Southern California Bight
1998 Regional Marine Monitoring Survey
(Bight'98)

Coastal Ecology Workplan

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I. INTRODUCTION

The Southern California Bight (SCB; Figure I-1), an open embayment in the coast between Point Conception and Cape Colnett (south of Ensenada), Baja California, is an important and unique ecological resource. The SCB is a transitional area that is influenced by currents from cold, temperate ocean waters from the north and warm, tropical waters from the south. In addition, the SCB has a complex topography, with offshore islands, submarine canyons, ridges and basins, that provide a variety of habitats. The mixing of currents and the diverse habitats in the SCB allow for the coexistence of a broad spectrum of species, including more than 500 species of fish and 1,500 species of invertebrates. The SCB is also a major migration route, with marine bird and mammal populations ranking among the most diverse in north temperate waters.

The coastal zone of the SCB is a substantial economic resource. Los Angeles/Long Beach Harbor is the largest commercial port in the United States, and San Diego Harbor is home to one of the largest US Naval facilities in the country. More than 100 million people visit southern California beaches and coastal areas annually, bringing an estimated $9B into the economy. Recreational activities include diving, swimming, surfing, and boating, with about 40,000 pleasure boats docked in 13 coastal marinas within the region (NRC 1990). Recreational fishing brings in more than $500M per year.

The SCB is one of the most densely populated coastal regions in the country, which creates stress upon its marine environment. Nearly 20 million people inhabit coastal Southern California, a number which is expected to increase another 20% by 2010 (NRC 1990). Population growth generally results in conversion of open land into non-permeable surfaces. More than 75% of southern Californian bays and estuaries have already been dredged and filled for conversion into harbors and marinas (Horn and Allen 1985). This “hardening of the coast” increases the rate of runoff and can impact water quality through addition of sediment, toxic chemicals, pathogens and nutrients to the ocean. Besides the impacts of land conversion, the SCB is already home to fifteen municipal wastewater treatment facilities, eight power generating stations, 10 industrial treatment facilities, and 18 oil platforms that discharge to the open coast.

Each year, local, state, and federal agencies spend in excess of $10M to monitor the environmental quality of natural resources in the SCB. Most of this monitoring is associated with National Pollutant Discharge Elimination System (NPDES) permits and is intended to assess compliance of waste discharge with the California Ocean Plan and the Federal Clean Water Act, which set water quality standards for effluent and receiving waters. Some of this information has played a significant role in management decisions in the SCB.

While these monitoring programs have provided important information, they were designed to evaluate impacts near individual discharges. Today, resource managers are being encouraged to develop management strategies for the entire SCB. To accomplish this task, they need regionally-based information to assess cumulative impacts of contaminant inputs and to evaluate relative risk among different types of stresses. It is difficult to use existing data to evaluate regional issues because the monitoring was designed to be site-specific and is limited to specific geographic areas. The monitoring provides substantial data for some areas, but there is little or no data for the areas in between. Beyond the spatial limitations, data from these programs are not easily merged to examine relative risk. The parameters measured often differ among programs. Even when the same parameters are measured, the methodologies used to collect the data often differ and interlaboratory quality assurance (QA) exercises to assess data comparability are rare.

1994 Pilot Project

To begin addressing these concerns, twelve agencies joined in a cooperative sampling effort in 1994, called the Southern California Bight Pilot Project (SCBPP). The SCBPP involved sampling 261 sites, using common methods, along the continental shelf between Point Conception and the United States/Mexico border. Assessments were made of water quality, sediment contamination, the status of biological resources and species diversity, and the presence of marine debris. The SCBPP provided a much-needed first "snapshot" of the state of the SCB.

Benefits derived from the SCBPP also included the development of new useful technical tools that could only be developed with regional data sets and participation by multiple organizations. For example, the project produced iron-normalization curves for the SCB, allowing distinction between natural and anthropogenic contributions of metals in sediments (Schiff and Weisberg 1998). A Benthic Response Index was developed that integrates complex benthic infaunal data into an easily interpreted form that describes the degree of perturbation at a site (Bergen *et al.* 1998). The project also produced a series of manuals containing standardized field, laboratory and data management approaches that increased comparability of data among participants, even after the SCBPP was completed.

1998 Survey

The proposed Southern California Bight 1998 Regional Monitoring Project (Bight'98) is a continuation of the successful cooperative regional-scale monitoring begun in southern California in 1994 during the SCBPP. Bight'98 builds upon the previous successes and expands on the 1994 survey by including more participants, sampling more habitats, and measuring more parameters. Fifty-five organizations, including international and volunteer organizations, have agreed to participate (Table I-1).

The inclusion of new participants provides several benefits. Cooperative interactions among many organizations with different perspectives and interests, including a combination of regulators and dischargers, ensures that an appropriate set of regional-scale questions will be addressed by the study. The additional resources brought by new participants also expands the number of habitats and indicators that will be sampled. Sampling for Bight'98 will include all of the areas sampled in 1994, plus a new focus on nearshore habitats (bays, harbors and beaches) and offshore islands. Bight'98 will also coordinate with a Mexican program to characterize the condition of SCB coastal waters south of the US border. The new indicators that will be measured include shoreline microbiology, biomarkers and new chemical measures.

The Bight'98 Survey is organized into three technical components: 1) Coastal ecology, 2) Shoreline microbiology, and 3) Water quality. This work plan provides a summary of the project design for the coastal ecology component. The work plan is supported by three companion documents detailing Field Methods and Logistics, Quality Assurance (QA), and Information Management. Separate work plans are also available for the shoreline microbiology and water quality two components of the program.

FIGURE I-1. Map of the Southern California Bight.

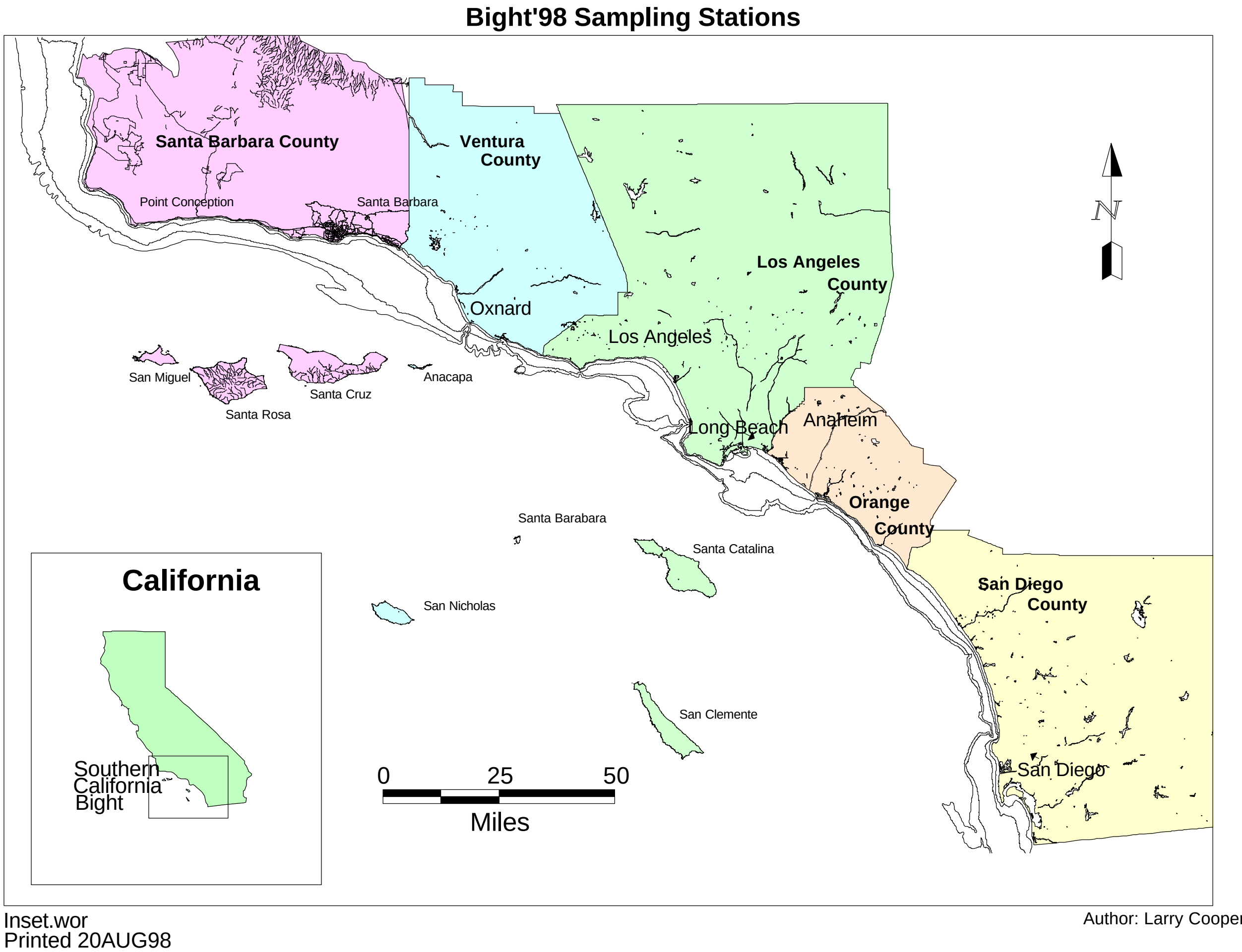

TABLE I-1. Participants in the Bight'98 Regional Monitoring Program. Participants in the coastal ecology component are asterisked.

AES Corporation*
Algalita Marine Research Foundation*
Aliso Water Management Authority (AWMA)*
Aquatic Bioassay and Consulting Laboratories (ABCL)*
Center for Environmental Cooperation (CEC)*
Central Coast Regional Water Quality Control Board*
Channel Islands National Marine Sanctuary (CINMS)*
Chevron USA Products Company*
City of Long Beach
City of Los Angeles Environmental Monitoring Division (CLAEMD)*
City of Los Angeles Stormwater Division
City of Oceanside*
City of Oxnard*
City of San Diego*
City of Santa Barbara
City of Ventura
Columbia Analytical Services*
Divers Involved Voluntarily in Environmental Rehabilitation & Safety (DIVERS)
Encina Wastewater Authority*
Goleta Sanitation District
Granite Canyon Marine Pollution Studies Lab*
Houston Industries, Inc.*
Instituto de Investigacione, Oceanologicas (UABC)
Los Angeles Department of Water and Power (LADWP)*
Los Angeles County Dept. of Beaches & Harbors*
Los Angeles County Dept. of Health Services
Los Angeles Regional Water Quality Control Board*
Los Angeles County Sanitation Districts (LACSD)*
Marine Corps Base - Camp Pendleton
National Fisheries Institute of Mexico (SEMARNAP)*
NOAA International Programs Office
NRG Energy, Inc.*
Orange County Environmental Health Division
Orange County Public Facilities and Resources (OCPFRD)*
Orange County Sanitation District (OCSD)*
San Diego County Dept. of Environmental Health
San Diego Interagency Water Quality Panel (Bay Panel)*
San Diego Regional Water Quality Control Board (SDRWQCB)*
San Elijo Joint Powers Authority*
Santa Ana Regional Water Quality Control Board*
Santa Barbara Health Care Services
Santa Monica Bay Restoration Project*
Secretaria de Marina (Mexican Navy)

TABLE I-1 (continued).

Southeast Regional Reclamation Authority (SERRA)*
Southern California Coastal Water Research Project (SCCWRP)*
Southern California Edison (SCE)*
Southern California Marine Institute (SCMI)
State Water Resources Control Board (SWRCB)*
Surfrider Foundation
University of California, Santa Barbara
USC Wrigley Institute for Environmental Studies (WIES)*
US EPA Region IX*
US EPA Office of Research and Development*
US Geological Survey
US Navy, Space & Naval Warfare Systems Center, San Diego (USN)*

II. STUDY DESIGN

A. Study Objectives

The overall goal of the coastal ecology component of Bight'98 is to assess the condition of the bottom environment and the health of the biological resources in the SCB. To accomplish this goal, Bight'98 will focus on four objectives:

1. Estimate the extent and magnitude of ecological change in the SCB,
2. Compare condition among selected geographic regions of the SCB,
3. Assess the relationship between biological responses and contaminant exposure, and
4. Describe historical trends at selected sites.

The first objective, estimating the amount of area (i.e., number of acres) in the Bight in which ecological conditions differ from reference conditions, is a departure from traditional approaches to environmental monitoring, which generally focus on estimating average condition. Estimating the areal extent of ecological change offers several advantages. First, it provides a more direct assessment of status. For instance, identifying that the average concentration of dissolved oxygen in the Bight is 6.7 ppm provides less useful information for environmental managers than does identifying what percentage of the area in the Bight fails to meet water quality standards. A second advantage of estimating areal extent concerns trend detection. If conditions in the Bight change over time such that some areas improve and others worsen, the average condition might not change. By estimating the areal extent of alteration, we will be better able to describe these changes.

The second objective of the survey is to compare condition among fifteen geographic areas of interest (Table II-1). These subpopulations of our study area were selected to represent a range of natural and potentially affected habitats, and represents a significant expansion from the number of habitats sampled in 1994. Comparison of their relative condition not only provides information about the geographic distribution of impacts, it also allows comparison of relative risk from a variety of point and non-point source discharges. Comparison of condition may be conducted by comparing the extent of area exceeding a threshold of concern or by comparison of mean condition.

The third objective will be accomplished by simultaneously collecting numerous measures of biological response, contaminant exposure and habitat condition (Table II-2) to better identify when exposure has reached a level of concern. Measuring multiple indicators also permits us to identify the most likely type of exposure leading to biological response. Such associations provide the information necessary for risk assessment, and for developing efficient regional strategies for protecting the environment by identifying the predominant types of stress in the system.

The fourth objective recognizes that management actions result from both assessment of present condition and from historical trends in condition. High levels of stress that are declining should result in different management actions than low levels that are increasing. This objective will be accomplished by sampling thirteen stations which have been investigated in prior monitoring programs. These stations are located in areas distant from known contamination sources, allowing assessment of integrated condition, rather than the effect of change from a particular point source.

Measuring temporal change at sites distant from known point sources will also allow us to assess the effects of the recent El Nino conditions on background faunal conditions in the SCB.

B. Sampling Design

The coastal ecology component of Bight'98 will involve sampling of 416 sites in the SCB between July 20 and September 7, 1998. The summer period was chosen for the study because it represents a period of steady weather during which the indicators we measure are expected to remain stable.

Maps of the sampling sites are provided in Appendix A. Sites were selected using a stratified random approach, with the strata corresponding to the subpopulations of interest in Table II-1. Stratification ensures that an appropriate number of samples are allocated to characterize each population of interest with adequate precision. We aimed to allocate thirty sites to each strata because this yields a 90% confidence interval of about ± 10% around estimates of areal extent (assuming a binomial probability distribution and p= 0.2; Figure II-1). This level of desired precision was selected because differences in response of less than 10% among subpopulations are unlikely to yield different management decisions.

Sites were selected randomly within strata, rather than by investigator pre-selection, to ensure that they are representative and can be extrapolated to the response of the entire strata. Although sites were selected randomly, a systematic component was added to the selection process to minimize clustering of sample sites. The systematic element was accomplished by using an extension of the sampling design used in the SCBPP and in EPA's Environmental Monitoring and Assessment Program (EMAP) (Stevens 1997). A hexagonal grid was randomly placed over a map of the sampling area, a subsample of hexagons chosen from this population, and one sample was obtained at a randomly selected site within each grid cell. The hexagonal grid structure ensures systematic separation of the sampling, while the random selection of sites within grid cells ensures an unbiased estimate of ecological condition. Further details about this site selection process are provided in Appendix B.

One of the design attributes of Bight' 98 is to maximize the coincidence of indicators, allowing us to relate biological response to chemical exposure and physical habitat condition. Measuring all parameters at all sites was not possible because the resources for Bight'98 are primarily in the form of in-kind services provided by participants, and not all participants measure all parameters. The number of sites sampled for each indicator group within each strata are presented in Table II-3. To maximize overlap of indicators, sites which receive fewer indicator measurements were randomly chosen (with a systematic element) as a subset of the sites at which all indicators are measured.

The number of sites on the maps in Appendix A exceeds the number of sites described in Table II-3 by about 10% in offshore areas and by about 20% in harbor areas. This difference between sample site selection and anticipated number of analytical results is in recognition that it may not be possible to sample all of the randomly-selected sites because of improper substrate type, depth restrictions, or dredging activities. To prevent an unacceptable loss of statistical power due to lost samples, the number of sites allocated was inflated by an expected site rejection rate, determined from historical sampling experience. Should the site rejection rate exceed this inflation factor by more than 10%, an additional set of random sites will be assigned during the survey.

While most sites in this study were selected randomly to address population estimation objectives, eighteen sites were pre-selected to address additional objectives. Thirteen sampling sites were assigned to locations that had been sampled in historical SCCWRP reference surveys. The purpose of these samples was to assess trends in condition of the SCB at far-field reference sites, as described in Objective 4 above. Seven of those sites were located along a 60m transect that had been sampled in 1977, 1985 and 1990. Six of the sites were located along a 30m transect that was sampled in 1985 and 1990.

An additional five sample points were assigned to river mouth areas to assess gradients in condition at varying distance from river mouths. Two of these site were assigned to the Los Angeles River, and one each to Aliso Creek, the San Gabriel River, and the Santa Ana River.

C. Indicators

Bight'98 will measure multiple indicators (Table II-2) at each site in order to relate contaminant exposure, biological response, and habitat condition. Collecting measures of contaminant exposure with measurements of biological response at common sites allows investigators to identify and statistically model associations between altered ecological conditions and particular environmental stresses. Habitat indicators help discriminate between changes caused by anthropogenic and natural factors.

One design principle of Bight'98 is that these indicators will be measured using uniform sampling methods throughout the Bight. The probability-based sampling design provides a framework for integrating data into a comprehensive regional assessment, but the validity of such an assessment depends on ensuring that all the data that contribute to it are comparable. Below, we present a short description of the methods used to measure the Bight'98 indicators; more detailed descriptions of the methods can be found in the accompanying Field Methods and Logistics, and Quality Assurance Manuals for the project.

Contaminant Exposure

1. Sediment Chemistry: Chemical analysis of sediment samples provides an assessment of contaminant exposure for bottom dwelling animals. Sediment samples will be collected from the top 2 cm of a Van Veen grab sample. The chemical analyte list includes both inorganic and organics (Table II-4) and was developed to include contaminants of local interest as well as those measured in the nationwide NOAA Status and Trends program. Measurement reporting limits have been adopted that will allow the data to be compared to NOAA sediment quality guidelines for anticipated biological effect (Long et al. 1995).

Organics

Organic compounds in sediments will be extracted with solvents and cleaned to remove interfering substances. PAHs will be analyzed by GC/MS or HPLC. Organochlorine pesticides and polychlorinated biphenyls will be analyzed by GC/ECD. The accuracy of PCB measurements will be enhanced by measuring 41 individual congeners in all samples with elevated concentrations. The PCB congener list was selected to include compounds that are abundant in the environment and compounds with a high potential for toxicity.

Inorganics
Metals in sediments will be analyzed by ICPMS or atomic absorption spectrophotometry after strong acid digestion. Mercury will be analyzed by cold vapor technique. In addition to trace metals, the reference elements iron and aluminum will also be measured in each sample. Normalization of the trace metal data to reference element concentrations will enable anthropogenic contamination to be distinguished from natural variations in background concentrations.

2. Interstitial Water Chemistry: Chemicals in the pore water between sand grains (interstitial water) are a more biologically available fraction of sediment contaminants than those bound to sand grains. Interstitial water will be extracted by centrifugation and subsamples analyzed for trace metals (Cd, Cu, Ni, Pb, and Zn). Sediment acid volatile sulfides concentration, which partially controls the partitioning of metals from the bound to the interstitial phase, will also be measured.

3. Marine Debris: The amount of plastic, metal and other anthropogenic debris on the bottom is a measure of human influence on the bottom. Debris captured in trawls will be classified by type (e.g., plant material, plastic, and cans) and scored according to relative abundance.

Biological Response

While indicators of contaminant exposure provide an important measure of the influence of anthropogenic materials on the marine environment, it is the effect of this exposure upon biological processes that determines the significance of the contaminants. The effect of contaminant exposure will be examined through a variety of indicators:

4. Benthic Infauna: Benthic infauna (animals that live in the sediment) are an important part of the ocean food web. Because infauna generally reside in one location for most of their lives and are chronically exposed to sediment contaminants, they are an excellent indicator of environmental quality. Samples for infaunal analysis will be taken with a 0.1 m^2 modified Van Veen grab. Samples will be washed through a 1.0 mm stainless steel screen and preserved for identification to the lowest practical taxonomic unit.

5. Demersal fish and megabenthic invertebrate assemblages: Demersal fish and megabenthic invertebrates are more mobile than the benthic infauna, but are still closely associated with the bottom and chronically exposed to sediment contaminants. Demersal fish and megabenthic invertebrates will be collected with a semiballoon otter trawl with 7.6-m headrope length and a 1.3 cm cod-end mesh. Trawls will be towed for 10 min at 0.8-1.0 m/s along depth isobaths. All fish and most invertebrates will be identified to species, counted, and weighed.

6. Gross fish pathology: The presence and extent of external diseases (e.g. fin rot and tumors) and anomalies (e.g. skeletal deformities or abnormal coloration) will be recorded from fish collected in the trawls for assemblage analysis. Specimens with unusual or unidentified conditions will be returned to the laboratory for detailed examination.

7. Sediment and interstitial water toxicity: Toxicity tests provide a direct measure of the effect of contamination on benthic organisms. These tests complement sediment chemistry measurements by providing a measure of the combined toxic effect of the complex mixture of contaminants present in sediment or in the water in the pores between sediment grains (interstitial water). Sediment samples will be collected from the top 2 cm of a Van Veen grab sample. A suite of four different test methods will be used in order to evaluate both acute and sublethal effects.

Amphipod survival
The toxicity of bulk sediments will be assessed using an amphipod survival test conducted according to USEPA methods. Amphipods will be exposed to a 2 cm layer of test sediment for 10 days and then examined to determine the percent survival. The amphipod *Eohaustorius estuarius* was selected for this study because of its wide tolerance to variations in habitat characteristics and to provide comparability with recent toxicity information from other monitoring programs in California.

Microtox®
Sublethal toxicity of interstitial water will be evaluated using the Microtox® test, in which changes in light production of a luminescent bacteria (*Vibrio fisheri*) are measured. This test was selected because it requires a small volume of sample and is relatively insensitive to ammonia toxicity. The test will be conducted using a 15 minute exposure to a 2 ml sample of interstitial water. Test measurements will be made at several dilutions of interstitial water and the median effect concentration (EC50) will be calculated.

QwikLite
Sublethal toxic effects will also be measured using the QwikLite test, which measures changes in light production from a luminescent marine phytoplankton (*Gonyaulax polyedra*). Several concentrations of each sample will be tested in order to calculate the median effect concentration. Sediment leachates will be prepared by mixing sediment and water in a 1:4 ratio and then allowing the mixture to settle. This test measures the toxicity of materials that are able to rapidly desorb from sediment particles.

P450 RGS
Sediment extracts will be analyzed for the presence of dioxin-like chemical compounds using the P450 Reporter Gene System (RGS). This test uses a human cell line which has been modified to produce a luminescent reaction when a gene responsible for the metabolism of certain organic contaminants (e.g., dioxins, coplanar PCBs, high molecular weight PAHs) is induced. The cells are exposed to a solvent extract of the test sediment for 16 hours and then measured to determine the change in luminescence. The degree of gene induction is compared to that produced by a standard and the results expressed as PAH or dioxin equivalents.

8. Fish Tissue Chemistry: The objective of the fish tissue chemistry measurements will be to estimate health risk to marine birds, mammals and wildlife from the consumption of fish tissue. This will be addressed by measuring the whole body concentration of the chlorinated organics compounds asterisked in Table II-4. Fish in the SCB are largely segregated by depth range and no single species occurs over all of the range that will be sampled in Bight'98. To address this data comparability issue, species comprising a feeding guild (i.e. species with similar feeding strategies) will be targeted for collection and analysis. The primary target species (Category I, Table II-5) consist of species from the sanddab guild, which preliminary analyses indicate have comparable contaminant accumulation rates. An alternate guild (the Turbot guild; Category II) was identified for collection in the event that the required number of fish from Category I target species are not collected.

9. Fish Biomarkers: Biomarkers are biochemical indicators of chemical exposure and sublethal effect that can be measured in field collected organisms. Biomarkers provide a more sensitive measure of fish health than the physiological or acute responses measured by external pathology or assemblages. Two biomarkers will be measured in the fish species collected for tissue chemistry measurements (Table II-5).

DNA damage

The integrity of DNA in fish blood cells will be examined by measuring DNA strand breakage using a procedure known as the Comet assay. In this test, blood cells are added to agarose-coated microscope slides and then ruptured to release the DNA. An electric field is used to separate the broken and intact portions of the DNA from individual cells. The extent of DNA breakage is indicated by the relative size of the damaged DNA portion of the sample and is measured using an epifluorescence microscope. The relative amount of damage is determined by comparing the data with reference samples having a known degree of effect. Increases in cellular DNA damage have been found to coincide with decreased health status in various types of organisms.

Bile FACs

Bile FACs (Fluorescent aromatic compounds) is a measure of recent PAH exposure in fish. Exposure of fish to PAH compounds is difficult to measure using conventional analytical chemistry methods because fish have the ability to rapidly metabolize these compounds. The bile FACs method measures the concentration of PAH metabolites that are excreted in bile. Fish will be collected by trawl and dissected on board to remove the gall bladder. In the laboratory, a bile sample is removed from the gall bladder and analyzed by HPLC (fluorescence detection) to determine the concentration of high and low molecular weight PAH metabolites. Metabolite concentrations will be normalized to bile protein content.

Habitat Condition

The distribution of biota is also affected by natural habitat factors, such as grain size and the amount of organic matter present. Habitat indicators will be measured to help distinguish the relative effects of natural and anthropogenic factors on biotic distribution.

10. Sediment grain size: Grain size will be measured with a laser diffraction technique, a method that provides greater resolution between particle size classes with less variability than conventional pipette techniques. Two instruments will be used: 1) A Horiba LA900 which measures 74 size classes of particles between 0.05-1019 μm and 2) a Coulter LS230 that measures 116 size classes between 0.04-2000 μm.

11. Total Organic Carbon (TOC): TOC will be measured with a Carlo Erba 1108 Elemental Analyzer equipped with an AS/23 Autosampler.

12. Mineralogy: Mineralogy provides additional information about the shape and nature of the sediment grains. The amount of clay in the sediment will be determined by the diffraction of x-rays. The amount of heavy minerals in the sediment will be measured by counting mineral grains on glass slides.

D. Coordinated Studies in Mexico

While the focus of Bight'98 is on the US side of the border, a comparable, coordinated study will be conducted at 90 sites in Mexican coastal shelf waters. The Mexican component will share the first Objective of the US study, and will assess the area of 10 to 200 m depth between the Mexican border and Ensenada. The sample sites, shown in Appendix C, were selected using the Bight'98 sampling design.

The Mexican component is presently limited to the collection and processing of sediment chemistry samples, though additional funding is being sought to add benthic infauna and toxicity measures, which will complete the benthic triad and allow relationship between chemical exposure and biological response measures. All sampling effort and laboratory analysis for Mexican sampling sites will be conducted by Mexican scientists, who have helped prepare, and will follow, the procedures outlined in the Bight'98 Field Methods and QA manuals. Mexican scientists have also participated in all laboratory intercalibration exercises conducted by their US counterparts.

Coordinating these programs will allow the first unbiased comparison of relative condition between the coastal waters of the two countries. Joint participation in intercalibration exercises also provides an opportunity to establish comparability that can be exploited in cooperative programs that extend beyond the tenure of Bight'98

FIGURE II-1. 90% Confidence Intervals about an estimate of percent of area changed as a function of sample size.

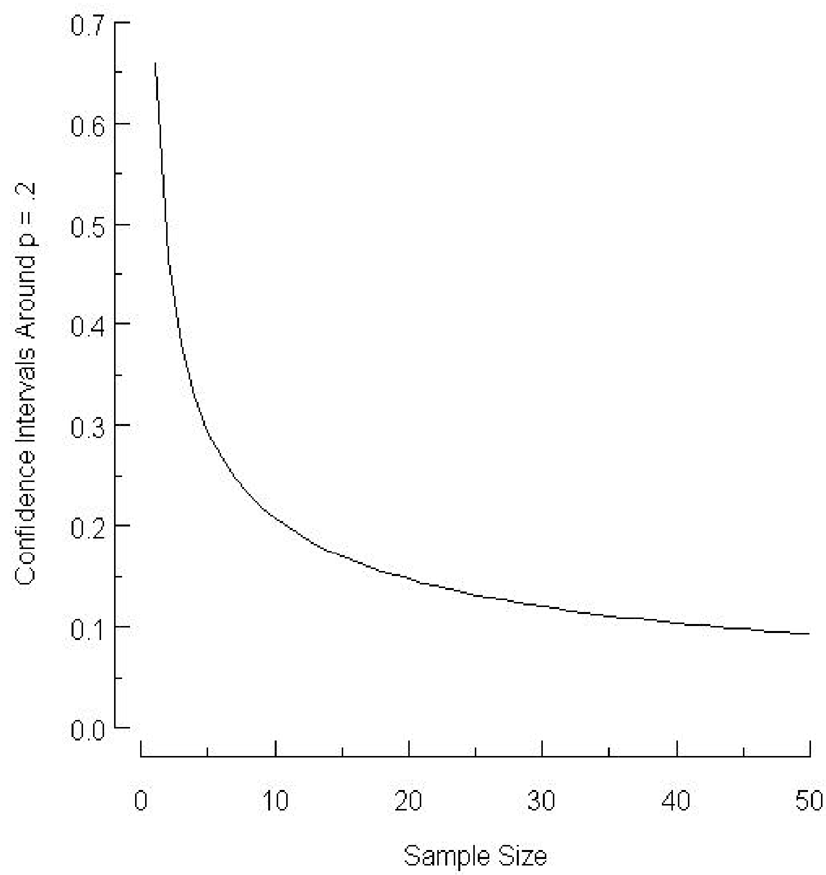

TABLE II-1. Subpopulations of interest in Bight'98.

Offshore
- a. River mouths
- b. Large POTW Outfalls
- c. Small POTW Outfalls
- d. Other offshore areas
  - — Shallow (5-30 m)
  - — Mid-depth (30-120 m)
  - — Deep (120-200 m)

Bays/Harbors
- a. Ports/Industrial
- b. Marinas
- c. San Diego Bay

Islands
- a. Channel Islands - California Current Influence
- b. Channel Islands - Davidson Current Influence
- c. Catalina Island

Historically sampled sites
- a. Seven 60 m sites (1977, 1985, 1990)
- b. Six 30 m sites

TABLE II-2. Indicators to be measured in Bight'98.

<u>Biological response</u>
- Benthic infauna
- Fish assemblage
- Fish pathology
- Macroinvertebrate assemblage
- Fish tissue chemistry
- Toxicity
- — *Eohaustorius*
- — Microtox
- — Quiklite
- Biomarkers
- — DNA damage
- — Bile FACs

<u>Contaminant exposure</u>
- Sediment chemistry
- Interstitial metal chemistry
- Acid volatile sulfides
- P450 Reporter Gene System (RGS 450)
- Debris

<u>Habitat</u>
- Grain size
- Mineralogy
- Sediment organic carbon

ABLE II-3. Sample sizes in the subpopulations for Bight'98.

	Sediment Chemistry	Benthic Infauna	Fish Biomarker	Fish Assemblage	Sediment Toxicity	Fish Tissue	Interstícial Water
Total	296	362	111	354	247	294	173
Offshore							
River mouths	44	44		44	44	44	15
Large POTW	30	30		30	15		
Small POTWs	36	36		36	15	36	15
Other offshore							
5-30 m	30	30		30	30	30	12
120-200 m				30		20	
Bays/Harbors							
Ports/Industrial	35	35	10	10	35	10	35
Marinas	39	39	12	12	39	12	39
San Diego Bay	45	45	28	28	45	28	45
Other B/H Areas	39	39	29	29	39	29	39
Islands							
Channel Islands		46	60	60		25	
Catalina Island		20		30		15	
Historically Sampled							
60 m sites	7	7		7		7	
30 m sites	6	6		6		6	

TABLE II-4. Constituents that will be measured in sediment and fish tissue in Bight'98.

	Sediment	Fish		Sediment	Fish
Aluminum	Yes	No	chlordane	yes	yes
Antimony	Yes	No	PCB Congeners[a]	Yes	Yes
Arsenic	Yes	No	4,4'-DDT	Yes	Yes
Barium	Yes	No	2,4'-DDT	Yes	Yes
Beryllium	Yes	No	4,4'-DDD	Yes	Yes
Cadmium	Yes	No	2,4'-DDD	Yes	Yes
Chromium	Yes	No	4,4'-DDE	Yes	Yes
Copper	Yes	No	2,4'-DDE	Yes	Yes
Iron	Yes	No	5-phenyldecane	Yes	No
Lead	Yes	No	4-phenyldecane	Yes	No
Mercury	Yes	No	3-phenyldecane	Yes	No
Nickel	Yes	No	2-phenyldecane	Yes	No
Selenium	Yes	No	6-phenylundecane	Yes	No
Silver	Yes	No	5-phenylundecane	Yes	No
Zinc	Yes	No	4-phenylundecane	Yes	No
Acenaphthene	Yes	No	3-phenylundecane	Yes	No
Acenaphthylene	Yes	No	2-phenylundecane	Yes	No
Anthracene	Yes	No	6-phenyldodecane	Yes	No
Benz[a]anthracene	Yes	No	5-phenyldodecane	Yes	No
Benzo[a]pyrene	Yes	No	4-phenyldodecane	Yes	No
Benzo[b]fluoranthene	Yes	No	3-phenyldodecane	Yes	No
Benzo[e]pyrene	Yes	No	2-phenyldodecane	Yes	No
Benzo[g,h,i]perylene	Yes	No	7&6-phenyltridecane	Yes	No
Benzo[k]fluoranthene	Yes	No	5-phenyltridecane	Yes	No
Biphenyl	Yes	No	4-phenyltridecane	Yes	No
Chrysene	Yes	No	3-phenyltridecane	Yes	No
Dibenz[a,h]anthracene	Yes	No	2-phenyltridecane	Yes	No
Fluoranthene	Yes	No	7-phenyltetradecane	Yes	No
Fluorene	Yes	No	6-phenyltetradecane	Yes	No
Indeno(1,2,3-c,d)pyrene	Yes	No	5-phenyltetradecane	Yes	No
Naphthalene	Yes	No	4-phenyltetradecane	Yes	No
Perylene	Yes	No	3-phenyltetradecane	Yes	No
Phenanthrene	Yes	No	2-phenyltetradecane	Yes	No
Pyrene	Yes	No	Total organic carbon	Yes	No
2,6-Dimethylnaphthalene	Yes	No	Lipid	No	Yes
1-Methylnapthalene	Yes	No			
2-Methylnapthalene	Yes	No			
1-Methylphenanthrene	Yes	No			
1,6,7-Trimethylnaphthalene	Yes	No			

[a]Congeners 18, 28, 37, 44, 49, 52, 66, 70, 74, 77, 81, 87, 99, 101, 105, 110, 114, 118, 119, 123, 126, 128, 138, 149, 151, 153, 156, 157, 158, 167, 168, 169, 170, 177, 180, 183, 187, 189, 194, 201, 206.

TABLE II-5. Target species of fish for bioaccumulation and biomarker measurements.

Common Name	Scientific Name
Category I	
Longfin sanddab	*Citharichthys xanthostigma*
Pacific sanddab	*Citharichthys sordidus*
Gulf sanddab	*Citharichthys fragilis*
Speckled sanddab	*Citharichthys stigmaeus*
Slender sole	*Eopsetta exilis*
California halibut (<20 cm)	*Paralichthys californicus*
Petrale sole (<20 cm)	*Eopsetta jordani*
Category II	
Diamond turbot	*Hypsopsetta guttulata*
Spotted turbot	*Pleuronichthys ritteri*
C-O sole	*Pleuronichthys coenosus*
Hornyhead turbot	*Pleuronichthys decurrens*
Dover sole	*Microstomus pacificus*
English sole	*Pleuronectes vetulus*
Rock sole	*Pleuronectes bilineatus*

III. LOGISTICS

Bight'98 is a complex project with 11 organizations collecting samples (Table III-1) and 12 organizations processing them in the laboratory (Table III-2). For most samples, collection and processing will be conducted by different organizations. Such complexity requires an effective plan for transferring and tracking samples among organizations. The details of that plan are provided in Bight'98 Field Methods and Logistics Manual; a short summary of that plan is provided here.

SCCWRP will be responsible for tracking all samples collected during Bight'98. Chain of custody forms will be used to track each sample from the time it is collected to its final destination in the laboratory. At the end of each sampling day, the field crew will fill out a form for each set of samples to be transferred. This form will be signed by the crew member transferring the samples and the laboratory staff member receiving them. A copy of the form will be kept and the original form with signatures will accompany the samples. Copies of all chain of custody form will to be faxed or delivered to SCCWRP.

Samples being processed by the organization collecting the samples will be sent directly to the organization's laboratory. All other samples will be sent to SCCWRP for re-distribution to the processing lab. For items that must be processed quickly (Toxicity, AVS), samples will be redistributed to the processing labs at the end of every week. All other items will be accumulated and redistributed at the mutual convenience of SCCWRP and the processing labs.

TABLE III-1. Number of stations to be sampled by each organization participating in field collections.

	Sediment Sampling	Trawl Sampling
City of Los Angeles	28	19
Los Angeles County Sanitation Districts	19	20
Orange County Sanitation District	30	—
City of San Diego	80	64
U. S. Navy	7	16
Channel Islands National Marine Sanctuary	44	64
University of Southern California	22	32
Seaventures	14	—
Aquatic Bioassay and Consulting Laboratories	52	57
MEC Analytical Systems	12	106
MBC	89	—
Total	397	378

TABLE III-2. Number of samples to be processed by each participating laboratory.

	Benthic Infauna	Fish Tissue Chemistry	Amphipod Toxicity	Microtox	Quiklite	DNA Biomarker	Bile FACs
City of Los Angeles	77	106	30				
Los Angeles County Sanitation Districts	30	28					
Orange County Sanitation District		10	60	173			
City of San Diego	107	67	20				
U.S. Navy					173	111	
So. California Coastal Water Research Project			40				111
Aquatic Bioassay and Consulting Laboratories		53		52			
MEC Analytical Systems	88		15				
CRG Labs		83					
Columbia Analytical Systems							
U.S. Geological Survey							
U.S. EPA Office of Research & Development							
Marine Pollution Studies Lab			30				

TABLE III-2 (continued). Number of samples to be processed by each participating laboratory.

	Sediment Inorganic Chemistry	Sediment Organic Chemistry	Molecular Markers	Interstitial Metals/ AVS	RGS 450	Total Organic Carbon	Mineralogy	GrainSize
City of Los Angeles	45	45						209
Los Angeles County Sanitation Districts	20	20						
Orange County Sanitation District	50	50						
City of San Diego	87	87						158
U.S. Navy								
So. California Coastal Water Research Project			296			296		
Aquatic Bioassay and Consulting Laboratories								
MEC Analytical Systems								
CRG Labs		94						
Columbia Analytical Systems	94				296			
U.S. Geological Survey							362	
U.S. EPA Office of Research & Development				173				
Marine Pollution Studies Lab								

IV. INFORMATION MANAGEMENT

A. Overview of Approach

Bight'98 is based on the principle of partnership; all participating organizations will have equal and complete access to the data collected during the project. Historically, each organization has collected and managed its own data. Consequently, there are many different information management systems in Southern California, which impedes sharing of data among project participants. Bight'98 will address this challenge by developing and implementing an integrated, uniform, and well-documented information management system (IMS). The foundation for this system was developed during the SCBPP, when procedures were developed to facilitate data transfer and sharing between participants, and will be enhanced for Bight'98 to include a more rigorous quality assurance program. The highlights of the system are presented here; additional details are presented in an accompanying information management manual.

The core of the IMS will be a set of standardized data transfer protocols (SDTP) for sharing information among project participants. These protocols will be an expansion of the formats developed during the SCBPP and will detail the information to be submitted with each sample collection or processing element, the units and allowable values for each parameter, and the order in which that information will be submitted. Use of SDTP allows each participating organization to retain their existing data management system, yet output the data in a manner that allows sharing among organizations.

The SDTP calls for sharing of data at the level of individual replicate, rather than in a summarized format. The protocols will also carry summary quality assurance (QA) information, though routine laboratory QA procedure data (e.g. blanks, spikes) will be retained at the individual laboratory. Our objective in selecting which QA data to carry within the IMS will be to provide the user enough information to evaluate the data.

A second attribute of the IMS will be centralized data storage. Bight'98 includes many collaborators, with eleven boats responsible for sampling and a dozen labs responsible for laboratory processing, which precludes a distributed system. The centralized location will be at SCCWRP, where it will be stored on personal computers in Microsoft Access.

B. Data Flow and Quality Assurance

Each field crew or laboratory generating data will initially enter it into their own data management system and subject it to their internal QA/QC procedures. Recommended QA will include double punching of data and range checks. Data will next be reformatted into the SDTP and submitted to the Information Management Officer (IMO) at SCCWRP in comma-delimited, ASCII format.

Upon receipt, the IMO will check the data for errors, such as inclusion of all required fields, range checks, and proper naming conventions for text fields. Most of the error checking will be automated, conducted by a computer program developed specifically for Bight'98. The program will identify potential errors in the data by comparing the submitted values to expected ranges and formats specified in the information management plan. Small errors will be corrected by the IMO with the consent of the submitting lab; data sets with larger errors will be returned to the providing lab for correction, along with a list of corrections that the organization needs to make.

Once the IMO has certified that the data is consistent with the SDTP requirements, the data will be distributed to the Technical Committee Chair (TCC) responsible for that class of data. The TCC, with assistance of their Technical Committee, will review the data with respect to scientific content. This review will involve plotting of data and examining interrelationships among individual parameter responses and will address more extensive data quality issues than can be accomplished by range checking alone. The TCC will communicate any identified data problems to the IMO.

All corrections to the data will be made by the IMO; access to the database for other users will be in read-only form. Prior to making any changes, the IMO will document the changes and receive (written or electronic) concurrence from the organization that originated the data. The IMO will only make changes in the centralized data base; originating organizations will be responsible for making corresponding changes in their own internal data storage systems. All changes to the data will be documented in a computerized file available to all data users.

C. Data Availability

All data from Bight'98 will be made publicly available, though the schedule of availability will vary by user class. The different schedules recognize the differing levels of quality assurance and data documentation that will have been completed at various stages in the project. Four classes of user have been identified:

1. Information Management Officer: All organizations will submit data to the IMO within one month of completing their assigned sample collection or laboratory processing task. The amount of time before data is expected to reach this stage varies by indicator and is summarized in Table IV-1.

2. Technical Committee Members: The Technical Committee Chairs will be provided data of the type for which they are responsible immediately following certification by the IMO that the data follows the SDTP formats. The TCCs will work with their Committee members to conduct scientific content review.

3. Steering Committee Members: All project participants will have access to data once the TCC has conducted initial scientific review for data quality. TCCs will be asked to complete this review within three months.

4. General Public: Data will be released to the general public once the TCC has conducted initial data analysis and the Steering Committee has accepted an oral report from the TCC that summarizes the major project results for that data type. TCCs will be asked to make this presentation, and provide summary results tables from the presentation, within six months of releasing data to the Steering Committee.

Each release of data will include comprehensive documentation. This documentation will include a lookup tables used to populate specific fields in specific tables, access control, and database table structures (including table relationships). It will also include quality assurance classifications of the data (flags, as appropriate) and documentation of the methodologies by which the data were collected (metadata).

TABLE IV-1. Expected elapsed time between the end of sampling and transfer of data to the Information Management Officer, including the time required for sample processing, internal QC checks, and data entry using the SDTP.

Benthic infauna	12 mo.
Grain size	6 mo.
Total organic carbon	6 mo.
Mineralogy	9 mo.
Sediment organics	12 mo.
Sediment metals	6 mo.
Sediment acid volatile sulfides	6 mo.
Interstitial water metals	6 mo.
Amphipod survival	3 mo.
Microtox	6 mo.
QwikLite	3 mo.
RGS 450	12 mo.
Fish biomarkers	6 mo.
Fish and megabenthic invertebrate assemblages	3 mo.
Fish pathology	3 mo.
Fish tissue chemistry	12 mo.
Debris	3 mo.

V. QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance/quality control (QA/QC) is an important part of any environmental monitoring project. A carefully planned QA/QC program ensures that the data collected are scientifically valid, comparable, and adequate to meet the goals of the study. QA/QC is particularly important for large monitoring projects like Bight'98 that involve many participants.

The QA/QC program consists of two distinct but related activities: quality assurance and quality control. Quality assurance includes design, planning, and management activities conducted prior to the study to ensure that the appropriate kinds and quantities of data are collected. Quality control activities are implemented during the project to evaluate the effectiveness of the QA activities in controlling measurement bias and error. QA activities are emphasized in Bight'98 due to the distributed implementation of the project. The QA and QC activities are outlined below; a complete description of the QA/QC elements for each field or laboratory component can be found in the Bight'98 Quality Assurance Plan.

A. Quality Assurance Elements

The QA activities are intended to ensure that comparable data are collected and that the number of lost or damaged samples are minimized. Four types of QA activities will be conducted prior to the collection or analysis of samples.

- **Standardization of sample collection, processing, and analysis methods**
  The use of standardized field sampling methods is important for ensuring data comparability because the type of gear and how it is used can affect the final data. Methods for the collection and handling of samples in the field will be standardized and documented in the Bight'98 Field Methods and Logistics Manual. In addition, some analytical methods (e.g., sediment toxicity testing) will be standardized among laboratories. Standardization of analytical methods is not possible for all parameters due to differences in instrumentation among laboratories. For these parameters, comparability of the analytical measurements will be documented by a performance-based program that includes the analysis of standard reference materials.

- **Training workshops for field and laboratory personnel**
  Standardized methods cannot specify every detail of a procedure or anticipate unusual events. Training of field and laboratory personnel is needed to ensure that the methods are being followed correctly and that the participants have an adequate level of expertise to conduct the study. Bight'98 training activities will include meetings of field and laboratory technical committees to discuss methods, joint workshops with the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT), exchange of voucher specimens, and field review/training exercises for sampling and fish dissections methods.

- **Establishment of Measurement Quality Objectives**
  Measurement Quality Objectives (MQOs) specify acceptable levels of precision, accuracy, and completeness for each measurement (Table V-1). Establishment of standard, quantitative MQOs for precision and accuracy will ensure that individual data sets produced by the field crews and laboratories will be comparable and free of any crew- or

laboratory-specific bias. An MQO of 90% for completeness has been established for Bight'98. Completeness is a measure of the proportion of the expected, valid data that is actually collected during a measurement process. Large monitoring programs typically lose some samples due to logistical difficulties or failure to achieve laboratory quality control criteria. The sampling design for Bight'98 is sufficiently redundant to absorb the loss of up to 10% of the samples without compromising the goals of the program

- **Interlaboratory comparison exercises**
  The comparability of laboratory data produced during Bight'98 will be assessed prior to the survey, since multiple laboratories will be measuring most indicators (Table II-3). Presurvey interlaboratory comparison exercises are especially valuable since they provide an opportunity to identify problems and correct them before data quality is compromised. Participation in presurvey interlaboratory comparison exercises is a requirement of laboratories processing Bight'98 samples. These exercises will include the analysis of split samples for sediment chemistry and the identification of fish and invertebrate voucher specimens.

B. Quality Control Elements

A QC program will be conducted to ensure that measurement error and bias are identified, quantified, and accounted for or eliminated if practical. The QC program is performance based, which means that data quality is assessed on the basis of each laboratory's ability to produce measurements that meet specific MQOs. The Bight'98 QC program includes both internal and external procedures.

Internal QC procedures include activities performed on the Bight'98 samples. For chemistry, toxicity, and biomarker measurements, internal procedures include routine checks of instrument calibrations and analysis of spiked and duplicate samples. These internal QC checks are conducted on a frequent basis during the survey, so that problems with personnel or instrumentation can be identified and corrected at an early stage. Taxonomic performance for benthic infauna will be evaluated by the reanalysis of a subset of the samples. Taxonomic performance for identification of megabenthic invertebrates and demersal fish will involve expert re-identification of voucher specimens.

External QC procedures include the analysis of reference or split test samples among laboratories to provide an ongoing evaluation of interlaboratory data comparability. In addition, field performance audits will be conducted by individuals designated by the technical committees. The performance audits will include visits to each vessel during the survey to verify that the correct sampling and taxonomic procedures are used.

TABLE V-1. Measurement Quality Objectives for Bight'98.

Indicator group	Accuracy	Precision	Completeness
			90%
Benthos			90%
sample collection	NA[1]	NA	90%
sorting	5%	NA	90%
counting	10%	NA	90%
identification	10%	NA	90%
sediment grain size	NA	20%	90%
total organic carbon	15%	20%	90%
mineralogy	NA	10%	90%
Sediment chemistry			
organics	30%	30%	90%
metals	20%	30%	90%
RGS 450	NA	2sd[2]	90%
Sediment Toxicity			
amphipod survival	NA	2sd	90%
Interstitial water			
Microtox	NA	2sd	90%
QwikLite	NA	2sd	90%
Fish assemblages			
sample collection	NA	NA	90%
counting	10%	NA	90%
identification	5%	NA	90%
length (fish only)	10%	10%	90%
biomass	NA	10%	90%
gross pathology	NA	NA	90%
Fish tissue chemistry			
Contaminants in fish	30%	30%	90%
Fish biomarkers			
bile FACs	30%	30%	90%
DNA damage	NA	2sd	90%

[1] not applicable
[2] reference toxicant EC50 is within 2 standard deviations of the average value for lab

VI. PROJECT MANAGEMENT

A. Management Structure

Almost a thousand people from 50 organizations are involved in the planning and implementation of Bight'98. Success of the program depends largely on an effective management structure to communicate project objectives and coordinate the effort among participants to produce data that are reliable and comparable. This is being accomplished with a three-tier management structure; the three tiers have distinct roles and provide the opportunity for participation by different levels of personnel from within each participating organization (Figure VI-1).

At the center of the Bight'98 management structure is the Steering Committee, which is composed of scientifically-trained, mid-level managers from each of the participating agencies (Table VI-1). The Steering Committee is responsible for overall planning of the project, including establishing project objectives, developing the sampling design and selecting the indicators to be measured. Steering Committee members are responsible for defining the resources their organization bring to the project and for ensuring that the objectives set forth for the project are achievable within the cumulative set of resources available. The Steering Committee also serves as a point of technical review for all documents that are produced by the project. Participation on the Steering Committee ensures each participating organization the opportunity to direct the program through a consensus building process.

The Steering Committee is supported by eight technical subcommittees, which are responsible for recommending technical approaches to accomplish the objectives set forth by the Steering Committee. There are two different types of technical committees that support the Steering Committee. The first group are discipline-specific committees, including Sediment Chemistry (which has formed metals, PAH and PCB subcommittees), Toxicology, Fish, Benthic Infauna, Water Quality and Microbiology. The second group are cross-cutting committees, including Field Methods/Logistics and Information Management. Technical committees are responsible for preparing methods and quality assurance manuals for the project. They are responsible for implementing the quality assurance procedures (e.g. intercalibration exercises) prior to the study and the quality control assessments during the study. Additionally, the discipline-specific committees are responsible for preparing the reports that summarize project data from within their discipline. Technical Committee representatives are generally scientists with extensive knowledge within the discipline and are appointed by Steering Committee members. Technical Committees ensure that the abilities and expertise available from the diverse participants in Bight'98 are exercised to the fullest advantage throughout the project. Appendix D lists current members of each Technical Committee.

Technical Committees make recommendations and present draft documents to the Steering Committee. The Steering Committee is responsible for assessing whether these recommendations and documents are consistent with the project objectives and for assessing whether the costs of the recommendations are consistent with the resources available for conducting the project. The Steering Committee is also responsible for resolving conflicts that arise within or among Technical Committees.

The third tier of project management is the SCCWRP Commission, which is the primary audience for the products of this project. SCCWRP is a joint powers agency, that is coordinating Bight'98. The SCCWRP Commission is a nine-member board that is composed of the highest level of management from each of the largest municipal dischargers to Southern California Bight and from each of the agencies responsible for regulating discharge to the Bight. Reporting to the SCCWRP Commission, which meets on a quarterly basis, ensures that the questions addressed by Bight'98 remain relevant to current management issues. Reporting to the Commission also maximizes the likelihood that the project results will be incorporated into the southern California environmental management decision-making arena.

B. Project Reporting

Bight'98 will produce four types of technical reports. The first will be Technical Committee reports, with each Technical Committee assigned a group of indicators to be included in their report (Table VI-2). These reports will focus on addressing the core questions of the project. Generally, the Technical Committees will be asked to present their reports orally to the Steering Committee about six months after the data have past Technical Committee QA review. Written reports will generally follow about six months after the oral report.

While Technical Committees are being asked to produce draft written reports within one year after data availability, this is an aggressive schedule that may require some flexibility. Bight'98 involves a large number of participants and includes measurement of new indicators in unfamiliar habitats. More importantly, one of the focal points of the Bight'98 reporting process will be consensus among project participants, and consensus about data interpretation is not always reached quickly. All project participants are provided the opportunity to place members on any of the Technical Committees that are preparing reports; in addition, all project reports will be reviewed by the Steering Committee, where additional opportunity for discussion will take place. One of the strengths of the 1994 SCBPP was the healthy dialog that took place among the varied project participants, an aspect we'd like to mimic in Bight'98.

The second type of report will be indicator development reports. Indicator development reports will assess the quality of information produced by selected indicators, or will use information from the project to enhance information produced by a set of measurements. Examples of such reports include the iron-normalization curves and Benthic Response Index developed during the SCBPP. Indicator development reports will lag the basic Technical Committee reports because they typically require data from multiple indicator groups, which may be available on different time schedules. Indicator development reports may be produced as appendices to Technical Committee reports, if they are available in an appropriate time frame.

The third type of report will be cross-cutting reports that relate biological response to contaminant exposure. The target date for these reports will be about three years after sample collection. These reports take longer to produce because they require expertise and interaction among multiple Technical Committees. In addition, these reports require multiple types of data and are time-limited by the last data to became available from the laboratory.

The last type of report will be an Executive Summary Report (ESR). The target ESR will be a 25 page document that summarizes all aspects of the projects findings and is intended for easy reading by upper level managers and the general public. The first three types of reports will generally be long, technically complex, and contain many details of interest only to the most dedicated scientists. The ESR will be prepared in recognition that our primary audience for this study is the SCCWRP Commission and other SCB environmental managers. The Steering Committee will have the responsibility for selecting from and summarizing the massive amount of information that will be produced in this project into a format that can be easily assimilated by the primary target audience. The ESR will follow production of the other document types and should be available about three years after sampling is completed.

FIGURE VI-1. Project Management Structure for Bight'98.

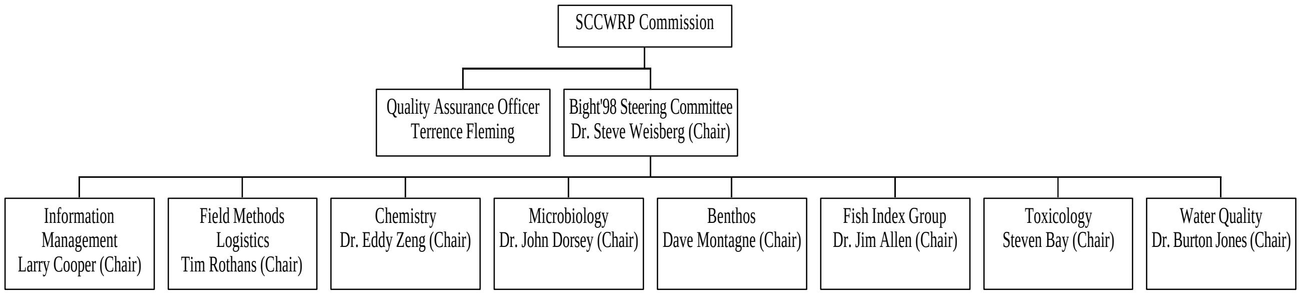

TABLE VI-1. 1998 Regional Monitoring Steering Committee Members.

Anson, Nancy	Encina Wastewater Authority
Branch, Nicki	San Elijo Joint Powers Authority
Dojiri, Mas	City of Los Angeles Environmental Monitoring Division (CLAEMD)
Fangman, Sarah	Channel Islands National Marine Sanctuary (CINMS)
Fleming, Terry	US EPA, Region IX
Grovhoug, Jeff	US Navy, Space & Naval Warfare Systems Center, San Diego
Harley, Ann	Aliso Water Management Authority (AWMA) Southeast Regional Reclamation Authority (SERRA)
Herbinson, Kevin	Southern California Edison (SCE)
Ito, Neil	Chevron USA Products Company
Jones, Darcy	San Diego Regional Water Quality Control Board (SDRWQCB)
Lyons, Michael	Los Angeles Regional Water Quality Control Board (LARWQCB)
Mayville, Steve	Santa Ana Regional Water Quality Control Board.
Michael, Pete	San Diego Regional Water Quality Control Board (SDRWQCB)
Mikel, Tim	Aquatic Bioassay & Consulting Laboratories (ABCL)
Mofidi, Fazi	Los Angeles Department of Water and Power (LADWP)
Moore, Bruce	Orange County Public Facilities and Resources Department (OCPFRD)
Noble, Rachel	USC Wrigley Institute for Environmental Studies (WIES)
Pennell, Gus	City of Oceanside
Rao, Linda	State Water Resources Control Board (SWRCB)
Robertson, George	Orange County Sanitation District (OCSD)
Stull, Jan	Los Angeles County Sanitation Districts (LACSD)
Vereker, Lori	City of San Diego
Weisberg, Steve	Southern California Coastal Water Research Project (SCCWRP)

TABLE VI-2. Technical Committee responsible for reporting of each indicator.

Benthic Infauna
- Infauna
- Grain Size
- Total organic carbon
- Mineralogy

Chemistry
- Sediment organics
- Sediment metals
- Sediment acid volatile sulfides
- Interstitial water metals
- Molecular markers

Toxicology
- Amphipod survival
- Microtox
- QwikLite
- RGS 450
- Fish biomarkers

Fish
- Fish and megabenthic invertebrate assemblages
- Fish pathology
- Fish tissue chemistry
- Debris

VII. LITERATURE CITED

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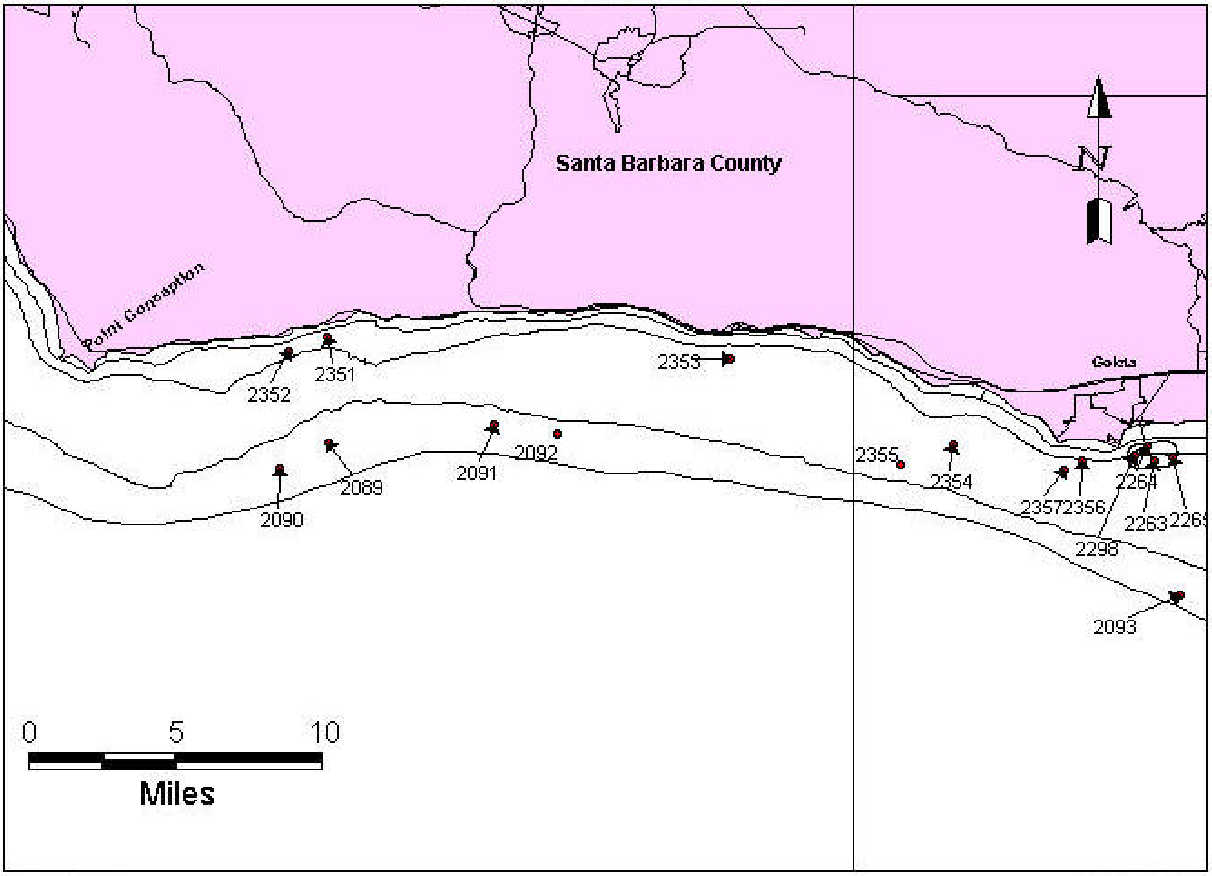
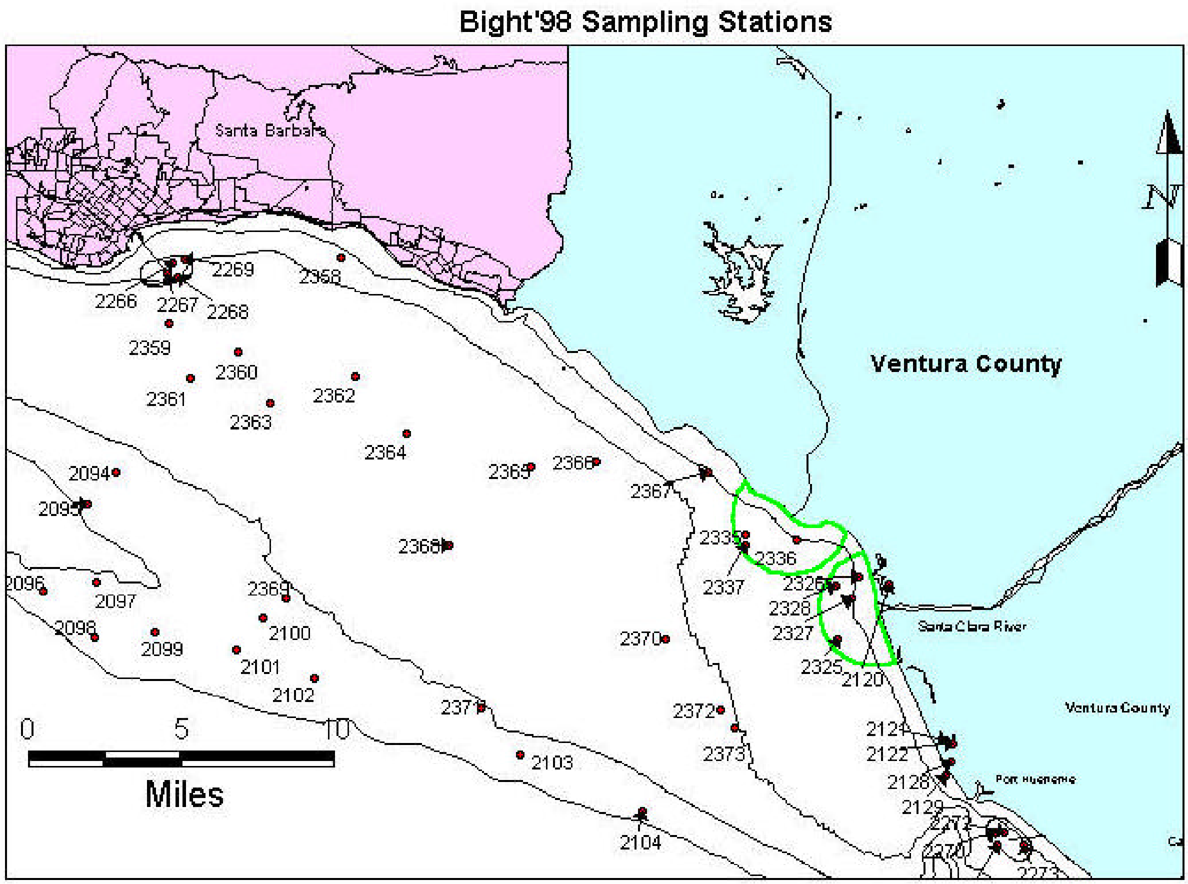
APPENDIX A. MAPS OF SAMPLING SITES

Bight'98 Sampling Stations




Bight'98 Sampling Stations
Santa Barbara
Ventura County
Santa Clara River
Ventura County
Port Hueneme
Miles
0
5
10
N
2269
2358
2266
2267
2268
2359
2360
2361
2362
2363
2364
2365
2366
2367
2094
2095
2368
2335
2336
2337
2096
2097
2369
2326
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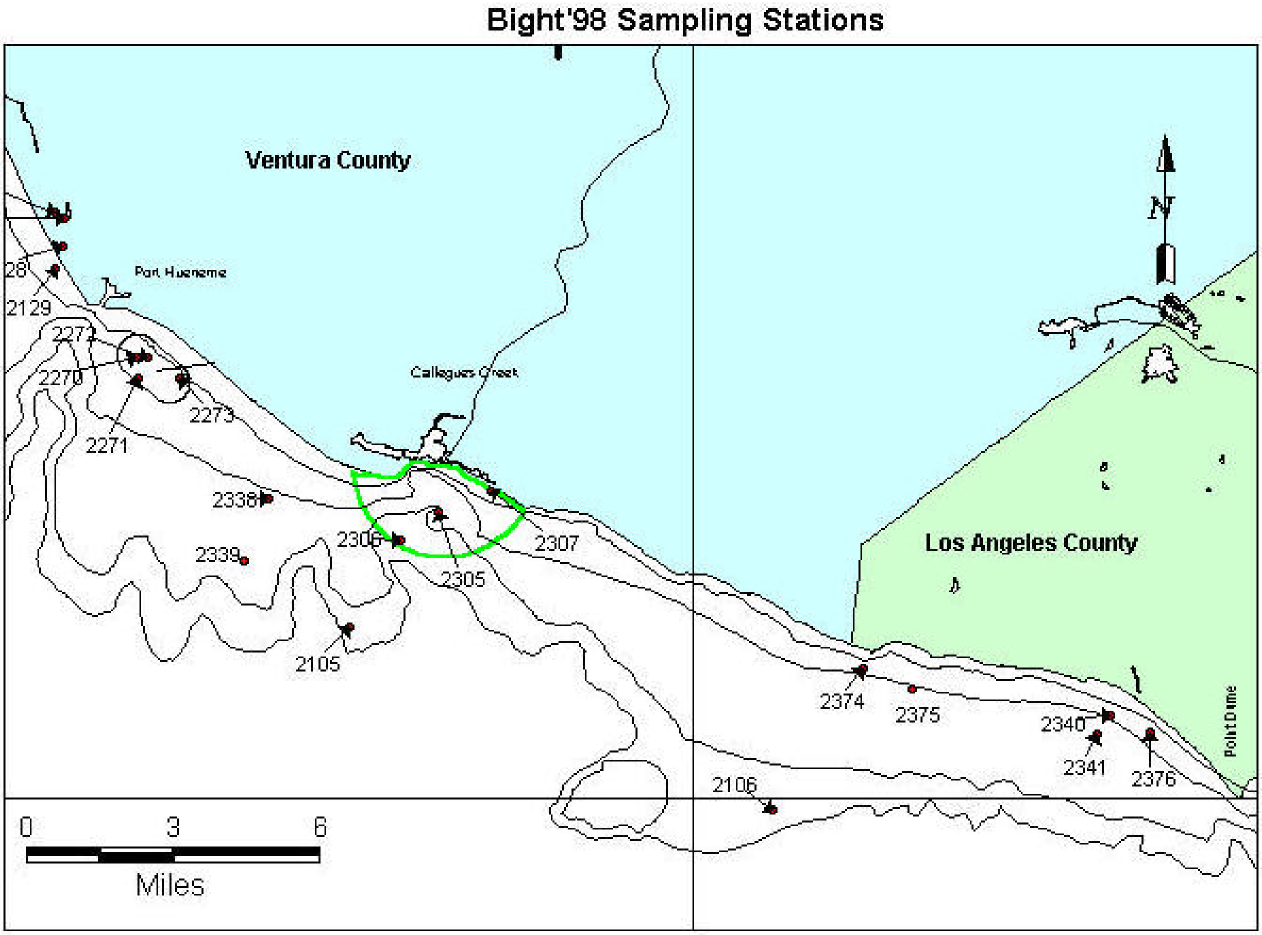
Bight'98 Sampling Stations
Ventura County
Port Hueneme
Calleguas Creek
Los Angeles County
Point Dume
N
2129
2272
2270
2273
2271
2338
2339
2306
2305
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2340
2341
2376
2106
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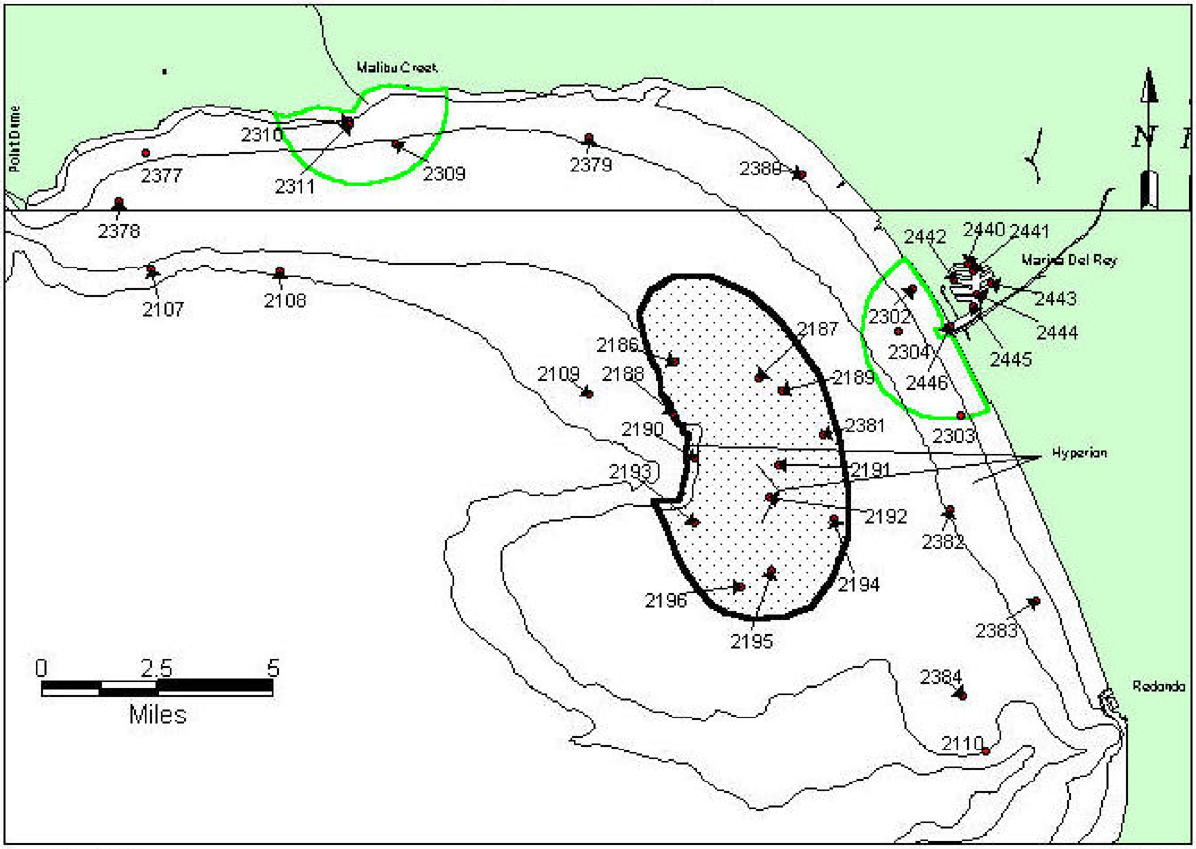
3
6
Miles

Bight'98 Sampling Stations



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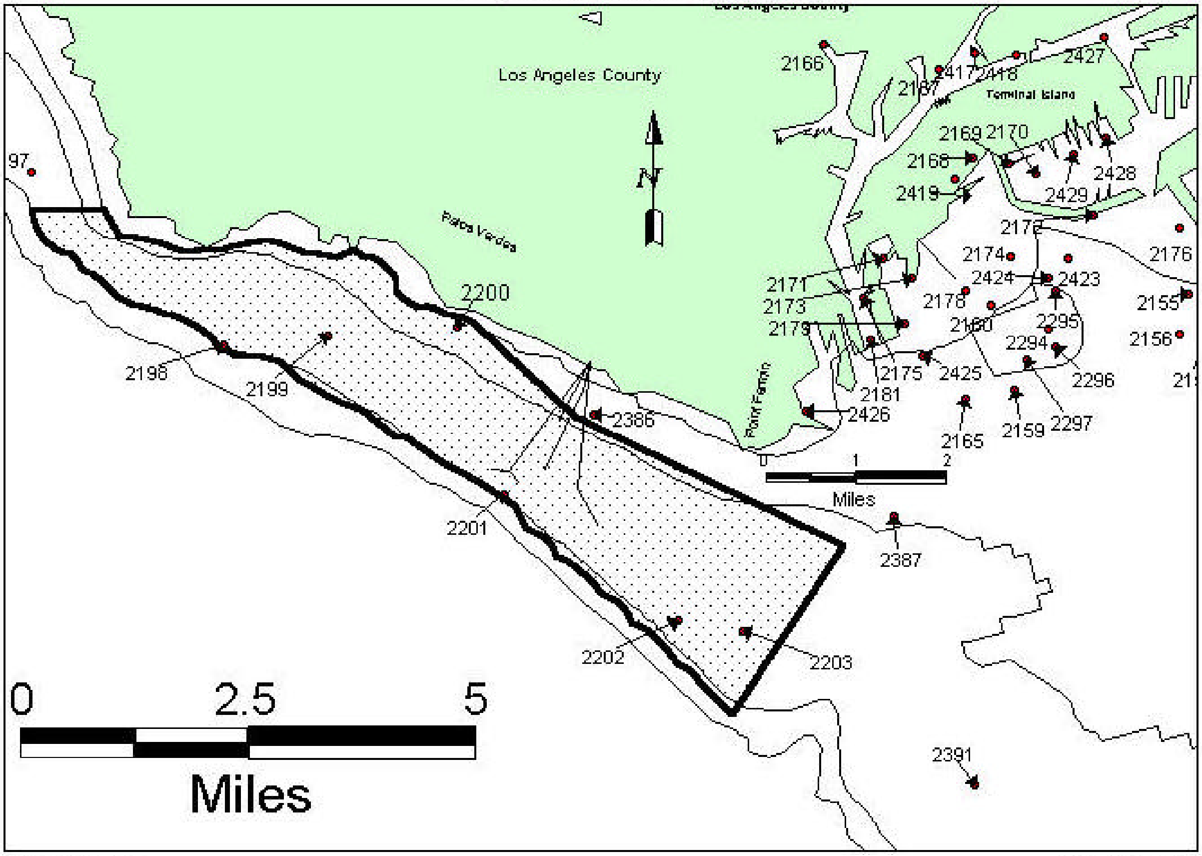
Printed 13AUG98

Author: Larry Cooper

Bight'98 Sampling Stations



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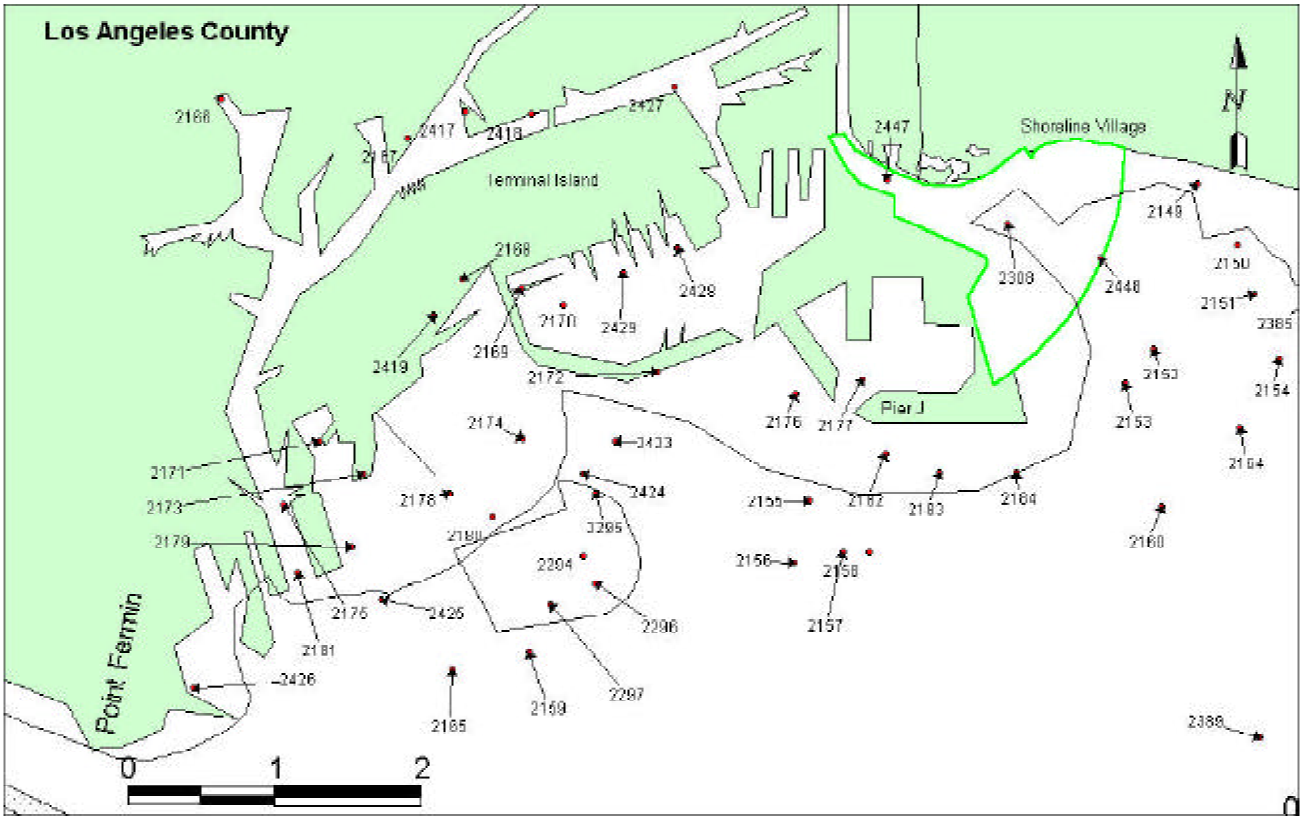
Author: Larry Cooper


Los Angeles County
Terminal Island
Shoreline Village
Pier J
Point Fermin
N
0
1
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2166
2167
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2418
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2150
2151
2385
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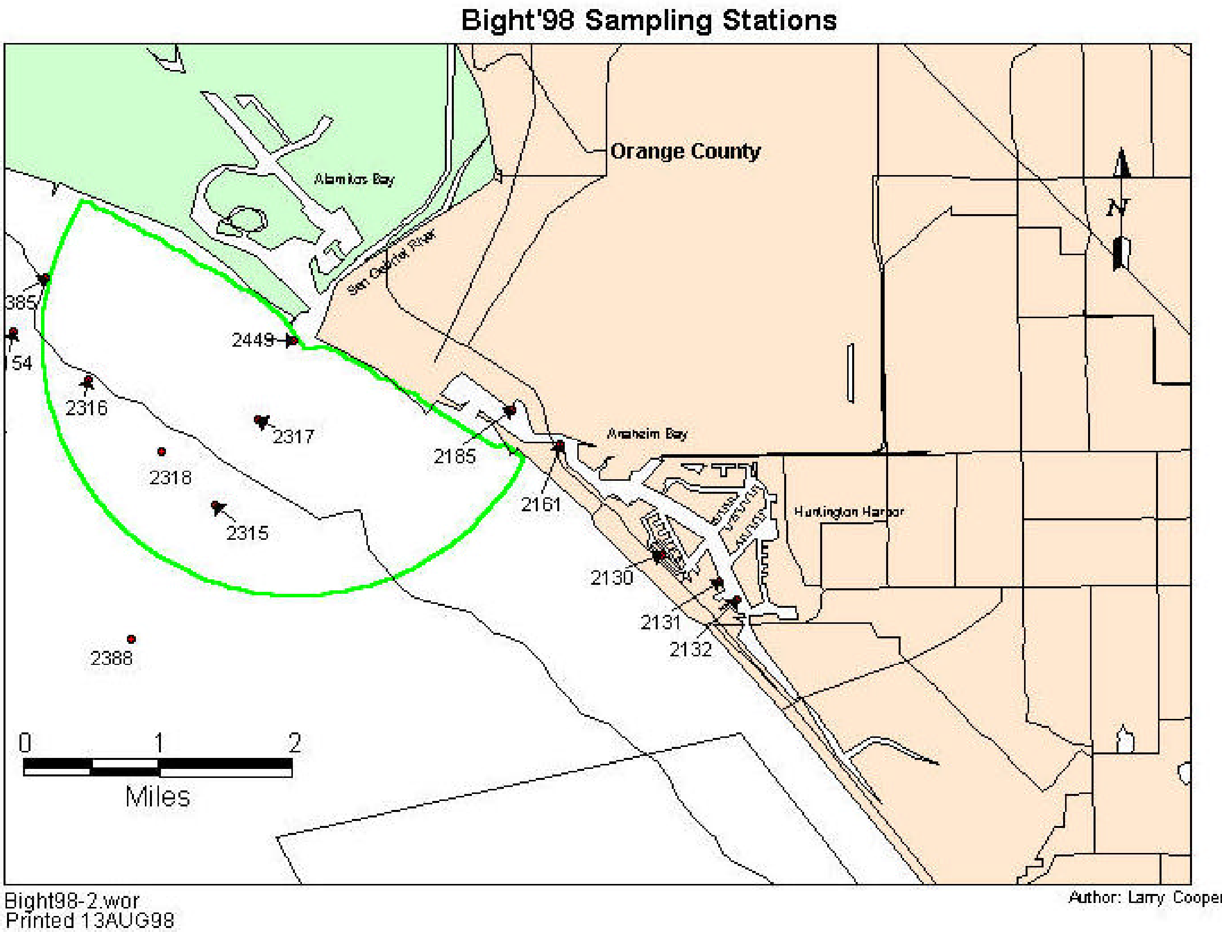
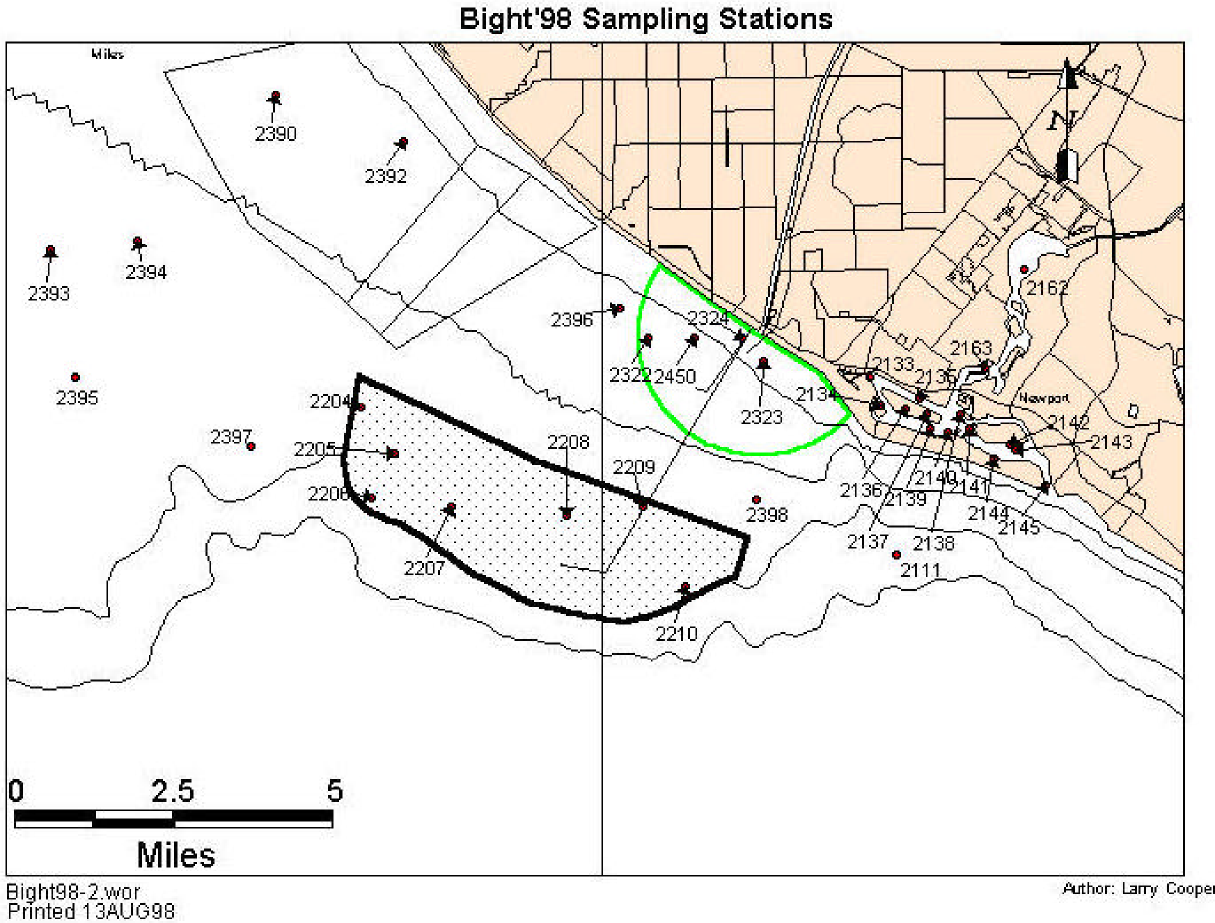
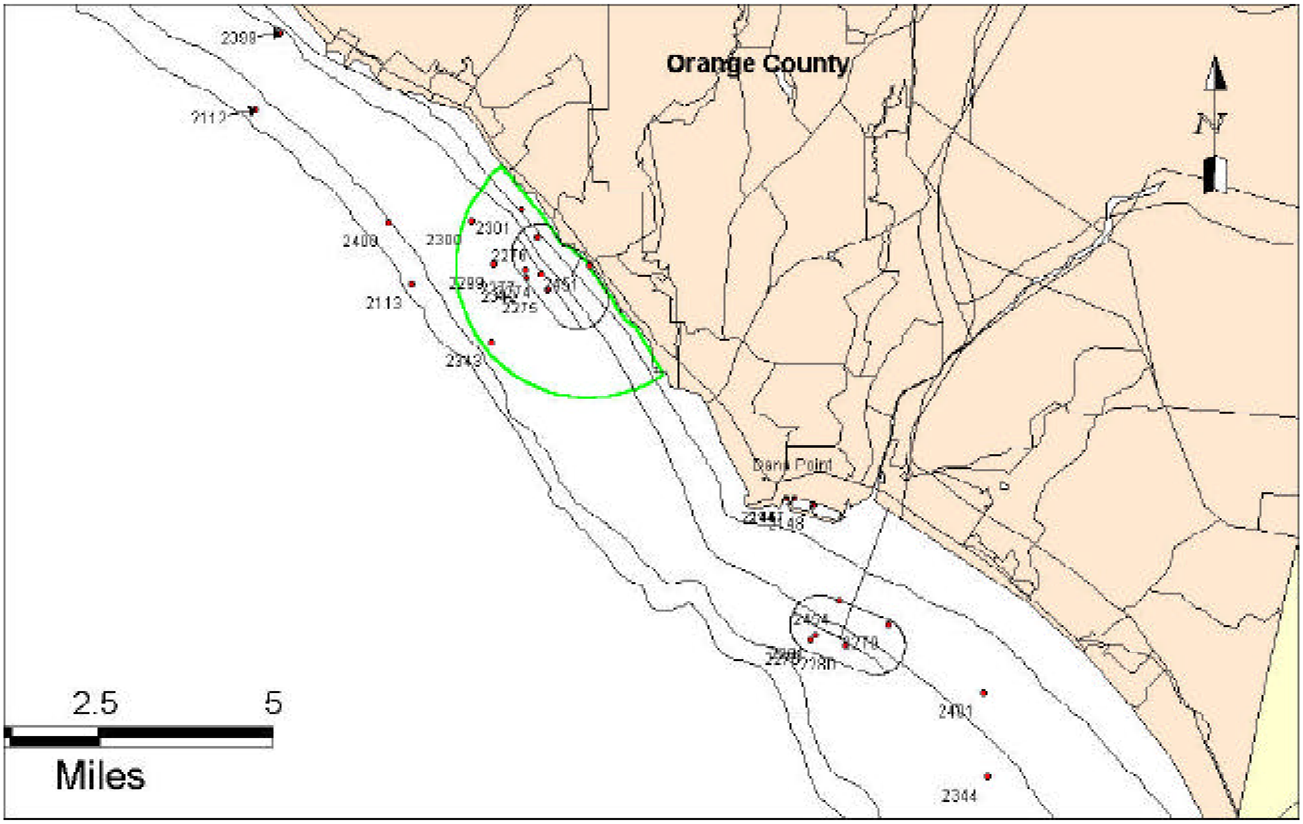
2159
2389

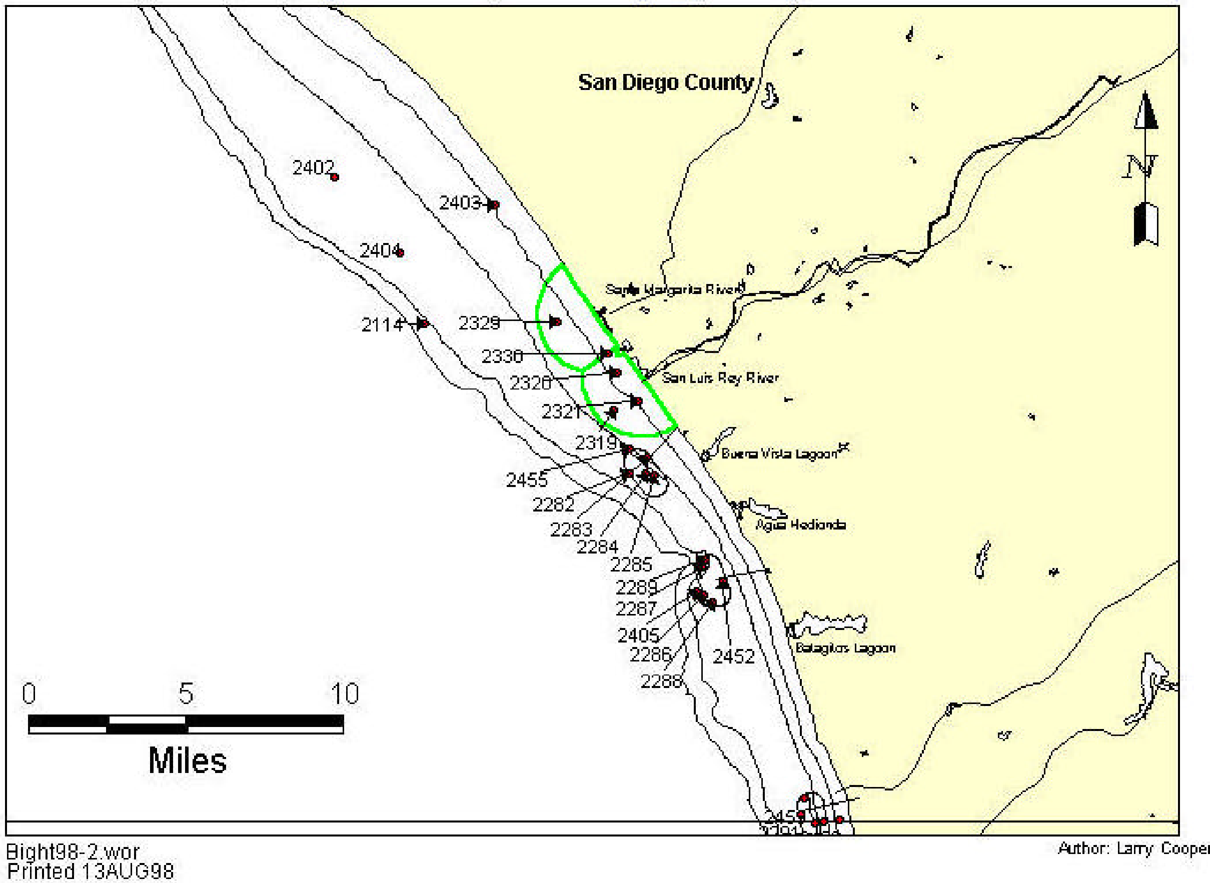


Bight'98 Sampling Stations
Orange County
Alamitos Bay
San Gabriel River
Anaheim Bay
Huntington Harbor
N
385
54
2449
2316
2317
2318
2315
2185
2161
2130
2131
2132
2388
0
1
2
Miles
Bight98-2.wor
Printed 13AUG98
Author: Larry Cooper


Bight'98 Sampling Stations
Miles
2390
2392
2393
2394
2395
2396
2397
2398
2204
2205
2206
2207
2208
2209
2210
2322
2450
2324
2323
2134
2133
2135
2163
2162
Newport
2142
2143
2136
2139
2140
2141
2144
2145
2137
2138
2111
N
0
2.5
5
Miles
Bight98-2.wor
Printed 13AUG98
Author: Larry Cooper


Orange County
N
2398
2112
2400
2300
2301
2276
2113
2299
2451
2275
2343
Dana Point
2148
2424
2278
2401
2344
2.5
5
Miles

Bight'98 Sampling Stations



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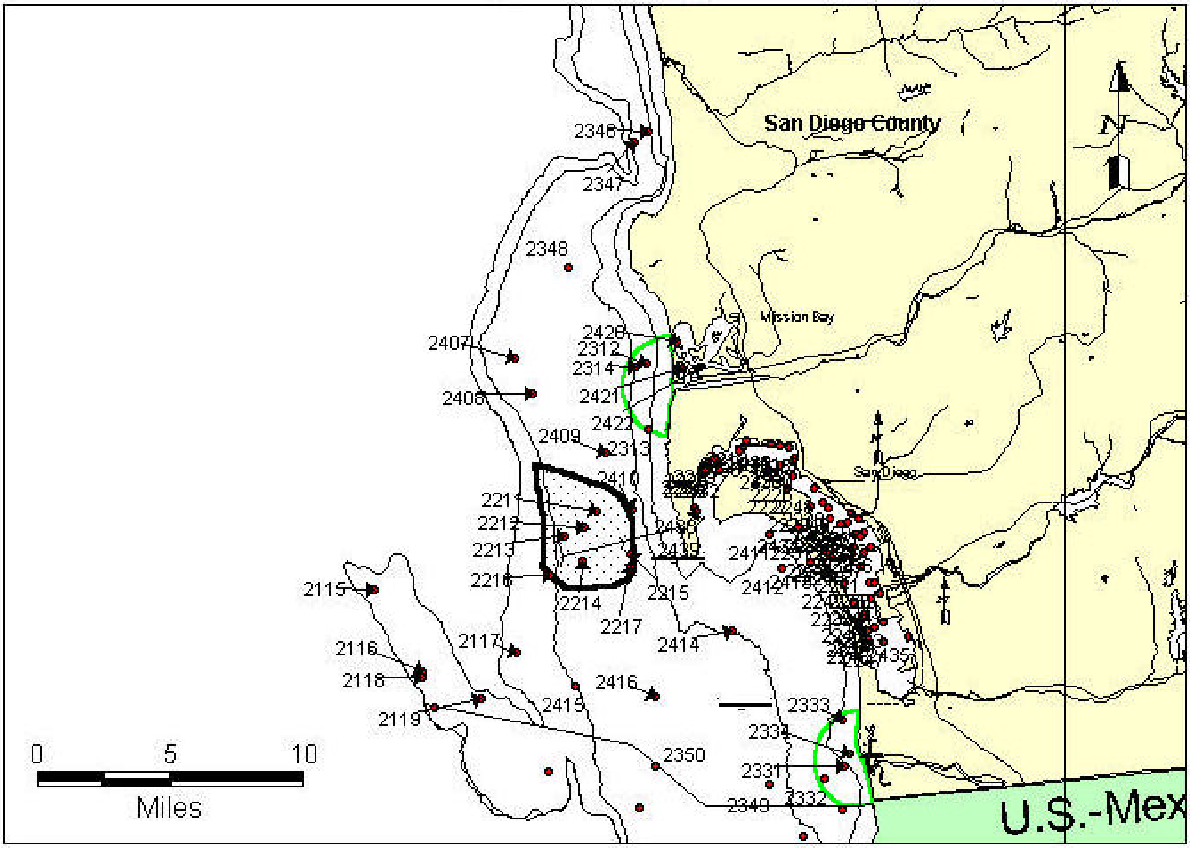
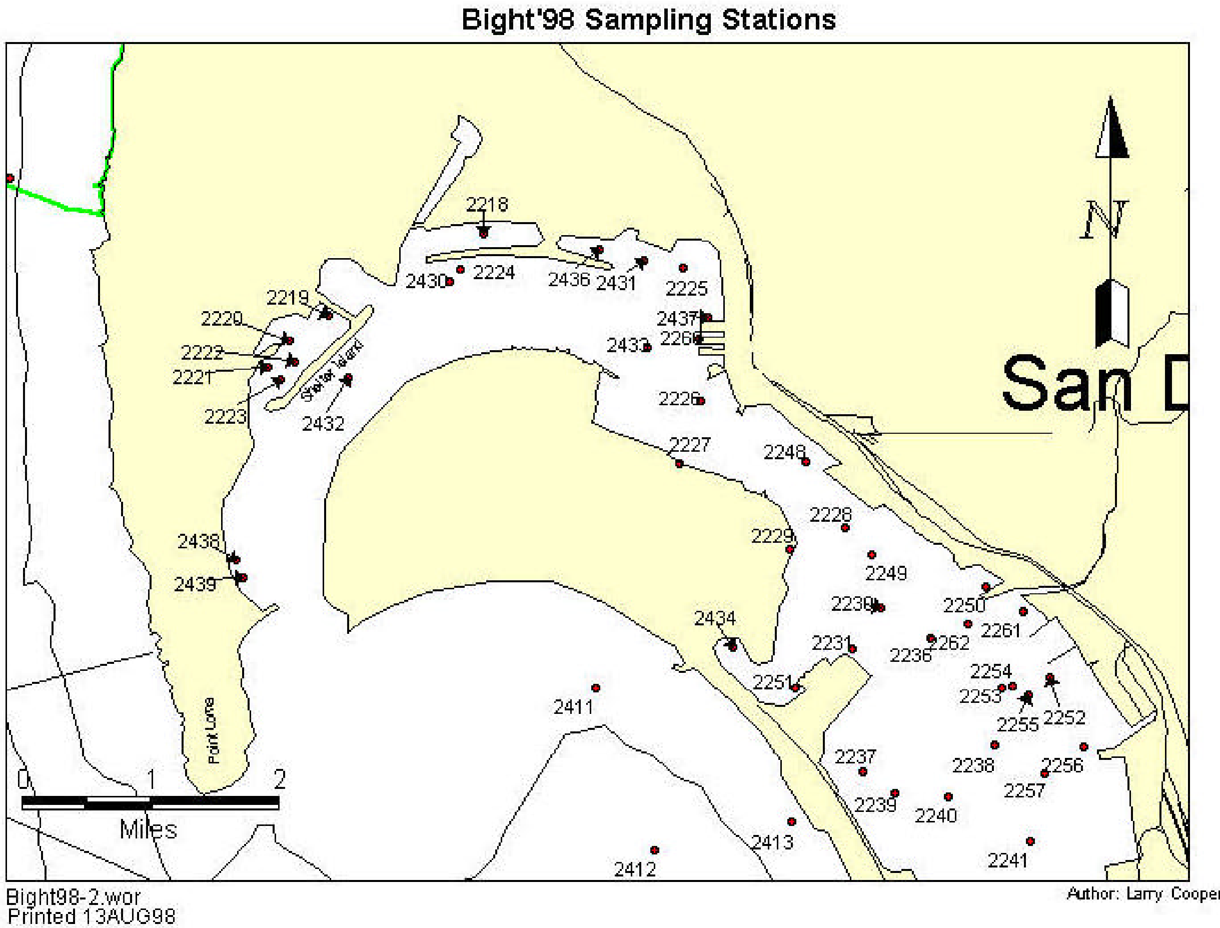
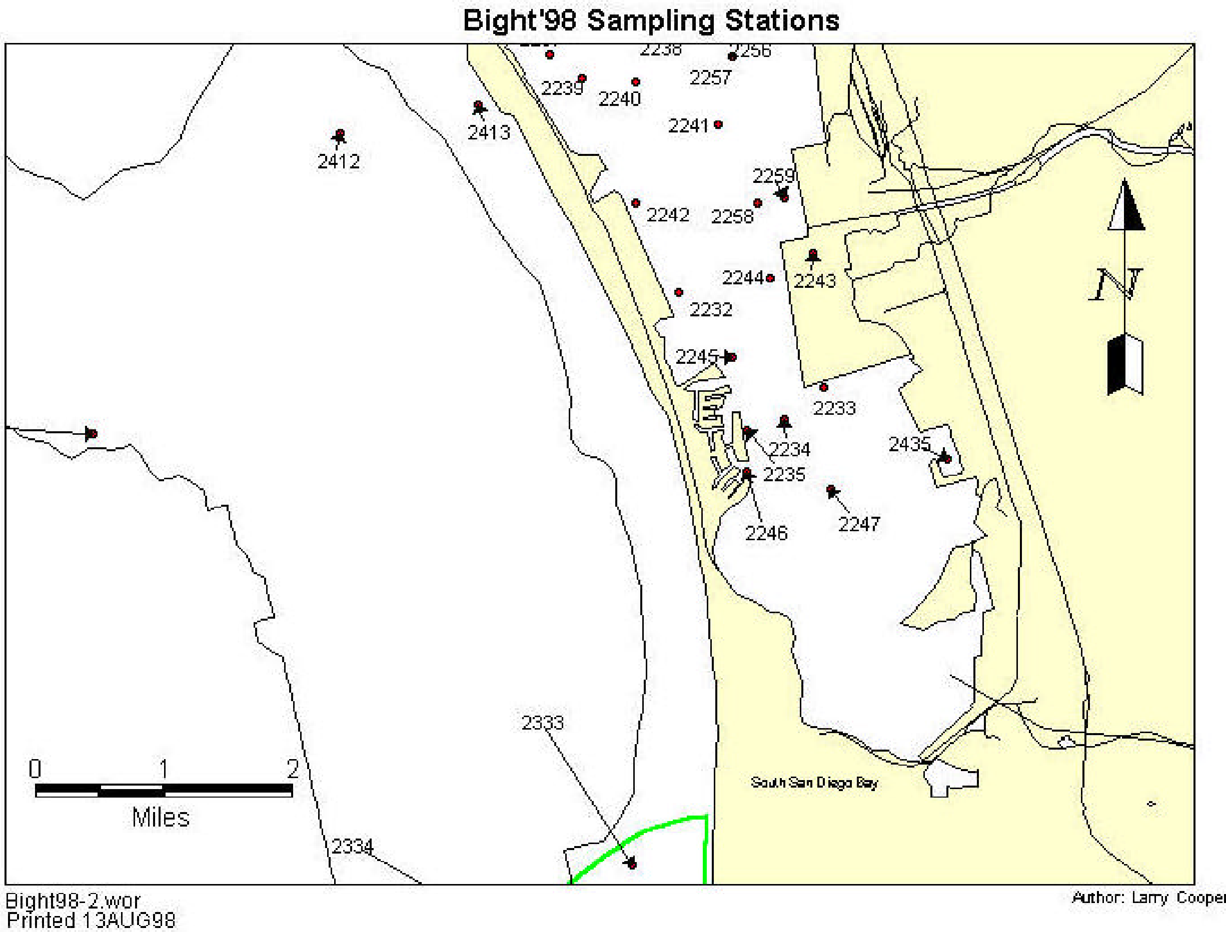


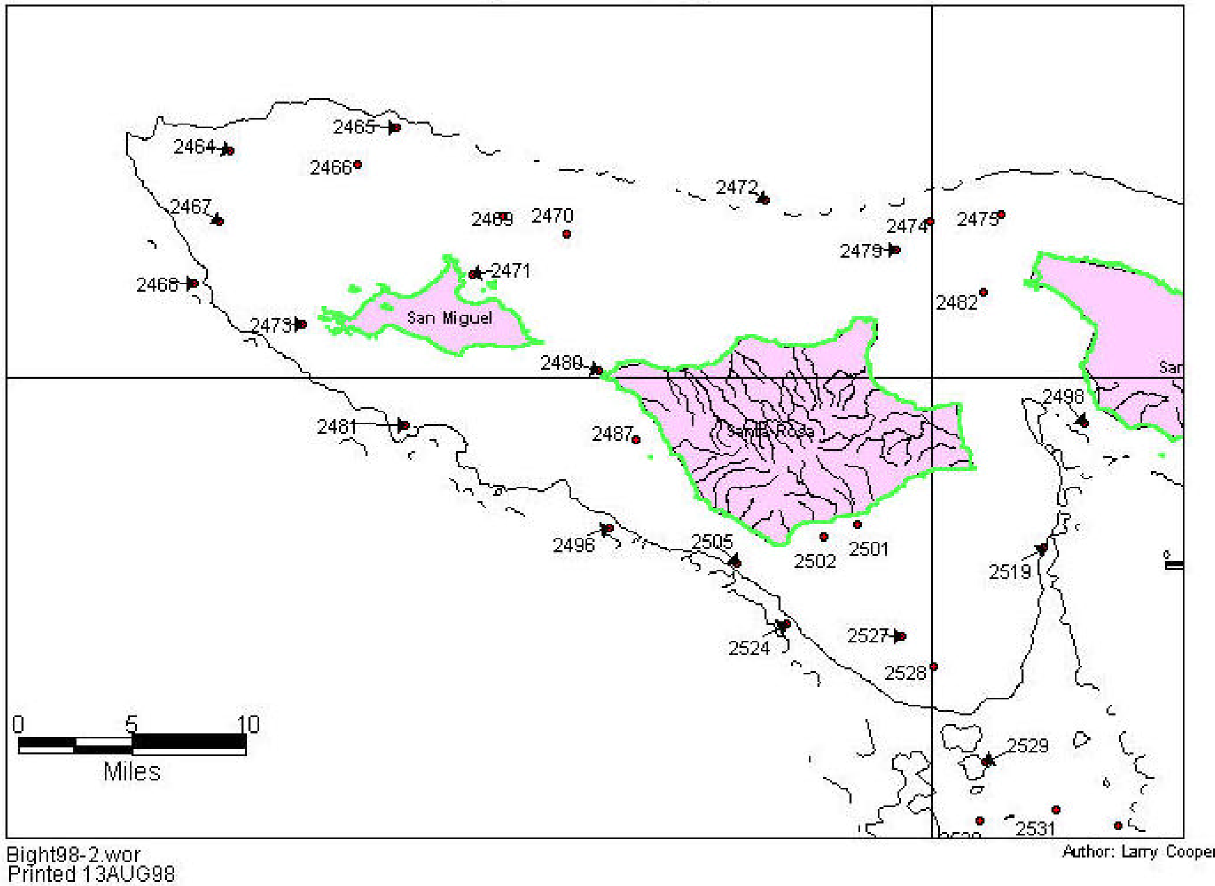
Bight98-2.wor
Printed 13AUG98

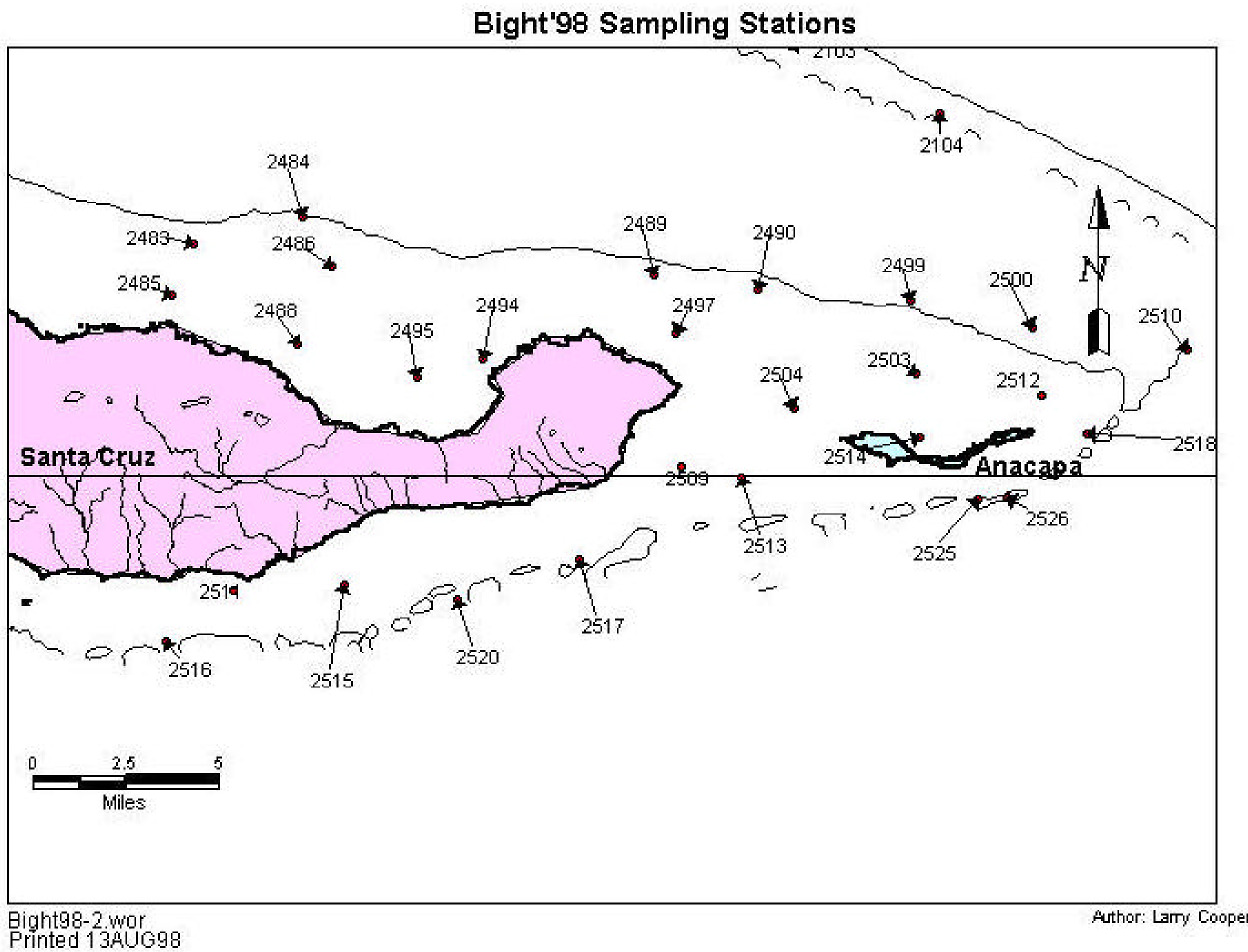
Author: Larry Cooper


Bight'98 Sampling Stations
N
San D
Shelter Island
Point Loma
0
1
2
Miles
2218
2224
2430
2436
2431
2225
2219
2220
2222
2221
2223
2432
2437
2433
2260
2226
2227
2248
2228
2229
2249
2438
2439
2230
2250
2434
2231
2236
2262
2261
2254
2251
2253
2255
2252
2411
2237
2238
2256
2257
2239
2240
2413
2412
2241
Bight98-2.wor
Printed 13AUG98
Author: Larry Cooper


Bight'98 Sampling Stations
2238
2256
2257
2239
2240
2413
2241
2412
2259
2242
2258
2244
2243
2232
2245
2233
2234
2435
2235
2246
2247
N
2333
0
1
2
Miles
2334
South San Diego Bay
Bight98-2.wor
Printed 13AUG98
Author: Larry Cooper

Bight'98 Sampling Stations




Bight'98 Sampling Stations
2104
2484
2483
2486
2485
2488
2495
2494
2489
2497
2490
2499
2500
2510
2504
2503
2512
2514
Anacapa
2518
Santa Cruz
2509
2513
2525
2526
2511
2517
2516
2515
2520
0
2.5
5
Miles
N
Bight98-2.wor
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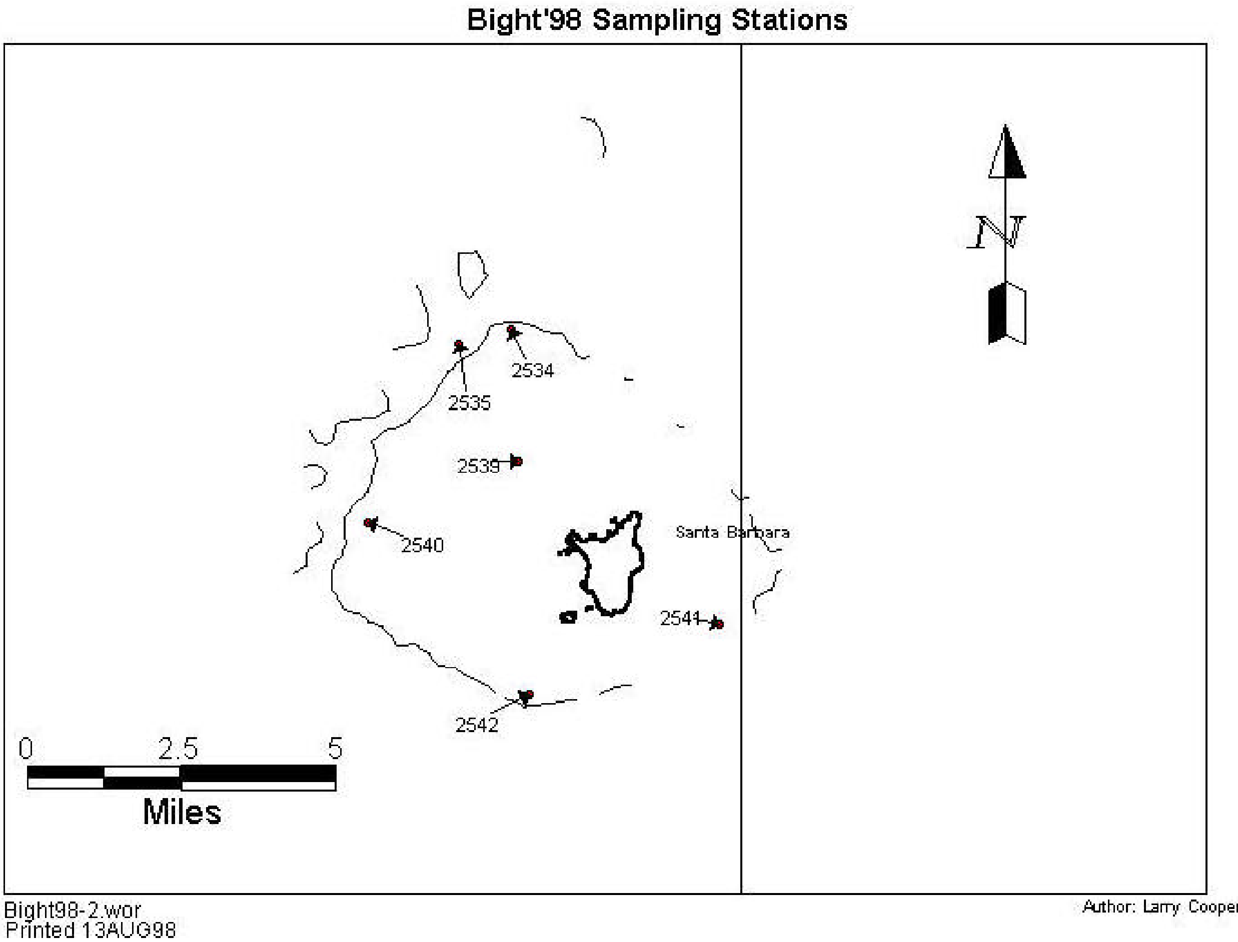
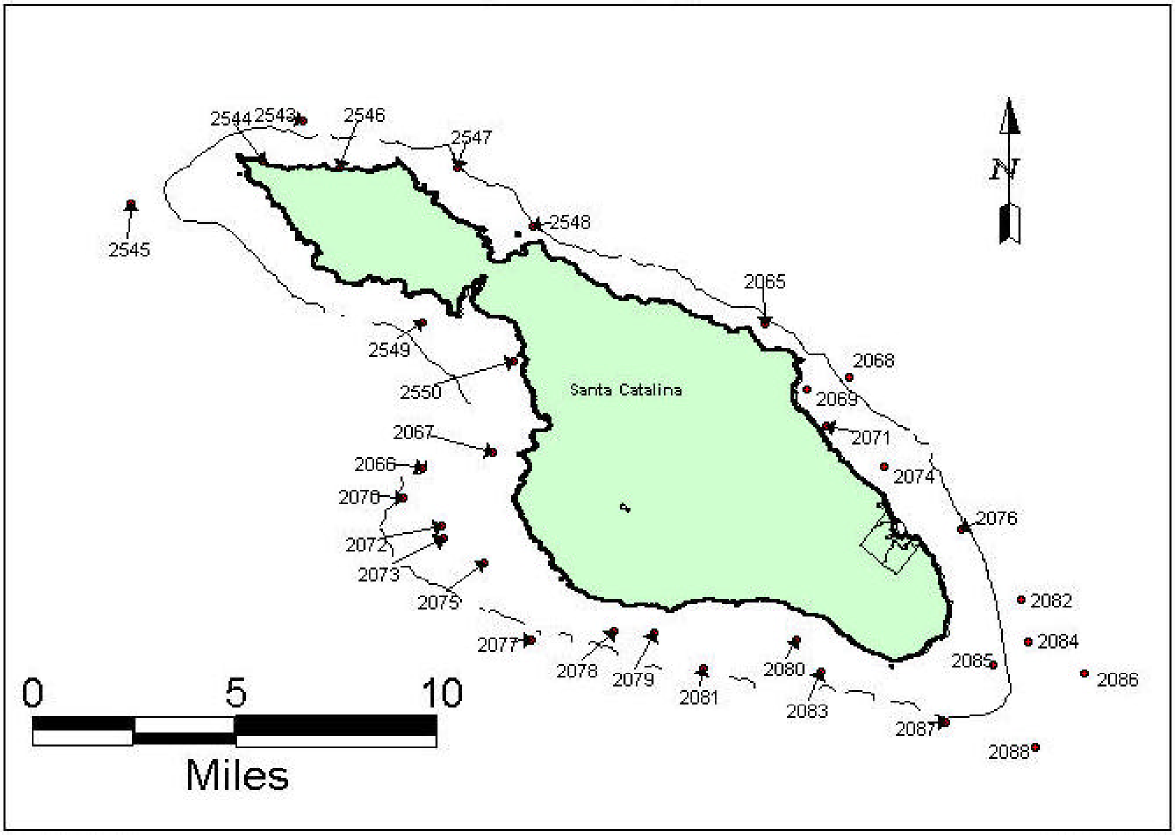
Author: Larry Cooper

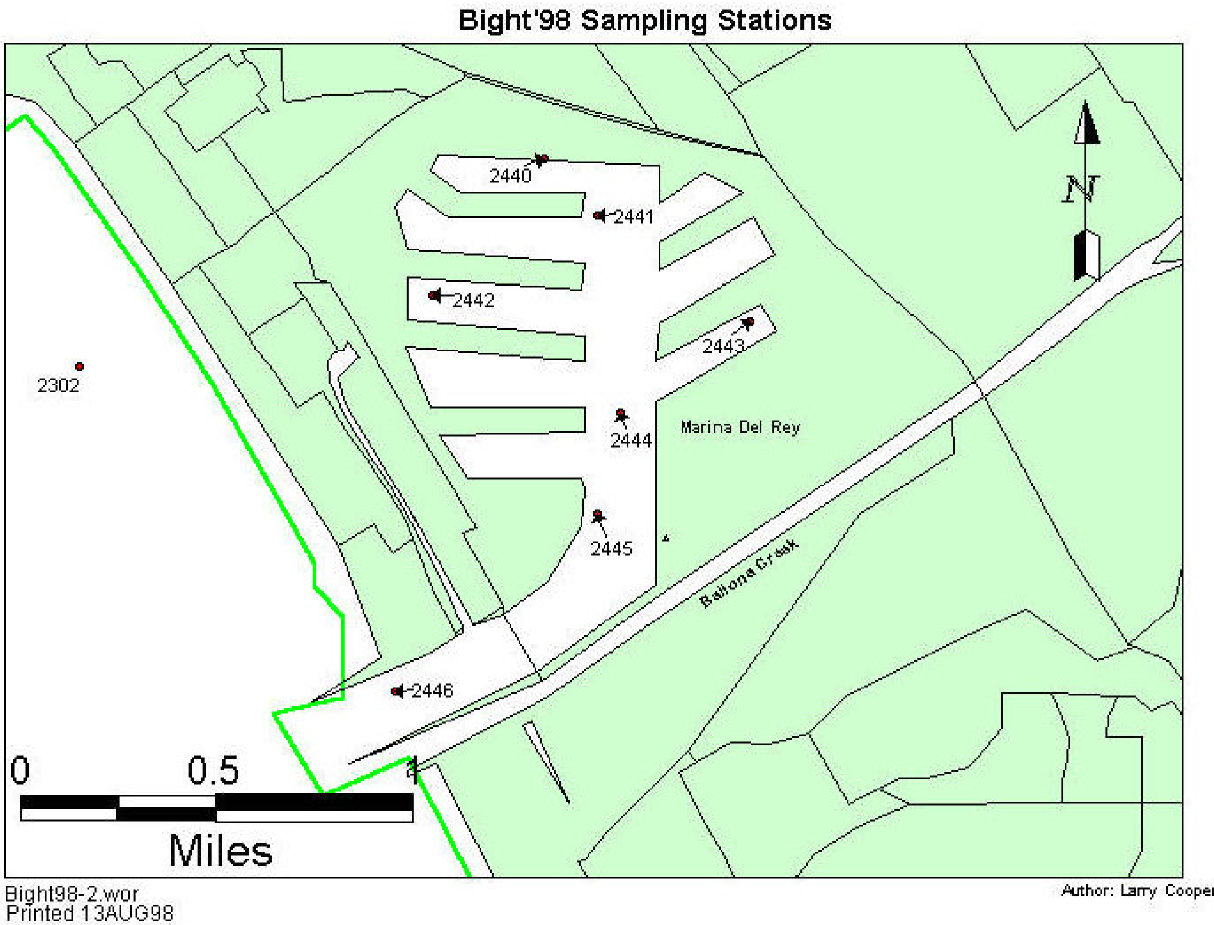

Bight'98 Sampling Stations
2534
2535
2539
2540
Santa Barbara
2541
2542
0
2.5
5
Miles
N
Bight98-2.wor
Printed 13AUG98
Author: Larry Cooper

Bight'98 Sampling Stations



Bight98-2.wor
Printed 13AUG98

Author: Larry Cooper


Bight'98 Sampling Stations
2440
2441
2442
2443
2302
2444
Marina Del Rey
2445
Ballona Creek
2446
0
0.5
1
Miles
N
Bight98-2.wor
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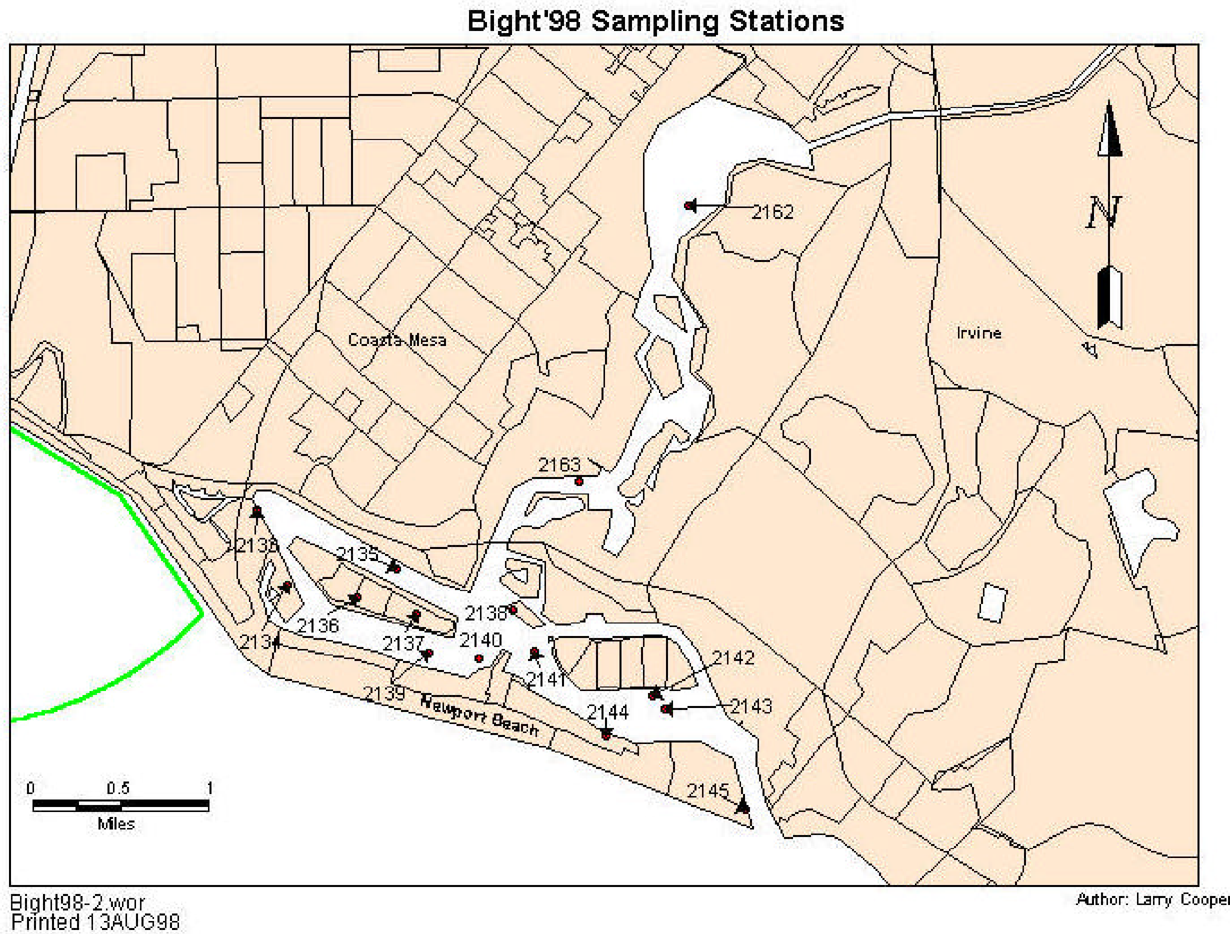
Author: Larry Cooper


Bight'98 Sampling Stations
2162
Coasta Mesa
Irvine
N
2163
2133
2135
2134
2136
2137
2138
2140
2141
2139
Newport Beach
2142
2143
2144
2145
0
0.5
1
Miles
Bight98-2.wor
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APPENDIX B. SAMPLE SITE SELECTION PROCESS

Sample sites for Bight'98 were selected using an extension of the sampling design used in the SCBPP and by EPA's Environmental Monitoring and Assessment Program (EMAP) (Stevens 1997). The design calls for a double randomization superimposed upon a spatially systematic element. The systematic element is created by linearizing two dimensional space using hexagons that spatially order the sample frame and then stratifying that linear space. The double randomization follows from random selection of individual hexagons within the stratified units, and then random selection of specific sampling coordinates within the selected hexagon.

The address scheme used to spatially order the hexagonal grid was developed by picking one of the hexagons near the center of the study area and linking it with the six adjacent hexagons to form a cluster of seven hexagons, or a *hexal*. The seven hexagons were numbered starting in the center with 0, and proceeding up and clockwise (Figure B-1). Construction of the addressing system continued by surrounding the hexal just formed with six other hexals of the same shape (Figure B-2). This time, however, the seven components of the hexal are themselves hexals rather than hexagons. This pattern of a central figure surrounded by six identical figures can be continued indefinitely.

The resulting figures have interlocking shapes, so that they fit together leaving no spaces. At each stage, the figures are numbered in the same manner: the central figure is numbered 0, and the other six are numbered in sequence by moving up and clockwise. This numbering scheme produced a hierarchical numbering system and a spatial address for each hexagon. The highest order digit corresponded to the highest order hexal, the next digit specified a hexal within the high-order hexal, and so on down to the low order digit which specified a hexagon.

The subsample was chosen by placing the hexagons along a number line in the order given by the hierarchical numbering system. Each hexagon was assigned a unit length on the line, and then the hexagons were subsampled using a systematic sample with a random start. The selection interval was the ratio of the required sample size to the number of hexagons on the line. This procedure selected a random point r between 0 and 1, the length of the selection interval. That point falls in the unit length associated with some hexagon, and the random point in that hexagon becomes a sample point. Subsequent points and hexagons were selected at equal intervals (i) along the line at r+i, r+2i, r+3i and so on.

Implementing this design involved application of the EMAP hexagonal grid system at 5 different levels of enhancement, corresponding to the various subpopulations. The enhancements were 4x9x9x9 for Bays and Harbors, 3x4x4 for Deep subpopulations, 3x3x3x4 for Islands, 3x7x7 for Large POTWs, and 3x3x4 for Shallow and Mid-depth subpopulations. The enhancements were chosen to achieve the minimum number of sites per subpopulation.

To maximize overlap of indicators, the design was first implemented for the indicator group with the highest sample density within each subpopulation. Random subsamples of these were then selected to produce nested designs for the indicator groups that were measured at a smaller number of sites within the subpopulation.

Within the river mouths and small POTW strata, there was an additional design criterion to assign nearly equal numbers of sample sites to each of the individual discharge areas. For river mouths, this was accomplished by laying out a systematic random sample, resulting in approximately 3 sites per river mouth. A simple random sample of 4 sites were placed in each Small POTW.

FIGURE B-1. Hexal produced by joining adjacent hexagons.

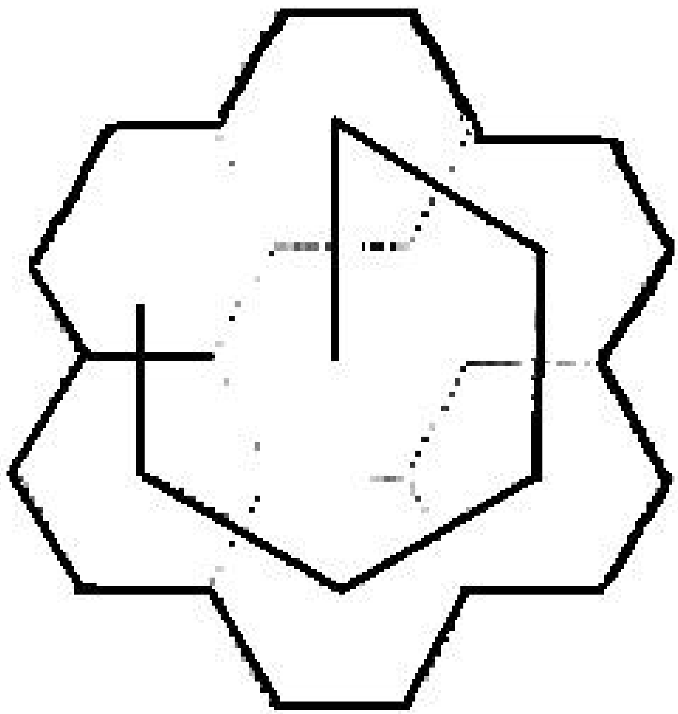
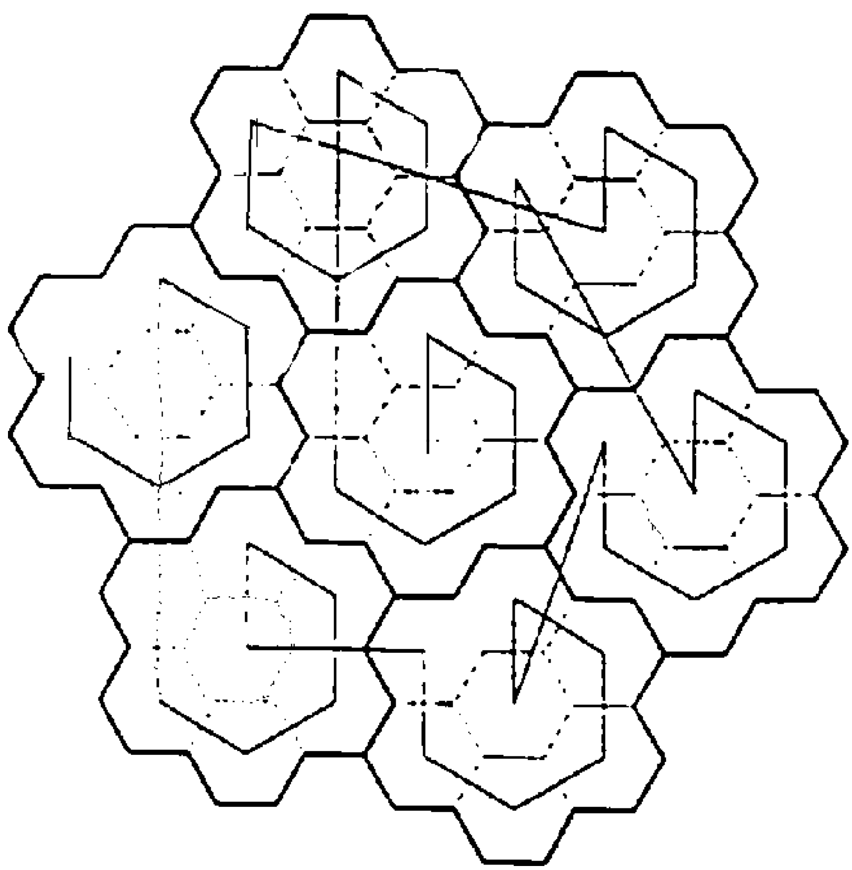
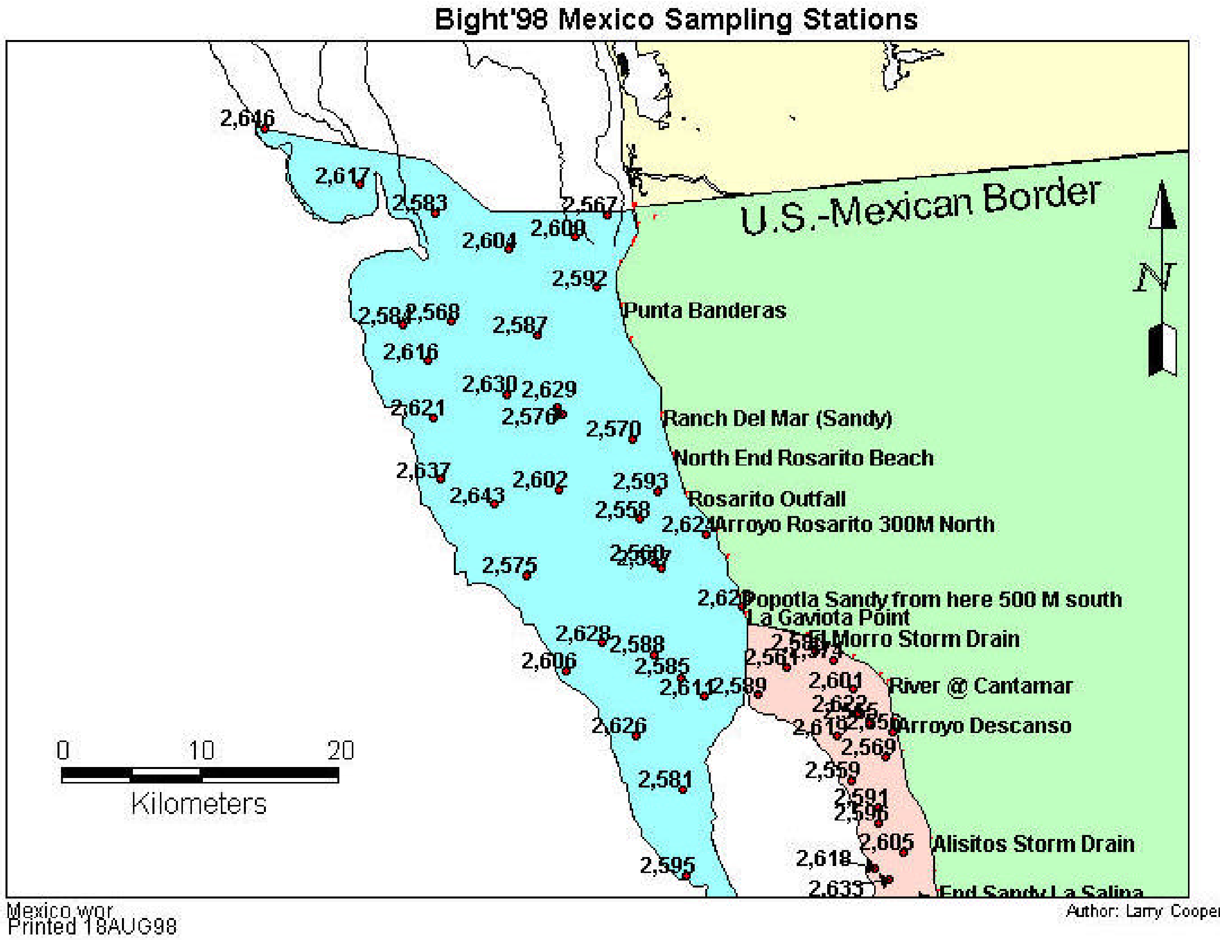


FIGURE B-2. Order of joining seven adjacent hexagals.



APPENDIX C. MAPS OF MEXICAN SAMPLING SITES


Bight'98 Mexico Sampling Stations
U.S.-Mexican Border
N
Punta Banderas
Ranch Del Mar (Sandy)
North End Rosarito Beach
Rosarito Outfall
Arroyo Rosarito 300M North
Popotla Sandy from here 500 M south
La Gaviota Point
El Morro Storm Drain
River @ Cantamar
Arroyo Descanso
Alisitos Storm Drain
End Sandy La Salina
0
10
20
Kilometers
Mexico.wor
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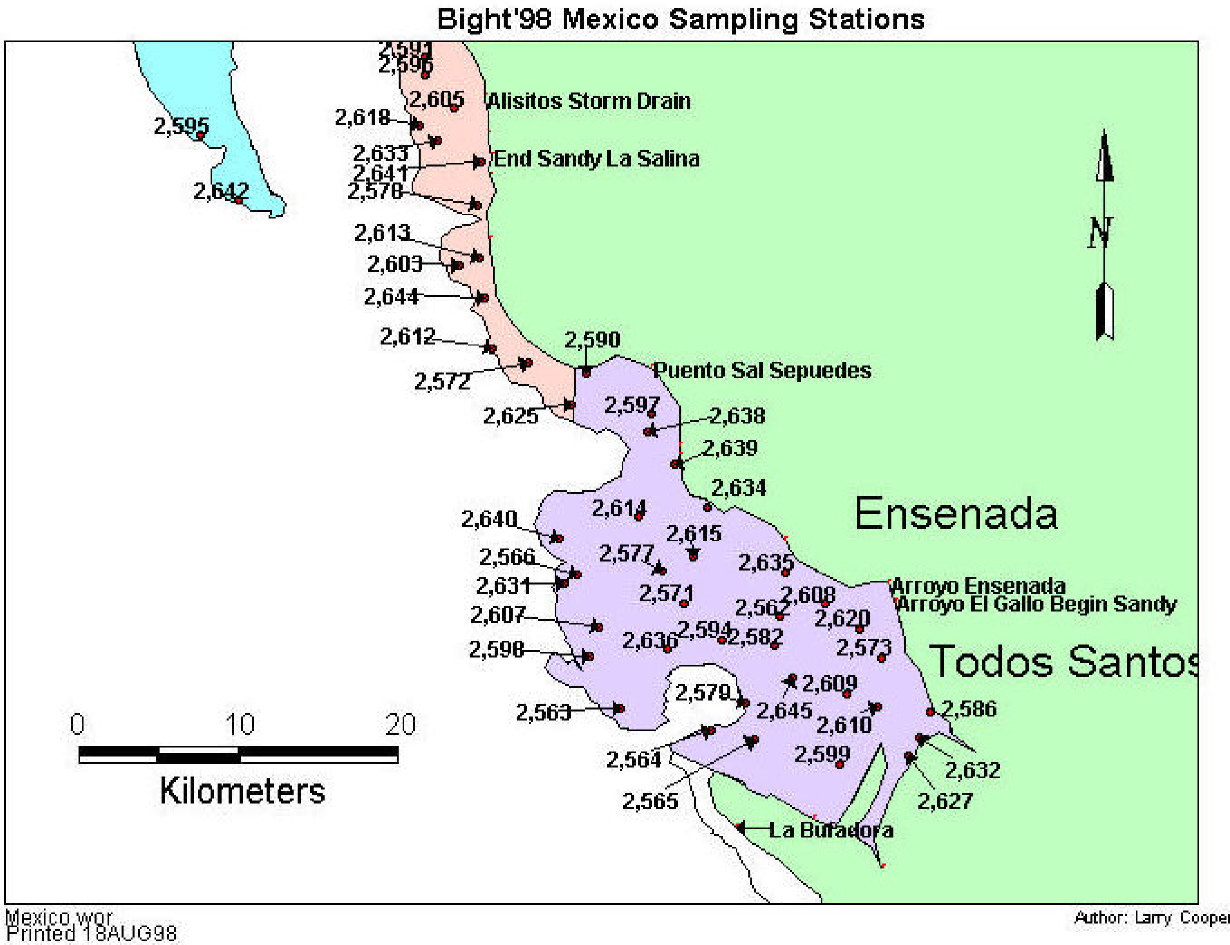
Author: Larry Cooper


Bight'98 Mexico Sampling Stations
2,596
2,605
Alisitos Storm Drain
2,618
2,595
2,633
2,641
2,578
End Sandy La Salina
2,642
2,613
2,603
2,644
2,612
2,590
2,572
Puento Sal Sepuedes
2,597
2,638
2,625
2,639
2,634
Ensenada
2,640
2,614
2,615
2,566
2,577
2,635
2,631
2,571
2,608
Arroyo Ensenada
Arroyo El Gallo Begin Sandy
2,607
2,562
2,620
2,636
2,594
2,582
2,573
2,598
Todos Santos
2,579
2,609
2,563
2,645
2,586
2,610
2,564
2,599
2,632
2,565
2,627
La Bufadora
N
0
10
20
Kilometers
Mexico.wor
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Author: Larry Cooper

APPENDIX D. MEMBERSHIP OF TECHNICAL COMMITTEES

<u>Benthic Committee</u>	
Bergen, Mary	Southern California Coastal Water Research Project
Dalkey, Ann	City of Los Angeles Environmental Monitoring Division
Diener, Doug	MEC Analytical
Cadien, Don	Los Angeles County Sanitation Districts
Gerlinger, Tom	Orange County Sanitation District
Laur, David	Aquatic Bioassay and Consulting Laboratories
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Stull, Jan	Los Angeles County Sanitation Districts
Velarde, Ron	City of San Diego
Weisberg, Steve	Southern California Coastal Water Research Project
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Chao, C.C.	City of San Diego
Christensen, Kim	Orange County Sanitation District
Gabrielian, Elly	Los Angeles County Sanitation Districts
Gossett, Rich	CRG Laboratories
Huang, Ray	City of Los Angeles Environmental Monitoring Division
Hussain, Azra	Southern California Coastal Water Research Project
Lilieuthal, Ron	City of San Diego
Nguyen, Cahn	Orange County Sanitation District
Phillips, Charlie	SAIC
ushton, Kim	City of Los Angeles Environmental Monitoring Division
Sakamoto, Kim	Orange County Sanitation District
Schlickman, David	City of San Diego
Schneider, Rudi	Los Angeles County Sanitation Districts
Shoja, Parvaneh	City of Los Angeles Environmental Monitoring Division
Zeng, Eddy (Chair)	Southern California Coastal Water Research Project
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Gossett, Rich	CRG Laboratories
Hussain, Azra	Southern California Coastal Water Research Project
Macias, Vinicio	Instituto de Investigaciones Oceanologicas (UABC)
Nguyen, Cahn	Orange County Sanitation District
Schneider, Rudi	Los Angeles County Sanitation Districts
Shoja, Parvaneh	City of Los Angeles
Zeng, Eddy	Southern California Coastal Water Research Project

PCB Sub-Committee

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Chang, Shoumo	Los Angeles County Sanitation Districts
Chappelle, Don	Los Angeles County Sanitation Districts
Christensen, Kim	Orange County Sanitation District
Chou, C.C.	City of San Diego
Gossett, Rich (Chair)	CRG Laboratories
Hussain, Azra	Southern California Coastal Water Research Project
Lilieuthal, Ron	City of San Diego
Nguyen, Cahn	Orange County Sanitation District
Ruston, Kim	City of Los Angeles Environmental Monitoring Division
Shoja, Parveneh	City of Los Angeles Environmental Monitoring Division
Villaescusa, Julio	Instituto de Investigaciones Oceanologicas (UABC)
Zeng, Eddy	Southern California Coastal Water Research Project

Trace Metals Sub-Committee

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Schlickman, David (Chair)	City of San Diego
Tsai, Yu-Li	Orange County Sanitation District
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Diehl, Dario	Southern California Coastal Water Research Project
Fangman, Sarah	Channel Islands National Marine Sanctuary
Grovhoug, Jeff	US Navy, Space & Naval Warfare Systems Center, San Diego
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Mengel, Mike	Orange County Sanitation District
Montagne, Dave	Los Angeles County Sanitation Districts
Moore, Charles	Algalita Marine Research Foundation
Nielsen, Ken	SeaVentures
O'Brien, Fred	Orange County Sanitation District
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Weisberg, Steve	Southern California Coastal Water Research Project

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Gartman, Robin	City of San Diego
Groce, Ami	City of San Diego
Hastings, Sean	Channel Islands National Marine Sanctuary
Herbinson, Kevin	Southern California Edison
Ito, Neil	Chevron USA Products Company
Lagos, Steve	City of San Diego
Laur, Dave	Aquatic Bioassay and Consulting Laboratories
Lyons, Michael	Los Angeles Regional Water Quality Control Board
Moore, Shelly	Southern California Coastal Water Research Project
Phillips, Tony	City of Los Angeles Environmental Monitoring Division
Rao, Linda	State Water Resources Control Board
Roney, Jim	City of Los Angeles Environmental Monitoring Division
Stull, Jan	Los Angeles County Sanitation Districts
Tang, Chi-Li	Los Angeles County Sanitation Districts
Weisberg, Steve	Southern California Coastal Water Research Project

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Meyer, Steve	City of San Diego
Mikel, Tim	Aquatic Bioassay and Consulting Labs
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Tang, Chi-Li	Los Angeles County Sanitation Districts
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Reclamation Authority	
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Lyons, Michael	Los Angeles Regional Water Quality Control Board

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Meehan, John	City of Oxnard
Moore, Doug	Orange County Environmental Health Division
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Noble, Rachel	USC Wrigley Institute of Environmental Studies
O'Connell, Linda	State Water Resources Control Board
Orozco, Victoria	Instituto de Investigaciones Oceanologicas (UABC)
Perez, Arturo Ornelos	Instituto de Investigaciones Oceanologicas (UABC)
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Reid, Dan	Santa Barbara Health Care Services
Schulz, Don	Surfrider Foundation
Stone, Kathy	San Diego County Department of Environmental Health
Vainik, Patty	City of San Diego
Vogel, Karl	MCB Camp Pendleton AC/S Environmental Security
Wallace, Hazel	City of Long Beach Department of Health & Human Services
Walker, Kathy	Los Angeles County Sanitation Districts
Weisberg, Steve	Southern California Coastal Water Research Project
Werner, Kathleen	Goleta Sanitation District

<u>Toxicology Committee</u>

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Anderson, Jack	Columbia Analytical Services
Armstrong, Jeff	Orange County Sanitation District
Asato, Stanford	City of Los Angeles Environmental Monitoring Division
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Brown, Jeff	Southern California Coastal Water Research Project
Gerlinger, Tom	Orange County Sanitation District
Gutoff, Dave	City of San Diego
Lapota, Dave	US Navy, Space & Naval Warfare Systems Center, San Diego
Lyons, Michael	Los Angeles Regional Water Quality Control Board
Mikel, Tim (Co-Chair)	Aquatic Bioassay and Consulting Laboratories
Reeve, Matt	State Water Resources Control Board
Steinert, Scott	Computer Sciences Corporation
Wiborg, Lan	City of San Diego

<u>Water Quality Committee</u>

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Duggan, Ross	City of San Diego
Fangman, Sarah	Channel Islands Marine Sanctuary
Jones, Burt (Chair)	University of Southern California
Katz, Chuck	US Navy, Space & Naval Warfare Systems, Center, San Diego
Lyons, Michael	Los Angeles Regional Water Quality Control Board
Meyer, Marty	Aquatic Bioassay and Consulting Laboratories

Mengel, Mike	Orange County Sanitation District
O'Brien, Fred	Orange County Sanitation District
O'Donohue, Diane	City of San Diego
Shisko, John	City of Los Angeles Environmental Monitoring Division
Steele, Alex (Co-Chair)	Los Angeles County Sanitation Districts
Stern, Fred	Los Angeles County Sanitation Districts
Weisberg, Steve	Southern California Coastal Water Research Project
White, Brian	City of Los Angeles Department of Water and Power