	14	<2		4.2	4.6	<2	26	
		HSL 002	<2.0	<1.0	<8	39	<2		6.5	<2	<2	94	
		HSL 013	4.5	1	18	92	44		15	<2	<2	360	461
		HSL 013		<1.0	<8	5	<2		<4		<2	17	151
		HSL 013		<1.0	<8	9.2	<2		<4		<2	27	<50
		HSL 013		<1.0	<8	15	<2		<4		<2	26	<50
		HSL 013											<50
		HSL 013		<0.5	2.6	25	4.8		9.9		<1	54	<50
		HSL 013		<0.5	3.7	54	4		6.3		<1	150	160
		HSL 013	<2.0	<1.0	<8	31	2.1		<4	<2	<2	42	
		HSL 013		<1.0	<8	3.6	<2		<4		<2	15	
		HSL 013		<1.0	<8	6.3	<2		<4		<2	32	
		HSL 013		<1.0	<8	17	<2		<4		<2	29	
		HSL 013		<1.0	<8	6.4	<2		<4		<2	22	
		HSL 013		<1.0	<8	8.2	<2		<4		<2	34	
		HSL 013		<0.5	1.6	17	2.1		6.6		<1	34	
		HSL 013		<0.5	2.1	41	1.9		5.4		<1	110	
		HSL 013		6.2	<2	27	3.5		<2		120		250
		HSL 013		11	<2	150	3.4		<2		164		462
		HSL 013		<4	<2	13					560		<50
		HSL 013		<1.0	<8	2.2	<2		6.5		<2	18	<50
		HSL 013		<1.0	<8	3.2	<2		<4		<2	25	<50
		HSL 013											<50
		HSL 013			<0.5	<1	3.8	1.9		6.8		<1	33000
		HSL 013		<0.5	7.7	19	4.7		7.4		<1	36	52
		HSL 013		<0.5	<1	15	1.5		9		<1	61	62

ASBS	Responsible Party	Nearest Discharge	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	NH3N
Heisler Park (cont.)	City of Laguna Beach	HSL 013	1.37	0.091	0.505	0.966	0.324		0.432	0.02	<0.01	5.77	200
		HSL 013		<4	<2	<10	2.5		<2				
		HSL 013		4	<2	62	2.3		2.6				
		HSL 013		<4	<2	12							
		HSL 013		<1.0	<8	2.7	<2		7.6		<2	27	
		HSL 013		<1.0	<8	3.2	<2		<4		<2	19	
		HSL 013		<1.0	<8	4.2	<2		<4		<2	<10	
		HSL 013		<1.0	<8	3.3	<2		<4		<2	15	
		HSL 013		<0.5	<1	2.8	1.1		6.7		<1	29	
		HSL 013		<0.5	<1	12	<1		<4		<1	12	
		HSL 013		<0.5	<1	12	<1		9.6		<1	53	
		HSL 013		<0.5	6.2	7.1	2.8		6		<0.5	22	
		HSL 013		<0.5	<0.5	2.6	<0.5		2.8		<0.5	3.5	
		HSL 013		4.6	<2	120	4.2		3		240		252
		HSL 013		4.9	<2	130	2.2		<2		52		157
		HSL 013		<4.0	<2	60					120		155
		HSL 013		<4.0	<2	67					180		266
		HSL 013		<0.5	4.3	12	2.8		6.6		<1	30	<50
		HSL 013		<0.5	8.3	26	10		14		<1	110	<50
		HSL 013		<0.5	6.6	27	4.7		5.3		<1	93	260
		HSL 013	1.42	0.05	0.535	0.364	0.212		0.417	0.013	<0.01	12.8	<100
		HSL 013		<4.0	<2	110	3.9		3.3				
		HSL 013		<4.0	<2	87	2		<2				
		HSL 013		<4.0	<2	39							
		HSL 013		<4.0	<2	51							
		HSL 013		<0.5	3.3	9	4.7		4.3		<1	36	
		HSL 013		<0.5	<1	10	<1		6.9		<1	67	
		HSL 013		<0.5	2.2	18	<1		<4		<1	51	
Irvine Coast	The Irvine Company	IRV 001	0.045		1.54								
		IRV 001	1.48		0.199								
		IRV 002	<1	<5	21	<5	<0.2	15	<2.5	<2.5	26		110
La Jolla	City of San Diego	SDL165	1.16	ND	1.19	7.83	ND	ND	2.63	ND	0.19	11.1	300
		SDL165	1.36	ND	1.77	5.36	2.8	ND	2.19	ND	ND	13.5	300
Laguna Point to Latigo Point	Los Angeles County	MUG 371	4.82	0.04	4.63	0.26	0.08	0.01	0.49	0.05	0.24	4.80	NT
		MUG001	51	<1	<5	10	<5	<0.02	13	<2.5	<2.5	<25	<2000
		MUG001	58	<1	<5	20	<5	<1	13	<2.5	<2.5	<25	<2000
		MUG142											200.0

ASBS	Responsible Party	Nearest Discharge	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	NH3N
Laguna Point to Latigo Point (cont.)	Los Angeles County	MUG142	5.32	0.38	7.01	3.36	0.88	0.07	7.38	0.76	0.21	4.08	NT
		MUG147											NT
Newport Beach	City of Newport Beach	NEW 020		4.58		2.85							10
		NEW 020	4.3	10.2		29.3	2.85	0.0285	27.9	37.4	<0.1	47.8	
		NEW 020	3.04	3.75		31.4	1.54	<0.01	19.6	46	<0.01	32.6	
Pacific Grove	Monterey Bay Aquarium	PCG 244	1.282	0.036	0.435	0.5	0.032	ND	0.252	0.01	ND	6.644	ND
		PCG 244											ND
		PCG 247	1.58	0.05	1.15	4.54	0.685	0.019	1.61	0.043	<0.1	19.3	<10
		PCG 259	1.419	0.113	1.575	13.501	0.789	ND	1.518	0.196	ND	12.376	10
		PCG 247	1.54	0.046	1.21	4.54	0.66	0.018	1.58	0.05	<0.1	19.9	
		PCG 261	1.17	0.036	<5	0.416	0.067	<0.005	0.927	<0.01	<0.005	2.66	<10000
		PCG 262	0.954	0.035	0.355	0.555	0.141	ND	0.197	0.026	ND	5.047	20
		PCG 262	0.955	0.034	0.325	0.589	0.145	ND	0.229	0.031	ND	5.112	20
		PCG 247	1.75	0.1	0.38	0.338	0.093	0.019	0.17	0.098	ND	0.652	10000
		PCG 247	1.71	0.085	0.35	0.341	0.089	0.018	0.166	0.098	ND	0.576	20000
		PCG 260	1.16	0.019	0.39	0.535	0.067	0.012	0.216	0.056	<0.005	2.65	
		PCG 260	1.23	0.033	0.37	0.27	0.26	<0.01	0.15	0.05	0.06	1.91	
		PCG 248	1.183	0.036	0.865	0.204	0.111	ND	0.327	0.02	ND	4.852	
		PCG 261	1.17	0.036	<5	1.5	0.44	<0.005	1.76	<0.01	<0.005	4.07	
San Clemente Island	Department of Defense, US Navy	SCI 026											100
		SCI 026											100
		SCI 026											100
		SCI 026											100
		SCI 026											100
		SCI 026											150
		SCI 026											200
		SCI 026											200
		SCI 026											200
		SCI 026											230
		SCI 026											230
		SCI 026											280
		SCI 026											300
		SCI 026											400
		SCI 026											590
		SCI 026											600
		SCI 026											890
		SCI 026											1220

ASBS	Responsible Party	Nearest Discharge	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	NH3N
San Clemente Island (cont.)	Department of Defense, US Navy	SCI 026											1650
		SCI 026											1700
		SCI 026											1870
		SCI 026											2450
		SCI 026											3000
		SCI 026											4400
		SCI 026											5700
		SCI 026											5800
		SCI 026											6400
		SCI 026											6400
		SCI 026											7700
		SCI 026											9200
		SCI 026											10000
		SCI 026											18400
		SCI 026											21600
		SCI 026											<10
		SCI 026											<70
		SCI 026											<100
		SCI 026											<100
		SCI 026											<100
		SCI 026											<100
		SCI 026											<100
		SCI 026											<100
		SCI 026											<100
		SCI 026											<100
		SCI 026											<100
		SCI 026											<100
		SCI 026											<100
		SCI 026											<100
		SCI 026											<100
		SCI 026											<200
		SCI 026	<10		<10	20	<5	<4	<10	<10	<10	<20	
		SCI 026	<10	<10	<10	20	<10	<0.8	<10	<10	<10	50	
		SCI 026	<10	<10	<10	50	<10	<0.4	<10	<10	<10	30	
		SCI 026	<4	4	12	30	3	<0.4	<7	<4	<5	30	
		SCI 026	<5	<5	<10	6	6	<0.4	<20	<5	<5	40	
		SCI 026	<10	<10	<10	50	<2	<0.8	<10	<10	<10	30	
		SCI 026	<10	<10	<10	40	<2	<0.4	<10	<10	<10	40	

ASBS	Responsible Party	Nearest Discharge	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	NH3N
San Clemente Island (cont.)	Department of Defense, US Navy	SCI 026	<10	<10	<1	40	<2	<1	<10	<10	<10	<50	
		SCI 026	<10	<10	<10	40	2	<1	<10	<10	<10	40	
		SCI 026	<0.2		3	34	<0.3	<0.4	<0.7	<0.1	<0.5	41	
		SCI 026	<10		<10	40	<10	<1	<10	<20	<10	50	
		SCI 026	<0.2		2	32	<5	<0.8	<5	<5	<5	50	
		SCI 026	<0.3	0.2	1	36	<0.3	<1	2.4	1.1	<0.5	41	
		SCI 026	1	<0.1	1	14	<0.1	<0.4	<0.2	2	<0.1	33	
		SCI 026	<3	0.9	<20	10	0.5	<0.07	3.6	0.7	<0.1	55	
		SCI 026	1.2	<0.5	<0.5	23.6	0.8	<0.1	3.5	<0.5	<0.5	51.2	
		SCI 026				19.7							
		SCI 026				24.9							
San Nicholas Island	Department of Defense, US Navy	SNI001	ND	ND	ND	20	ND	ND	ND	ND	ND	60	400
		SNI001											<200
		SNI001	<0.01	<0.005	<0.01	0.02	<0.01	0.00001	<0.01	<0.01	<0.01	0.07	
		SNI001	ND	ND	ND	0	ND	ND	ND	ND	ND	ND	
		SNI001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		SNI001	ND	ND	ND	20	ND	0.03	ND	ND	ND	ND	
		SNI001	ND	ND	ND	20	ND	0.03	ND	ND	ND	60	
		SNI001	ND	ND	ND	ND	ND	ND	ND	ND	ND	70	
Trinidad Head	Trinidad Rancheria	TRI 030	1.1	0.3	3.5	41.2	1.98	ND	5.5	0.6	MD	206	

<u>Note</u>: A bold number indicates that readings exceeded the California Ocean Plan Table B Objective.

Appendix D. Toxicity Data

Stormwater Runoff TUc					
No.	**ASBS**	**Fish**	**Mysid**	**Kelp**	**Echinoderm**
		Menidia beryllina	*Mysidopsis (Americamysis) bahia*	*Macrocystis pyrifera*	*Strongylocentrotus purpuratus*
6	Trinidad Head	1 TUc at all locations	1 TUc at all locations	2, 2, <16, 1, 1, 1, 1, 4	2, 2, 2, <32.26, 2, 2, 32.26, 2
8	Redwood National Park	1		<1.6	<1.6
9	James V. Fitzgerald	1 (survival), 1 (growth)		<1.6 (germ), <1.6 (germ)	<1.6
15	Ano Nuevo	1 (survival), 1 (growth)		<1.6 (germ), <1.6 (germ)	<1.6
19	Pacific Grove		>1 (Growth)	>1 (Germ)	
24	Laguna Pt to Latigo Pt	1	2	>16 (Brown and Caldwell) 1.8 (Nautilus)	
25	Northwest Santa Catalina Island				
28	Southeast Santa Catalina Island				
29	La Jolla (Weston, for City of San Diego)		Prsv 01: 1.43, Prsv 01MZ: 1.33, Prsv 02: 1.45, PRsv 02MZ: 1.33,	Prsv 02: 1.67 (germination)- >16 (growth) Prsv 02 MZ: 16 (germination), 4 (growth)	Prsv 02: 2, Prsv 02 MZ: 1
30	Heisler Park		2		2
31	San Diego-Scripps				
32	Robert E. Badham				
33	Irvine Coast	1	2R: 2 (survival), 8 (growth)	2 (germination)	

Stormwater Runoff TUa					
No.	**ASBS**	**Fish**	**Mysid**	**Kelp**	**Echinoderm**
		Menidia beryllina	*Mysidopsis (Americamysis) bahia*	*Macrocystis pyrifera*	*Strongylocentrotus purpuratus*
6	Trinidad Head				
8	Redwood National Park				
9	James V. Fitzgerald				
15	Ano Nuevo				
19	Pacific Grove		<1.0		
24	Laguna Pt to Latigo Pt	0.5 (?)			
25	Northwest Santa Catalina Island				
28	Southeast Santa Catalina Island				
29	La Jolla (Weston, for City of San Diego)		~1.4		
30	Heisler Park		1.5		1
31	San Diego-Scripps				
32	Robert E. Badham		0.4		
33	Irvine Coast	0.6			

Ocean Rec. Water TUc					
No.	**ASBS**	**Fish**	**Mysid**	**Kelp**	**Echinoderm**
		Menidia beryllina	*Mysidopsis (Americamysis) bahia*	*Macrocystis pyrifera*	*Strongylocentrotus purpuratus*
6	Trinidad Head				
8	Redwood National Park				
9	James V. Fitzgerald	1 (survival), 1 (growth)		1 (germ), 2 (growth)	1
15	Ano Nuevo	1 (survival), 1 (growth)		2 (germ), 2 (growth)	1
19	Pacific Grove				
24	Laguna Pt to Latigo Pt				
25	Northwest Santa Catalina Island	1			**TH1**: 1, **TH2**: 16, **TH3**: 16, **1 G1:** 1, **CP2:** 1
28	Southeast Santa Catalina Island				
29	La Jolla (Weston, for City of San Diego)		1.4	ASBS offshore: 1 (germ), 1 (Growth)	1
30	Heisler Park				
31	San Diego-Scripps				
32	Robert E. Badham		1.18 (survival), 1.8 (biomass)	4 (Germination), 1.33 (Growth)	1.33
33	Irvine Coast				

Ocean Rec. Water TUa					
No.	**ASBS**	**Fish**	**Mysid**	**Kelp**	**Echinoderm**
		Menidia beryllina	*Mysidopsis (Americamysis) bahia*	*Macrocystis pyrifera*	*Strongylocentrotus purpuratus*
6	Trinidad Head				
8	Redwood National Park				
9	James V. Fitzgerald				
15	Ano Nuevo				
19	Pacific Grove				
24	Laguna Pt to Latigo Pt				
25	Northwest Santa Catalina Island				
28	Southeast Santa Catalina Island				
29	La Jolla (Weston, for City of San Diego)		1.3		
30	Heisler Park	0.65	0.6	0.6	
31	San Diego-Scripps				
32	Robert E. Badham				
33	Irvine Coast				

Appendix E: NOAA NS&T Mussel Watch Program Data

Location	Constituent	1988			
Farallon Island/East Landing	1-Methylnaphthalene	0			
	1-Methylphenanthrene	0			
	2,6-Dimethylnaphthalene	0			
	2-Methylnaphthalene	0			
	Acenaphthene	0			
	Acenaphthylene	0			
	Anthracene	0			
	Benz[a]anthracene	0			
	Benzo[a]pyrene	0			
	Benzo[b]fluoranthene	0			
	Benzo[e]pyrene	0			
	Benzo[g,h,i]perylene	0			
	Benzo[k]fluoranthene	0			
	Biphenyl	0			
	Chrysene	0			
	Dibenz[a,h]anthracene	0			
	Fluoranthene	0			
	Fluorene	0			
	Indeno[1,2,3-c,d]pyrene	0			
	Naphthalene	0			
	Perylene	0			
	Phenanthrene	0			
	Pyrene	0			
	Arsenic	16			
	Cadmium	6.3			
	Chromium*	0.96			
	Copper	9.033			
	Lead	2.9			
	Mercury	0.15			
	Nickel	1.293			
	Selenium	3.2			
	Silver	0			
	Zinc	163.333			
	Aluminum	87.667			
	Iron	116.667			
	Manganese	0			
	Tin	0.97			

Location	Constituent	1989			
Klamath River/Flint Rock Head	1-Methylnaphthalene	0			
	1-Methylphenanthrene	0			
	2,6-Dimethylnaphthalene	0			
	2-Methylnaphthalene	0			
	Acenaphthene	0			
	Acenaphthylene	0			
	Anthracene	0			
	Benz[a]anthracene	0			
	Benzo[a]pyrene	0			
	Benzo[b]fluoranthene	0			
	Benzo[e]pyrene	0			
	Benzo[g,h,i]perylene	0			
	Benzo[k]fluoranthene	0			
	Biphenyl	0			
	Chrysene	0			
	Dibenz[a,h]anthracene	0			
	Fluoranthene	0			
	Fluorene	0			
	Indeno[1,2,3-c,d]pyrene	0			
	Naphthalene	0			
	Perylene	0			
	Phenanthrene	0			
	Pyrene	0			
	Arsenic	5.9			
	Cadmium	3.167			
	Chromium*	9.2			
	Copper	13.333			
	Lead	0.73			
	Mercury	0.07			
	Nickel	11.667			
	Selenium	2.133			
	Silver	0			
	Zinc	95.667			
	Aluminum	760			
	Iron	1466.67			
	Manganese	0			
	Tin	0.018			

Location	Constituent	1999	2001	2003	2005

Point Delgada Shelter Cove	1-Methylnaphthalene	2.72	6.1	8.9	13.7
	1-Methylphenanthrene	1.95	5	1	1.4
	2,6-Dimethylnaphthalene	2.66	5	6.5	12.8
	2-Methylnaphthalene	4.94	15.3	26.5	24.4
	Acenaphthene	2.85	2.4	3	5.4
	Acenaphthylene	0.44	1.8	0.6	0
	Anthracene	0.79	3.2	1.6	0.2
	Benz[a]anthracene	0.37	6.3	1.8	0.3
	Benzo[a]pyrene	6.76	0.8	0.6	0.4
	Benzo[b]fluoranthene	0.94	0	2.3	1.5
	Benzo[e]pyrene	5.45	7.7	1.3	1.2
	Benzo[g,h,i]perylene	1.53	2.2	1.9	1.2
	Benzo[k]fluoranthene	0.31	0	0.7	0.2
	Biphenyl	2.15	6.4	6.8	8.1
	Chrysene	1.6	19.3	3.8	1.9
	Dibenz[a,h]anthracene	0.19	0	0.3	0
	Fluoranthene	1.09	30.8	2	1.1
	Fluorene	5.67	5.3	4.2	4
	Indeno[1,2,3-c,d]pyrene	0.26	1.4	0.4	0
	Naphthalene	8.16	24.4	36.6	20.6
	Perylene	2.7	5.6	0.5	0.9
	Phenanthrene	6.24	44.4	25.1	9.2
	Pyrene	1.41	21.8	1.8	1.6
	Arsenic	8.35	15.5	11.1	11.1
	Cadmium	2.05	7.12	8.34	5.05
	Chromium*	3.1	2.97	3.35	1.44
	Copper	10.4	10.9	12.4	8.24
	Lead	0.854	2.09	1.9	1.73
	Mercury	0.112	0.32	0.101	0.11
	Nickel	3.32	3.82	4.5	1.24
	Selenium	3.04	3.34	2.56	2.12
	Silver	0.067	0	0.378	0.403
	Zinc	117	195	117	161
	Aluminum	1360	747	792	196
	Iron	1180	748	1870	344
	Manganese	30.3	16.3	30.3	8.41
	Tin	0	0.125	0.202	0

Location	Constituent	1999	2001	2003	2005
Pacific Grove	1-Methylnaphthalene	2.83	1.7	18.5	10.7

Lovers Point					
	1-Methylphenanthrene	0.62	0.3	0.8	0.9
	2,6-Dimethylnaphthalene	1.3	1.3	6.2	9.2
	2-Methylnaphthalene	9.01	4.7	40.1	23.3
	Acenaphthene	3.4	0.3	2.5	3.5
	Acenaphthylene	1.53	0.2	0.3	0
	Anthracene	2.6	0	1	0.4
	Benz[a]anthracene	0.85	0.4	1	0.3
	Benzo[a]pyrene	7.98	0	0	0
	Benzo[b]fluoranthene	1	0	0	0
	Benzo[e]pyrene	4.14	0	0	0
	Benzo[g,h,i]perylene	0.88	0	0.3	0
	Benzo[k]fluoranthene	0.71	0	0	0
	Biphenyl	2.21	3.5	9.2	7.6
	Chrysene	1.43	1.3	2	1
	Dibenz[a,h]anthracene	0.15	0	0	0
	Fluoranthene	2.12	0.8	1.9	1.1
	Fluorene	5.37	0.4	1.4	2.8
	Indeno[1,2,3-c,d]pyrene	0.48	0	0	0
	Naphthalene	11.04	8.9	41.5	22.6
	Perylene	16.83	0	1.4	0
	Phenanthrene	5.58	3.5	6.4	7.5
	Pyrene	1.74	0.4	0.7	1.2
	Arsenic	11.2	12.5	11.3	12.9
	Cadmium	4.94	6.39	13	8.39
	Chromium*	2.14	1.57	2.24	1.82
	Copper	7.52	6.85	7.3	7.8
	Lead	3.92	5.76	6.2	5.48
	Mercury	0.119	0.116	0.237	0.077
	Nickel	2.57	1.74	1.9	1.72
	Selenium	3.19	2.16	1.93	1.8
	Silver	0.094	1.02	0	0.048
	Zinc	157	160	162	166
	Aluminum	381	91.6	138	175
	Iron	350	169	341	248
	Manganese	5.95	4.35	6.43	5.48
	Tin	0	0.302	0.158	0

Location	**Constituent**	**1999**	**2001**	**2003**	**2005**
Point Dume	1-Methylnaphthalene	19.5	2.6	2.2	5.9

	1-Methylphenanthrene	2.6	0.3	0	0
	2,6-Dimethylnaphthalene	8	1.6	2.1	42
	2-Methylnaphthalene	30.3	14.2	10.4	14.1
	Acenaphthene	4.7	0.6	0.3	2.8
	Acenaphthylene	1.5	0.2	0.2	0
	Anthracene	1.8	0	0.3	0.4
	Benz[a]anthracene	1.2	0.4	0.4	0.5
	Benzo[a]pyrene	1.6	0	0	0
	Benzo[b]fluoranthene	0.5	0	0	0
	Benzo[e]pyrene	1.5	0	0	0
	Benzo[g,h,i]perylene	1.2	0	0	0
	Benzo[k]fluoranthene	0.7	0	0	0
	Biphenyl	4.8	2.5	4.1	4.9
	Chrysene	2.9	1.5	1.2	0.2
	Dibenz[a,h]anthracene	0.1	0	0	0
	Fluoranthene	1.9	1.2	0.7	0.6
	Fluorene	5.5	0.6	0.8	1.8
	Indeno[1,2,3-c,d]pyrene	0.5	0	0	0
	Naphthalene	45.6	22.6	9	16.4
	Perylene	2.4	0	0	1.1
	Phenanthrene	9.3	5.8	6	4
	Pyrene	4.1	0.5	0.4	1.7
	Arsenic	9.83	9.37	6.21	7.94
	Cadmium	2.79	2.13	1.55	1.63
	Chromium*	1.36	1.4	0.862	5.44
	Copper	6.95	7.6	5.13	7.98
	Lead	1.53	1.15	1	1.98
	Mercury	0.08	0.073	0.067	0
	Nickel	1.36	1.16	0.84	1.4
	Selenium	2.58	2.55	1.98	1.84
	Silver	2.59	3.09	2.07	1.57
	Zinc	149	130	94.6	88.1
	Aluminum	238	138	55.2	288
	Iron	332	309	127	552
	Manganese	5.89	9.16	3.07	10.6
	Tin	0	0	0	0.14

Location	**Constituent**	**1998**	**2000**	**2002**	**2004**
S. Catalina I. Bird Rock	1-Methylnaphthalene	2	1.5	2.7	5.4

	1-Methylphenanthrene	0.4	0.5	0.6	0.4
	2,6-Dimethylnaphthalene	0.8	1.4	1.7	4.8
	2-Methylnaphthalene	3.5	3.7	8	10.2
	Acenaphthene	1.5	0.8	0	2
	Acenaphthylene	0.4	0.1	0	0.3
	Anthracene	0.5	0.2	0	0.3
	Benz[a]anthracene	0.3	0.3	0.3	0
	Benzo[a]pyrene	1.2	0	0	0
	Benzo[b]fluoranthene	0.7	0	0	0
	Benzo[e]pyrene	0.9	0	0	0
	Benzo[g,h,i]perylene	0.2	1.2	0	0
	Benzo[k]fluoranthene	0.3	0	0	0
	Biphenyl	1.2	1.9	6.2	4.9
	Chrysene	0.7	1	0.6	0
	Dibenz[a,h]anthracene	0	0.5	0	0
	Fluoranthene	0.6	0.6	0.6	0.9
	Fluorene	1	0.4	1	1.6
	Indeno[1,2,3-c,d]pyrene	0.2	0.8	0	0
	Naphthalene	4.8	8.3	8.9	10.7
	Perylene	0.6	0	0	0
	Phenanthrene	1.9	3.5	4.1	3.9
	Pyrene	0.5	0.3	0.2	1.9
	Arsenic	14.1	12.5	10.3	14.7
	Cadmium	4.47	5.96	4.1	4.97
	Chromium*	4.71	1.37	0.992	1.32
	Copper	6.71	4.83	5.19	6.93
	Lead	1.41	1.14	1.36	1.36
	Mercury	0.121	0.074	0.096	0.077
	Nickel	4.26	1.78	1.13	2.52
	Selenium	2.64	2.72	2.84	3.53
	Silver	1.12	0.382	0.308	0.101
	Zinc	91.4	118	116	130
	Aluminum	645	36.4	8.82	37.3
	Iron	635	96.1	56.3	104
	Manganese	11.9	4.52	3.34	4.62
	Tin	0	0	0	0

*Note: Chromium is measured in total chromium.

Appendix F: California State Mussel Watch Data Summary, 1977-99

Trinidad Head

At the Trinidad ASBS, results for ten constituents (aluminum, chromium, copper, mercury, manganese, nickel, selenium, oxychlordane, cis-chlordane and chlorpyrifos) at times indicated elevated levels above the EDL 85. Of the 23 analyses, eight results for aluminum, five results for chromium, four results for copper, one result for mercury, 14 results for manganese, and two results for selenium were above the EDL 95 for during the period 1977 to 1999. Of the 8 organic chemistry analyses performed, one result for gamma chlordane, six results for oxychlordane, and seven results for chlorpyrifos were above the EDL 95 from 1982 to 1999.

Point Reyes Headlands
At Point Reyes ASBS, only results for two constituents, oxychlordane (one out of one test) and o,p'DDD (one out of five tests) indicated elevated levels above the EDL 95.

James V. Fitzgerald
At the James V. Fitzgerald ASBS, results for eight constituents (aluminum, chromium, nickel, oxychlordane, p,p'DDE, PCB 1248, PCB 1254, and total DDT) at times indicated elevated levels above the EDL 85. Of the 8 metals analyses, three results for aluminum, one result for chromium and two results for nickel were above their respective EDL 95 during 1977 to 1999. Of the 9 organic chemistry analyses, two results for oxychlordane, three results for chlorpyrifos, one result for PCB 1248, one result for p, p'DDE and one result for total DDT were above the EDL 95.

Año Nuevo
At Año Nuevo ASBS, eight constituents (mercury, p,p'DDD, p,p'DDE, o,p'DDT, p,p'DDT, total DDT, PCB 1254, and dieldrin) at times indicated elevated levels for the EDL 85. Six out of six results for mercury were above EDL 95 from 1977 to 1982. Out of four organic analyses performed, four results for p,p'DDE, four results for total DDT, and three results for PCB 1254 were above the EDL 95.

Pacific Grove
At the Pacific Grove ASBS, 14 constituents (cadmium, copper, mercury, lead, zinc, trans-nonachlor, oxychlordane, chlorpyrifos, dachtal, p, p'DDD, o, p'DDT, endosulfan, alpha heptachlor and pentachlorophenol) at times indicated elevated levels for the EDL 85. Of the 26 metals analyses, the highest frequency for exceeding the EDL 95 was for lead (nine results) and zinc (nine results).

Carmel Bay
At the Carmel Bay ASBS, results for seven constituents (cadmium, nickel, selenium, dachtal, p,p'DDT, total endosulfan and heptachlor) at times indicated elevated levels above the EDL 85. Of these cadmium (16 out of 32 tests) most frequently exceeded the EDL 85.

Northwest Santa Catalina Island & Southeast Santa Catalina Island
At Santa Catalina Island (the general location for four ASBS), only four constituents (aluminum, manganese, lead and zinc) at times indicated elevated levels. Lead was the constituent with consistent elevated levels (ten out of ten tests) exceeded the EDL 85.

Robert E. Badham

At Robert E. Badham ASBS, ten constituents (silver, copper, manganese, mercury, lead, zinc, dachtal, p,p'DDT, PCB 1254, and p,p'DDD) at times indicated elevated levels. Silver (seven out of seven tests), lead (six out of seven tests), PCBs (five out of six tests) and p,p'DDT (six out of seven tests) most frequently exceeded the EDL 85.

La Jolla

At the San Diego Scripps and La Jolla ASBS, only four constituents (silver, lead, zinc, and o,p'DDT) at times indicated elevated levels. Silver (six out of eight tests) and lead (five out of eight tests) most frequently exceeded the EDL 85.

Appendix G. State Mussel Watch Data - 2001-2005

Location	Constituent	2001-2002	2002-2003	2003-2004	2004-2005
Trinidad Head	Silver	-8	0.015	ND	ND
	Aluminum	502	1044	90	1250
	Asimuth	6.3	15.49	9.14	9.31
	Cadmium	3.64	6.15	6.28	8.4
	Chromium	4.55	5.62	6.85	6.11
	Copper	7.09	11.62	8.22	7.36
	Magnesium	13.2	21.69	16.47	15.38
	Nickel	3.32	3.65	5.85	4.74
	Lead	0.75	1.11	1.11	1.59
	Selenium	2.7	3.91	3.09	2.36
	Zinc	73	99	110	136
	Mercury	0.08	0.075	0.093	0.117
	Chlordane	NT	NT	-8	NT
	DDE,p,p'	NT	NT	-8	NT
	CCDAN	NT	1.24	1.04	NT
	TCDAN	NT	1.03	-8	NT
	TOTCL	NT	2.27	1.04	NT
	DDDOP	NT	-8	-8	NT
	DDDPP	NT	-8	-8	NT
	DIELD	NT	3.75	7.3	NT
	HCHA	NT	4.48	3.62	NT
	HEPOX	NT	1.2	1.09	NT
	PCB54	NT	-8	16	NT
	TPCB	NT	-8	NT	NT
Bodega Head	Silver	0.06	0.05	0.11	ND
	Aluminum	239	28	326	475
	Asimuth	10.77	9.61	8.87	11.06
	Cadmium	9.3	17.3	13.97	15.12
	Chromium	2.49	1.2	5.32	2.88
	Copper	6.14	4.75	8.08	6.48
	Magnesium	6.93	4.48	5.66	6.49
	Nickel	3.56	1.38	4.55	1.77
	Lead	1.33	0.44	0.91	1.55
	Selenium	4.83	3.49	3.05	ND
	Zinc	161	66	133	153
	Mercury	0.308	0.96	0.143	0.224
	Chlordane	NT	NT	1.89	NT
	DDE,p,p'	NT	NT	4.86	NT
	CCDAN	NT	1.75	1.06	NT
	TCDAN	NT	2.11	-8	NT

Location	Constituent	2001-2002	2002-2003	2003-2004	2004-2005
Bodega Head (cont.)	TOTCL	NT	3.86	1.06	NT
	DDDOP	NT	-8	-8	NT
	DDDPP	NT	5.44	-8	NT
	DIELD	NT	7.3	7.44	NT
	HCHA	NT	2.2	2.33	NT
	HEPOX	NT	1.3	1.06	NT
	PCB54	NT	-8	-8	NT
	TPCB	NT	-8	NT	NT
J. Fitzgerald	Silver	0.09	0.123	ND	ND
	Aluminum	407	379	634	538
	Asimuth	9.95	9.1	10.11	9.43
	Cadmium	6.31	9.18	7.01	6.62
	Chromium	3.37	2.35	2.94	3.06
	Copper	6.6	5.96	7.61	7.24
	Magnesium	6.33	5.21	8.03	6.25
	Nickel	2.71	2.52	3.01	1.73
	Lead	0.98	0.93	1.16	1.02
	Selenium	3.95	5.06	4.29	2.28
	Zinc	122	105	155	123
	Mercury	0.15	0.124	0.166	0.133
	Chlordane	NT		1.06	NT
	DDE,p,p'	NT		5.68	NT
	CCDAN	NT	3.04	1.12	NT
	TCDAN	NT	2.99	-8	NT
	TOTCL	NT	6.03	1.12	NT
	DDDOP	NT	-8	-8	NT
	DDDPP	NT	4.43	-8	NT
	DIELD	NT	8.39	6.37	NT
	HCHA	NT	1.73	1.51	NT
	HEPOX	NT	1.44	-8	NT
	PCB54	NT	17	13	NT
	TPCB	NT	17		NT
Pacific Grove	Silver	0.09	0.037	ND	NT
	Aluminum	248	311	95	NT
	Asimuth	13.93	12.37	14.2	NT
	Cadmium	12.93	10.91	13.24	NT
	Chromium	2.05	2.2	2.44	NT
	Copper	6.51	6.14	7.16	NT
	Magnesium	4.32	4.15	3.55	NT
	Nickel	2.87	3.18	3.16	NT
	Lead	3.21	3.11	3.08	NT
	Selenium	4.03	4.58	3.64	NT
	Zinc	207	188	192	NT

Location	Constituent	2001-2002	2002-2003	2003-2004	2004-2005
Pacific Grove (cont.)	Mercury	0.2	0.136	0.133	NT
	Chlordane	NT	NT	1.29	NT
	DDE,p,p'	NT	NT	18.2	NT
	CCDAN	NT	3.07	1.82	NT
	TCDAN	NT	3.42	1.35	NT
	TOTCL	NT	6.49	3.17	NT
	DDDOP	NT	5.15	5.86	NT
	DDDPP	NT	5.4	-8	NT
	DIELD	NT	10.4	11.1	NT
	HCHA	NT	1.69	-8	NT
	HEPOX	NT	-8	-8	NT
	PCB54	NT	21	18	NT
	TPCB	NT	21	NT	NT

Note: NT = Not Tested
Note: ND = Not Detected