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

Shoreline Microbiology Workplan

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Prepared for:
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I. INTRODUCTION

The Southern California Bight (SCB; Figure I-1), an open embayment in the coast between Point Conception and Cabo Colnett (south of Ensenada), Baja California, is an important and unique recreational resource. World renowned for its recreational waters, more than 100 million people visit Southern California beaches and coastal areas annually to sunbathe, surf, swim, skin- and SCUBA-dive. The average number of visitors to Santa Monica Bay beaches on a summer weekend alone is more than 600,000 (Economic Resources Data, 1993).

Southern California is also one of the most densely populated coastal regions in the country, which creates stress upon these recreational resources. Nearly 20 million people inhabit coastal Southern California, a number that is expected to increase another 20% by 2010 (NRC 1990). Population growth generally results in conversion of open land into non-permeable surfaces. This "hardening of the coast" increases the rate of runoff and can impact water quality through addition of sediment, toxic chemicals, microbial pathogens and nutrients to the ocean. Besides the impacts of land conversion, the SCB is 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.

An important part of ensuring public safety in shoreline recreational areas is bacteriological monitoring. Monitoring of bacteriological water quality along the shoreline of the SCB is currently performed by 20 agencies taking measurements at 510 stations. These agencies include health departments and municipal dischargers in compliance with National Pollution Discharge Elimination System (NPDES) permits. Together, these organizations collect and analyze 77,730 samples annually to assess beach quality (Schiff et al. 1998).

Although this represents an impressive amount of bacteriological monitoring, the data cannot be easily integrated to provide a regional assessment of condition. Most monitoring programs are spatially focused on a small set of high-use beaches or other areas of concern and the data from these programs cannot be easily extrapolated to assess the condition of the coast as a whole. Moreover, many of the organizations involved in beach monitoring use different indicators to assess beach quality, and even those that measure the same indicators often use different sampling or analysis methodologies; interlaboratory exercises to assess data comparability are rare. The inconsistencies with bacteriological monitoring in the recreational waters of coastal California have been recognized by the State of California, which recently passed legislation, Assembly Bill 411, requiring the State Health Services to adopt procedures that increase consistency in data collection and reporting.

Recognizing the need for greater consistency and communication, all of the agencies that routinely monitor bacteriological water quality of Southern California beaches have agreed to conduct an integrated survey to assess the overall condition of the southern California shoreline in the summer of 1998. The study will also include an element in which volunteer monitoring organizations will enhance sampling effort within selected portions of the Bight. The study will be coordinated by the Southern California Coastal Water Research Project (SCCWRP) as one component of the Southern California Bight 1998 Regional Monitoring Program (Bight'98), in which 55 organizations (Table I-1) have agreed to cooperate in assessing the overall condition of the SCB ecosystem. Bight'98 builds upon the success of a similar SCCWRP-coordinated regional monitoring effort conducted in

1994 to assess the condition of offshore ecological habitats (SCBPP 1998).

This document presents the work plan for the shoreline microbiology component of Bight'98. Similar work plans are available for coastal ecology and water quality components of Bight'98.

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

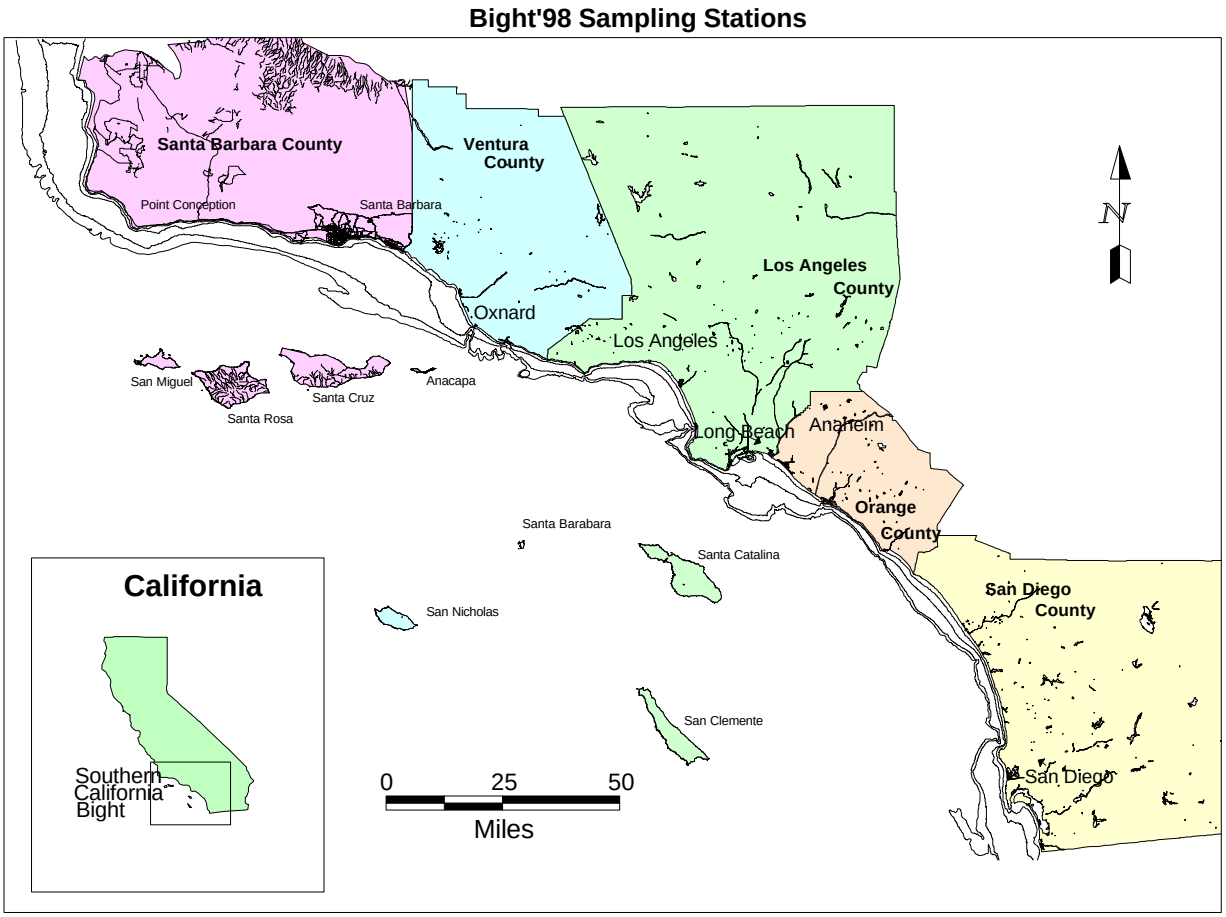


TABLE I-1. Participants in the Southern California Bight 1998 Regional Monitoring Program (Bight'98). [a] Denotes participants in the microbiology component. [b] Denotes participants in the volunteer portion of the microbiology component.

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

TABLE I-1 (continued). Participants in the Southern California Bight 1998 Regional Monitoring Program (Bight'98). [a] Denotes participants in the shoreline microbiology component. [b] Denotes participants in the volunteer portion of the shoreline microbiology component.

Southeast Regional Reclamation Authority (SERRA)[a]
Southern California Coastal Water Research Project (SCCWRP)[a]
Southern California Edison (SCE)
Southern California Marine Institute(SCMI)[b]
State Water Resources Control Board (SWRCB)[a]
Surfrider Foundation[b]
USC Wrigley Institute for Environmental Studies (WIES)[a]
University of California, Santa Barbara
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. Objectives

The overall goal of the shoreline microbiology component of Bight'98 is to assess the microbiological water quality of the southern California recreational shoreline. Four objectives will be addressed to accomplish this goal:

1. Determine the extent of shoreline meeting bacterial water quality standards;

2. Compare indicator bacteria levels among different types of shoreline;

3. Compare the response yielded by different indicator bacteria; and

4. Assess the association between runoff and waterborne human enteric virus.

The first objective, estimating the extent of SCB shoreline meeting bacterial water quality standards, differs from the objective of most existing bacteriological monitoring programs, which focus on assessing the need for bathing restrictions on individual high use or high risk beaches. Most existing programs have a temporal focus, sampling many sites daily. Bight'98 will have a greater emphasis on spatial dispersion of sampling sites, which will be achieved using a randomized sample design; our goal in greater sample site dispersion is to estimate the percentage of shoreline mile-days in which bacteriological standards are met. This approach will provide the public with a clearer picture of the overall condition of the shoreline, and is intended to complement existing monitoring focused on special interest locations.

The second objective involves comparing bacteriological conditions among six types of shoreline (Table II-1). Comparison of relative condition not only provides information about the geographic distribution of impacts, it also allows comparison of relative water quality between areas with and without runoff. Stratifying by habitat also allows better assessment of water quality in less popular swimming areas, such as rocky shoreline, which are not the focus of the routine monitoring programs, but may be used for near shore water recreation.

The third objective will be accomplished by simultaneously measuring three frequently used indicator bacteria (total coliform, fecal coliform, enterococcus). Simultaneous sampling will allow quantification of degree of correspondence among the different indicator bacteria and among the different thresholds used for public health warnings. At present, public health advisories are based variously on total coliform counts, total to fecal coliform ratios, and/or enterococcus counts. Bight'98 will determine how often, and for what type of shoreline stratum, these different indicators and thresholds produce differing results.

The fourth objective will be to assess the extent to which waterborne human enteric viruses are associated with runoff. One important focus of research on recreational water monitoring has been the development of new indicators of water quality. Viral pathogens represent a significant portion of those waterborne pathogens which cause disease, yet have been studied very little in recreational seawater. Poliovirus, one of the human enteric viruses, is a direct indicator of human

fecal contamination because humans that have been immunized with the vaccine strain of poliovirus actively shed it. In addition to enumerating enteric viruses in runoff, the human enteric virus results will be compared to the bacteriological indicator results as a part of accomplishing Objective 3.

TABLE II-1. Subpopulations of interest for the Microbiology Component of Bight'98.

A. Sandy Beach
   1. High use (lifeguard service present)
   2. Low use (no lifeguard service provided)

B. Rocky Shoreline
   1. High use (popular surfing or diving areas)
   2. Low use (not popular surfing or diving areas)

C. Storm Drains
   1. Perennial (flowing year round)
   2. Ephemeral (flow not constant)

B. Sampling Design

The shoreline microbiology component of Bight'98 will involve sampling of 213 sites along the SCB coastline between August 2 and September 5, 1998. Each site will be sampled once per week during the five week study period. The summer was chosen for the study because it is the period of maximum beach bathing usage. If the project is successful, the study will be repeated during the winter wet season, when stormwater runoff typically leads to the highest shoreline microbiological counts of the year.

Maps of the sampling sites are provided in Appendix A. Sites were selected using a stratified random approach, with the strata corresponding to the populations 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. Sample size was determined as the number of samples necessary to achieve a 95% confidence interval of about +/- 5% around estimates of areal extent.

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 stratum. 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 extension of the sampling design used in the National Stream Survey (Messer *et al.,* 1986, Overton, 1985, 1987). A partition is randomly placed over a map of the sampling area, a subsample of partitions is chosen from this population, and one sample is obtained at a randomly selected site within each partition. The partition structure ensures systematic separation of the sampling, while the random selection of sites within partitions ensures an unbiased estimate of water quality. Further details about this site selection process are provided in Appendix B.

The perennial water outlet strata will be sampled in two ways. First, samples will be allocated to the mouths of a selected set of water outlets; the mouth will be defined as the oceanic area closest to the mouth. Second, a set of sites will be selected at random distances, up to 100 yards, from the mouth of the water outlets. Not all water outlets will receive both types of samples because the resources are not available to accommodate both types in all areas of the SCB. When available, however, the combination of sites will allow determination of attenuation rate for bacterial levels as a function of distance from water outlets.

Water outlets will also be sampled to address the fourth objective. Virus detection assays for a group of human enteric viruses will be performed on a randomly selected subset of 15 water outlets that exceed a stated flow minimum. Results of detection of human enteric virus analyses will be correlated with bacterial indicators to evaluate relationships between these indicators.

In addition to the baseline sampling design, the study will also include an adaptive component in which the level of sampling is increased in areas where elevated indicator bacteria levels are found. Criteria for increased sampling are based on exceeding a single sample maximum of:

Total coliforms $\geq$10,000 cfu or MPN/100 ml; or
Fecal coliforms $\geq$ 400 cfu or MPN/100 ml; or
Enterococcus $\geq$104 cfu/100 ml; or
Coliform Index (fecal/total coliform x 100) $\geq$ 20, if total coliform $\geq$ 5,000 cfu or MPN/100 mL

The adaptive component will involve sampling additional sites on either side of the elevated indicator site within a week following the observation. For sites located on open shoreline, the adaptive sites will be located 100 yards on either side of the elevated site; for water outlet sites, the adaptive sites will be located 25 yards on either side.

C. Indicators

All three bacterial indicators currently used for routine monitoring of recreational water in Southern California, total coliforms, fecal coliforms, and enterococcus will be measured for the shoreline microbiology component of Bight'98. Samples will be collected in ankle-deep waters, when the wave is coming toward the sampler. Sample bottles will be stored on ice and in the dark during transportation, and laboratory analysis will begin within 6 hours of sampling.

Several analytical methods will be used for laboratory analysis of the samples. The study is conducted primarily through the donation of in-kind services and not all facilities that monitor bacteriological water quality in Southern California use the same methods. A performance based approach will be used to ensure data comparability among labs; intercalibration tests using common samples will be performed and only laboratories that meet the performance criteria will be permitted to participate. Further details on the intercalibration process are provided in Section IV.

The methods to be used by each participant are outlined in Table II-2 and described below; more detailed information on the methods can be found in *Standard Methods for the Examination of Water and Wastewater, 19th Edition, 1995*.

Total and Fecal Coliform:

Total and fecal coliforms are a group of bacteria typically found in fecal contamination. The total coliform group consists of several genera of bacteria belonging to the family Enterobacteriaceae. Fecal coliform bacteria are the component of total coliforms that are found in the feces of warm-blooded animals. Detection of this subset of organisms is based on incubation of the sample at an elevated temperature above that of the total coliform procedure.

Three methods will be used to measure coliform bacteria. The first is membrane filtration (MF). MF is a direct plating method for the detection and enumeration of bacteria in water.

The second method will be multiple tube fermentation (MTF). MTF involves inoculating multiple tubes of broth with dilutions of sample. Organism density is based on the number of tubes with acid and gas production at the various dilutions and reported in terms of the Most Probable Number (MPN). This number is based on certain probability formulas and is an estimate of the mean density of organisms in the sample.

TABLE II-2. Number of sample sites and laboratory methods to be used by each of the project participants. Some participants will be processing samples using multiple methods.

	Total Coliforms	Fecal Coliforms	Enterococcus
Santa Barbara County			
Santa Barbara Health Care Services	24[c]	24[c]	24[d]
City of Santa Barbara	7[b]	7[b]	7[d]
Goleta Sanitation District	7[b]	7[b]	7[b]
Ventura County			
Ventura WWTP	7[b]	7[b]	7[b]
City of Oxnard	7[b]	7[b]	7[b]
Aquatic Bioassay Labs	5[b]	5[b]	5[b]
Los Angeles County			
City of LA, EMD	16[a]	16[a]	16[a]
County San. Dist. LA County	5[a]	5[a]	5[a]
Los Angeles Co. Dept. Health Services	15[c]	15[c]	15[d]
City of Long Beach	3[a]	3[a]	3[a]
Orange County			
Orange County Sanitation District	15[c]	15[c]	15[a,d]
Orange County Env. Health Div.	22[c]	22[c]	0
AWMA/SERRA	16[a]	16[a]	16[a]
San Diego County			
Encina Wastewater Authority	5[a]	5[a]	5[a]
City of Oceanside	3[b]	3[b]	3[a]
City of San Diego	36[a]	36[a]	36[a]
MCB Camp Pendleton	4[b]	4[b]	4[a]
San Diego Co. Dept. Env. Health	6[b]	6[b]	0
San Elijo Joint Powers Authority	3[b]	3[b]	3[b]

[a]MF
[b]MPN
[c]Colilert®
[d]Enterolert®

A third method will be the Colilert® (Idexx, Inc.) test. This is a commercially available product that uses a MTF type format with defined substrate technology to detect the presence or absence of total coliform or *E. coli* density in a water sample. In this medium, the detection of coliforms is based upon a color change for total coliform and the release of a fluorogen by an enzyme produced only by *E. coli*. This assay is read within 24 hours. The Colilert® reagent detects *E. Coli*, which is used to estimate fecal coliform densities.

Enterococcus:

The enterococcus group of bacteria is a subgroup of the fecal streptococci, which are also used as an indicator for determining the extent of fecal contamination of recreational surface waters. Detection of enterococcus will be performed using MF, MTF and Enterolert® (Idexx, Inc.), a test for enterococcus that is similar to Colilert®.

Enteric Virus:

Human enteric viruses will be studied at a subset of water outlet sites using the reverse transcriptase polymerase chain reaction (RT-PCR) of Tsai *et al.* (1993). Detection of human enteric viruses (such as poliovirus, echovirus, and Coxsackie virus) will be accomplished by concentrating a 20 L seawater sample to a volume of 1 ml. RT PCR, in conjunction with a set of primers specific for the pan-enteric virus family (a family of Picornaviridae that comprises poliovirus, echovirus, and Coxsackie virus), will be used to amplify target RNA from the concentrated seawater sample.

D. Coordinated Volunteer Studies

Citizen monitoring is an ongoing and valuable asset in assessing the condition of SCB beaches, and is assisted by many of the organizations participating in Bight'98. Bight'98 represents an opportunity for enhancing both this interaction and the project. For Bight'98, volunteer effort will contribute to the project data, thereby improving the precision of our estimates. This cooperation is important because there is no baseline funding for Bight'98, all of the effort for the project is through in-kind services provided by participants. For the volunteers, the collaborative nature of the program provides an unique opportunity for technical interaction and integration with their professional counterparts, including participation in the survey's intercalibration exercises and data base development activities.

The volunteer organizations, coordinated through the Los Angeles Region Volunteer Monitoring Council (Chaired by Gwen Starrett of the State Water Resources Control Board), have agreed to participate in Bight'98 in three ways:

1) Enhancing the microbiological sampling program in the areas of Long Beach and Seal Beach, and the South Bay area of Santa Monica Bay;

2) Adding a shoreline trash assessment element in Orange County; and,

3) Assisting with collecting water samples for analyses of virus.

Augmentation of the shoreline microbiological program will involve the addition of 14 sampling sites between Cabrillo Beach and Anaheim Bay, and six sample sites between Ballona Creek and the Palos Verdes peninsula (Appendix C). This will add to the project's overall precision and will also

allow estimates of condition for these local areas that will be compared to the condition of the remainder of southern California shoreline. The sampling sites were selected using the same statistical design as above, but will be limited to sandy beaches. Sampling will occur once per week for five weeks, as in the remainder of the survey, and will entail fecal and total coliform measurements using the Colilert test.

The volunteer microbiological sampling will be a coordinated, rather than integrated, part of the program. As a coordinated program, the sample sites will be selected as a supplement to the primary Bight'98 program. One of the challenges of a randomized sample design is that all sites must be sampled; a non-random subset of a randomly selected set of sites is still a biased sample. The primary program design will be unaffected if the volunteer effort is unsuccessful. On the other hand, if the volunteers are successful in collecting all of their assigned samples, their effort will become a seamless and powerful addition to the program. The volunteers will participate in all quality assurance activities conducted by their professional counterparts (See Section IV of the work plan) prior to and during the survey to maximize data comparability. The volunteers will be assisted by the Southern California Marine Institute (SCMI), a consortium of local universities. All of the coliform analysis for the volunteer component will be conducted at the SCMI Fish Harbor laboratory.

The second part of the volunteer contribution will be to quantify the amount of trash, and its replenishment rate, along the Orange County shoreline. Twenty-one randomly selected sites will be sampled biweekly for a six week period starting August 2. Sampling will occur primarily at shoreline microbiology sites; coordinating the trash and microbiological surveys will allow an investigation of the relationship between beach water quality and a measure of human activity at the beach. A map of the sampling sites is provided in Appendix C.

Each sample site will consist of a 25 yard wide area, which will be divided into three zones: Intertidal Zone: low tide mark to high tide mark, Beach Berm Zone: high tide mark to 10 meters past the high tide mark, and the Back Beach Zone, which includes the rest of the shoreline until reaching pavement or cliffs. The form that will be used to record data is modeled after that used by the Center for Marine Conservation during their Beach Cleanup days, but modified to record specific brands for fast food trash, beverage cans, bottles, etc. (Table II-3). Trash will be collected from the beach, sorted according to brand, enumerated and weighed.

The third manner in which the volunteers will support Bight'98 is through collection of the virus samples. Virus samples require collection and concentration of about 20 liters of water, which consumes a large amount of the sampler's time. This can not be accomplished by the same personnel that collect the bacterial samples, which must be returned to the laboratory and processed within six hours of collection. Volunteer efforts will be an important asset in allowing implementation of the virus element.

E. Coordinated Studies in Mexico

While the focus of Bight'98 is on the US side of the border, a comparable, coordinated microbiology study will be conducted by Mexican scientists at 30 shoreline sites between the border and Ensenada. The Mexican component of the study will attempt to answer the same question about percent of shoreline mile-days exceeding indicator bacteria thresholds of concern, but the assessment will be limited to sandy beaches (20 sites) and perennial water outlets (10 sites). Sample sites were

selected using the same probability-based sampling design as in the US portion of the study; a map of the Mexican sampling sites is presented in Appendix C.

The Mexican study will measure total and fecal coliforms using MTF at each site weekly for five weeks, starting August 2. All sampling effort and laboratory analyses for Mexican sampling sites will follow the same QA procedures as in the US portion of the study, as outlined in Section IV of this work plan. Mexican scientists will participate in the study's pre-survey laboratory intercalibration exercises, and during the study will process the same interlaboratory quality control samples (described in Section IV) as 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.

Table II-3. Data collection form to be used in trash survey.

Bight Project Trash Survey

Station/Location:		Date:	Time:
GPS Coordinates:			
Group Name:			
Group Leader:		Phone:	
Member:		Phone:	
Member:		Phone:	
Recorder:		Phone:	

Circle One

Weather Code:	Clear	Overcast	Partly Cloudy	Blowing Sand	Thunderstorm	Rain	Drizzle	Fog
Surf:	1-3 ft		4-6 ft	7+ ft				
Tide:	Low		Med	High				
Sea State:	Calm		Choppy	White Caps				
Outlet Water:	Flowing		Not Flowing					
People:	1-5		6-10	11-20	21-50	51+		

Glass

		QTY	Weight	% Of Each Brand Name (Labels) by Count & Weight
				Use Page 4 if necessary
Bottles/Jars:	Beverage Bottles			
	Food Jars			
	Other Bottles / Jars			
	Fluorescent Light Tubes			
	Light Bulbs			
	Pieces			
	Other Glass			

Metal

		QTY	Weight	% Of Each Brand Name (Labels) by Count & Weight
				Use Page 4 if necessary
Bottle Caps				
Cans:	Aerosol			
	Beverage			
	Food			
	Other (Specify)			
Crab / Lobster Traps				
55 Gal Drums:	Rusty			
	New			
Pieces				
Pull Tabs				
Wire				
Other (Specify)				

III. INFORMATION MANAGEMENT

A. Overview of Approach

Information gathering in Bight'98 will be based on the principle of partnership; all participating organizations will have equal and complete access to the data collected during the project. Historically, data sharing between agencies performing monitoring programs has been impeded because each agency organized and managed its own data using its own information management system. Bight'98 will address this challenge by developing and implementing an integrated, uniform, and well-documented information management system (IMS).

The core of the IMS will be a set of standardized data transfer protocols (SDTP) for data sharing. These protocols will detail the information to be submitted for each sample. Data will be submitted in defined column comma-delimited ASCII format. Information will include collection or processing elements unique to that particular sample, the units of measure and allowable values for each parameter. Use of SDTP allows each participating organization to retain their existing data management system, yet output the data in a manner that allows merging the data into a single data base.

A second attribute of the IMS will be centralized data storage. The microbiology component of Bight'98 includes more than twenty collaborating organizations and volunteer groups responsible for sampling and/or analyses, which precludes a distributed system. The centralized location will be at SCCWRP, where it will be stored on personal computers in Microsoft Access.

B. Standard Data Transfer Protocols (SDTP)

The SDTP will include three data tables, following a relational data base structure (Table III-1). In the relational structure, the three data tables are linked by one or more common fields. Linking types of data that are recorded at different frequencies minimizes redundant data entry. Use of multiple data tables also allows data collected at different locations or points in time (e.g., lab vs field) to be entered separately, minimizing the possibility of data loss.

The first data table is the station table, which contains a single data record for each station that is sampled in the survey. The table includes station descriptors, such as location described in latitude, longitude and landmarks that can be used to locate the site.

The second data table is the sampling table, which contains a record for each sample collected. This table includes sampling date, time, and environment descriptors such as weather, surf, floatables, and the number of people in the water. The sampling table is linked to the station table by the StationID field. Typically, there will be five records (weeks) in the sampling table for every record in the station table.

The third table is the results table, which contains a record for every laboratory result. This table includes information about the method used for analysis, the start time of the analysis, and the analysis results. The results table is linked to the sampling table by StationID and Date. For most participating laboratories, there will be three (indicator bacteria analyses) records for each sampling event.

C. Data Flow and Quality Assurance

Each 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 data entry followed by second level verification of the entry and a range check. Following review from the Laboratory Director, or appointee, data then will be exported to the project Information Management Officer (IMO) at SCCWRP in the proper 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 and the submitting lab will be notified of the corrections; data sets with larger errors will be returned to the submitting 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 sent to the Microbiological Committee Chair (MCC). The MCC, with assistance of the Microbiology Committee, will review the data with respect to scientific content. This review may 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. Technical issues or questions of scientific content will be resolved by the MCC.

All corrections to the data will be made by the IMO, who alone will have authority to modify the database. All other users will receive the data in read-only form. Prior to making any changes, the IMO will document the changes and receive (written or electronic) concurrence of the organization that generated 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 that is available to all data users.

D. Data Availability

All data from Bight'98 will be made publicly available, though the schedule of availability will vary by user class. The varying schedule of data availability recognizes the differing levels of quality assurance and data documentation that will have been completed at various stages in the project and the user specific documentation required for accurate interpretation of the data . 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/processing task.

2. Technical Committee Members: The Technical Committee Chair will be provided data from all labs immediately following certification by the IMO that the data follows the SDTP formats. The TCC will work with 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. The TCC will be asked to complete this review within three months.

4. General Public: Data will be released to the general public once a draft report documenting the study has been prepared and presented orally to the Steering Committee. The TCC will be asked to prepare the report and make the presentation within six months of releasing data to the Steering Committee.

Release of data will include comprehensive documentation. This documentation will include database table structures (including table relationships) and lookup tables used to populate specific fields in specific tables. Releases to the public will also include quality assurance classifications of the data (flags, as appropriate) and documentation of the methods by which the data were collected (metadata).

TABLE III-1. Standard data transfer protocol tables for the shoreline microbiology component of Bight'98.

A. Microbiology Station Table

Name	Type	Size	Required	Source List
StationID	Text	10	Y	
Latitude	Number	8	Y	Decimal Min. Nad83
Longitude	Number	8	Y	Decimal Min. Nad83
Stationdesc	Text	255		Narrative description
Comments	Text	80	Y	Additional remarks

B. Microbiology Sampling Table

Name	Type	Size	Required	Source List
StationID	Text	50	Y	
Sampledate	Date	8	Y	dd/mmm/yy
Sampletime	Time	8	Y	hh:mm
AgencyCode	Text	2	Y	1
WeatherCode	Text	25	Y	8
Surf	Text	10		(Low1-3)Mid(4-6), High 7+ft)
SeaState	Text	50	Y	calm, rough, whitecap
Evidence Of Sewage	Text	3		Yes/No
WaterOutletFl	Text	3		Yes/No
Peopleinwater	Number	3		In Water w/50 yards
StationFailCode	Number	2	Y	40
Comments	Text	50	Y	additional remarks

C. Microbiology Results Table

StationID	Number	10		
SampleDate		8		
Parameter Code	Text	50	Y	
Qualifier	Text	50		
Result	Number	8	Y	
Units	Text	20	Y	CFU/100ml MPN/100ml
LabCode	Text	2	Y	1
AnalysisMethod	Text	50	Y	
StartTime	Date/Time	8	Y	hh:mm
SampleType	Text	50	Y	list
Comments	Text	50	Y	additional remarks

IV. QUALITY ASSURANCE AND QUALITY CONTROL

A quality assurance/quality control (QA/QC) program 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 a large monitoring project like Bight'98 that involves 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 kind, quantity and quality 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.

A. Quality Assurance Elements

Two types of QA activities will be conducted prior to the implementation of the program: 1) Standardizing methods for those activities that can be standardized given differences in the underlying measurement methods and 2) intercalibration exercises to assess and control the variability introduced by inclusion of multiple laboratories and measurement methods.

Methods standardization

Each laboratory will be ELAP certified and will follow *Standard Methods for the Examination of Water and Wastewater*, 19th edition, 1995 (*Standard Methods)* Methods 9020, 9030, 9040 or 9050. Labs will also ascribe to common guidelines regarding culture media, water, equipment and instrumentation, and data handling.

Sampling Collection

Sterile sample bottles will be used (Whirl-Pak bags are acceptable) and will be labeled with the proper sample ID. The sampler will use aseptic technique, making certain that the bottle does not touch the ocean bottom. The sample will be collected on an incoming wave, with the sampler downstream and away from the bottle, and the mouth of the bottle facing into the current. After the sample is taken, the bottle will be immediately tipped to decant enough sample to ensure 1-2 inches of airspace in the sample bottle. The bottle will be tightly capped and promptly stored on ice in the dark. Laboratory analysis will begin within 6 hours of sample collection.

Media

Whenever possible, commercially available pre-sterilized media will be used. Dehydrated media will be stored in tightly closed bottles in the dark and kept at less than 30° C in a low humidity atmosphere. Media will be used within 6 months after opening. All media will be sterilized at autoclave temperature of 121° C for 15 minutes.

Water

Water used to prepare culture media and reagents will be distilled or demineralized reagent grade and stored out of direct sunlight to prevent growth of algae. All labs will use water

tested and found free from traces of dissolved metals and bactericidal or inhibitory compounds including residual chlorine or chloramines and nutrients.

Equipment and Instrumentation

Hot-air sterilizing ovens will be of sufficient size to prevent internal crowding, give uniform and adequate sterilizing temperatures of 170 ± 10° C, and be equipped with suitable thermometers or temperature recording devices. Autoclaves will be of sufficient size to prevent internal crowding, provide uniform temperatures, equipped with an accurate thermometer or temperature recording device, an accurate timing device, a pressure gauge and capable of reaching the desired temperature within 30 minutes. Sterilization conditions will be documented for each cycle. pH meters will be accurate to 0.1 pH units. Balances will provide a sensitivity of at least 0.1 g at a load of 150 g. Analytical balances will have a sensitivity of 1mg under a load of 10 g. Refrigerators will maintain a temperature of 1 to 4.4° C.

Procedures

Positive and negative growth performance and sterility tests will be done on newly prepared batches of media. Proper functioning of coliform water baths will be demonstrated while analyses are in progress using control cultures of *E. coli* and *Enterobacter aerogenes* in EC Broth. MPN broth cultures will be read at 24 +/- 2 hours, total and fecal coliform MF plates will be read at 22-24 hours. Enterococcus using mE will be read at 48 hours. Enterococcus using mEI will be read at 24 hours. Those using the enrichment method for MF analysis of total coliforms will be allowed 2 more hours for observation and analyses of colonies. Those MPN tubes that demonstrate no gas formation (in either LTB or BGB) at 24 +/- 2 hours will be reincubated and re-examined after a total of 48 +/- 3 hours have elapsed. Users of the 18 hour Colilert® method will analyze their results after 18-20 hours of incubation.

Intercalibration exercises

Twenty-one organizations (including the volunteer and Mexican organizations) will be processing samples during this survey, and a variety of processing methodologies will be used. To maximize data comparability, a series of presurvey laboratory intercalibration exercises were conducted. Each laboratory was required to achieve minimum accuracy and comparability goals during these exercises as a prerequisite to their participation in the regional survey.

Five intercalibration exercises were performed. The first three involved processing 15 standard samples (five replicates at each of three concentrations) for each of the three bacterial indicators to be measured in the study. The standard samples were prepared by a single laboratory and distributed to all participants for processing five hours after sample creation. The standard samples were created at known concentrations using transport media and stock cultures. Each laboratory was permitted to use the methods they intend to use within the survey. Processing of five replicates allowed assessment of: 1) variability within labs, 2) variability among labs, and 3) variability among methods. The project goal is to ensure that the extra variability added by multiple labs and multiple methods is small compared to the natural variability within a typical laboratory. The last two intercalibration tests were similar to the first three except that the a single concentration was tested and the standard sample was created by spiking sewage effluent into a seawater matrix.

All labs were required to meet the following performance criteria in the intercalibration exercise: 1) 80% or more of their sample results must be within an order of magnitude of the group median, and 2) the laboratory's mean result (of five replicates) for each test must be within half of an

order of magnitude of the group average. These ranges were selected based upon typical within-laboratory variability observed for the MTF test. Laboratories failing to meet these acceptance criteria, were required to work with the QA Officer to troubleshoot the problem, and to successfully perform an additional intercalibration test prior to participating in the project.

B. Quality Control Elements

During the survey, five activities will be undertaken to ensure that measurement error and bias are identified, quantified, and accounted for or eliminated if practical: external reference samples, duplicate analyses, processing of blank samples (to assess whether contamination of samples occurs), positive and negative controls, and method verification.

External reference samples

Twice during the study period, seawater samples spiked with sewage effluent will be distributed to all participating laboratories and analyzed for total coliforms, fecal coliforms, and enterococci. The samples will be analyzed by the same method used in the survey and will be used to assess whether the cross-laboratory variability established in the pre-survey intercalibration exercises are being achieved during the survey.

Duplicate Analyses

Ten percent of the samples collected for the project on a given day will be run in duplicate. An attempt will be made to select samples that yield positive results for the duplicate analyses.

Blanks

One blank dilution water or rinse sample will be analyzed per batch of samples processed.

Controls

One positive control will be run per day along with the batch of project samples. The positive controls will be based on *E. coli* as the indicator organism for total and fecal coliforms; *E. coli* and *Enterobacter aerogenes* for coliform water bath controls, and *Enterococcus faecalis* for the Enterococcus controls.

Method Verification

Method verification will be performed at each lab according to the procedures currently used.

V. PROJECT MANAGEMENT

A. Management Structure

Almost a thousand people from more than 40 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.

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 V-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 consistent with 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. For the Shoreline Microbiological Component of Bight'98, the Steering Committee is supported by the Microbiological Technical Committee. About 30 members representing 26 agencies participate on this committee (Table V-2). Members of this group typically manage, or are technical experts, for various microbiological monitoring programs of recreational waters throughout the region. Many also are involved in the development of regulatory policy associated with the safety of swimmers and the quality of recreational waters.

The Microbiological Committee is responsible for preparing methods and quality assurance procedures for the project, implementing the quality assurance procedures (e.g., intercalibration exercises) prior to the study and the quality control assessments during the study, and for preparing the reports that summarize the microbiological data. The role of the Microbiological Committee differs from that of most other Technical Committees in that they have also been asked to develop a recommended sampling design for the shoreline component; this work plan was produced primarily by the Microbiological Committee for Steering Committee review. The Microbiological Committee has a larger role because the shoreline survey has a unique set of questions and habitats to be sampled compared to other Technical Committees, and because a number of organizations participate only in the Microbiological component of Bight'98 and do not have Steering Committee representation. The larger role of the Microbiological Committee ensures that the interests of those organizations are incorporated.

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 process.

B. Project Reporting

The Bight'98 Shoreline Microbiology Component will produce a technical report that includes the following four elements: 1) an assessment of the percent of shoreline (and selected subpopulations) meeting water quality standards, 2) an evaluation of the relative response among the indicator development 3) a QA assessment of results from the intercalibration exercises, and 4) an inventory of existing bacteriological monitoring in the Bight.

The first two elements focus on addressing the core objectives of the project. The third element will provide an overview of the intercalibration exercises, which are the first interlaboratory exercise to include such a large range of participants using a variety of methods. The fourth element will provide a summary of current routine shoreline bacteriological monitoring that exists in the Southern California Bight. Preparation of this summary was a necessary part of planning for the shoreline microbiological component of Bight'98.

TABLE V-1. Bight'98 Steering Committee Members.

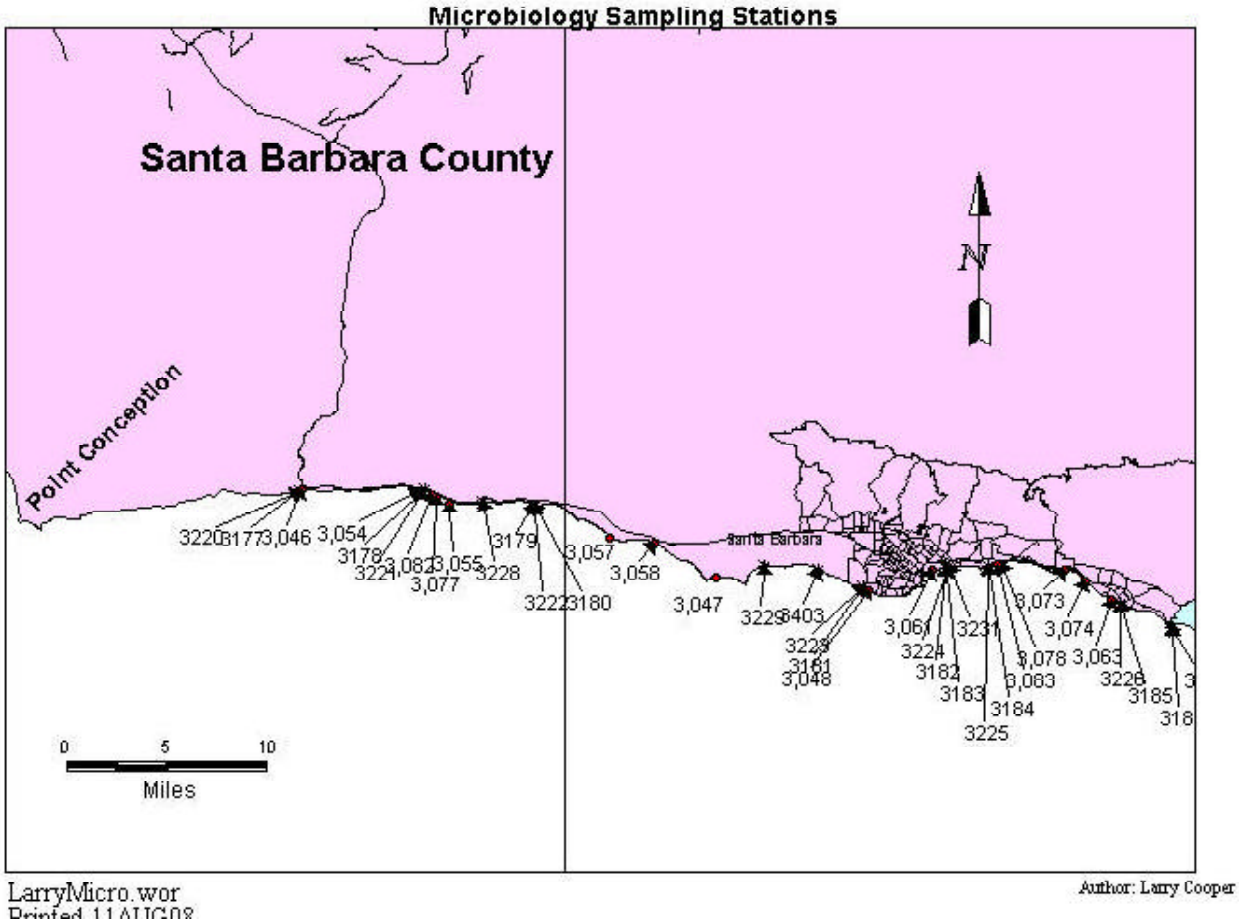
Anson, Nancy	Encina Wastewater Authority
Branch, Nicki	San Elijo Joint Powers Authority
Dojiri, Mas	City of Los Angeles, EMD
Fleming, Terry	US EPA, Region IX
Herbinson, Kevin	Southern California Edison (SCE)
Grovhoug, Jeff	US Navy (SPAWAR SYS,. CEN, San Diego)
Harley, Ann	AWMA, SERRA
Fangman, Sarah	Channel Islands National Marine Sanctuary
Ito, Neil	Chevron
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 Labs
Mofidi, Fazi	Los Angeles Department of Water and Power
Moore, Bruce	Orange County Public Facilities and Resources Department (OCPFRD)
Noble, Rachel	University of Southern California
Pennell, Gus	City of Oceanside
Rao, Linda	State Water Resources Control Board
Robertson, George (Co-Chair)	Orange County Sanitation District (OCSD)
Stull, Jan	Los Angeles County Sanitation Districts (LACSD)
Vereker, Lori	City of San Diego
Weisberg, Steve (Chair)	Southern California Coastal Water Research Project
Worcester, Karen	Central Coast Regional Water Quality Control Board.

TABLE V-2. Microbiology Committee Members.

Amador, Ric	City of San Diego
Anson, Nancy	Encina Wastewater Authority
Baez, Bernardo Flores	Instituto de Investigaciones Oceanologicas (UABC)
Branch, Nicki	San Elijo Joint Powers Authority
Cressey, Ron	City of Los Angeles Environmental Monitoring Division
Davis, Don	City of Ventura
Dorsey, John (Chair)	City of Los Angeles, Stormwater Division
Gal, Maria	City of Oceanside
Gregorio, Dominic	Southern California Marine Institute
Harley, Ann	Aliso Water Management Authority and Southeast Regional Reclamation Authority
Honeybourne, Larry	Orange County Environmental Health Division
Jay, Florence	City of Ventura Wastewater Treatment Plant
Joy, Jayne	Marine Corps Base-Camp Pendleton
Lehner, Jim	Los Angeles County Sanitation Districts
Lyons, Michael	Los Angeles Regional Water Quality Control Board
Marcelino, Phil	Aquatic Bioassay and Consulting Laboratories

Mazur, Monica	Orange County Environmental Health Division
McGee, Charles (Co-Chair)	Orange County Sanitation District
Meehan, John	City of Oxnard
Moore, Doug	Orange County Environmental Health Division
Mora, Roxana Rico	Instituto de Investigaciones Oceanologicas (UABC)
Nakauchi, Steve	City of Long Beach Dept. of Health & Human Services
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)
Peters, Greig	San Diego Regional Water Quality Control Board
Petralia, Jack	Los Angeles County Department of Health Services
Pinigis, Dennis	Marine Corps Base-Camp Pendleton
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

APPENDIX A. MAPS OF SAMPLING SITES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Santa Barbara County
Point Conception
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Santa Barbara
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3,054
3178
3224
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3,055
3,077
3228
3179
3222
3180
3,057
3,058
3,047
3229
3403
3223
3161
3,048
3,061
3224
3182
3183
3225
3231
3184
3,083
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3,063
3228
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Miles
0
5
10
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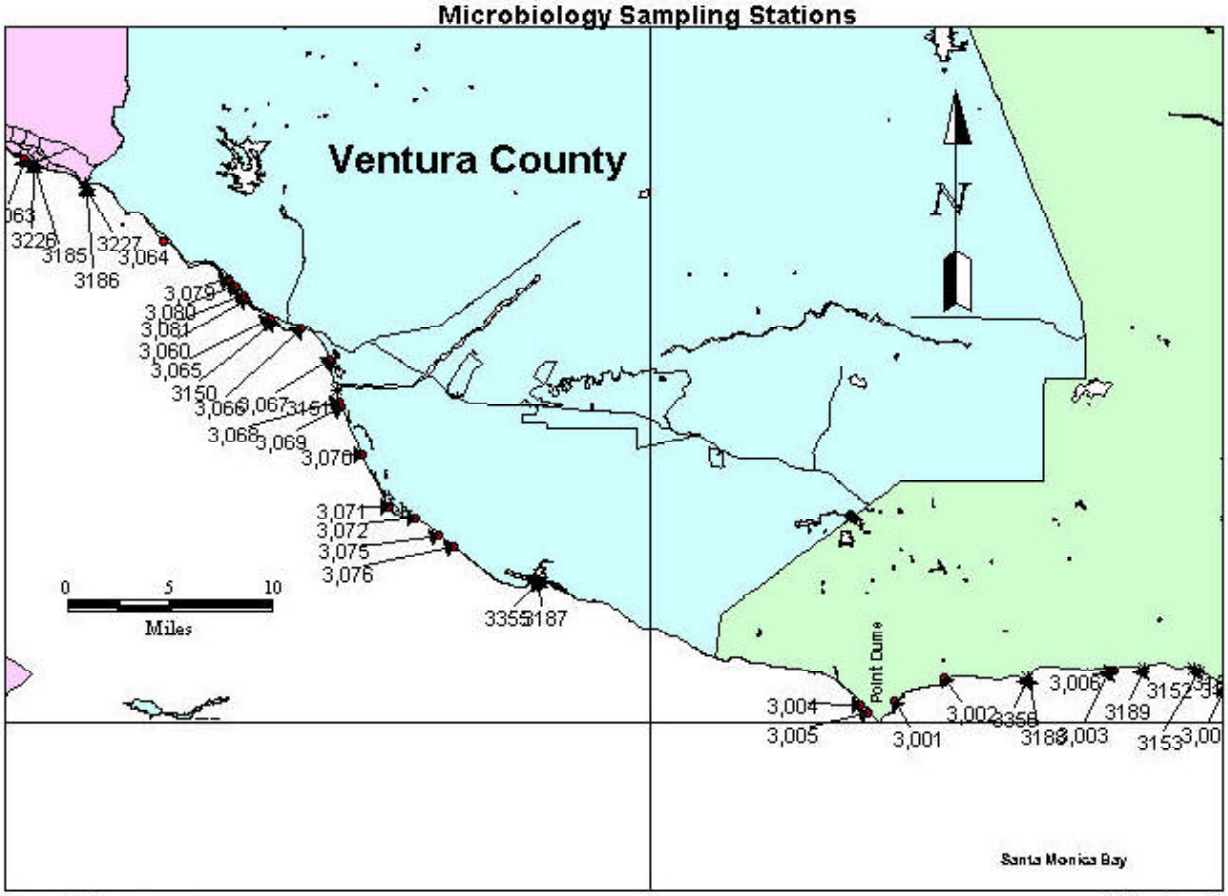
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3186
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3,060
3,065
3150
3,066
3,067
3,068
3,069
3,070
3,071
3,072
3,075
3,076
3355
3187
0
5
10
Miles
Point Dume
3,004
3,005
3,001
3,002
3358
3188
3,003
3,006
3152
3189
3153
Santa Monica Bay
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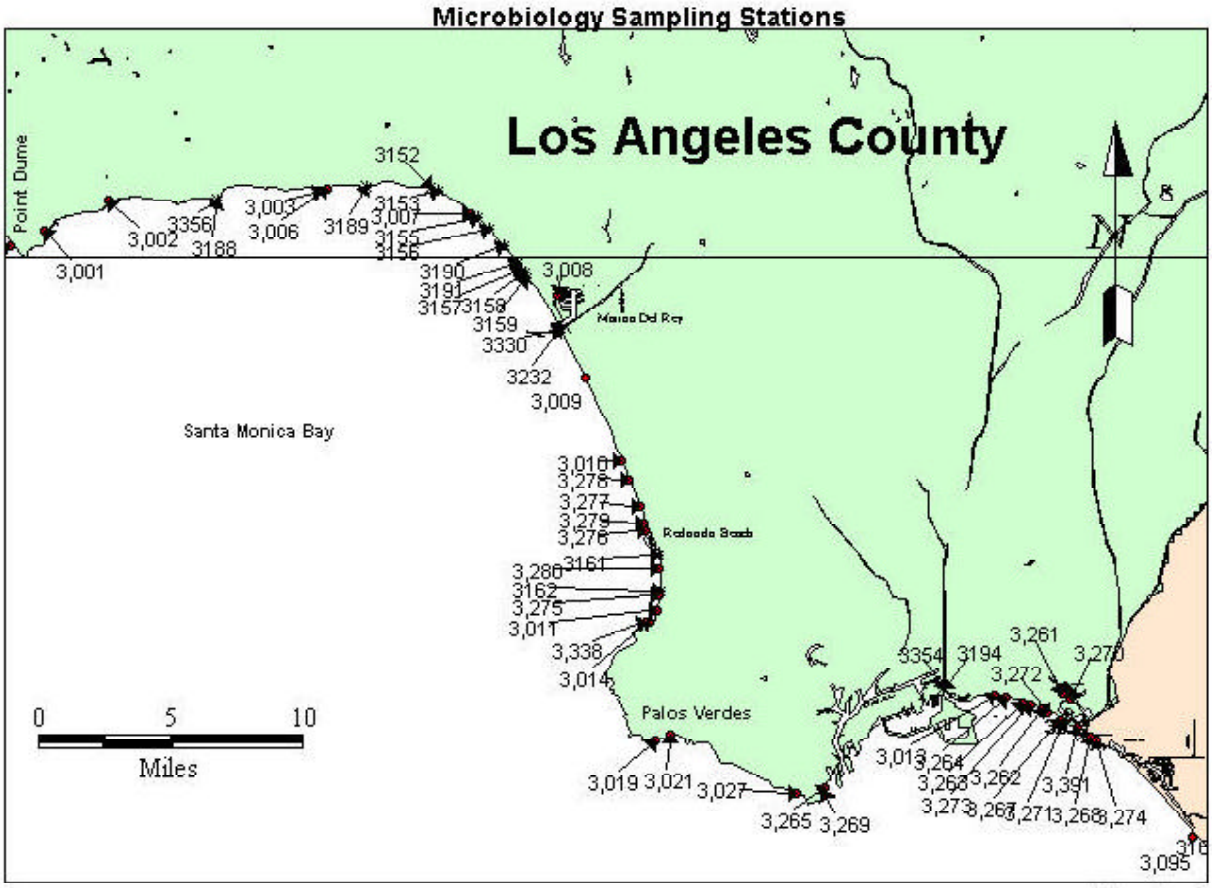

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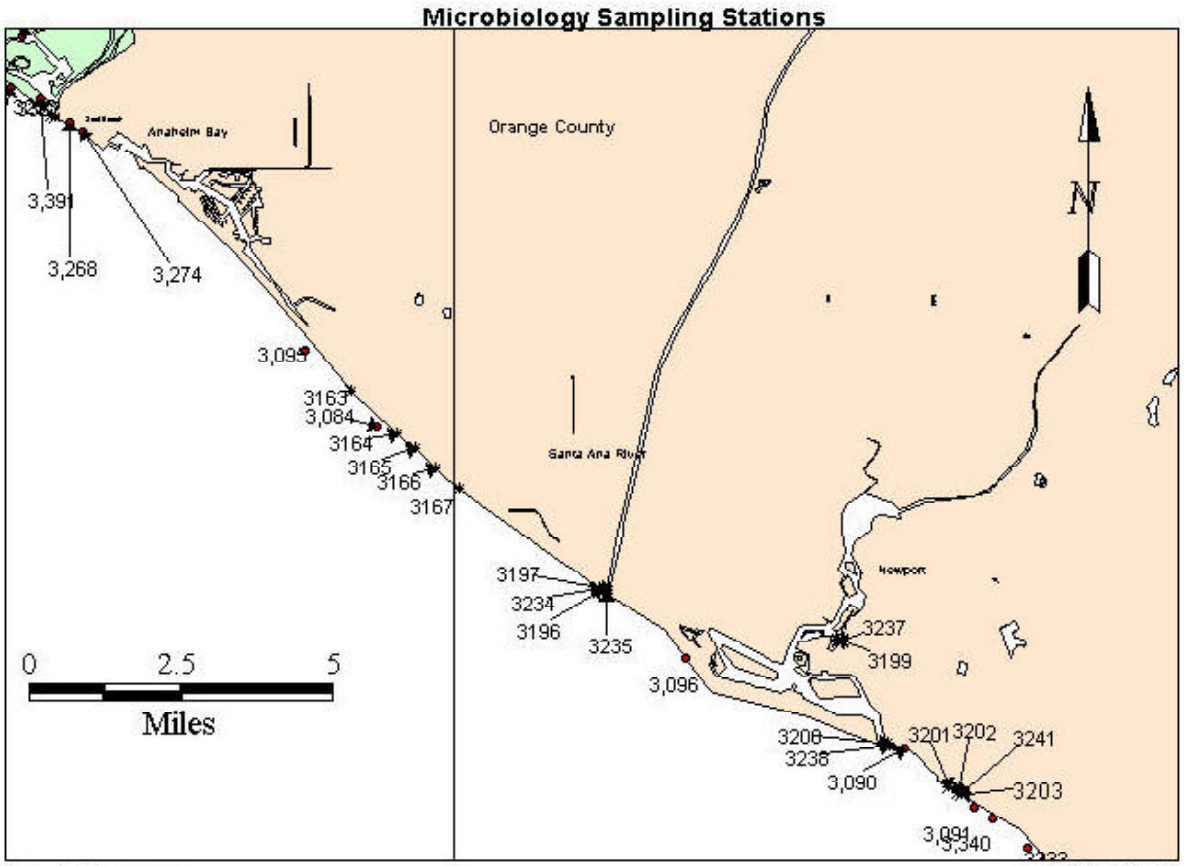
Microbiology Sampling Stations
Anaheim Bay
Orange County
Santa Ana River
Newport
N
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3,268
3,274
3,095
3163
3,084
3164
3165
3166
3167
3197
3234
3196
3235
3,096
3237
3199
3208
3236
3,090
3201
3202
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3,091
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0
2.5
5
Miles
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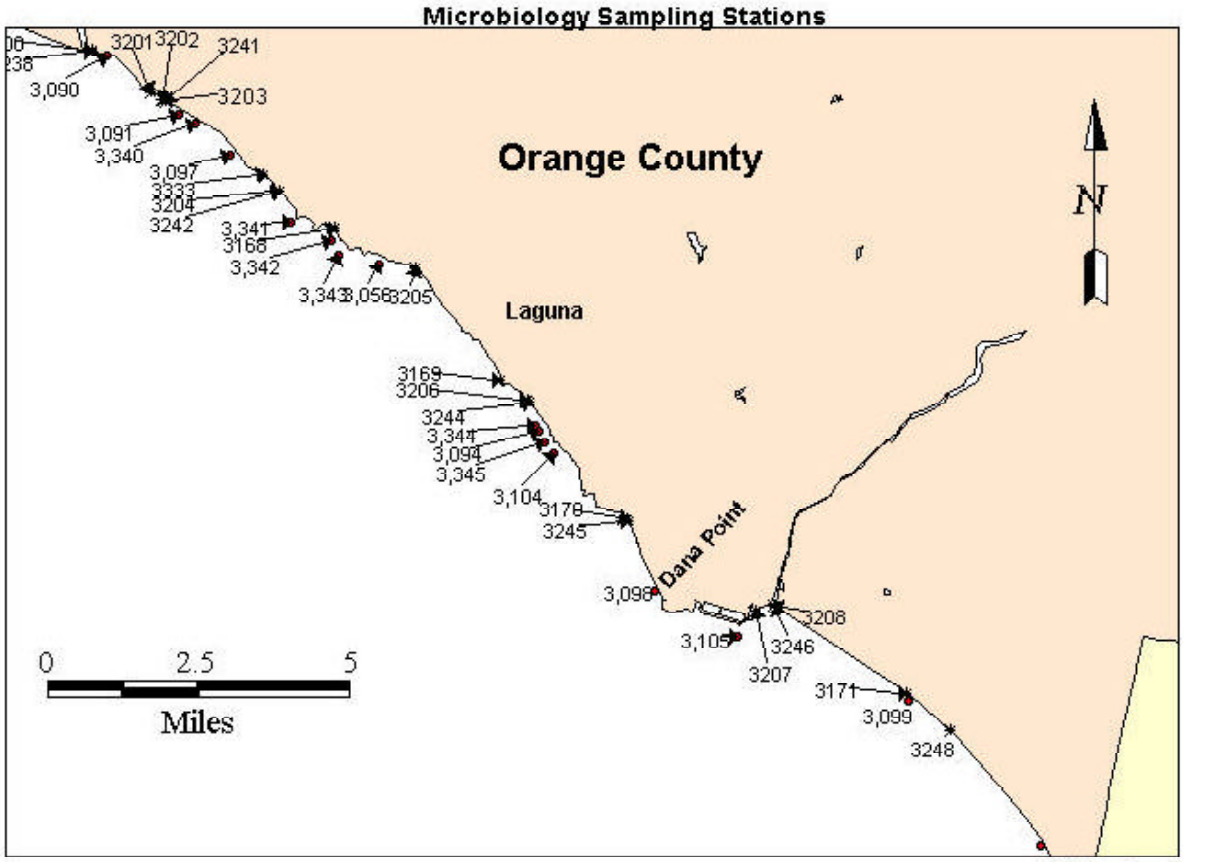
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Laguna
Dana Point
N
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2.5
5
Miles
3201
3202
3241
3,090
3203
3,091
3,340
3,097
3333
3204
3242
3,341
3166
3,342
3,343
3,056
3205
3169
3206
3244
3,344
3,094
3,345
3,104
3178
3245
3,098
3208
3,105
3246
3207
3171
3,099
3248
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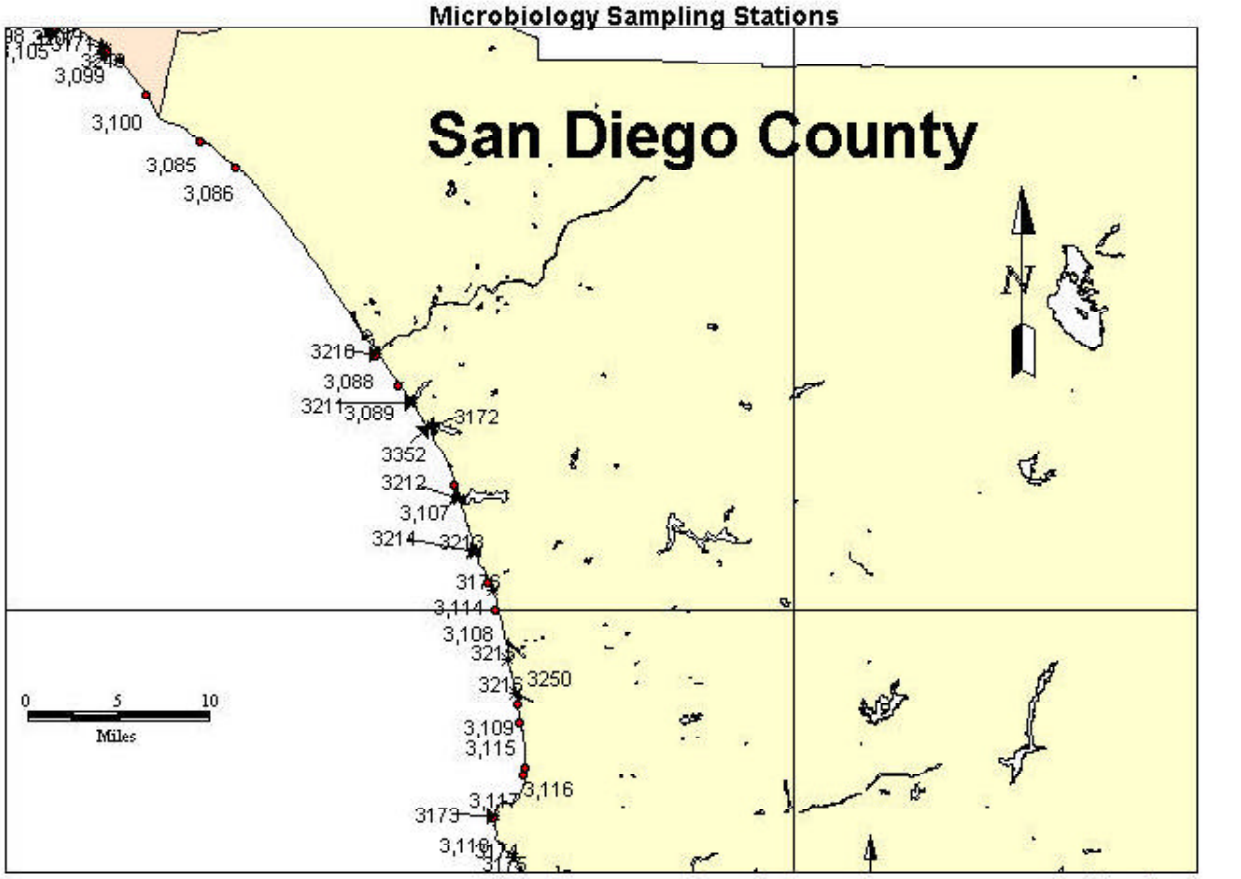
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San Diego County
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3,100
3,085
3,086
3216
3,088
3211
3,089
3172
3352
3212
3,107
3214
3,114
3,108
3250
3,109
3,115
3,116
3,117
3173
3,118
N
0
5
10
Miles
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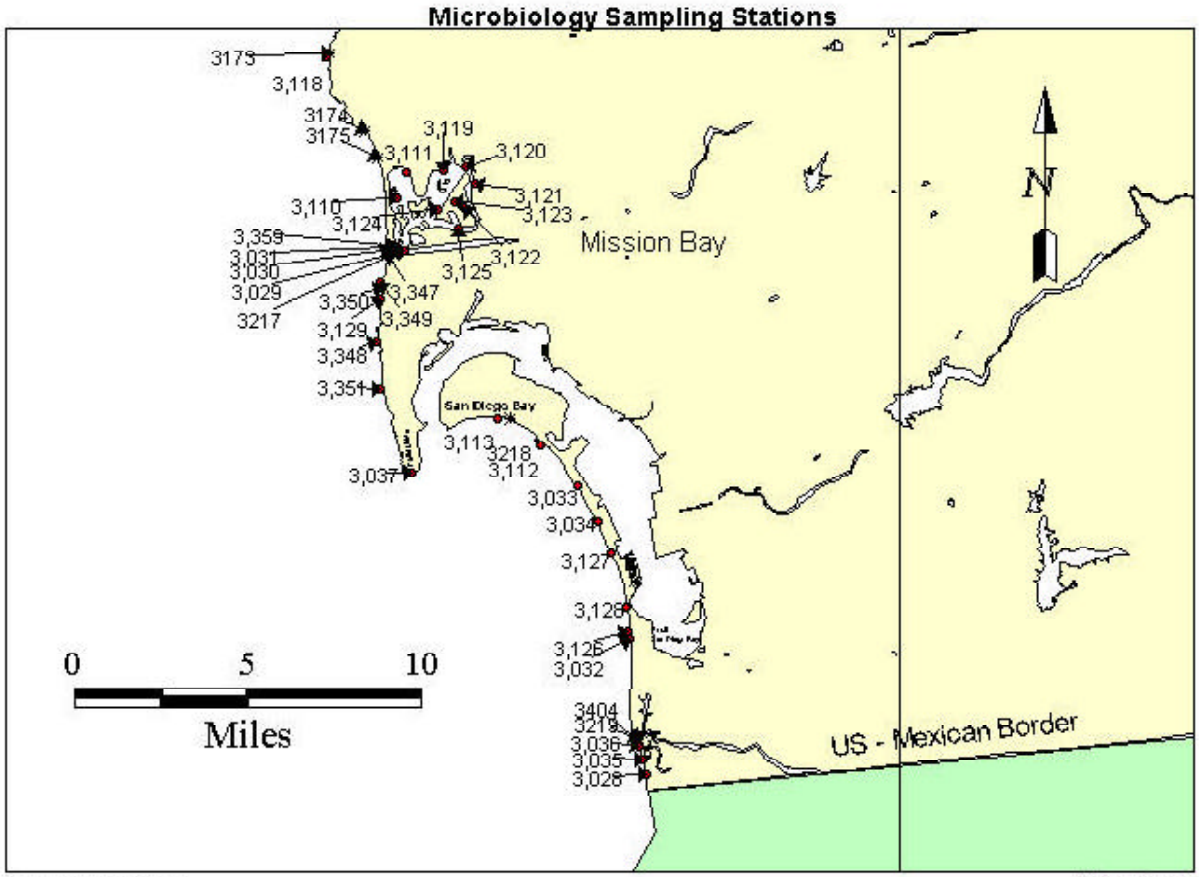
Microbiology Sampling Stations
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3174
3175
3,119
3,111
3,120
3,121
3,123
3,110
3,124
3,359
3,031
3,030
3,029
3217
3,122
3,125
3,350
3,347
3,349
3,129
3,348
3,351
Mission Bay
San Diego Bay
3,113
3218
3,112
3,037
3,033
3,034
3,127
3,128
3,126
3,032
3404
3219
3,036
3,035
3,026
US - Mexican Border
N
0
5
10
Miles
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APPENDIX B. SAMPLE SITE SELECTION PROCESS

APPENDIX B. SAMPLE SITE SELECTION

The sampling sites for the shoreline microbiology component of Bight'98 were selected using a stratified random design with systematic spatial structure. The six strata were described in the main body of the workplan. The number of samples allocated to each strata was that which was necessary to achieve 95% confidence intervals within +/-5% of the true value.

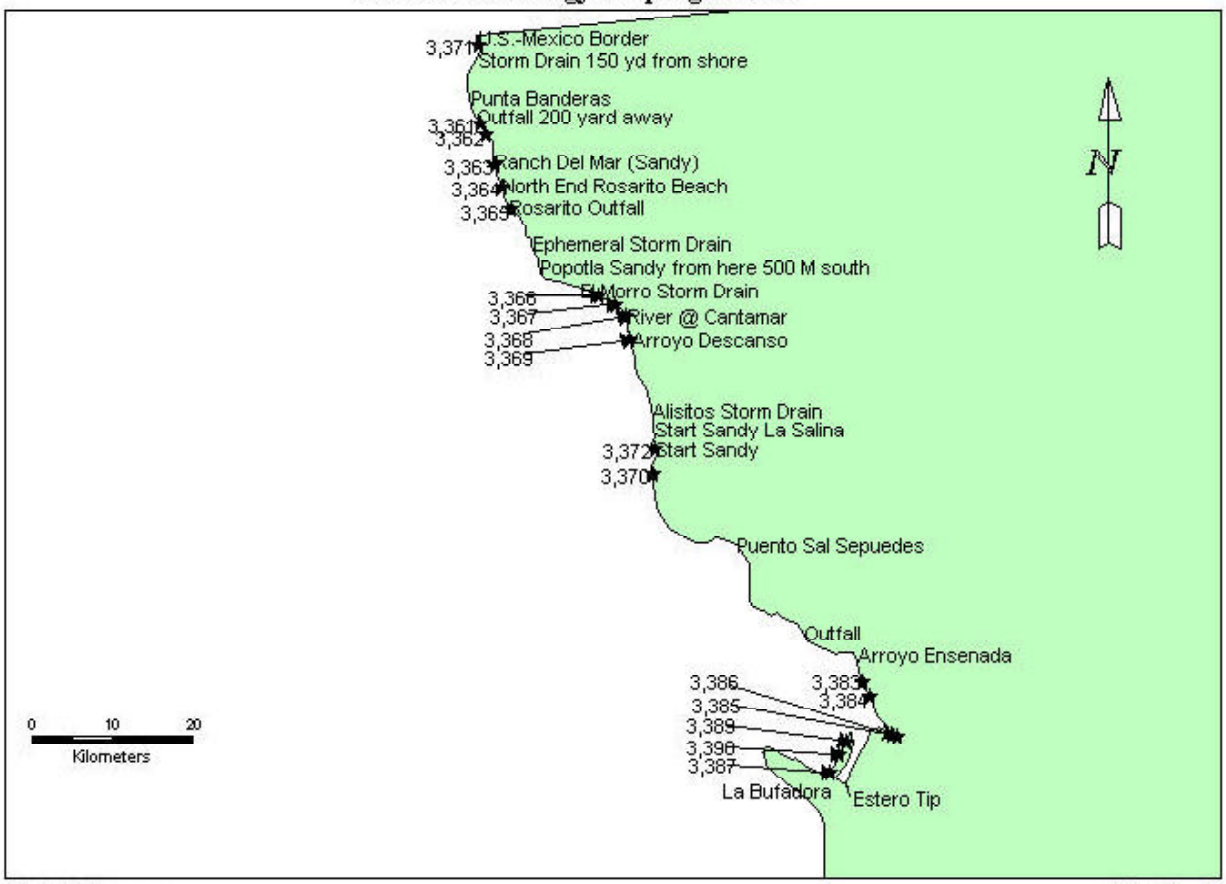
A systematic component was added to the sample design to achieve spatial separation of sample sites along the shore. This was accomplished using an extension of the sampling design used in the National Stream Survey (Messer *et al.*, 1986, Overton, 1985, 1987). In this approach, each stratum was subdivided into a series of sections. These unique sections were each identified by a count variable. The sections of like-strata shoreline were joined together into a strata line. A partition was created for each strata line, with the number of intervals in the partition equal to the sample size. The partition was randomly placed over this strata line by selecting a random starting point for the beginning of the first interval. Based on this starting point, the intervals were defined as consecutive equal-width lengths. A simple random sample of one point was then chosen from within each interval. Each point was then translated back to the shoreline using the section count variable. The resulting sample possessed spatial separation of sites as well as a random component to ensure statistical validity.

This site selection process was implemented separately by County, with the number of sites within a stratum within a County proportional to the percentage of southern California shoreline of that stratum type occurring within the County. A County-specific selection process was implemented to accommodate additional County-specific effort beyond that necessary to achieve the program's precision goals.

The inclusion probability for each sample site was calculated based on stratum and county designation. Each sample site represented a defined shoreline length. Beach samples represented 200 yards and water outlet samples represented 50 yards. Based on this definition, the entire sampleable shoreline had a finite number of possible representative samples, say N. This was the sum of possible representative samples per stratum ($N_{stratum}$). The probability of selecting a specific representative site in a particular strata was $1/N_{stratum}$. The inclusion probabilities for the sample stations were obtained by multiplying the stratum sample size by $N_{stratum}$, the stratum population size. The inclusion probabilities were based on the GIS information at the time of the sample selection process.

APPENDIX C. MAPS OF SAMPLING SITES FOR THE COORDINATED STUDIES

Mexico Microbiology Sampling Stations



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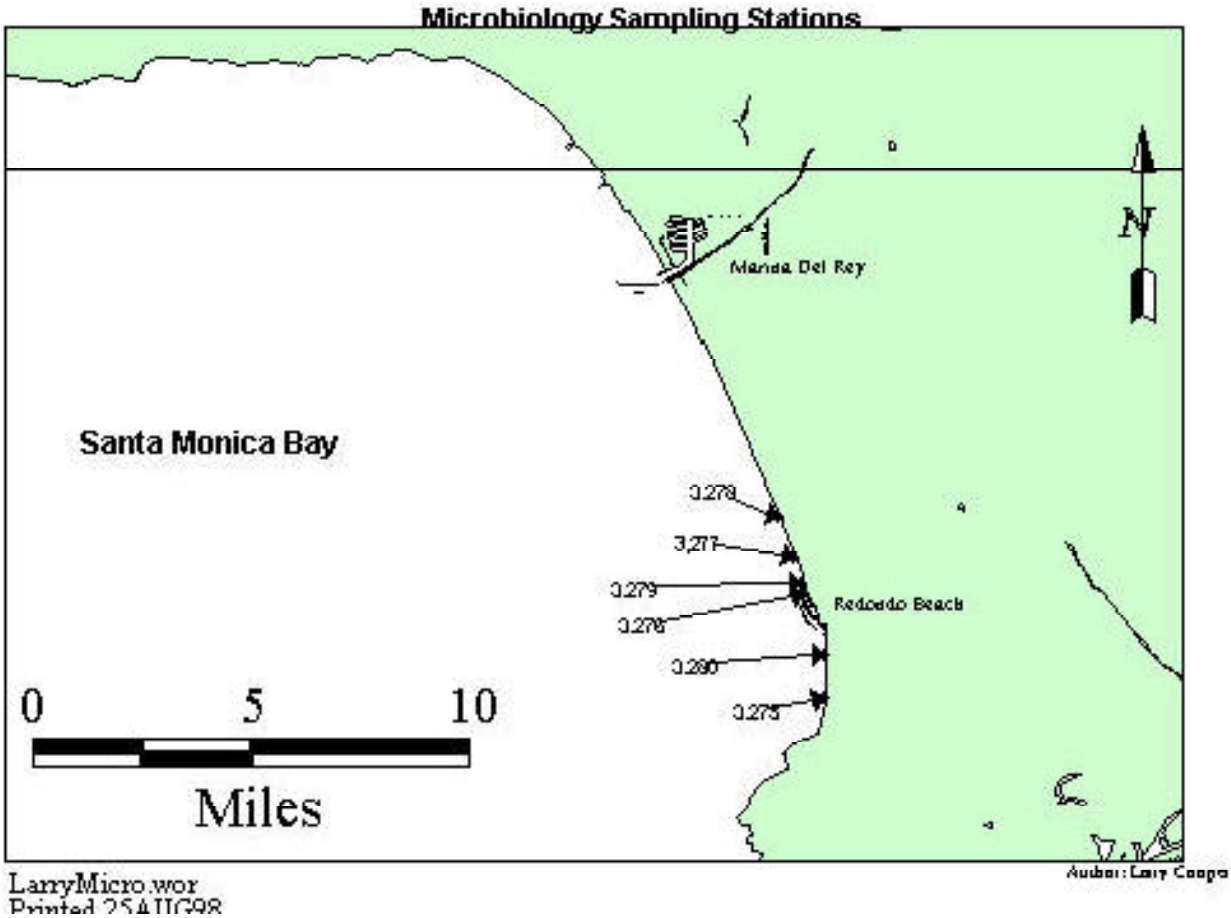
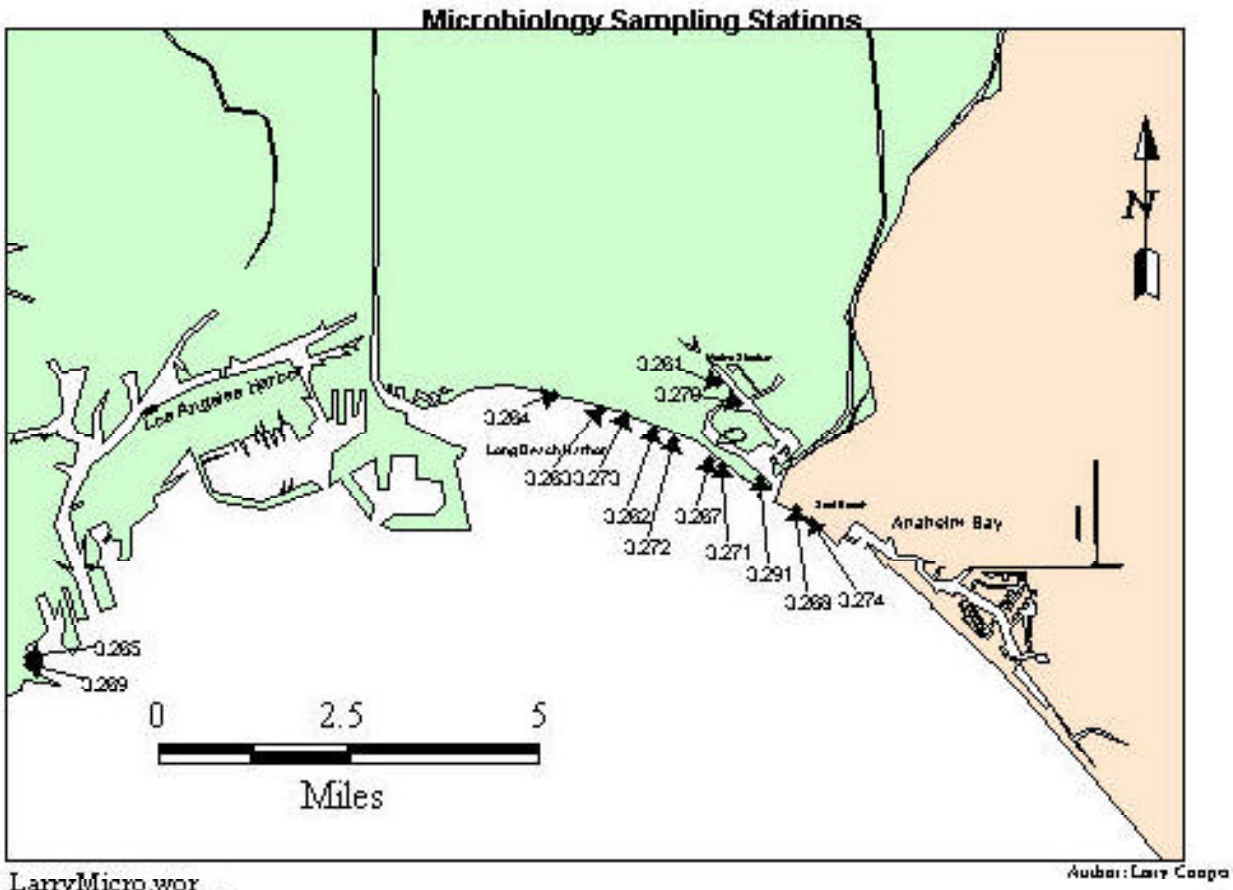

Microbiology Sampling Stations
Marina Del Rey
N
Santa Monica Bay
3,278
3,277
3,279
3,276
3,280
3,275
Redondo Beach
0
5
10
Miles
LarryMicro.wor
Printed 25AUG98
Author: Larry Cooper



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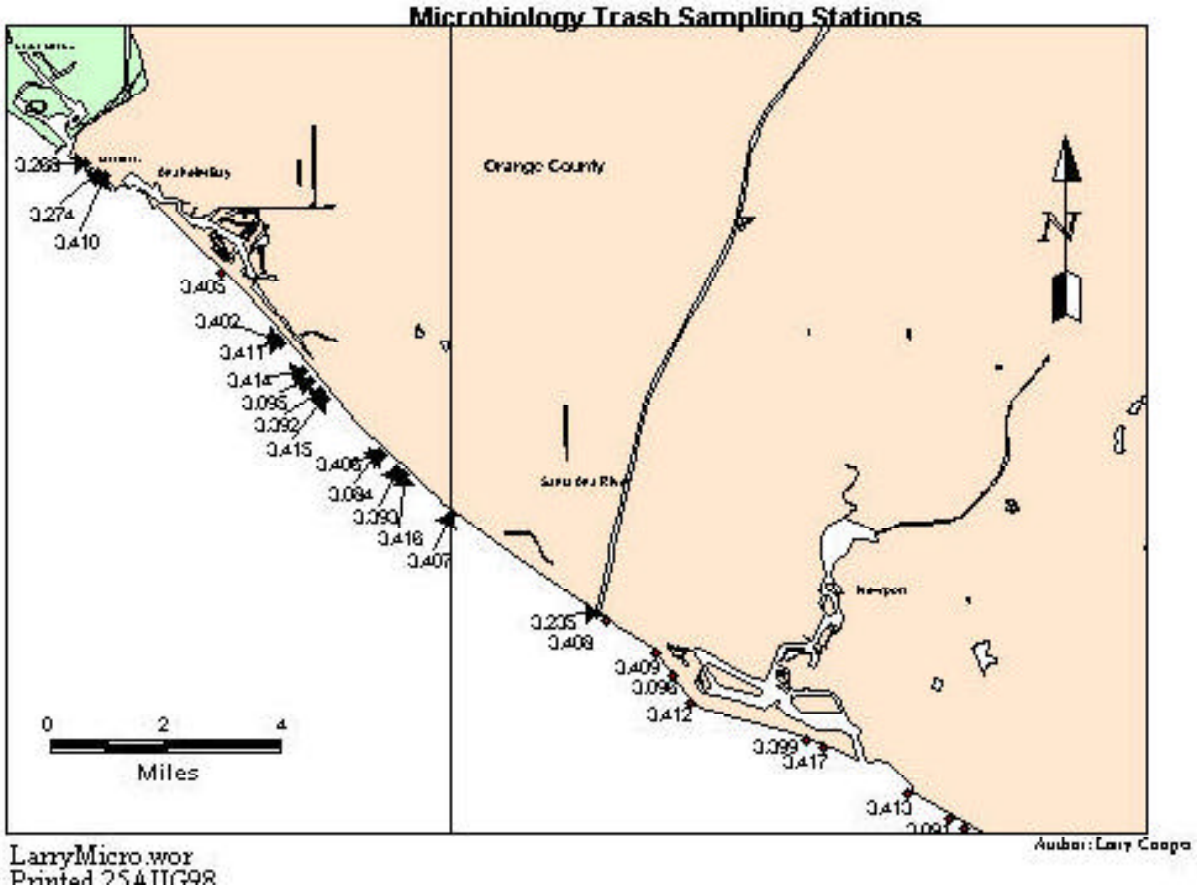
Microbiology Trash Sampling Stations
Orange County
N
0.268
0.274
0.410
0.405
0.402
0.411
0.414
0.095
0.092
0.415
0.406
0.094
0.093
0.416
0.407
0.235
0.408
0.409
0.096
0.412
0.099
0.417
0.413
0
2
4
Miles
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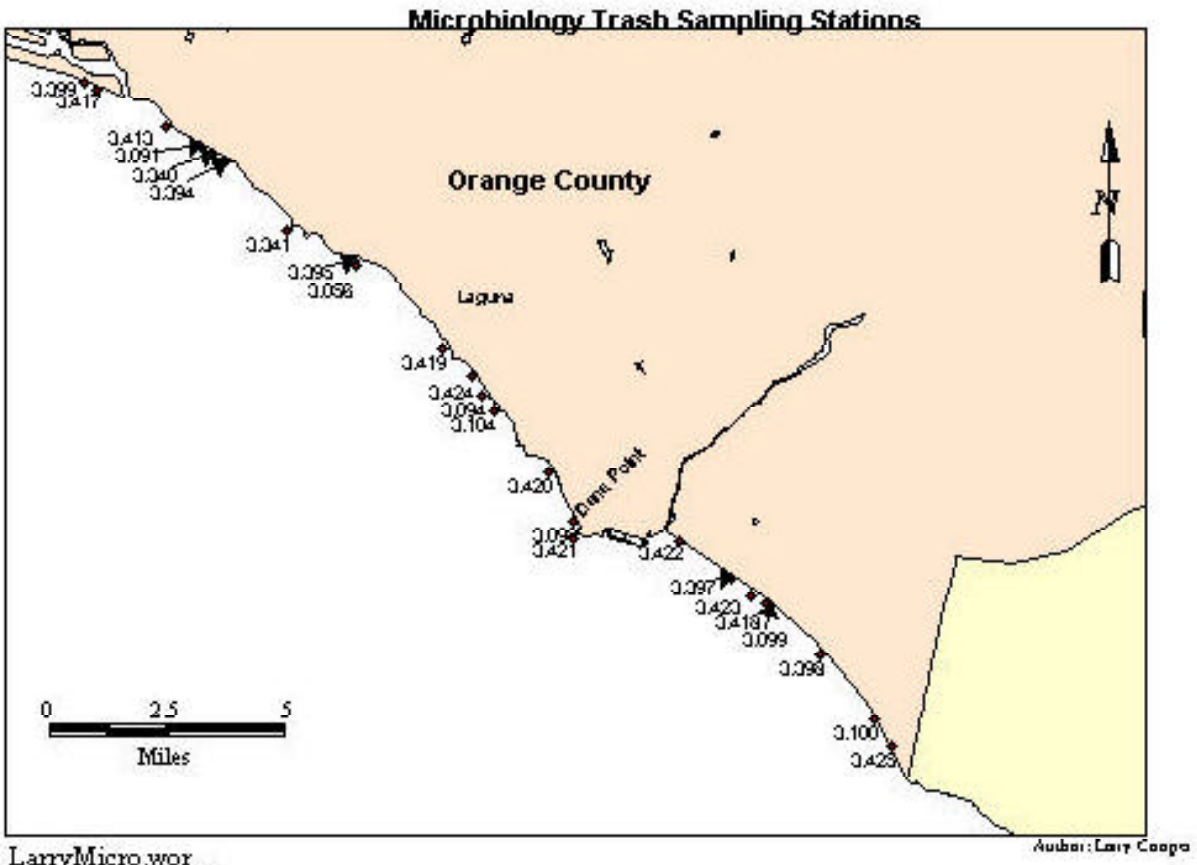
Printed 25AUG98
Author: Larry Coopo



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