SWAMP
Surface Water Ambient Monitoring Program

SWAMP Assement Repot for the Central Coast Region	2000-03

Central Coast Ambient Monitoring Program Hydrologic Unit Report for the 2000-03 Estero Bay Watershed Rotation Area

2003

California Water Boards

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1 Executive Summary

2 Introduction

2.1 Addressing Priorities of the State

2.2 Overview of the Surface Water Ambient Monitoring Program in California

California Assembly Bill 982 (Water Code Section 13192; Statutes of 1999) required that the State Water Resources Control Board (SWRCB) assess and report on State water monitoring programs and prepare a proposal for a comprehensive surface water quality monitoring program. In the SWRCB Report to the Legislature from November 2000, entitled "Proposal for a comprehensive ambient surface water quality monitoring program", the SWRCB proposed to restructure the existing water quality monitoring programs into a new program, the Surface Water Ambient Monitoring Program (SWAMP). This new program is intended to provide comprehensive statewide environmental monitoring focused on information necessary to effectively manage the State's water resources. The program is designed to be consistent, cooperative, adaptable, scientifically sound, and to meet clear monitoring objectives. The program focuses on spatial and temporal trends in water quality statewide. It will facilitate reporting and categorizing of the State's water quality under Sections 305 (b) and 303 (d) of the Federal Clean Water Act. Specific program technical details can be found in the SWAMP Quality Assurance Management Plan (QAMP) (Puckett 2002).

Specifically, the statewide SWAMP is designed to meet four goals:

1. Create an ambient monitoring program that addresses all hydrologic units of the State.

2. Document ambient water quality conditions in potentially clean and polluted areas.

3. Identify specific water quality problems preventing the realization of beneficial uses of water in targeted watersheds.

4. Provide the data to evaluate the overall effectiveness of water quality regulatory programs in protecting beneficial uses of waters of the State.

2.3 Goals and Objectives of the Central Coast Ambient Monitoring Program

The Central Coast Regional Water Quality Control Board is responsible for water quality issues along the central coast of California. The region extends from southern San Mateo County in the north to northern Ventura County in the south, and includes Monterey, Santa Cruz, San Benito, San Luis Obispo, Santa Barbara and portions of Santa Clara counties. The Central Coast Ambient Monitoring Program is the Central Coast Regional Water Quality Control Board's ambient monitoring program, and a major portion of its funding comes from SWAMP**.** The goal of monitoring in the Central Coast region is to provide a screening level assessment of water quality in all hydrologic units, based on a variety of chemical, physical and biological indicators. Monitoring data is used to evaluate beneficial use support in the surface waters of the Region. Monitoring approaches include conventional water quality, water toxicity, sediment chemistry and toxicity, tissue chemistry, rapid bioassessment for benthic invertebrates, and habitat assessment. The Central Coast region uses a rotating basin approach where conventional water quality monitoring is conducted monthly at all sites, and at a subset of the sites other monitoring approaches are conducted annually or biannually. Coastal confluence sites, just above salt water influence, are monitored continuously, and serve for long-term trend monitoring and as "integrators" of upstream impacts.

It is the intent of the SWAMP program in the Central Coast Region to monitor and assess all the waters of the Region, using a weight-of-evidence approach. Data is intended for use in evaluating waterbodies for 305(b) reporting and 303(d) listing. General programmatic objectives of the monitoring program are to:

1. Determine the status and trends of surface, estuarine and coastal water quality and associated beneficial uses in the Central Coast Region
2. Coordinate with other data collection efforts
3. Provide information in easily accessible forms to support decision-making

The following specific monitoring objectives address questions posed in the SWAMP Monitoring Guidance related to beneficial use support. The monitoring approach and the water quality criteria that address these beneficial uses are discussed.

Is there evidence that it is unsafe to swim?
Beneficial Use: Water Contact Recreation (REC-1)
Objective(s): At sites throughout water bodies that are used for swimming, or that drain to areas used for swimming, screen for indications of bacterial contamination by determining percent of samples exceeding adopted water quality objectives and EPA mandated objectives. CCAMP data as well as data collected by local agencies and organizations will be used to assess shoreline and creek conditions.
Monitoring Approach: Monthly monitoring for indicator organisms (e.g. *E. coli*, fecal coliform, Enterococcus); compilation of data from other sources
Assessment Limitations: CCAMP currently samples for fecal and total coliform; assessments are typically based on these two parameters only. Sampling is conducted at a monthly interval only; Basin Plan criteria are typically based on percent exceedance within a 30-day period. The Basin Plan objective for geomean of fecal coliform is based on 5 samples in a 30-day period; monthly sampling is not conducive to calculating exceedances based on the 30 day objective, but is a useful measure of the magnitude of the problem.
Criteria:

- 10% of samples over 400 MPN/100 ml fecal coliform
- Geomean of fecal coliform over 200 MPN/100 ml
- 10% of samples over 235 MPN/100 ml *E. coli*

- 10% of samples over 104 MPN/100 ml Enterococcus (bays and estuaries only)
- Fecal to Total coliform ratio over 0 .1 when Total Coliform exceeds 1000 MPN/100 ml (bays and estuaries only)

Is there evidence that it is unsafe to drink the water?
Beneficial Use: Municipal and Domestic Water Supply (MUN)
Objective(s): At sites throughout water bodies that are sources of drinking water, determine percent of samples that exceed drinking water standards or adopted water quality objectives used to protect drinking water quality. Screen for presence of chemicals which may cause detrimental physiological response in humans using multi-species toxicity testing
Monitoring Approach: Monthly sampling for nitrate, general minerals and pH; annual or bi-annual multi-species toxicity testing and followup chemistry or toxicity identification evaluations where possible.
Assessment Limitations: CCAMP does not typically sample for metals or organic chemicals in water; assessment is based on conventional parameters and toxicity only.
Criteria:

- Nitrate (as N) over 10 mg/L
- pH under 6.5 or above 8.3
- Water toxicity effects significantly greater than reference tests and survival, growth, or reproduction less than 80% of control

Is there evidence that it is unsafe to eat fish and other aquatic resources?
Beneficial Uses: Commercial and Sport Fishing (COMM), Shellfish Harvesting (SHELL)
Objective(s): At sites located near the lower ends of streams and rivers, and in lakes, enclosed bays and estuaries, screen for chemical pollutants by determining the concentration of chemical contaminants in fish and shellfish samples, and assess whether samples exceed several critical threshold values of potential human impact (advisory or action levels).
Monitoring Approach: Annual fish and mussel tissue collection and chemical analysis
Assessment Limitations: CCAMP samples for an array of metals and organic chemicals commonly analyzed by the State Mussel Watch Program and the Toxic Substances Monitoring Program. This array does not include all currently applied pesticides, pharmaceuticals, and numerous other synthetic organic chemicals. Many chemicals do not have readily available human health criteria or advisory levels.
Criteria: Exceedance of Office of Environmental Health Hazard Assessment Criteria for fish and shellfish tissue and other relevant criteria and guidelines.

Is there evidence that aquatic life uses are not supported?
Beneficial Uses: Cold Freshwater Habitat (COLD); Preservation of Biological Habitats (BIOL); Warm Freshwater Habitat (WARM); Wildlife Habitat (WILD); Rare and Endangered Species (RARE); Spawning (SPAWN)

Objective(s): At sites along the main stem and at the lower ends of major tributaries of streams and rivers, screen for indications of water quality and sediment degradation for aquatic life and related uses, using several critical threshold values of toxicity, biostimulation, benthic community condition, habitat condition, and physical and chemical condition.

Monitoring Approach: Spring synoptic sampling for sediment and water column toxicity, sediment chemistry, benthic invertebrate assemblages, and associated habitat quality. Toxicity Identification Evaluation and/or chemistry follow-through for toxic sites. Monthly conventional water quality monitoring for nutrients, dissolved oxygen, pH, turbidity, chlorophyll and water temperature. Pre-dawn or 24-hour continuous sampling for dissolved oxygen.

Assessment Limitations: CCAMP samples for an array of metals and organic chemicals commonly analyzed by the State Mussel Watch Program. This array does not include all currently applied pesticides, pharmaceuticals, and numerous other synthetic organic chemicals. Habitat sampling is conducted only in association with benthic invertebrate sampling and is not comprehensive. Sampling sites are located typically at the lower ends of major tributaries, streams and rivers within each Hydrologic Unit.

Critera:

- Sediment or water toxicity effects significantly greater than reference tests and survival, growth, or reproduction less than 80% of control
- Sediment concentrations of organic chemicals above detection limits
- Tissue concentrations of organic chemicals over established U.S. Fish and Wildlife and National Academy of Sciences guidelines for protection of aquatic life. Tissue concentrations for chemicals without guidelines above detection limits.
- Dissolved oxygen levels lower than 7.0 mg/L in cold water streams and 5.0 mg/l in warm water streams
- Median oxygen levels less than 85%.
- pH levels lower than 7.0 or above 8.5
- Unionized ammonia levels over 0.025 mg/L as N.
- Biostimulatory risk rank above scoring range of high quality sites, for a given stream stratum
- Index of Biotic Integrity below scoring range of high quality sites, for a given stream stratum

Is there evidence that agricultural uses are not supported?

Beneficial Use: Agricultural supply (AGR)

Objective(s): At sites throughout waterbodies that are used for agricultural purposes, determine percent of samples with concentrations of nutrients and salts above screening values or adopted water quality objectives used to protect agricultural uses.

Monitoring Approach: Monthly sampling for nutrients and salts

Assessment Limitations: CCAMP does not typically sample for all of the parameters identified in the Central Coast Water Quality Control Plan for protection of agricultural beneficial uses.

Criteria:

- pH below 6.5 or above 8.3
- Electrical conductivity over 3000 for salinity
- Sodium absorbtion ratio over 9.0
- Chloride over 106 mg/L
- Boron over 2.0 mg/L
- Sodium over 69 mg/L
- Ammonium over 30 mg/L
- Nitrate over 30 mg/L as N

Is there evidence that aesthetic and other non-contact recreational uses are not supported?
Beneficial Use: Non-Contact Water Recreation (REC-2)
Objective(s): At sites throughout waterbodies that are used for non-contact recreation, screen for indications of bacterial contamination by determining the percent of samples exceeding adopted water quality objectives and assess aesthetic condition for protection of non-contact water recreation
Monitoring Approach: Monthly sampling for pathogen indicator organisms (E. coli, total and fecal coliforms); monthly qualitative assessment of % algal cover, presence of scum, odor, trash, etc.
Assessment Limitations: CCAMP does not currently conduct a formal assessment for trash.
Criteria:

- pH under 6.5 or over 8.3
- 10% of samples over 4000 MPN/100 ml fecal coliform
- Dry weather turbidity persistently over 10 NTU
- Algal cover persistently over 25%
- Scum, odor, trash, oil films present

2.4 Overview of the Central Coast Ambient Monitoring Program Approach

The CCAMP mission statement is to collect, assess and disseminate water quality information to aide decision makers and the public in maintaining, restoring and enhancing water quality and associated beneficial uses in the Central Coast Region. The CCAMP monitoring strategy calls for dividing the Region into five watershed rotation areas and conducting synoptic, tributary based sampling each year in one of the areas. Approximately thirty sites are monitored in each watershed rotation area. Over a five-year period all of the Hydrologic Units in the Region are monitored and evaluated. In addition to the rotational approach, thirty-one of the Region's coastal creeks and rivers are monitored continuously just upstream of their confluence with the Pacific Ocean.

The CCAMP strategy of establishing and maintaining permanent long term monitoring sites provides a framework for trend analysis and detection of emergent water quality problems and maintenance of high quality waters. CCAMP uses a variety of monitoring approaches to characterize status and trends of coastal watersheds, including conventional water quality analysis, benthic invertebrate bioassessment, analysis of tissue and sediment for organic chemicals and metals, and toxicity evaluation.

In order to develop a broad picture of the overall health of waters in the Central Coast Region, a similar monitoring approach is applied in each watershed area. This provides compatibility across the Region and allows for prioritization of problems across a relatively large spatial scale. However, additional watershed specific knowledge is incorporated into the study design, so that questions which are narrower in focus can also be addressed. For example, in watersheds where Total Maximum Daily Load assessments are being undertaken, other program funds can be applied to support additional monitoring for TMDL development. Special studies are undertaken as funding and staffing permits to further focus monitoring on questions of interest in individual watersheds.

Watershed characterization involves three major components: acquisition and evaluation of existing data, monitoring of surface water and habitat quality, and developing a watershed assessment based on findings.

Evaluation of existing sources of data

Existing sources of data are evaluated for pollutants of concern, historic trends, data gaps, etc. These include Department of Health Services, USGS, Department of Fish and Game, Department of Pesticide Regulation, Toxic Substances Monitoring Program, STORET, NPDES discharge data, and other sources. Data from County, City, and other selected programs are also acquired. Selected data is compiled into the CCAMP data base format and used along with data collected by CCAMP to evaluate standard exceedances, pollutant levels which warrant attention, beneficial use impairment, and other pertinent information. Basic GIS data layers, where available, describing land use, geology, soils, discharge locations, etc. are used in analysis and display of data, to further understanding of probable sources and causes of identified problems.

Monitoring approaches

Table 2.4a indicates the relationship between monitoring types and beneficial uses recognized in the Central Coast Basin Plan. Monitoring approaches currently employed by CCAMP are shown in bold. It is intended that the program become more comprehensive as funding allows for additional monitoring approaches, but the current suite of monitoring activities addresses all beneficial uses to some degree. Virtually all major rivers and streams and their immediate tributaries in Region 3 are designated for cold water fisheries, commercial and sport fishing, contact and non-contact recreation, groundwater recharge, municipal and domestic supply, spawning, and migration beneficial uses. Many also support threatened and endangered species and biological habitats of special significance. Because these important beneficial uses tend to be universal in the Region and require most stringent water quality objectives, the CCAMP suite of indicators targets these beneficial uses particularly, and is intended to be applied uniformly at all sites.

Table 2.4a. Relationship between beneficial uses and monitoring activities.
X - monitoring approaches currently employed by CCAMP
+ - monitoring approaches not currently employed by CCAMP

	CWQ	Sed Chemistry	H2O Chemistry	Tissue Chemistry	Rapid Bioassessment	Toxicity	Geomorphology	Habitat	Remote Sensing	Flow	Sedimentation
Municipal & Domestic	X		+	X					+	X	
Estuarine Habitat	X	X	+	X	X	X	+	+	+	X	+
Marine Habitat	X	X	+	X	X	X	+	+	+		+
Wildlife Habitat	X	X	+	X	X	X	+	+	+	X	+
Biological Habitat of Special Significance	X	X	+	X	X	X	+	+	+	X	+
Rare & Endangered Species	X	X	+	X	X	X	+	+	+	X	+
Fish Migration	X	X	+	X	X	X	+	+	+	X	+
Fish Spawning	X	X	+	X	X	X	+	X	+	X	X
Shellfishing	X			X							
ASBS	X	X	+	X	X	X	+	+	+	X	+
Agricultural Supply	X	X	+			X				X	
Industrial Process Supply	X		+			X					
Industrial Service Supply	X								+		+
Groundwater Recharge	X		+			X	+		+	X	
Fresh Water Replenishment	X		+			X	+		+	X	
Navigation	X	X				X	+		+	X	+
Hydroelectric Power Generation	X						+		+	X	
Water Contact Recreation	X										
NonContact Recreation	X										
Commercial and Sport Fishing	X	X	+	X	X	X	+	+	+	X	
Aquaculture	X	X	+	X		X					
Warm Water Habitat	X	X	+	X	X	X	+	+	+	X	+
Coldwater Habitat	X	X	+	X	X	X	+	+	+	X	+

2.5 Scope of the Report

This report provides a data summary for watershed monitoring completed during fiscal years 1 - 3 (00-01 through 02-03) of the SWAMP Program. This includes CCAMP watershed rotation monitoring of the Estero Bay Hydrologic Unit (307) between January 2002 and March 2003 as well as coastal confluences monitoring at six sites in this Hydrologic Unit since April of 2001. The 2002 rotation area included Coastal watersheds of San Luis Obispo County between San Carpoforo Creek at the northern edge of the county and the Arroyo Grande watershed to the south. The report provides an analysis of beneficial use support and determination of impairment for monitored streams.

3 Estero Bay Hydrologic Unit Description

The coastal watersheds of the Estero Bay Hydrologic Unit are in western San Luis Obispo County. Sixteen of the larger watersheds in the Hydrologic Unit were sampled by CCAMP during the 2002 sampling year. These are shown in Table 3.1 with the approximate watershed acreage, as identified in the hydrologic subarea shape file (Cal Water 2.2).

Table 3.1. Estero Bay Hydrologic Unit watersheds and the approximate acreage of each (from Cal Water 2.2).

Waterbody Name	Watershed Acreage
San Carpoforo Creek	22,800
Arroyo de la Cruz	27,775
Pico Creek	9,500
San Simeon Creek	51,500
Santa Rosa Creek	30,400
Villa Creek	13,800
Cayucos Creek	11,900
Old Creek	6,790 (above Whale Rock Reservoir)
Toro Creek	9,940
Morro Creek	18,000
Chorro Creek	30,000
Los Osos Creek	14,200
Coon Creek	11,000
San Luis Obispo Creek	54,150
Pismo Creek	30,080
Arroyo Grande Creek	**37,300 (BELOW LOPEZ DAM)**

Steelhead trout are an important resource in most of these creeks, and the southern portion of this Unit is typically considered the southern extent of their viable range. TMDL listings in this area include Morro Bay (for metals, pathogens, and sedimentation), Chorro Creek (for metals, nutrients, and sedimentation), Los Osos Creek (for nutrients, priority organics, and sedimentation), and San Luis Obispo Creek (for nutrients, pathogens, and priority organics). Larger Estero Bay Hydrologic Unit watersheds that were monitored by CCAMP in the 2002 sampling year are described below.

Several urban areas including San Simeon, Cambria, Cayucos, Morro Bay, Los Osos, San Luis Obispo, Pismo Beach, Arroyo Grande, and Oceano are found in the area. Major land uses in the area include grazing, agriculture and residential. In the watersheds of San Simeon, Santa Rosa, Villa, Cayucos, Old, Toro and Morro Creeks the primary land uses are grazing, vineyards, avocado and orange orchards on multiple ranch properties. In recent years an increasing number of ranches are converting to vineyards and avocado orchards. Some areas include intensive agricultural cropping activities, particularly in the lower watersheds of Chorro Creek, Los Osos Creek, San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek. There are additional land uses that have affected water quality in several of these watersheds, these are discussed in more detail in the following paragraphs.

In the San Simeon Creek watershed the creek mouth is located within the boundary of San Simeon State Park Campground. Upstream of this location there is gravel mining occurring in the stream terraces. Also located just upstream from the campground are Cambria Community Services District wastewater percolation ponds and spray fields. The San Luis Obispo Waste Water Treatment Plant (WWTP) discharges directly to San Luis Creek, resulting in consistently elevated phosphate levels downstream. A similar situation is found in Chorro Creek downstream of the California Men's Colony WWTP discharge. During some months of drier years the lowest reaches of these creeks are dominated by effluent flows.

Impoundments in several watersheds in the Unit have significantly altered stream hydrology and are barriers to fish passage. Old Creek watershed historically flowed to Estero Bay between Cayucos Creek and Toro Creek. Whale Rock Reservoir is located less than a mile from the ocean on this creek, creating a complete fish barrier for the majority of the watershed. Native steelhead trout populations are currently maintained in the reservoir by artificial spawning and rearing. Chorro Creek flows to Morro Bay Estuary at Morro Bay State Park. Morro Bay is recognized as both a State and National Estuary. The headwaters of Chorro Creek drain to Chorro Reservoir, which both impounds Chorro Creek water and serves as a terminal reservoir for Whale Rock reservoir. Chorro reservoir is located above the California Men's Colony facilities on California National Guard,Camp San Luis property. Low volume year-round releases from the reservoir are maintained as ordered by California Department of Fish and Game. The dam at Lopez Lake divides the Arroyo Grande watershed, with more than half of the watershed above the dam. Lopez Lake maintains continuous releases to the lower Arroyo Grande Creek channel. The dam represents a complete barrier for steelhead trout and has resulted in a significant reduction in anadromous spawning in this watershed. A small dam on Prefumo Creek, a tributary to San Luis Obispo Creek, has created Laguna Lake, which provides recreation for local residents as well as habitat for wildlife.

San Luis Obispo Creek has been channelized through the downtown areas of San Luis Obispo, and in one segment flows underneath the City. Creeks in the Area with extensive channelization include Pismo Creek and Arroyo Grande Creek. Pismo Creek is contained in a cement box channel between Highway 101 and the ocean as it flows through the City of Pismo Beach. Arroyo Grande Creek is completely channelized below Fair Oaks Boulevard and the channel is maintained for flood control through annual removal of vegetation. Flood control in lower Arroyo Grande Creek is an ongoing local problem.

Extensive monitoring of Chorro watershed was conducted as part of the U.S. EPA National Monitoring Program (NMP) from 1992 through 2000 (CCRWQCB 2003) and the Morro Bay Volunteer Monitoring Program (VMP) since 2000. CCAMP has continued monitoring at two of the NMP sites on Chorro Creek. NMP and VMP data shows that Chorro Creek is impaired by nutrients, wide swings in diurnal dissolved oxygen levels, fecal coliform and sedimentation. A nutrient TMDL completed in 2002 identified the WWTP as the primary source of nutrient enrichment in the watershed.

Several sources of data exist for San Luis Creek, including volunteer data collected by the Land Conservancy of San Luis Obispo, data collected by Regional Board (including both CCAMP and TMDL staff) and data from the City of San Luis Obispo. A nutrient TMDL was developed for the watershed in 2003. The nutrient TMDL has identified WWTP discharges and cropland in Stenner and Prefumo Creeks as sources of elevated nitrate in the main stem. The TMDL also identified the WWTP as the only significant source of ortho-phosphate in San Luis Creek.

Water quality monitoring in Pismo Creek and Arroyo Grande Creek is being conducted by watershed groups working with Central Coast Salmon Enhancement and Regional Board staff.

4 Sampling Design

Watershed rotation area monitoring sites are placed at safe access locations along the main stem of each major creek and river, typically upstream of each major tributary input, and also at the lower end of each major tributary. Sampling locations frequently are located at public bridge crossings because of all-weather public access. Care is taken to ensure that samples are not influenced by the bridge structure itself. Approximately thirty sites are allocated within the sampling area, in addition long-term coastal confluence sites are monitored continuously at thirty three creek mouths throughout the Region.

The CCAMP program design includes monthly monitoring for conventional water quality (CWQ) at all selected sites. At a subset of sites, generally selected based on hydrogeomorphological considerations or local issues of concern, other monitoring approaches are applied. These include sediment chemistry and toxicity, fish and freshwater clam tissue chemistry, benthic macroinvertebrate assessment and habitat assessment.

5 Methods

5.1 Conventional Water Quality

CCAMP staff collects monthly grab samples and field measurements for conventional parameters at all watershed rotation area and coastal confluence sites. Sampling is conducted following the protocols outlined in CCAMP Standard Operating Procedures (CCAMP 2000).

Field measurements are taken using a multi-analyte Hydrolab DS4a. Measured values are stored in a Surveyor 4a and subsequently downloaded. Data are also recorded on field data sheets, and are used to verify electronically recorded values. Probes are lowered to approximately two-thirds of the water's depth and allowed to equilibrate for at least one minute prior to recording measurements. Field measurements include dissolved oxygen, pH, conductivity, salinity, water temperature, chlorophyll a, and turbidity.

Samples are collected for laboratory analysis at the Central Coast Region's contract laboratory, BC Laboratories in Bakersfield, California. The laboratory analyzes samples for the following parameters: nitrate as N, nitrite as N, total ammonia, total phosphate as P, ortho-phosphate as P, dissolved solids, suspended solids, boron, calcium, chloride, magnesium, sodium, total and fecal coliform. Pre-cleaned 1-L plastic bottles are used to collect samples for nutrients, salts, dissolved and suspended solids analyses. Sterile and sealed 120ml plastic bottles containing sodium thiosulfate preservative are used to collect total and fecal coliform samples. Once collected, samples are stored in ice chests at 4º C until they are transferred to the contract laboratory. Proper chain of custody documentation is maintained for all samples as described in the SWAMP QAMP (Puckett 2002).

During the summer months (July-September) CCAMP staff collect pre-dawn dissolved oxygen measurements. Prior to 2002 CCAMP staff visited each site between 3 a.m. and 30 minutes before sunrise to collect in-situ dissolved oxygen measurements using the Hydrolab DS4a. Beginning in the summer of 2002 CCAMP staff deploy a Hydrolab mini-sonde at each site for 24 hours. The mini-sonde measures dissolved oxygen and pH every 30 minutes. Each mini-sonde is programmed to warm up for two minutes with a circulator to allow the dissolved oxygen to equilibrate. Measurements are stored internally and downloaded following mini-sonde retrieval. Instruments are secured inside ABS pipes and cabled to stationary objects.

<u>Quality Assurance</u>

Hydrolab probes (both the DS4a and the mini-sonde) are calibrated prior to and following each sampling event. Probes are calibrated using laboratory certified standards for pH, conductivity and turbidity, and are air calibrated for dissolved oxygen. Chlorophyll *a* is calibrated using a manufacturer supplied "calibration cube". Calibration data is recorded in an Excel spreadsheet and is used to evaluate instrument performance. The SWAMP QAMP has defined +/- 20% difference as the maximum allowable variation between the calibration standard and post calibration measurement of the standard (Puckett 2002, Appendix C).

A blind field duplicate sample is collected once per sampling trip, resulting in 10% total field duplicates. Duplicates samples, two bottles filled side by side, are labeled with a unique site tag to remain anonymous to the contract laboratory. Data from duplicates is compared to original samples and evaluated using the SWAMP maximum for relative percent difference of 25% (Puckett 2002, Appendix C).

The quality control measures employed by the contract laboratory are also evaluated using SWAMP criteria. These measures include but are not limited to matrix spike recovery, calibration control samples, blanks and lab duplicates.

CCAMP Biostimulatory Risk Index

CCAMP has developed a “Biostimulatory Risk Index” to serve as a screening tool to evaluate sites for risk of problems associated with eutrophication. A more complete description of the index and its use is found in Appendix A; however, it is briefly summarized in this section.

The Biostimulatory Risk Index is a combination of several different measures, or “metrics” of stimuli (nutrient concentrations) and responders (pH, dissolved oxygen, algal and plant cover, water column chlorophyll concentrations), which have been percentile ranked and combined to form a single value. CCAMP collects data on a number of parameters that serve as measures of biostimulation or response. The index is intended to characterize both in-situ monitoring site response to biostimulatory substances and the capacity of monitoring site water quality parameters to induce adverse biostimulatory responses in downstream areas. Some measures, such as nutrient and chlorophyll concentrations, serve as metrics based on magnitude alone (where higher concentrations are considered “worse” than lower concentrations and are ranked accordingly). Others are more complex, particularly “double-ended” parameters such as dissolved oxygen and pH. For example, both supersaturated and depressed concentrations of dissolved oxygen can be indicative of eutrophication. For such parameters the departure of the measurement from the Regional median value is used to calculate the metric (where a larger departure ranks worse than a smaller departure). Various forms of plant cover are stimulated by nutrients and can create nuisance conditions. The Index utilizes the maximum value from three qualitative estimates of percent cover for rooted plants, filamentous algae and periphyton, to calculate a plant cover metric.

5.2 Rapid Bioassessment

CCAMP staff collect benthic macroinvertebrates (BMIs) following California Stream Bioassessment Protocols (Harrington 1999 as cited in Puckett 2000, Appendix G) in two consecutive spring seasons at each site. All BMI samples are processed and identified to the lowest possible taxon at the Department of Fish and Game Aquatic Bioassessment Laboratory (DFG-ABL).

Samples are collected during base-flow conditions. Sampling reaches are always selected in association with conventional water quality monitoring sites. When riffle habitat is present, a reach of stream containing riffles is selected for sampling. Riffles are typically the most taxonomically diverse microhabitats within streams, and are targeted for BMI sample collection. Three riffles within each stream reach are randomly selected for sampling. At each riffle, a transect location is randomly chosen from all possible meter marks along the upper third of the riffle. Three samples are collected along the transect, which is perpendicular to the direction of flow, using a D-shaped kick net. A 1x2 foot area of substrate upstream of the kick-net is disturbed for 1 minute at each site. The three samples from each transect are composited into a single sample. Each sample is preserved in 95% ethanol until analyzed.

When riffle habitat is not present, a representative 100m reach is measured out and three transect locations are chosen randomly from the 100 possible meter marks in the reach. At each transect location the two margins and thalweg are sampled by disturbing a 1 x 2-foot portion of substrate upstream of the kick-net to approximately 4-6 inches in depth. The three site collections per transect are composited to create one sample that is sieved to 0.5 mm and preserved in 95% ethanol. All samples are stored at the Central Coast Regional Board until they are transferred with the appropriate chain of custody forms to the DFG laboratory at Rancho Cordova for identification. At the laboratory, BMI samples are randomly sub-sampled and sorted to obtain 300 individuals per sample. These individuals are stored in an ethanol-glycerin solution, identified to genus or the lowest possible taxonomic unit, and enumerated. Metrics calculated from individual count data include abundance, taxa richness and composition, taxa tolerant or intolerant of impaired conditions, and relative dominance of functional feeding groups. All organisms identified and included in the individual taxa list for each site are labeled with scientific name, date and location collected, and are returned to CCAMP for archiving.

Physical and habitat characteristics are estimated at each site based on visual observations, which score the following habitat parameters on a 1-20 scale: epifaunal substrate, embeddedness, velocity/depth regimes, sediment deposition, channel flow, channel alteration, riffle frequency, bank vegetation, bank stability, and riparian zone width. Field samplers are trained by CDFG staff to conduct this assessment, and scores are intercalibrated for consistency prior to start of sampling.

5.2.1 CCAMP INDEX OF BIOTIC INTEGRITY

The CCAMP Index of Biotic Integrity (CCAMP-IBI) is a sum of several ranked metric scores, including taxonomic richness, number of Ephemeroptera taxa, number of Trichoptera taxa, number of Plecoptera taxa, percentage of intolerant individuals (with tolerance scores of 0, 1, or 2), percentage of tolerant individuals (with tolerance scores of 8, 9 or 10), percent dominant taxon, and percent predators. This index includes all metrics utilized by Karr and Chu (1999) in their Index of Biotic Integrity, with the exception of "clinger taxa count" and "long-lived taxa count". The CCAMP program has been utilizing this index for a number of years for evaluating benthic invertebrate data in the Central Coast. In the past year, a Southern California Index of Biotic Integrity has been developed (Ode et al. 2005), which has incorporated data from the Central Coast Region and more southerly regions. This index includes percent collect-gatherer + collector-filterer, percent non-insect taxa, percent tolerant taxa, *Coleoptera* richness, predator richness, percent intolerant individuals, and EPT richness. Metrics selected for the Southern California IBI were screened using several selection criteria, including range of scoring, responsiveness to disturbance, and minimal inter-correlation. We have evaluated the performance of the CCAMP IBI against the Southern California IBI and find that they are relatively well correlated (R^2=0.72) (Figure 5.2.1a). In the future, we will incorporate the Southern California IBI into the analysis of our benthic data.

CCAMP-IBI scores range from 0 to 10. Sites in the lowest quartile of all CCAMP bioassessment data score below approximately 3.0, as a site average. Sites in the highest quartile score above 6.0. We have examined these quartile break points relative to other indices of water quality and this is discussed in more detain in Appendix B.

5.3 Water Toxicity

Sampling for toxicity to fathead minnow larvae (*Pimephales promelas*) and water fleas (*Ceriodaphnia dubia*) is conducted at a subset of watershed rotation area sites by CCAMP staff. Samples are collected in four 1-gallon amber glass bottles and are maintained at 4° C until delivery to the laboratory within 48 hours. Toxicity testing is performed at the University of California Davis Marine Pollution Studies Laboratory at Granite Canyon (UCD-GC). All tests are conducted for seven days, at 25ºC according to US EPA (1994) protocols. Water quality parameters including conductivity, hardness, alkalinity, pH, dissolved oxygen, and ammonia are measured at the beginning of each test. Test solutions are renewed daily; dissolved oxygen and pH are measured on the old solution and replacement solution. Temperature is monitored continuously by a temperature probe in an additional test solution placed in the controlled temperature room. Details of toxicity testing methods can be found in the SWAMP QAMP (Puckett 2002, Appendix F).

Larvae of the fathead minnow are purchased from an organism supplier and received on test initiation day (less than 24 hours old). Ten fish are randomly distributed to ten test containers containing 250 mL of sample. Test containers are checked daily, and the number of living fish recorded; immobile fish that do not respond to a stimulus are considered dead. Survival and growth endpoints (as dry weight) were recorded for each test container at the end of seven days.

Water flea neonate individuals (<24 h old) are introduced singly into small cups containing 15 mL sample. Each sample includes ten replicates. Survival and reproduction are monitored daily in each replicate. Survival and reproduction endpoints (number of neonates and broods) were recorded for each test container at the end of seven days.

Samples are also tested for chlorpyrifos and diazinon using Enzyme-Linked Immunosorbent Assay (ELISA). All ELISA analyses are performed at UCD-GC with kits from Strategic Diagnostics Inc. (Newark, DE). The lowest detectable doses are 30 ng/L for diazinon and 50 ng/L for chlorpyrifos (Sullivan and Goh 2000).

<u>Quality Assurance</u>

Field duplicate samples are tested to estimate the variability in results associated with sampling and laboratory procedures. All toxicity tests include both positive and negative controls. Positive controls tests are conducted monthly at the laboratory and concurrently with test samples. These controls consist of a dilution series of copper (from cupric chloride) to determine the LC_{50} values for *C. dubia*. Reference toxicant test are conducted to determine whether organism response is within prescribed limits and control chart variations are noted in interoperations of the data. Negative controls consist of laboratory dilutions of water adjusted with sea water to the lowest and highest conductivity observed in the test samples. Data acceptability for 7 day chronic toxicity testing for *C. dubia* is determined by the following criteria: control samples have greater than 80% survival, surviving females average 15 neonates and at least 60% of the surviving females have at least 3 broods (see the UCD-GC SOP document included in Puckett 2002 for more detailed QAQC information).

To verify accuracy of the ELISA method, an external standard is quantified with each batch. Accuracy of these measurements is considered acceptable if the measured value is within 20% of the known concentration. In addition, 5% of the samples measured using the ELISA method are also measured using an EPA analytical method for comparison. The measurement is considered acceptable if the relative percent difference between the results using the two methods is less than 50%. The SWAMP QAPP allows the program manager to determine control limits for external QA assessments (Puckett 2002).

5.4 Sediment Chemistry and Toxicity

Bed sediment samples are collected by Marine Pollution Studies Laboratory (MPSL-DFG) staff at a subset of watershed rotation area sites. Sampling targets fine-grained sediments within the wetted creek channel. A pre-cleaned Teflon™ scoop is used to collect the top 2 cm of sediment from five or more sub-sites into a pre-cleaned glass composite jar. After an adequate amount of sediment is collected, it is homogenized thoroughly and aliquoted into pre-cleaned, pre-labeled sample jars (glass or polyethylene, as appropriate) for organic chemical, metal or toxicological analysis. Once collected, samples are stored at 4°C and shipped with appropriate chain-of-custody and handling procedures to the analytical laboratories (MPSL-DFG, Rancho Cordova-DFG and UCD-GC). Field data sheets are completed for each sampling event to document conditions and sampling notes. Details on sediment sampling are described in the bed sediment procedures outlined in the SWAMP QAMP (Puckett 2002, Appendix D).

Analysis for metal concentrations in sediment samples is conducted at MPSL at Moss Landing. Organic chemical, polynuclear aromatic hydrocarbons, total organic carbon, and grain size analyses are conducted at the DFG laboratory at Rancho Cordova. Analysis and QC procedures used by these laboratories are outlined in the SWAMP QAMP (Puckett 2002).

Toxicity and ELISA analyses are conducted at UCD-GC. Ten-day sediment toxicity testing using *Hyalella azteca* (EPA 2000) is conducted using eight 100-mL replicates, each with 10 *Hyalella* individuals. Water quality parameters, including conductivity, hardness, alkalinity, pH, dissolved oxygen, and ammonia are measured in overlying water from one replicate of each sample at the beginning and end of each test. Dissolved oxygen is measured daily in one replicate of each sample. Temperature is monitored continuously by placing a probe in an additional test solution in the controlled temperature room. Endpoints recorded after ten days are survival and growth (as dry weight).

Quality Assurance

Sediment toxicity QA procedures such as field duplicates, and positive and negative controls are similar to those discussed in the section on water toxicity. See Puckett (2002) for a complete discussion on QAQC procedures. In sediment toxicity tests the positive control test consists of a dilution series of cadmium (from cadmium chloride). The negative control for *Hyalella* consists of reference sediment subjected to the same well-water renewals as the samples.

5.5 Tissue Bioaccumulation

Resident fish and transplanted freshwater clams (*Corbicula fluminea*) are used to assess bioaccumulation of organic chemicals and metals in streams and lakes throughout the watershed rotation areas.

MPSL-DFG staff performs deployment, collection and preparation of fresh water clams at a subset of watershed rotation sites. Clams are collected from Big Break Lake near the Sacramento River Delta, and tested for contamination prior to deployment. Clams are deployed for one month in anchored polypropylene mesh bags, approximately 15 cm above the streambed. Approximately 25 to 50 clams, 20 to 30 mm in diameter, are deployed at each site for each analysis (organics and metals). After a month-long deployment, clams are collected and sent to the laboratory for analysis. Clams intended for metals analysis are transported in plastic bags; clams intended for organic analysis are bagged in aluminum, then plastic. All sample handling is performed with methods designed to minimize contamination. Details of clam collection, handling, deployment and retrieval can be found in the SWAMP QAMP (Puckett 2002, Appendix D).

Fish sampling in reservoirs and at watershed rotation area sites is conducted by the DFG-ABL through the Toxic Substances Monitoring Program (TSMP). Two to four composite samples containing four fish each are collected for each species. Within each composite the smallest fish is at least 75% the length of the largest fish. Larger, older fish are targeted. When the target species is a food fish, the minimum size is set at the legal angling size or practical eating size for that species.

Fish collection techniques used include boat and backpack electrofishing, gill netting and seine netting. Fish species and length are recorded. Fish are sacrificed and wrapped in aluminum foil or Teflon®. The heads and tails of fish larger than the wrapping material are removed prior to wrapping (gut contents are kept intact). Fish are kept on dry ice in the field, and then frozen at -20º C prior to analysis. Details of fish sampling methods used in the TSMP can be found in the CDFG-MPSL Standard Operating Procedure document, Method 102 (CDFG-MPSL 2001).

6 Estero Bay Hydrologic Unit Assessment

In this section, the Estero Bay Hydrologic Unit is evaluated according to questions posed in the SWAMP report to the Legislature (2000). It is only possible to address these questions in terms of analytes actually evaluated, for the given sampling period and sampling frequency. For example, from the standpoint of assessing whether water is of adequate quality to drink, only a few of the many chemicals with drinking water standards have been evaluated. However, when violations of standards and criteria are found, they support conclusions of water quality impairment.

6.1.1 Summary of monitoring

Table 6.1a. Specific monitoring activities conducted at sites in the Estero Bay Hydrologic Unit (HU 310). **CWQ** - Conventional Water Quality; **BMI** - Benthic Macroinvertebrate Assessment; **Sed Chem & Tox** - Sediment Chemistry and Toxicity; **Tissue Chem** - Tissue Chemistry analysis.

Site Tag	Monitoring Site	CWQ	BMI	Water Tox	Sed Chem & Tox	Tissue ChemChem
310ADC	Arroyo de la Cruz at Highway 1	X	X			99
310ARG	Arroyo Grande Creek at 22nd Street	X	X	X	02	
310AGB	Arroyo Grande Creek at Biddle Park	X	X			
310AGF	Arroyo Grande Creek at Fair Oaks	X				
310AGS	Arroyo Grande Creek at Strother Park	X				
310AGR	Arroyo Grande Creek lagoon					99, 01
310LOL	Lopez Lake, Arroyo Grande Creek Arm					01
310CAY	Cayucos Creek at Highway 1	X				
310TWB	Chorro Creek at South Bay Boulevard	X	X	X	98	01
310COO	Coon Creek at Coon Creek trail	X	X			
310BER	Los Berros Creek at Valley Rd.	X				
310 MOR	Morro Creek at Lila Keiser Park	X				
310OLD	Old Creek at Cottontail Creek Rd.	X	X			
310WRR	Whale Rock Reservoir, Old Creek arm					01
310PCO	Pico Creek at Highway 1	X				99
310PIS	Pismo Creek up stream of Highway 101	X	X	X		01
310PER	Prefumo Creek at Calle Joaquin	X				
310SCP	San Carpoforo Creek at Highway 1	X				
310SLC	San Luis Obispo Creek at Cuesta Park	X	X			
310SLV	San Luis Obispo Creek at Los Osos Valley Rd.	X	X	X	98, 02	
310SLM	San Luis Obispo Creek at Mission Plaza	X				
310SLB	San Luis Obispo Creek at San Luis Bay Dr.	X	X		98	
310SLO	San Luis Obispo Creek Lagoon					99 ,01
310SSU	San Simeon Creek at San Simeon Creek Rd.	X	X			
310SSC	San Simeon Creek at State Park foot bridge	X	X	X		99, 01
310SRU	Santa Rosa Creek at Ferassi Rd.	X	X			
310SRO	Santa Rosa Creek at Moonstone Dr.	X	X	X	98, 02	99, 01
310SCN	Stenner Creek at Nipomo Street	X	X			
310TOR	Toro Creek at Highway 1	X				
310VIA	Villa Creek at Highway 1	X				

310TUR	Warden Creek at Turri Rd.	X		X		

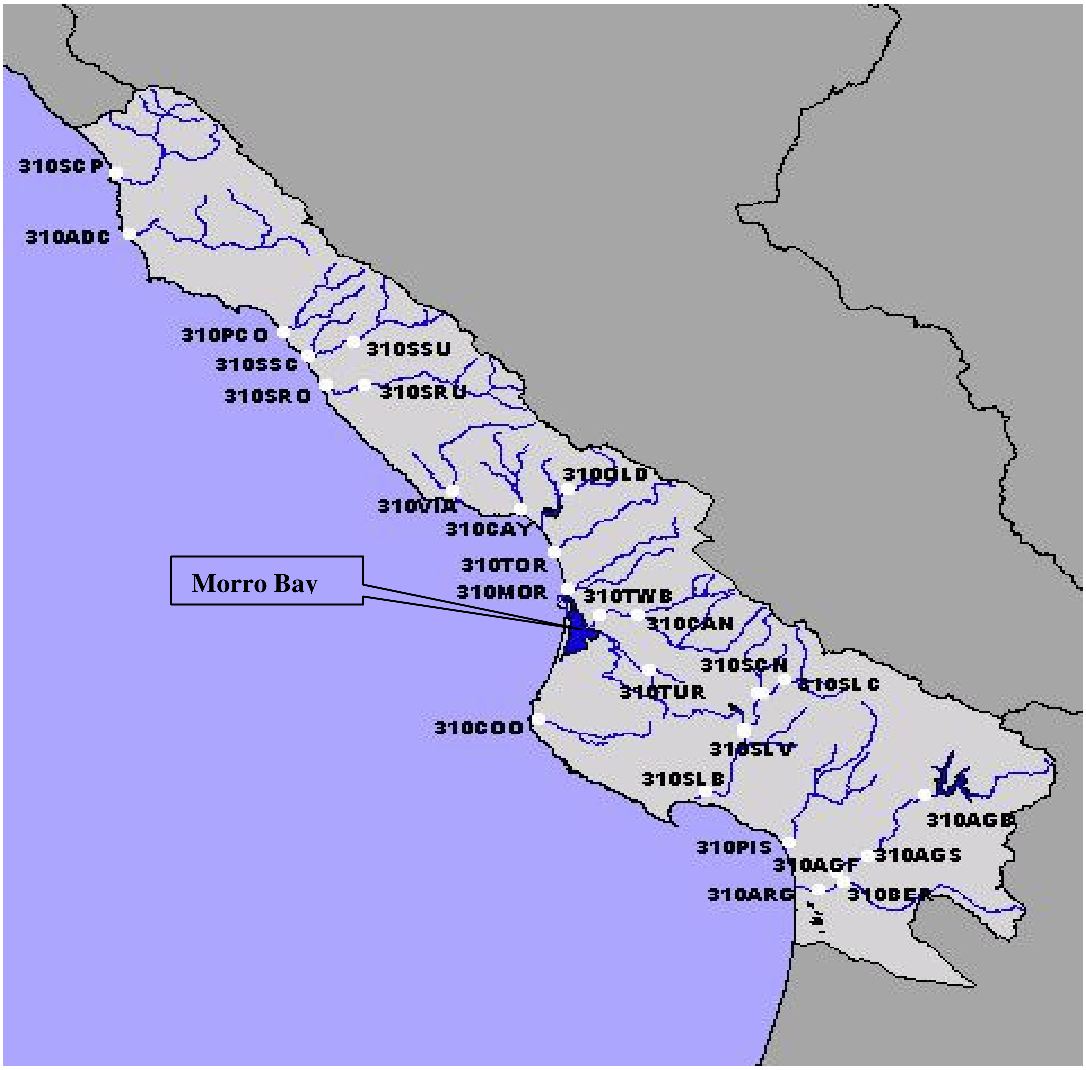

Figure 6.1a. CCAMP monitoring sites in the Estero Bay Hydrologic Unit.

Table 6.1b. Findings related to monitoring questions for sites in the Estero Bay Hydrologic Unit (HU310). **Yes** - evidence that a problem exists, **No** - no evidence that a problem exists, **S** – some evidence that a problem may exist, **NA** - not assessed

Site Tag	**Monitoring site**	**Unsafe to Swim?**	**Unsafe to drink?**	**Are aquatic life uses impaired?**	**Unsafe to eat fish?**	**Are agriculture uses impaired?**	**Aesthetics or non-contact recreation?**
310ADC	Arroyo de la Cruz at Highway 1	No		No	NA	No	S
310ARG	Arroyo Grande Creek at 22nd Street	Yes	Yes	Yes	NA	No	Yes
310AGB	Arroyo Grande Creek at Biddle Park	S	No	S	NA	No	No
310AGF	Arroyo Grande Creek at Fair Oaks	Yes	Yes	No	NA	No	Yes
310AGS	Arroyo Grande Creek at Strother Park	S	Yes	No	NA	No	S
310CAY	Cayucos Creek at Highway 1	No	Yes	No	NA	No	S
310TWB	Chorro Creek at South Bay Boulevard	Yes	No	S	No	No	S
310AGR	Arroyo Grande Creek lagoon	NA	NA	NA	S	No	NA
310LOL	Lopez Lake, Arroyo Grande Creek Arm	NA	NA	NA	No	No	NA
310CAN	Chorro Creek at Canet Road	Yes	No	No	NA	S	Yes
310COO	Coon Creek at trail below foot bridge	No	No	No	NA	No	No
310BER	Los Berros Creek at Valley Road	S	No	S	NA	Yes	S
310 MOR	Morro Creek at Lila Keiser Park	S	No	No	NA	No	S
310OLD	Old Creek at Cottontail Creek Road	S	No	No	NA	No	S
310WRR	Whale Rock Reservoir, Old Creek arm	NA	NA	NA	No	No	NA
310PCO	Pico Creek at Highway 1	No	No	S	No	No	S
310PIS	Pismo Creek up stream of Highway 1	S	No	Y	Yes	Yes	S
310PRE	Prefumo Creek at Calle Joaquin	Yes	Yes	S	NA	S	Yes
310SCP	San Carpoforo Creek at Highway 1	No	No	No	NA	No	S
310SLC	San Luis Obispo Creek at Cuesta Park	No	No	No	NA	No	S
310SLV	San Luis Obispo Creek at Los Osos Valley Rd.	S	Yes	Yes	NA	Yes	S
310SLM	San Luis Obispo Creek at Mission Plaza	Yes	Yes	No	NA	No	Yes
310SLB	San Luis Obispo Creek at San Luis Bay Drive	Yes	Yes	S	NA	No	Yes
310SLO	San Luis Creek Lagoon	NA	NA	NA	No	No	NA
310SSU	San Simeon Creek at San Simeon Creek Road	No	No	No	NA	No	No
310SSC	San Simeon Creek at State Park foot bridge	No	No	Y	NA	S	S
310SRU	Santa Rosa Creek at Ferassi Road	S	No	No	NA	No	No
310SRO	Santa Rosa Creek at Moonstone Drive	S	No	Yes	No	No	No
310SCN	Stenner Creek at Nipomo Street	Yes	No	S	NA	No	No
310TOR	Toro Creek at Highway 1	Yes	No	No	NA	No	NA
310VIA	Villa Creek at Highway 1	Yes	Yes	No	NA	No	No
310TUR	Warden Creek at Turri Road	Yes	No	S	NA	Yes	Yes

6.1.2 Is there evidence that it is unsafe to swim?

Fecal coliform levels exceeded the Basin Plan objective for body contact recreation (more than 10% of total samples exceeding 400 MPN/100 ml) at most sites in the Estero Bay Hydrologic Unit. Figure 6.1b shows percent exceedance of this objective by waterbodies in the Estero Bay Hydrologic Unit. At several sites geomean for fecal coliform data were over 200 MPN/100 ml (the Basin Plan objective states that geomean shall not exceed 200 MPN/100 ml for 5 samples in a 30-day period). Figure 6.1c shows the range and geomean of fecal coliform data collected at sites in the Estero Bay Hydrologic Unit.

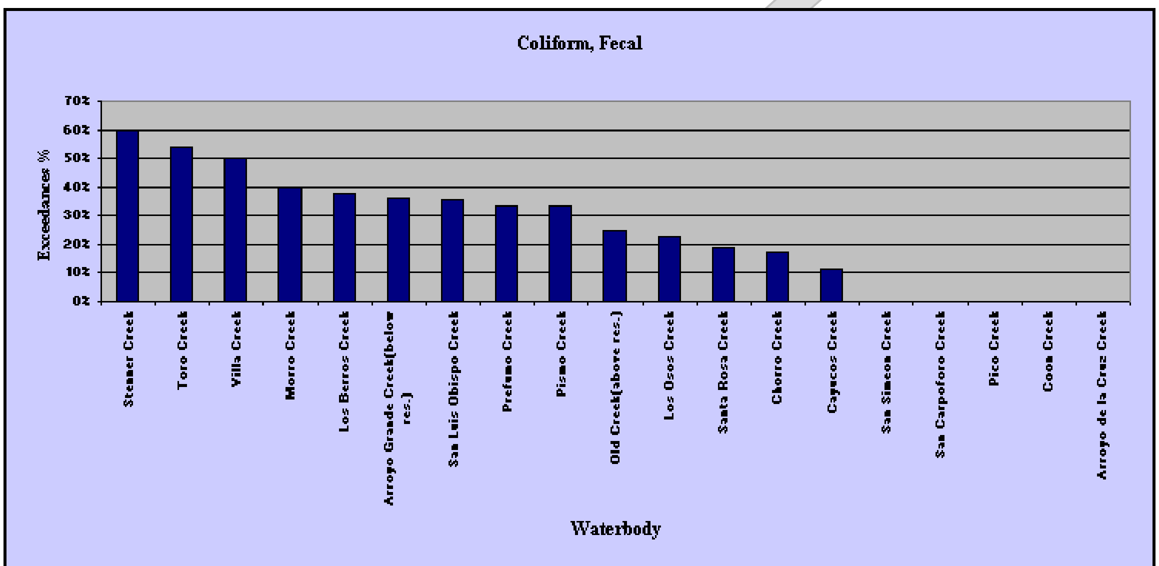

Figure 6.1b. Percent exceedance of the Basin Plan objective (400 MPN/100 ml) for streams monitored in the Estero Bay Hydrologic Unit, January 2001 and March 2003.

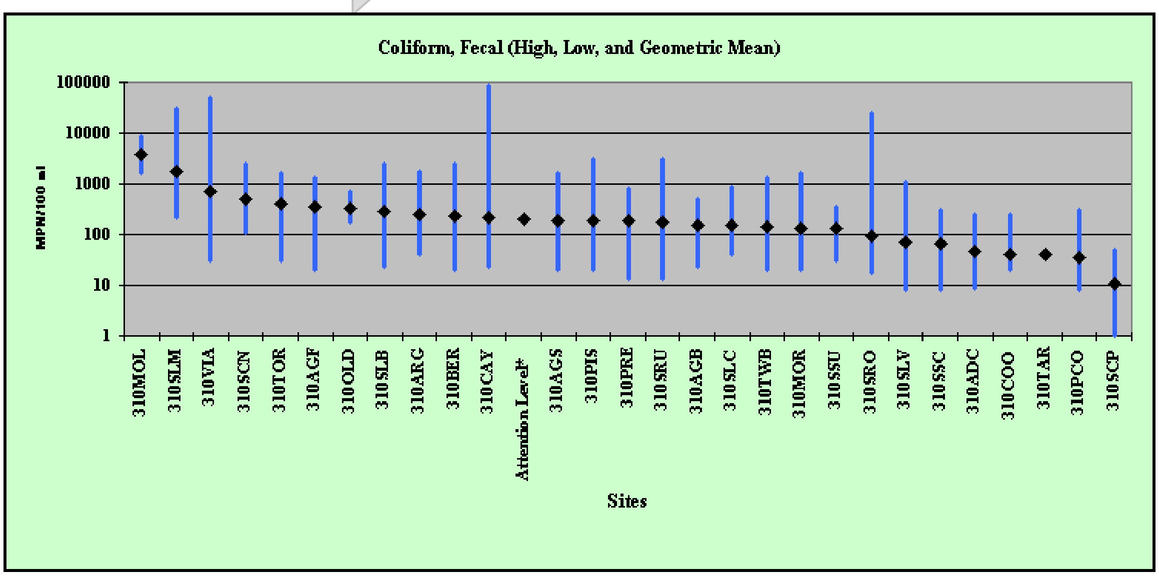

Figure 6.1c. Range and geomean of fecal coliform data collected at sites in the Estero Bay Hydrologic Unit between January 2001 and March 2003.

Fecal coliform levels in the northern streams of the Hydrologic Unit, north of Cambria, and at Coon Creek did not exceed either fecal coliform criteria (Figure 6.1b and c). In contrast, San Luis Obispo watershed sites at Mission Plaza (310SLM), San Luis Bay Drive (310SLB) and Stenner Creek (310SCN) exceeded both criteria. These sites are found within city limits and are heavily influenced by urban sources. Similarly, Arroyo Grande watershed sites at Fair Oaks (310AGF) and 22nd Street (310ARG) downstream of the city of Arroyo Grande exceeded both criteria. Other waterbodies with sites exceeding both criteria are located in agriculture and rangeland dominated watersheds, including Villa Creek (310VIA), Cayucos Creek (310CAY), Toro Creek (310TOR), Old Creek (310OLD), Warden Creek (310TUR), Chorro Creek at Canet Road (310CAN), Pismo Creek (310PIS) and Los Berros Creek (310BER) (a tributary to Arroyo Grande Creek).

Several sites in the Estero Bay Hydrologic Unit are identified as having evidence of beneficial use impairment in Table 6.1b. In some cases, waterbodies associated with these sites are already on the 303(d) list for impairment due to fecal coliform (Chorro, Los Osos, San Luis Obispo), or are tributaries to listed waterbodies (Stenner, Prefumo and Warden). Sites that are not listed as impaired for fecal coliform, but which show evidence of impairment include Arroyo Grande Creek, Villa Creek, and Toro Creek. Other sites that show some evidence of impairment (Table 6.1b), but do not either have sufficient cause or sufficient data to warrant listing include Cayucos Creek, Los Berros Creek and Old Creek.

6.1.3 Is there evidence that it is unsafe to drink the water?

Nitrate levels were below the Basin Plan objective at most sites in the Estero Bay Hydrologic Unit. However, three sites chronically exceeded the drinking water standard. As shown in Figure 6.1d, Prefumo Creek (310PRE, purple), San Luis Creek at Los Osos Valley Road (310SLV, green) and San Luis Creek at Bay Drive (310SLB, maroon) had consistently elevated nitrate levels. Prefumo Creek is a tributary to San Luis Obispo Creek and its confluence is upstream of the Los Osos Valley Road site (310SLV). The San Luis Obispo Creek site upstream of this (at Mission Plaza (310SLM)) did not show elevated nitrate concentrations. Prefumo Creek certainly contributes to elevated nitrates in the lower reaches of San Luis Obispo Creek, but the San Luis Wastewater Treatment Plant discharges to San Luis Obispo Creek just up stream of the confluence with Prefumo and is also a significant source of nutrients to the creek. This finding is consistent with the Total Maximum Daily Load analysis for this watershed (Rose 2003). That analysis determined that the Prefumo Creek nitrate load entering San Luis Obispo Creek is 59,305 lbs/yr; the point source load from the treatment plant is 304,496 lbs/yr. These two sources represent over 85% of the total load to San Luis Obispo Creek.

San Simeon Creek at Highway 1 (310SSC) was the only other site that exceeded the drinking water objective, in a single sample. In past years, Chorro Creek at South Bay Boulevard (310TWB) and Warden Creek at Turri Road (310TUR) have also exceeded the standard one or more times. Generally, nitrate reached its highest concentrations during late summer and early fall months.

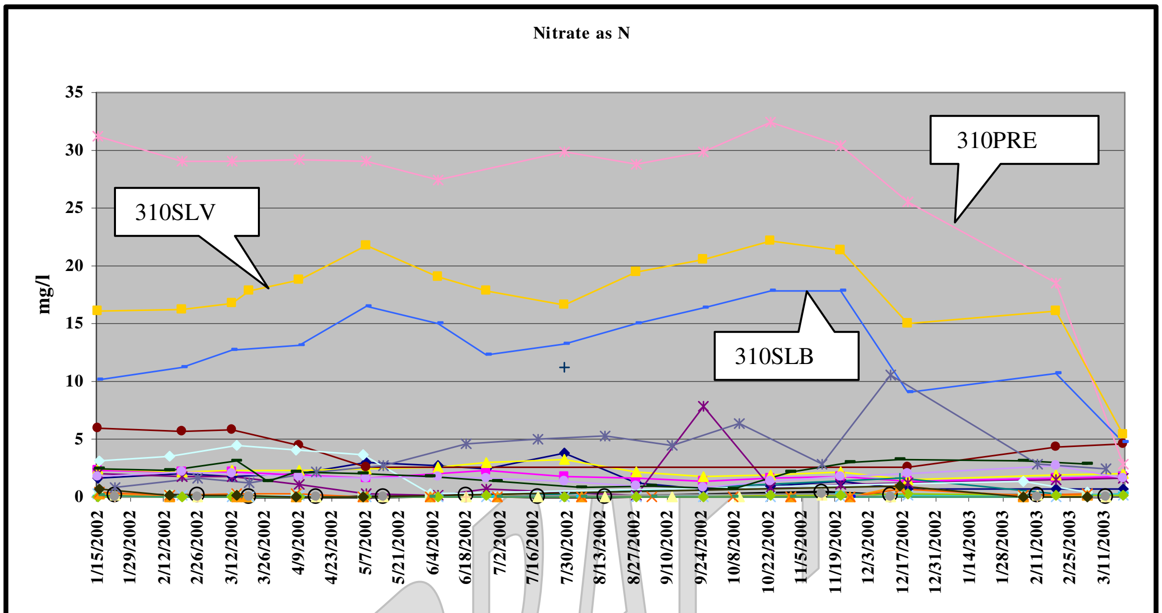

Figure 6.1d. Time series of nitrate (NO3 as N) at sites in the Estero Bay Hydrologic Unit. Pink line is Prefumo Creek (310PRE), Yellow line is San Luis Creek at Los Osos Valley Road (310SLV) and blue line is San Luis Creek as Bay Drive (310SLB).

The geology of the Central Coast tends to result in surface water pH levels that are near or greater than the upper Basin Plan objective for drinking water (8.3). However, several of the sites in this Hydrologic Unit did not have elevated pH levels. In both San Luis and Arroyo Grande Creek watersheds the pH levels did not exceed objectives in the upper reaches of the watershed but were elevated in the lower reaches. This may potentially be an indication of anthropogenic influence. Figure 6.1e shows percent exceedance of the upper pH objective for sites in the Hydrologic Unit. Sites that had more than 25% of total samples exceeding the Basin Plan objective included Cayucos Creek (310CAY), San Luis Obispo Creek at Mission Plaza (310SLM), and Arroyo Grande Creek at both Strother Park (310AGS) and Fair Oaks (310AGF). The pH at Arroyo Grande Creek at 22nd Street (310ARG) was elevated in 22% of the samples. No site had an average pH value exceeding the objective. The highest observed pH value in the Hydrologic Unit was 8.71 at Arroyo Grande Creek at 22nd Street (310ARG).

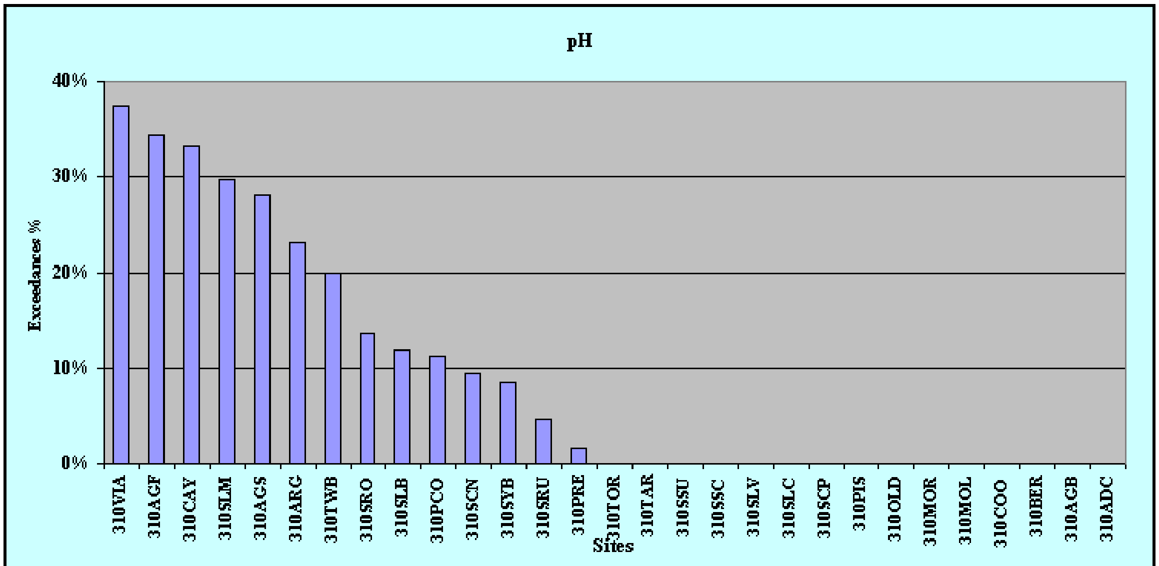

Figure 6.1e. Percent exceedances, between January 2001 and March 2003, of the upper Basin Plan objective for pH in drinking water at sites in the Estero Bay Hydrologic Unit.

Water toxicity tests were conducted at several sites in the Hydrologic Unit (Table 6.1a). No toxicity responses (survival or growth) were observed in tests conducted on fathead minnows, *Pimephales promelas*, or water fleas, *Ceriodaphnia dubia* with the exception of one sample from Arroyo Grande Creek. Water flea toxicity tests conducted in the sample from Arroyo Grande Creek at 22nd St. (310ARG) resulted in significantly reduced reproduction relative to the control sample.

6.1.4 Is there evidence that it is unsafe to eat the fish?

California Department of Fish and Game staff with the Toxic Substances Monitoring Program (TSM) collected resident fish from five sites in 1999 and from seven sites in 2001 (Table 6.1a) in the Estero Bay Hydrologic Unit.

In 1999, three-spined stickleback (*Gasterosteus aculeatus*) were collected from the coastal lagoon at Arroyo de la Cruz. No organic chemicals were detected in these fish tissues and metal concentrations were below Median International Standards.

In 1999 CDFG staff collected prickly sculpin (*Cottus asper*) from Pico Creek lagoon. Low levels of Nonachlor and chlordane were detected in fish tissues in this sample. Metals analysis of this sample showed elevated selenium (3.13 ppm) relative to Median International Standards. No other metal concentration exceeded the published standards.

In 1999 and in 2001, three-spined stickleback were collected from the coastal lagoon at San Simeon Creek. In both samples DDT, mostly in the form of DDE, was detected at low levels relative to National Academy of Sciences criteria.

In 1999 and in 2001, three-spined stickleback were also collected from the coastal lagoon at Santa Rosa Creek. DDT, mostly in the form of DDE, was detected at low levels in the

1999 sample relative to National Academy of Sciences criteria. Low levels of Nonachlor and chlordane were also detected in the 1999 sample. No organic chemicals were detected in the 2001 sample. The mercury concentration in the 1999 sample measured 0.318 ppm, near but not exceeding the criteria (0.500 ppm). In the 2001 sample the concentration was far lower, at 0.085 ppm. There is a known abandoned mercury mine in the Santa Rosa Creek watershed.

In 2001 sucker (*Catostomus* sp.) were collected from Whale Rock reservoir (310WRR) by CDFG staff. No organic chemicals were detected and metals concentrations were all below Median International Standards.

In 1999 and in 2001 shiner perch (*Cymatogaster aggregata*) were collected from San Luis Creek lagoon. In both samples, DDT, mostly in the form of DDE, was detected at low levels relative to National Academy of Sciences criteria. Also, samples collected in 1999 showed low levels of Nonachlor and chlordane.

CDFG staff collected pike minnow (*Ptychocheilus grandis*) from Chorro Creek at South Bay Boulevard (310TWB) in 2001. This sample analysis resulted in detection of low levels of DDE relative to the National Academy of Sciences criteria. No other organic chemical were detected in this sample.

In 1999 CDFG staff collected three-spined stickleback from the Arroyo Grande Lagoon. The tissues of the whole fish were analyzed for metals and organic chemicals. These analyses showed elevated selenium (3.18 ppm), relative to the Median International Standard. Analysis of this sample also detected several organic chemicals including chlordane, DDT and its metabolites, dieldrin and PCBs at low levels relative to the National Academy of Sciences guidelines and Food and Drug Administration action levels. The 2001 sampling effort in the Arroyo Grande watershed resulted in collection of largemouth bass (*Micropterus salmoides*) at both Lopez Lake in the Arroyo Grande Creek arm and downstream at the Arroyo Grande Creek lagoon. No organic chemicals were detected in the tissues of bass collected in Lopez Lake. However, DDT (primarily in the form of DDE), chlordane and trans nonachlor were again detected in the sample from Arroyo Grande Creek lagoon. The Arroyo Grande Creek watershed includes a very productive agricultural valley, especially below the reservoir. Although selenium and several other metals were detected in the *M. salmoides* samples, concentrations were below Median International Standards.

In the 2001 sample of prickly sculpin collected at Pismo Creek Lagoon several organic chemicals were detected. These chemicals included low levels of trans nonachlor, chlordane, DDE, and PCB. Metals analysis showed selenium levels in this sample exceeded the MIS.

6.1.5 Is there evidence that aquatic life uses are not supported?

Water and sediment toxicity tests were conducted at several sites in the Hydrologic Unit (see Table 6.1a). No toxicity responses (survival, reproduction or growth) were observed in tests conducted on fathead minnows, *Pimephales promelas*, water fleas, *Ceriodaphnia dubia* or amphipods *Hyallea azteca* with one exception. Water flea tests conducted on the sample from Arroyo Grande at 22nd St (310ARG) resulted in significantly reduced reproduction.

In 2002, sediment chemistry samples were collected at San Luis Creek at Los Osos Valley Road (310SLV) and at Santa Rosa Creek at Moonstone Drive (310SRO). Total PCBs from San Luis Creek (310SLV) measured 95.96ng/g, exceeding the NOAA UET (based on Microtox bioassay, NOAA SQuiRTs 1999) and the Florida TEL. Sediment chemistry data was not collected at upstream sites in either watershed. Organic chemicals detected in sediment from San Luis Creek (310SLV) are listed in Table 6.1c. None of these chemical concentrations exceed NOAA or Florida criteria. No organic pesticides were detected in the sediment sample from Santa Rosa Creek (310SRO).

Chromium levels in sediment from both the Santa Rosa Creek site (310SRO) and the San Luis Creek site (310SLV) exceeded the UET value (based on *Hyalella azteca* bioassay, NOAA SQuiRTs 1999). Chromium is common in the serpentine soils of San Luis Obispo County. No other metal had concentrations in excess of published criteria.

Table 6.1c. Organic Chemicals detected in sediment samples collected at sites in the Estero Bay Hydrologic Unit, March 2002.

Site Tag	Aldrin	Chlordane, Total	Chlorpyrifos	Dacthal	DDE(p,p')	DDT, Total	Dieldrin	Heptachlor epoxide	Nonachlor, trans	Oxadiazon	Total PCB
310SLV	0.569	7.44	2.45	1.14	3.75	3.75	2.36	1.15	3.11	20.3	95.955
310SRO											6.457
ERM marine		6				46.1	8				
Florida PEL		8.9				4450	6.67				
Florida TEL		4.5				6.98	2.85				
NOAA UET											26.00

In 1998, sediment chemistry data was collected at five sites, as shown in Table 6.1a. All sites exceeded the NOAA Effects Range Median (ERM) for nickel. This is not unusual for this Region, considering the geology of the area. In fact, Region 3 staff are currently recommending delisting Morro Bay for beneficial use impairment due to metals, as sources were determined to be natural. ERM values for other metals were never exceeded at any site in the Hydrologic Unit. The highest mercury levels in the Hydrologic Unit were observed at Santa Rosa Creek at Moonstone Drive (310SRO), measuring 0.55 mg/Kg, nearing but not exceeding the ERM value of 0.71 mg/Kg. There is a known abandoned mercury mine in the upper Santa Rosa Creek watershed.

Several organic chemicals were detected in sediment samples collected by CCAMP from creek mouths in the area in 1998. These include Lindane, cis-chlordane and DDT in the lower reaches of San Luis Obispo Creek and Lindane and DDT in lower Arroyo Grande Creek sediments. No sites had organic chemical concentrations in sediment in exceedance of NOAA ERM values, although DDT concentrations neared the ERM at the Arroyo Grande Creek site at 22nd Street (310ARG).

No site in the Estero Bay Hydrologic Unit had any exceedance of the Basin Plan objective for unionized ammonia in water.

Oxygen levels at several sites in the Hydrologic Unit were below the cold water habitat objective of 7.0 mg/L during the summer months. Sites including Pico Creek (310PCO), San Simeon Creek at the State Park campground (310SSC), Chorro Creek at South Bay Boulevard (310TWB), Prefumo Creek (310PRE), San Luis Creek at Bay Drive (310SLB), Pismo Creek (310PIS), Arroyo Grande Creek at Biddle Park (310AGB) and at 22nd Street (310ARG) had several measurements below the objective. Dissolved oxygen sags were confirmed at these sites in 24-hour monitoring conducted in August of 2002, in which dissolved oxygen was recorded every 30 minutes for 24 hours. The 24-hour monitoring also identified dissolved oxygen sags at additional sites including San Luis Obispo Creek at Los Osos Valley Road (310SLV), and Stenner Creek (310SCN). Depressed dissolved oxygen was not observed at these two sites in monthly monitoring. At Los Berros Creek (310BER), Morro Creek (310MOR) and Warden Creek at Turri Road (310TUR), depressed oxygen levels were observed in samples collected as the creek was drying up. Low flow conditions clearly contributed to the relatively high ranking of these sites by the CCAMP Biostimulatory Risk Index. However, the range of dissolved oxygen measurements at a given site is only one of the factors used to determine the risk ranking; the Index also incorporates other factors including pH, instream algal growth and nutrient concentrations. Sites at the lower ends of San Luis Obispo, Pismo, Morro, San Simeon, Arroyo Grande and Chorro all had relatively high scores for biostimulatory risk (greater than 4.0). Prefumo Creek (310PRE) and San Luis Obispo at Los Osos Valley Road (310SLV) also ranked high on the Biostimulatory Risk Index.

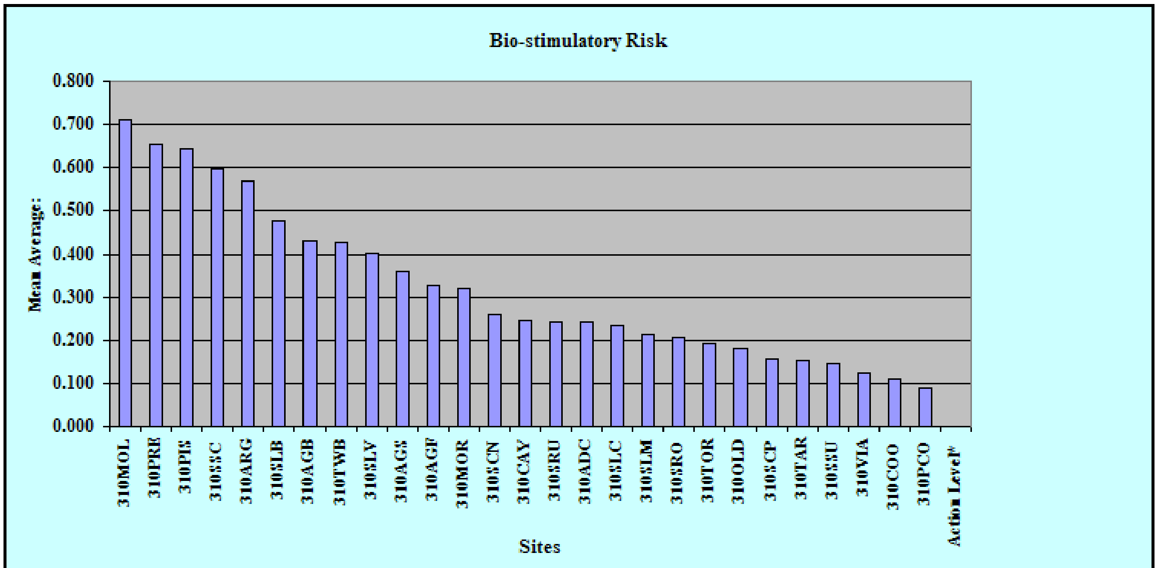

Figure 6.1f. Mean biostimulatory risk score between January 2001 and March 2003, for sites in the Estero Bay Hydrologic Unit.

Benthic invertebrate communities at many sites in the Estero Bay Hydrologic Unit were of high quality, with scores for CCAMP Index of Biotic Integrity over 6.0. These include upper watershed sites on San Luis Obispo Creek (at Cuesta Park (310SLC)) and Santa Rosa Creek (at Ferassi Road (310SLU)), and several other sites in the northern portion of the Unit (Figure 6.1g). These sites are all located in areas where the primary land uses are rangeland and rural residential. Two sites in the Hydrologic Unit had average IBI scores in the “Poor” range (below 3.0). These included Arroyo Grande Creek at 22nd Street (310ARG) and San Luis Obispo Creek at Los Osos Valley Road (310SLV). At both of these sites, riffle habitat was present, but species diversity and number of intolerant species was low. This was also true for other sites that had IBI scores in the “Fair” range (3-6), including San Luis Obispo Creek at Bay Drive (310SLB) and Stenner Creek (310SCN).

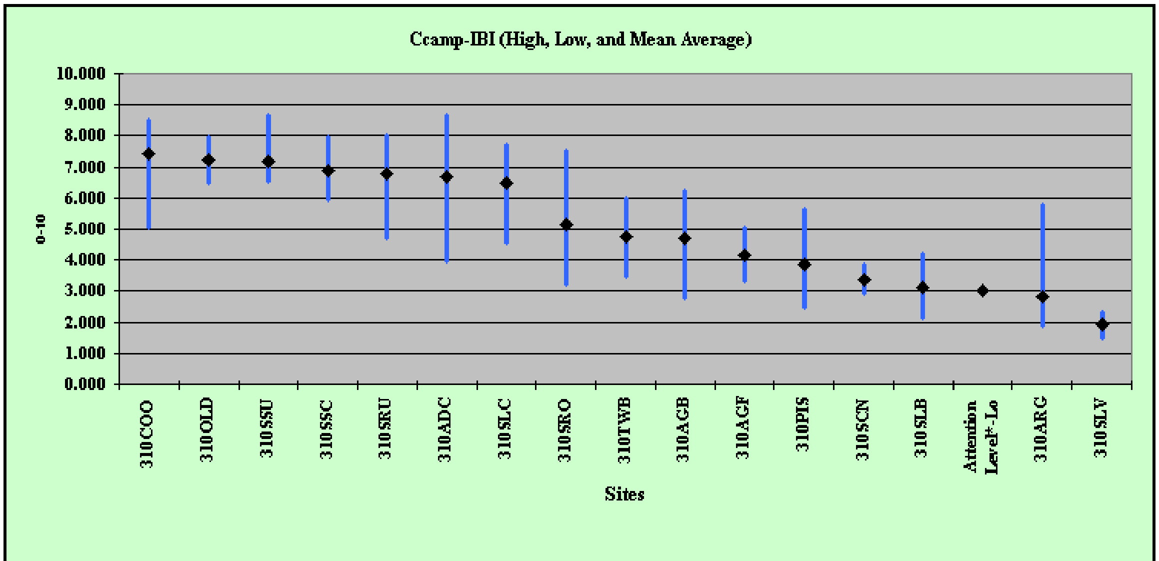

Figure 6.1g. Range and mean IBI scores, January 2001 and March 2003, in the Estero Bay Hydrologic Unit. Attention level is 3.0, the score below which poor biological integrity is indicated.

IBI scores, dissolved oxygen and pH levels in the lower San Luis Obispo Creek and Arroyo Grande Creek watersheds indicate impairment of aquatic life beneficial uses as identified by multiple factors. Sites above urbanized areas do not show the same level of impairment, implying that anthropogenic stressors are responsible. For both creeks, channelization, urbanization, and irrigated agriculture are prevalent in the lower watershed. San Luis Obispo Creek also is fed by a wastewater treatment plant discharge, just upstream of the Los Osos Valley Road site (310SLV).

6.1.6 Is there evidence that agricultural uses are not supported?

The Basin Plan nitrate objective for agricultural use was not exceeded at most sites in the Hydrologic Unit. The exception to this was at Prefumo Creek (310PRE), where the objective of 30 mg/L was exceeded on three occasions, and levels were consistently very elevated, around a median value of 29 mg/L as N.

The only site in the Estero Bay Hydrologic Unit where the conductivity objective for protection of agricultural uses was exceeded was at Pico Creek (310PCO), and only in a single sample. This site is located just above the lagoon, and the measurement was likely due to tidal influence that is common during winter months.

Relative to the Basin Plan objectives for agriculture use, boron was not elevated at any site in the Hydrologic Unit. However, several sites had average chloride and sodium levels that exceeded Basin Plan objectives. Sites which exceeded the chloride objective (106 mg/L) included Warden Creek (310TUR), Los Berros Creek (310BER), Pismo Creek (310PIS) and Chorro Creek at Canet Road (310CAN). The Warden Creek site had highest concentrations (averaging 219 mg/L), but during much of the sampling season had very low flow. This site is in an area of intensive irrigated agriculture. The average chloride levels at the downstream site on Chorro Creek (at South Bay Boulevard (310TWB)) were 81 mg/L, significantly lower than at Canet Road (310CAN) which averaged 112 mg/L. The main stem flow can be effluent-dominated during the dry season, which may explain elevated chloride concentrations at Canet Road. Two tributary inputs (San Bernardo and San Luisito Creeks) likely dilute chloride concentrations downstream of this site.

Warden Creek (310TUR), Los Berros Creek (310BER), Pismo Creek (310PIS) and Chorro Creek at Canet Road (310CAN) also had persistently elevated sodium levels, as did sites at San Simeon Creek at the State Park campground (310SSC) and San Luis Obispo Creek at Los Osos Valley Road (310SLV) and Bay Drive (310SLB). All of these sites exceeded the Basin Plan agricultural objective for sodium (69 mg/L). Several are downstream of wastewater treatment facilities; discharge data should be examined to determine if these facilities are contributing to the problem.

6.1.7 Is there evidence that aesthetic and non-contact recreation uses are not supported?

Persistently elevated fecal coliform levels were observed at San Luis Obispo Creek at Mission Plaza (310SLM). At this site 5 of the 15 samples exceeded 400 MPN/100 ml.

Turbidity levels in most creeks in the Hydrologic Unit were generally below 10 NTUs during the dry weather seasons, and were not the cause of aesthetic impairment.

In-stream algal cover varied greatly throughout the Hydrologic Unit. Many sites had low flow velocity or were nearly pooled (e.g. prior to drying up), and had nearly 100% algal cover throughout the summer. Sites with these characteristics included the following: San Carpoforo (310SCP), Warden Creek (310TUR), Los Berros Creek (310BER), San Simeon Creek at the campground (310SSC), Old Creek at Cottontail Creek Road (310OLD), Pismo Creek (310PIS), Cayucos Creek (310CAY) and Morro Creek (310MOR). Large algal mats were observed at many of these sites. There were also sites with relatively normal flow during the summer months and algae cover greater that 25%. These sites include San Luis Obispo Creek at Bay Drive (310SLB), Los Osos Valley Road (310SLV), Mission Plaza (310SLM) and Cuesta Park (310SLC), and Arroyo Grande Creek at 22nd Street (310ARG) and Fair Oaks (310AGF).

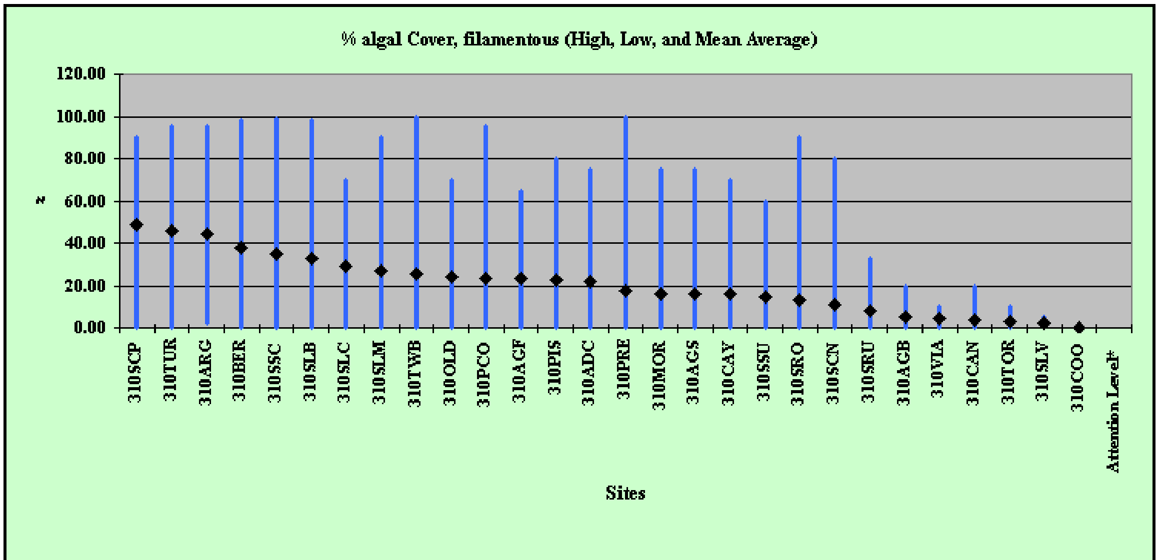

Figure 6.1h. Range and mean percent algal cover as estimated for sites in the Estero Bay Hydrologic Unit, January 2001 through March 2003.

6.1.8 Discussion

In general, water quality in the northern-most watersheds of the Estero Bay Hydrologic Unit is in good condition, although high levels of fecal coliform are common in some of these watersheds. Water quality impairment becomes increasingly a problem in the lower reaches of creeks south of Morro Bay, with the exception of Coon Creek (310COO) in Montana de Oro State Park. In the lowest reaches of the urbanized watersheds (San Luis Obispo, Arroyo Grande and Pismo Creeks) impairment of beneficial uses is evident. Anthropogenic sources have been identified in the San Luis Obispo Creek watershed (Rose 2003), but need further study elsewhere.

In addition to the data already discussed, there are other noteworthy observations. Site-specific objectives for total dissolved solids (TDS), sulfates, sodium and chloride were exceeded on several occasions at sites in Santa Rosa Creek, Chorro Creek, San Luis Obispo Creek and in Arroyo Grande Creek. On both San Luis Obispo and Chorro Creeks sites not meeting the objectives are downstream of wastewater treatment plant discharges, which are likely major sources. In Chorro Creek, chloride and TDS objectives were exceeded in 100% of samples collected at South Bay Boulevard (310TWB) and at Canet Road (310CAN). San Luis Obispo, Chorro, Arroyo Grande and Santa Rosa creeks all have site specific objectives for sodium of 50 mg/L. The two San Luis Obispo Creek sites (SLV and 310SLB) never met the objective. Chorro Creek at Canet Road (310CAN) also never met the objective, and it was met only 22% of the time farther downstream at South Bay Boulevard (310TWB). All four of these sites rarely met site-specific sulfate objectives (50 mg/L in Chorro Creek and 100 mg/L in San Luis Obispo Creek). The sulfate objective of 80 mg/L was violated 91% of the time on Santa Rosa Creek, at sites both above and below the community of Cambria. Arroyo Grande had no violations of its sulfate objective (200 mg/L) at the upstream site at Biddle Park (310ARB), but had high rates of exceedance at all sites farther downstream, implying that impacts begin downstream of the Biddle Park site. Because no upstream data exists for Chorro or Santa Rosa Creeks it is unclear whether violations are from anthropogenic sources.

Wastewater treatment facilities discharge directly to both San Luis Obispo Creek and to Chorro Creek. Elevated orthophosphate levels were observed at monitoring sites located downstream of these facilities, as shown in Figure 6.1i. Lower San Luis Obispo Creek sites (310SLV and 310SLB) consistently had the highest orthophosphate levels in the Hydrologic Unit. These elevated levels were not observed upstream of the WWTP at the Mission Plaza site (310SLM). Elevated orthophosphate levels are indirectly discussed in the preceding text as they are included in the calculation of the biostimulatory risk index.

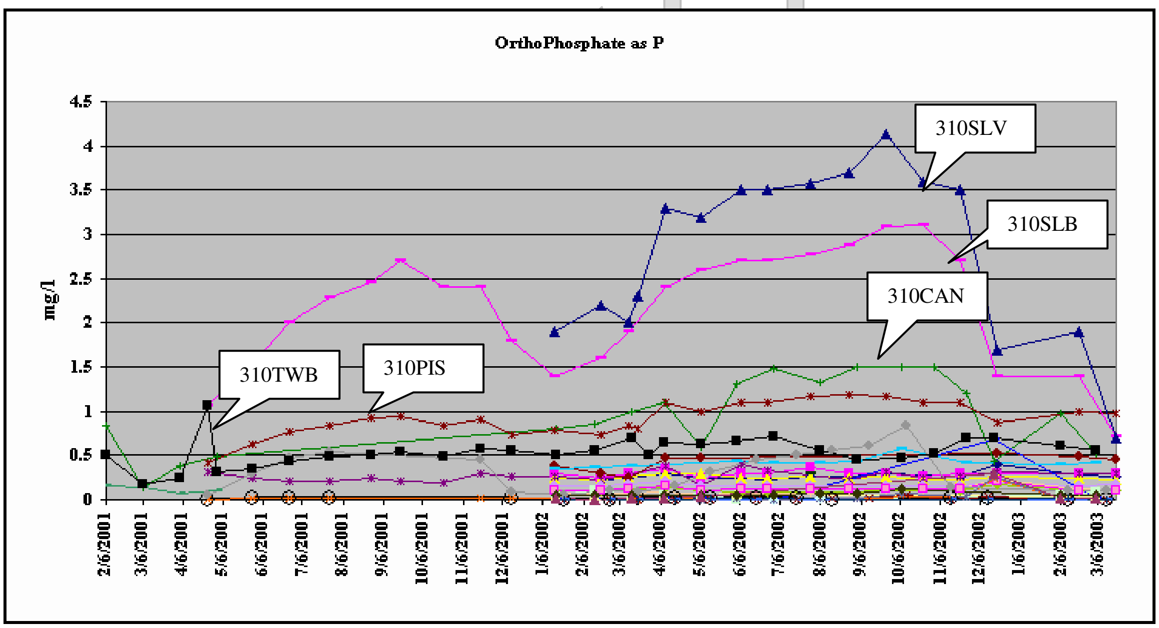

Figure 6.1j. Time series of orthophosphate data collected at sites in the Estero Bay Hydrologic Unit between January 2001 and March 2003. Blue triangles -San Luis Creek at Los Osos Valley Road (310SLV), Pink dashes - San Luis Obispo Creek at Bay Drive (310SLB), Maroon stars - Pismo Creek up stream of Highway 101 (310PIS), Green x - Chorro Creek at Canet Road (310CAN), Black squares - Chorro Creek at South Bay Boulevard (310TWB).

6.1.9 Conclusions

CCAMP monitoring activities in the Estero Bay Hydrologic Unit documented levels of fecal coliform, nitrate, pH, dissolved oxygen and several salts that do not meet Basin Plan water quality criteria (Regional Water Quality Control Board 1994). In several cases, creeks are already listed as impaired by these conditions. Other water quality parameters of concern include temperature, algae (attached and suspended), organic chemicals in sediment, and toxic effects to test organisms in both water and sediment
.

Creeks monitored by CCAMP that showed evidence of impairment and that are currently on the 2002 CWA section 303(d) list of impaired waters include Chorro Creek (listed for fecal coliform, nutrients and sedimentation / siltation) and San Luis Obispo Creek listed for(nitrate, pathogens and priority organics)

Prefumo Creek is a tributary to San Luis Obispo Creek, and as such has been considered in development of the nitrate TMDL for that watershed. However, special note should be given here that it has by far the highest concentrations of nitrate in the Hydrologic Unit, with levels consistently in the vicinity of 30 mg/L. Several creeks have levels of nitrate that, though they do not exceed the drinking water standard, are higher than they should be and could easily contribute to eutrophication. These creeks should be managed to prevent further increases and to reduce levels where possible. These include Arroyo Grande Creek and tributaries, Los Berros Creek, and San Simeon Creek.

Lower San Luis Obispo Creek and Arroyo Grande Creek should be considered for listing as impaired by high pH, in violation of drinking water objectives.

Specific Basin Plan violations at Arroyo de la Cruz included depressed dissolved oxygen levels in the summer months as this creek was drying up. Arroyo de la Cruz is designated as both cold and warm water aquatic habitat. At the CCAMP monitoring site (310ADC, located at Highway 1) 6 of 18 samples had oxygen measurements below the Basin Plan objective of 7.0 mg/L. This waterbody is not currently on the 303(d) and due to low flow conditions we do not recommend listing based on these data.

Specific Basin Plan violations at Arroyo Grande Creek include depressed dissolved oxygen levels in summer months, and elevated fecal coliform. At the waterbody level, 36% of all 69 samples exceeded 400 MPN/ml; the overall geomean for fecal coliform was 251 MPN/ml. We recommend that Arroyo Grande Creek be considered for listing as impaired for fecal coliform bacteria. Dissolved oxygen levels at Biddle Park downstream of the reservoir (310ARB) were frequently depressed below 7.0 mg/l, but almost never dropped below 6.0 mg/L, even in mid-summer. Considering the low flow conditions that were frequently present at this site, this is not considered by staff to be a serious water quality problem and we do not recommend that it be considered for listing.

We recommend that Villa and Toro Creeks be considered for listing as impaired for fecal coliform bacteria. They showed 50% and 54% violation of the Basin Plan objective of 400 MPN/100 mL, respectively.

Sites on several creeks violated site-specific objectives repeatedly for TDS, chloride, sulfate, and sodium. These creeks should be considered for listing as impaired for these various violations. These include Chorro Creek for TDS, chloride, sodium, and sulfate; San Luis Obispo Creek for sodium and sulfate; Arroyo Grande Creek for sulfate; and Santa Rosa Creek for sulfate. It would make sense to further evaluate salts in the upper Santa Rosa and Chorro Creek drainages to determine whether levels are elevated throughout the watershed or whether they increase with anthropogenic impact moving downstream. Elevated levels throughout the watershed should trigger evaluations of site-specific objectives for appropriateness.

- Follow up Monitoring
    - Evaluate upper watershed conditions of Chorro and Santa Rosa creeks for their ability to meet site specific salts objectives
    - Evaluate Pismo Creek for additional evidence of problems associated with selenium

- Basin Planning
    - Consider appropriateness of site-specific objectives for salts in Chorro and Santa Rosa Creeks pending results of follow-up monitoring
    - Consider appropriateness of pH objectives given apparently high background levels of pH in many watersheds

- Nonpoint Source Management
    - Manage for increasing impairment by nitrate for lower San Simeon, Los Berros, and Arroyo Grande creeks (and tributaries).
    - Manage to prevent biostimulatory risk in the lower ends of San Simeon, Morro, Arroyo Grande, Pismo, and San Luis Obispo creeks, as well as in Prefumo Creek, Los Berros Creek

- Orders
    - Revise National Pollutant Discharge Elimination System permits, Waste Discharge Requirements, Water Quality Certifications, etc. to:
        - Include monitoring for phosphorus (total and orthophosphate) as P, nitrogen (total, NO_3, NO_2, NH_3) as N, pH, temperature, dissolved oxygen, total dissolved solids, total suspended solids, sulfate, sodium, chloride and turbidity. Include benthic invertebrate monitoring in WWTP discharge permits upstream and downstream of discharge.
        - Manage nutrient sources/discharges
        - Manage for dissolved oxygen and temperature levels
        - Manage for total solids (dissolved and suspended) and salts,

The WWTP permit for the San Luis Obispo facility is up for review and revision in 2007 and the California Men's Colony WWTP permit will be revised February of 2006. CCAMP will provide recommendations to the appropriate regional board staff based on these data.

7 Quality Assurance

<u>Evaluating field data</u>

Field equipment is calibrated according to manufacturers specifications (Hydrolab Inc, 2002) prior to and following each sampling event. Field data is qualified with a flag and disabled from use in data calculations and determination of beneficial use impairment if the following is true:

- Post calibration measurements differ from the calibration standard values by more than 20% as identified in the SWAMP Quality Assurance Management Plan (QAMP) (Puckett 2002, Appendix C).

<u>Evaluating laboratory data</u>

Data is qualified with a flag if it meets one of the following criteria:

- Analyte of interest is not detected (non-detect), the minimum detection limit (MDL) and/or practical quantifiable limit (PQL) is higher than the SWAMP target reporting limit (TRL), and the MDL does not exceed levels of concern or Basin Plan objectives.
- The result is between the MDL and the PQL and these values are below the appropriate water quality criterion.
- The difference between the results from a blind field duplicate and an original sample exceeds the allowable relative percent difference (RPD) defined in the SWAMP QAMP (Puckett 2002, Appendix C). The maximum RPD for conventional parameters, synthetic organics and metals is 25%.
- Blind field duplicates for coliforms exceed the 95% confidence interval values.
- Holding time requirements are not met.

Data is qualified with a flag and disabled from use in calculations and determination of beneficial use impairment if it meets one of the following criteria.

- Analyte of interest is not detected (non-detect), MDL and/or PQL is higher than the SWAMP target reporting limit (TRL), and the non-detect value is near or exceeding a criterion.
- The surrogate spike recovery levels exceed the allowable range of acceptance as identified by the contract laboratory's quality assurance program (BC Labs, 2002). The acceptable levels vary between analytes.
- Matrix spike recovery values exceed the allowable recovery (percent recovery) as defined in the SWAMP QAMP (Puckett 2002, Appendix C). The maximum variation in percent recovery for conventional parameters and metal in sediment is 25%. For synthetic organics in sediment the required recovery is at least 50%.
- The batch precision violates the precision requirements defined in the SWAMP QAMP (Puckett 2002, Appendix C). These requirements are 80-120% precision for conventional parameters and 50-150% precision for organic chemicals in sediment and tissue.
- The method blank results exceed the MDL.
- The relative percent difference (RPD) between the blind field duplicate result and the original sample exceeds the allowable defined in the SWAMP QAMP

(Puckett 2002, Appendix C) and the difference between the two results is greater than twice the analyte's SWAMP TRL.

All data was evaluated relative to the SWAMP QA criteria. Flags that have been accepted are included in the database as qualifiers. These data are used by CCAMP in analyses but can be excluded by other users such as TMDL staff. Data, which are rejected because they are outside of the QA criteria defined in the SWAMP QAMP, are disabled from all analyses.

CCAMP field and laboratory data was evaluated using the SWAMP QAMP and CCAMP acceptability criteria outlined above. The contract laboratory submitted electronic QA/QC data for all results discussed in this report. In the Estero Bay Hydrologic Unit (HU) each sample sent to the lab was analyzed for 20 analytes. The contract laboratory assigned flags to a number of sample analytes. These flags were reevaluated using the SWAMP measurement quality objectives (MQOs) where appropriate.

SWAMP acceptability criteria were generally less strict than that of the contract laboratory. Therefore, several of the data were flagged by the contract laboratory and remained flagged in the CCAMP database but are acceptable for use in some data analyses using SWAMP criteria. Data that did not meet SWAMP acceptability criteria were flagged with the appropriate code and the term "reject". Rejected data was not included in any of the analyses discussed in this document.

There were a total of 839 flags generated during QA analysis of data collected from the Estero Bay Hu Between April 2001 and March 2003. Flags include those generated by the Region 3 contract laboratory such as matrix spike and continuing calibration exceedances as well as field duplicate analysis and field equipment calibration data analysis. Of these 839 flags 201 were outside the MQOs identified in the SWAMP QAMP (Puckett 2002). Rejected data are maintained in the database with a flag identifying the data as disabled. These data are not used in any assessments.

<u>Field Duplicates</u>

Blind field duplicate results were compared to original sample data. Data pairs were compared in terms of relative percent difference and determined to be unacceptable if the difference between duplicate pairs exceeded the analyte's specific MQOs and was greater than twice the TRL, as defined in the SWAMP QAMP (Puckett 2002). For each blind field duplicate pair, there are several different analytes.

Forty-nine blind field duplicate samples pairs were collected, each with 20 analytes analyzed by the contract laboratory. We identified 124 sample analytes or less than 10% of the total data set that did not meet the QA criteria defined above. All field duplicate samples failed both the SWAMP MQO and the "twice the TRL" criteria.

The contract lab also analyzed blind field duplicate samples for total and fecal coliform on all occasions. Because analysis of these data is not discussed in the SWAMP QAMP, we compared the duplicate result to the original sample using the 95% confidence interval table from Standard Methods (1999) for multiple tube dilutions. For these data, there nineteen field duplicates samples exceeded the above mentioned criteria.

MDLs / PQLs

Comparison of reported MDLs and PQLs relative to the target values defined in the SWAMP QAMP (Puckett 2002) can result in several flags including the following: result between MDL and PQL, MDL above TRL and PQL above TRL. Additional qualifying flags related to MDL and PQL results include the following: elevated MDL/PQL due to matrix interference and elevated MDL/PQL due to sample dilution. In the Estero Bay Hydrologic Unit the following flags were assigned to data collected between April 2001 and March 2003.

- Results were reported between the MDL and PQL for 465 analyte results. These results are considered estimated as they are detected but not quantified.
- Eighty-seven analyte results had elevated MDLs. Only four analyte results MDLs were elevated above SWAMP TRLs. None of these were of consequence to the data as they are not non-detects.
- Elevated MDLs were reported for one sample as a result of matrix interference.

Matrix Spikes

The contract laboratory identified a total of sixty sample analyte results for which there was a matrix spike recovery problem (being outside of the laboratory's quality control (QC) criteria. Reevaluation of these data using the SWAMP MQOs resulted in the rejection of thirty-six sample analytes.

Method Blanks

Six method blank flags have been assigned to phosphate data from a single batch in which the analyte was detected above the MDL.

Precision

Sample and batch precision flags were reported for fifty-five sample analytes by the contract laboratory. Using the SWAMP MQOs only fifteen of these were rejected. The remaining forty sample analytes are flagged but not disqualified.

Field Data

Field data collected using a Hydrolab DS4a were evaluated using Calibration records. First data are evaluated to determine if measurements are outside of the Calibration Range or if drift has occurred between pre and post calibration. In the Estero Bay HU field measurements consist of conductivity, pH, turbidity, dissolved oxygen, water temperature, salinity and Chlorophyll a. Twenty-five conductivity measurements were and six turbidity measurements are above their respective upper calibration ranges. Each of these is qualified with flags. One pH result is below the calibration range (7 and 10). Calibration records were also used to identify accuracy of the probes by comparing pre and post calibration data to identify drift. Eleven pH measurements have been disqualified because of calibration drift. Each of these measurements was collected in December of 2002.

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Appendix A. CCAMP Biostimulatory Risk Index

Introduction

Nutrients, such as nitrate, ammonia and phosphate, are often found at elevated concentrations in waterbodies of the Central Coast Region, and elsewhere in the State of California. Some nutrients have numeric objectives associated with particular beneficial uses. Specifically, to protect for municipal and domestic water supply, nitrate as N cannot exceed 10 mg/L. To protect against general toxicity, ammonia concentrations cannot exceed 0.025 mg/L. However, there are no numeric objectives that protect surface waters from the biostimulatory effects of excessive nutrients. Eutrophication results from a complex interaction of multiple nutrients, sunlight, substrate, water velocity, and other factors. It is difficult to identify specific nitrate or phosphate concentrations that represent thresholds over which problems will certainly occur. Consequently, the Central Coast Basin Plan narrative objective for biostimulatory substances is as follows:

> "Waters shall not contain bio-stimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses."

Understanding how to manage surface waters for biostimulation is complex, as interactions and effects of excessive nutrients are not always readily apparent. For example, a site that has excessive concentrations of phytoplankton or other algae may not display elevated concentrations of dissolved nutrients, as the nutrients may have already been taken up by plant material. This interplay of chemical, physical, and biological factors complicates assessment of overall water quality.

The Central Coast Ambient Monitoring Program has developed a "Biostimulatory Risk Index" to serve as a screening tool to simultaneously consider factors which serve as stimuli (nutrients), in parallel with those which act as responders (algal and plant cover, pH, dissolved oxygen and water column chlorophyll concentrations). The index is intended to characterize both in-situ monitoring site response to biostimulatory substances and the capacity of monitoring site water quality parameters to induce adverse biostimulatory responses in downstream areas. The index currently has no provision for addressing nutrient-poor waters, nor waters impacted by toxic effects associated with several of its components.

The Biostimulatory Risk Index is a combination of several different measures, or "metrics" of stimuli or response, which have then been ranked and combined to form a single value. The Central Coast Ambient Monitoring Program collects data on a number of parameters that are used in developing the preliminary Index, and serve as metrics. Some of these measures, such as nitrate concentration, may serve as metrics based on magnitude alone (where higher concentrations are considered "worse" than lower concentrations and are ranked accordingly). Others are more complex, particularly "double-ended" parameters such as dissolved oxygen and pH. For example, both supersaturated and depressed concentrations of dissolved oxygen can be indicative of eutrophication. Thus, one possible indicator of dissolved oxygen impairment is the departure of the measurement from the median value (where a larger departure ranks worse than a smaller departure).

Biostimulatory Risk Index Development

Index development included testing of a number of metrics that reflect various measures of nutrient stimulus and response. Candidate components included ranked concentrations of individual nutrient forms (such as unionized ammonia, orthophosphate, etc.), measures of dissolved solids, turbidity, various characterizations of percent vegetative cover and other measures. A subset of these candidates was selected for use.

Selected Components

- Chemical composite
  - Nitrate as N
  - Nitrite as N
  - Ammonia as N
  - Ortho-Phosphate as P

- Oxygen Saturation
- pH
- Chlorophyll *a*
- Plant Cover composite
  - Algal cover
  - Algal cover filamentous
  - Algal cover periphyton
  - Instream plant cover

Five metrics were developed and were calculated as follows:

1) c = Chemical composite metric = Sample percentile rank of summed concentrations (mg/L) of NO2-N + NO3-N + NH3-N + (PO4-P * 10)

This metric assumes that dissolved nutrients of various forms can all contribute to biostimulation, either at the site or downstream from it, and that they can be summed to represent overall nutrient availability, once adjustments have been made for the typical uptake ratio of phosphorus to nitrogen in plant tissue (1:10).

2) p = pH metric = Sample percentile rank departure from median of entire CCAMP dataset (8.2)

This metric reflects fluctuations in pH levels in response to photosynthetic and respiration activity by plants. Photosynthetic activity uses up carbon dioxide, causing bicarbonate ions to dissociate to create more CO2 and OH^-; this process increases alkalinity. The opposite is true during respiration and decay. This process assumes that pH that diverges widely from the median can be a measure of excessive plant activity, either as photosynthesis or respiration, and thus an indicator of biostimulation.

3) o = Oxygen metric = Sample percentile rank departure from median of entire CCAMP dataset for percent saturation (92.6)

The assumption driving this metric is that both depressed and supersaturated oxygen levels are indications of biostimulation. Samples taken in association with significant amounts of aquatic plant and algae growth may be supersaturated in late afternoon, and depressed in pre-dawn samples. Oxygen levels may remain depressed throughout the day when plant decay is prevalent. Percent saturation is used instead of dissolved oxygen concentration because it takes into account the confounding effects of water temperature and salinity.

4) a = Chlorophyll *a* component = Sample percentile rank of water column concentration of chlorophyll *a* (ug/L)

This metric assumes that higher concentrations of water column chlorophyll *a* are indications of phytoplankton abundance and hence of biostimulatory activity.

5) f = Flora component = Sample percentile rank of the maximum of one of the following: (Filamentous, Periphyton, or total Algal cover, instream plant cover)

This metric assumes that various forms of plant and algal cover represent uptake of nutrients from the stream system and hence indicate biostimulatory activity. Light availability, substrate and other factors affect which form of plant predominates; therefore this metric calculates rank based on the maximum value of the various forms quantified. This metric is not weighted highly because the quantified values are extremely subjective in nature and are highly variable.

Metrics are weighted and summed for each sampling event at each site, as follows:

$$a = 2^{(f1*c\ +\ f2*p\ +\ f3*o + f4*a\ +\ f5*f)}$$

Where:

f1=chemical composite weight = 6
f2= pH weight = 7
f3=oxygen weight = 5
f4=chlorophyll *a* weight = 9
f5=flora weight = 1

The mean percentile rank of ‘a’ for each site is utilized as the Biostimulatory Index for that site.

CCAMP staff evaluated performance of the index using data from the entire Region. Weighting factors f1, f2, f3, f4, and f5 were initially determined by confining the database under consideration to several hydrologic units well known to staff, and setting weighting factors to values that ranked sites in a sequence that was consistent with staff knowledge of the sites. Performance of the index was then examined in other hydrologic units not used to develop the weighting factors, using different staff, knowledgeable of site and waterbody characteristics in the new set of hydrologic units. Through iterative adjustment of weighting factors, index performance was tested until all staff agreed that site rankings best reflected overall staff knowledge of the sites.

Staff evaluated the final site ranking for evidence of threshold values at which sites begin to show overall impairment or cause downstream problems. Staff agreed that above an average index score of 0.40, sites begin to commonly show signs of impairment, including algal blooms, widely ranging dissolved oxygen concentrations, and elevated nutrient concentrations. We are using this value as a threshold for screening monitoring data for biostimulatory risk. Figure A.1. shows the mean and range of nitrate concentrations at sites scored for biostimulatory risk. Sites whose scores fall below the threshold of 0.40 virtually never exceed the drinking water standard for nitrate. 89% of these samples have site nitrate averages under 1.0 mg/L-N. Also, sites with a risk score of 0.40 or greater never have benthic invertebrate community index scores in the highest quartile (over 6.0) (Figure A.2.).

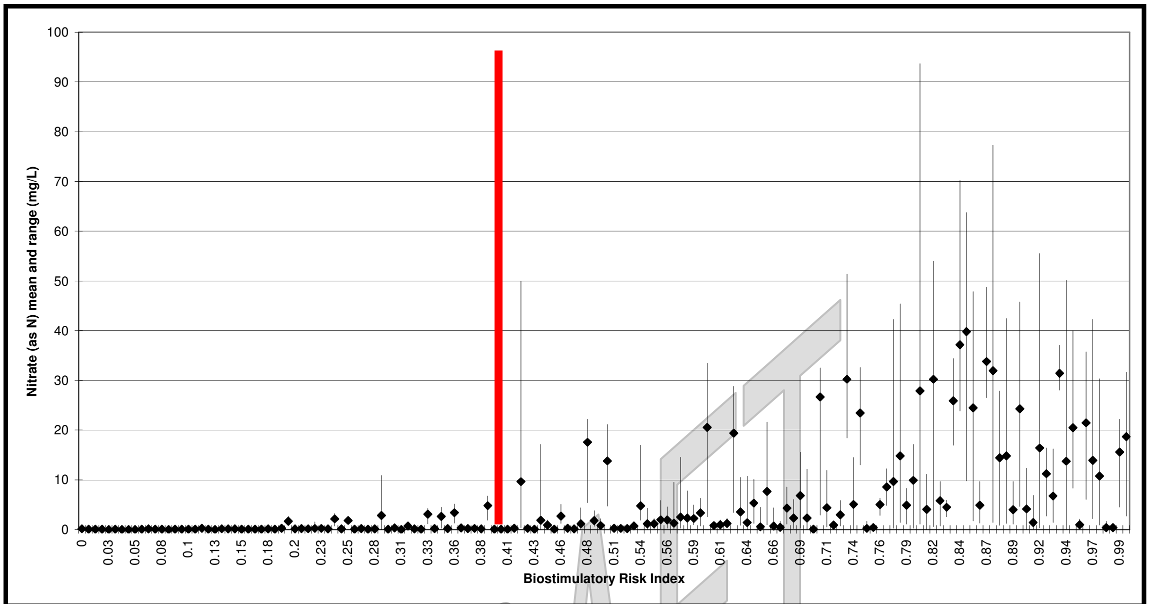


Figure A.1. Range and mean of Nitrate-N concentrations (mg/L) at sites scored for biostimulatory risk in the Central Coast Region. Biostimulatory risk threshold (0.40) indicated by red line.

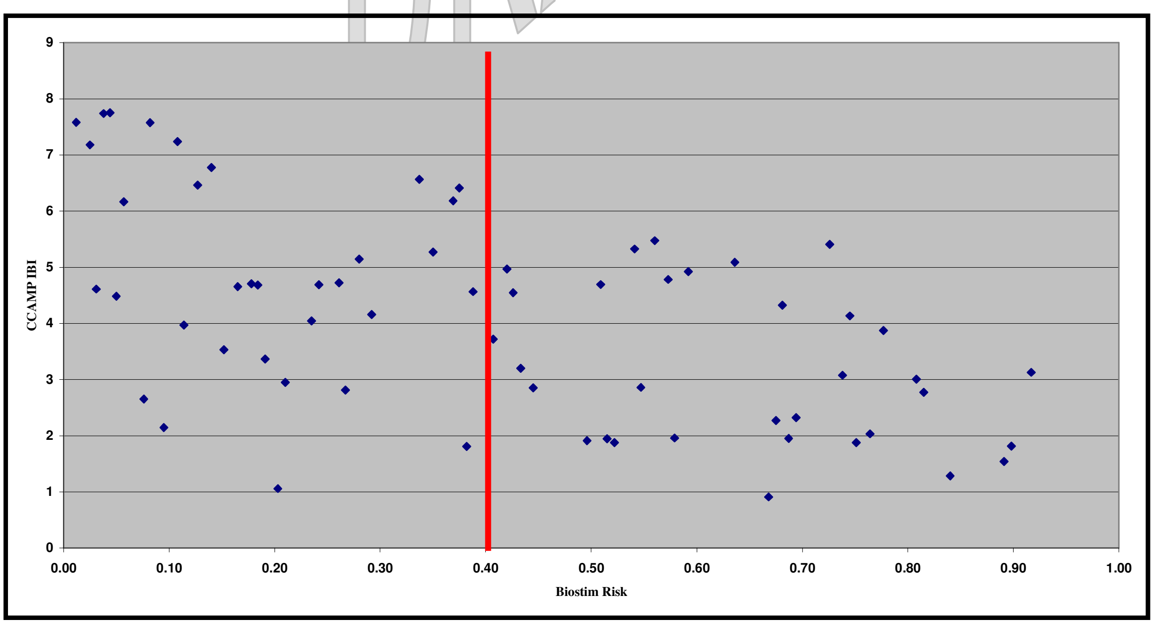


Figure A.2. Scatter plot of CCAMP-IBI scores against the Biostimulatory Risk Index for CCAMP sites. Biostimulatory risk threshold (0.40) indicated by red line.

Index development assumptions

The Bioassessment Risk Index is not based on bio-chemical process modeling. The only component of the index that deals with plant uptake of nutrients is the chemical composite component that assumes that phosphate concentration impacts occur at levels 10 times lower than nitrogenous compounds. The factor of ten was selected based on the typical ratio of these two nutrients in plant tissue. Freshwater systems tend to be limited by phosphorus. If the N:P ration is above 10:1 N:P a system will likely experience an algal bloom, the severity of which will be dictated by the amount of available phosphorus. (Schindler 1978 and Jaworski 1981). Examination of the data indicates that nitrogen is rarely the limiting nutrient in streams and rivers that exhibit problems with bio-stimulatory substances on the Central Coast of California. For this reason we selected a multiplier on the high end of literature values.

Since the Index is intended for use in moving water, it does not rely upon the assumption that effects will be located at the same place or time as causes.

Ranking of nutrient concentrations assumes that oligotropic conditions do not exist in the Central Coast Region and that a straight ranking of nutrient concentration from low to high reflects conditions moving from "good" (i.e. low concentrations) to "bad" (i.e. high concentrations). We have not documented conditions which appeared to be nutrient-poor in this Region.

The Index does not rely upon mass loading calculations (e.g. total pounds of a stressor delivered to a monitoring site). Biostimulatory impacts in stream and river systems are more related to concentrations found within a given reach than to nutrient loads moving through the reach. For example, during storm events very large quantities of nutrients move rapidly through river and stream systems with little or no impact on the streams and rivers. The true impacts of these nutrients are not manifest until they reach a 'terminal water body' such as a lake or the near shore ocean.

Biostimulatory Risk in the Central Coast Region

Figure A.3. shows the quartile rank of BioStim scores for all sites monitored by the Central Coast Ambient Monitoring Program. In general, Biostimulatory Risk Index scores are highest in areas of the Central Coast Region already known to suffer from very high levels of nutrients. Most of these areas are associated with intensive irrigated agricultural activity. Sites in the upper quartile of ranked scores are primarily in watersheds that have already been 303(d) listed as impaired by nutrients. Many are smaller tributaries that enter impaired rivers, such as Quail Creek (tributary to Salinas River), Little Oso Flaco Creek (tributary to Oso Flaco Creek), Main Street Canal, Orcutt-Solomon Creek and Blosser Channel (tributary to Santa Maria River), and Salsipuedes and Llagas Creeks (tributary to Pajaro River). Many of these tributaries have exceptionally high concentrations of nutrients and serve as major nutrients sources to the main stem systems. For example, Quail Creek concentrations have ranged as high as 94.7 mg/L for nitrate (as N) and 2.8 mg/L for orthophosphate (as P). Other waterbodies scoring in the top quartile are slow moving terminal waterbodies, such as Tembladero Slough, Moro Cojo Slough, and the Old Salinas River. These types of systems tend to have relatively high scores for pH, oxygen, and chlorophyll *a*, in addition to chemistry. Though much less common, some chemical scores are driven more by elevated phosphate concentrations than by nitrate. These include San Antonio and Carneros Creek sites. Santa Ynez River, Chorro Creek and San Luis Obispo Creek also have relatively high phosphate levels downstream of their respective wastewater treatment plant discharges. A few waterbodies not currently 303(d) listed for nutrients also scored in the top quartile. These include Franklin Creek, Arroyo Paradon Creek, Los Berros Creek and San Antonio Creek. They will be considered for 303(d) listing in the next listing cycle.

Waterbodies which fall in the lowest risk quartile include all of the Carmel River watershed, all creeks in the Santa Lucia Hydrologic Unit (along the Big Sur coast), most creeks in northern San Luis Obispo County (excluding San Simeon Creek), and small creeks in relatively undisturbed watersheds, such as Scott Creek (Santa Cruz County), Toro Creek, Old Creek above the reservoir, and Coon Creek (San Luis Obispo County), and El Capitan Creek and Gaviota Creek (Santa Barbara County). Several waterbodies which do not score in the lowest quartile overall have upper watershed sites with scores in the lowest quartile. These include San Luis Obispo Creek, Santa Ynez River, and San Simeon Creeks above their respective wastewater treatment plants.

Several of the creeks that score in the lowest quartile are dry in the summer, so scoring is calculated only from wet weather samples, which do not typically represent the worst case conditions relative to biostimulation. These include Montecito and San Ysidro Creeks in Santa Barbara County, both of which are channelized drainages passing through urban and agricultural land uses, and Villa Creek in San Luis Obispo County, which supports upstream irrigated agriculture.

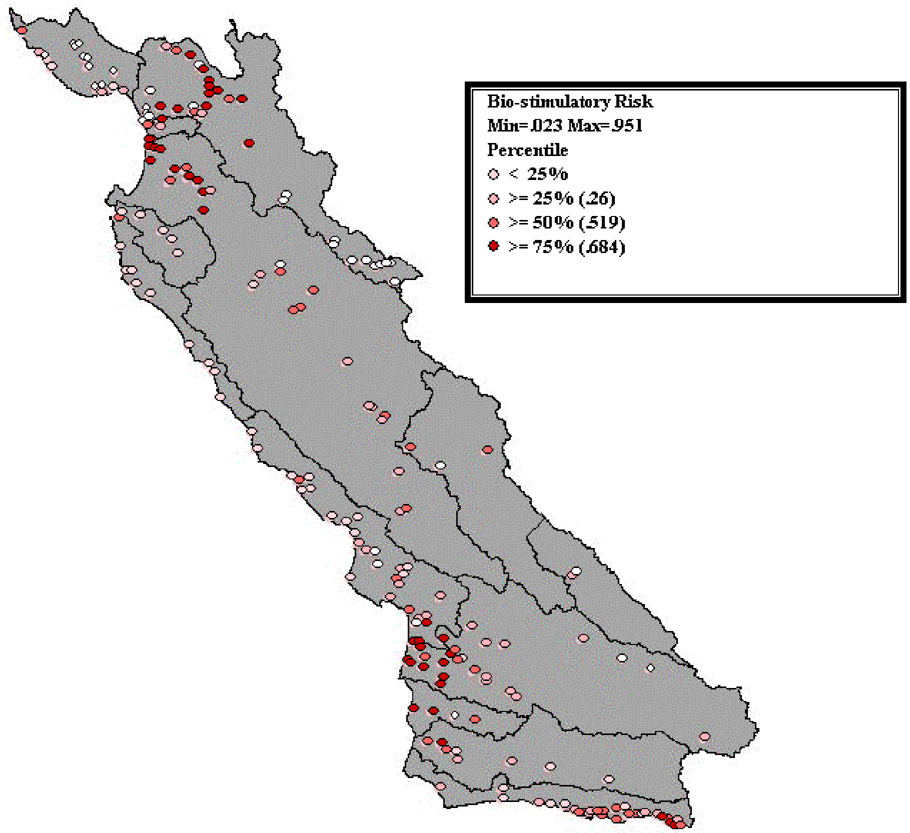


Figure A.3. Biostimulatory Risk Index scores for all sites monitored by CCAMP in the Central Coast Region between January 1998 and July 2005. Site scores are shown in quartiles, with sites ranked in the 75th quartile and above having the highest risk for eutrophic conditions.

Biostimulatory Risk Index and Waterbody Impairment

RWQCB staff have evaluated sites rankings alongside water quality and habitat data and subjectively made a determination of the Index score for creeks beginning to show "impairment". 0.40 was selected, as a site average. Sites in this range begin to show somewhat elevated nutrient concentrations, occasional algal blooms, and depressed dissolved oxygen concentrations.

Appendix B. CCAMP Index of Biotic Integrity

The CCAMP Index of Biotic Integrity (CCAMP-IBI) is a sum of several ranked metric scores, including taxonomic richness, number of Ephemeroptera taxa, number of Trichoptera taxa, number of Plecoptera taxa, percentage of intolerant individuals (with tolerance scores of 0, 1, or 2), percentage of tolerant individuals (with tolerance scores of 8, 9 or 10), percent dominant taxon, and percent predators. This index includes all metrics utilized by Karr and Chu (1999) in their Index of Biotic Integrity, with the exception of "clinger taxa count" and "long-lived taxa count". The CCAMP program has been utilizing this index for a number of years for evaluating benthic invertebrate data in the Central Coast.

CCAMP-IBI scores range from 0 to 10. Sites in the lowest quartile of all CCAMP bioassessment data score below approximately 3.0, as a site average. Sites in the highest quartile score above 6.0. We have examined these quartile break points relative to other indices of water quality as shown in the following figures.

Figure B.1. shows that at 60% of all sites in the lowest quartile, multiple measures of toxicity were present; only 20% of these sites had no evidence of toxicity. At sites in the highest quartile, 60% were free of toxicity and the remaining sites showed only a single indication of toxicity (such as reduced growth or reproduction).

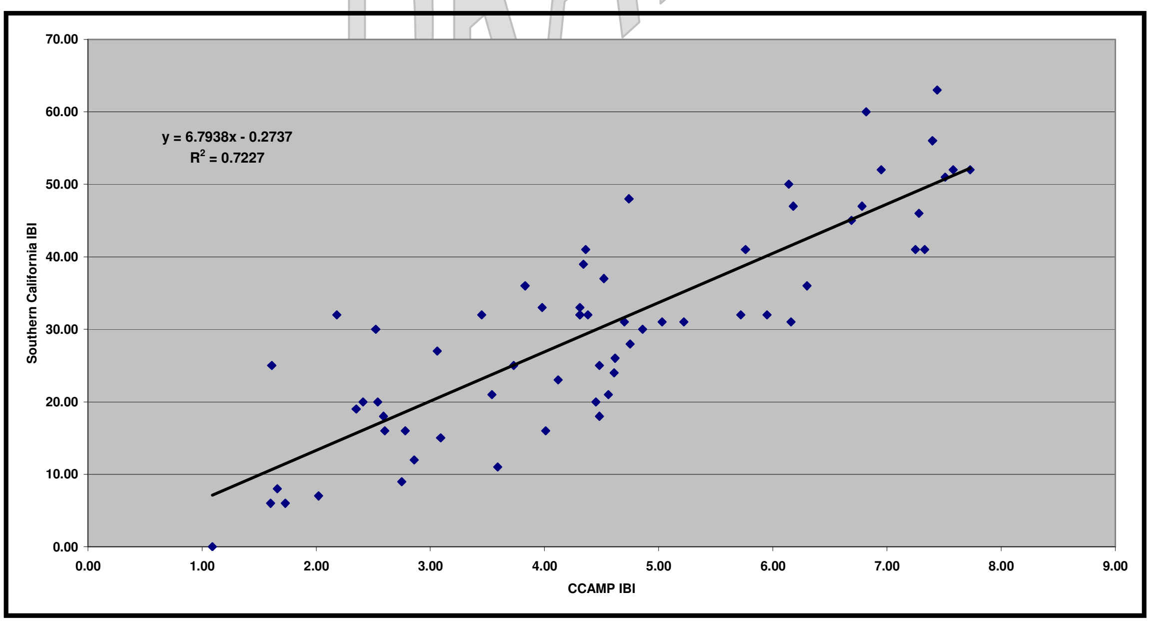
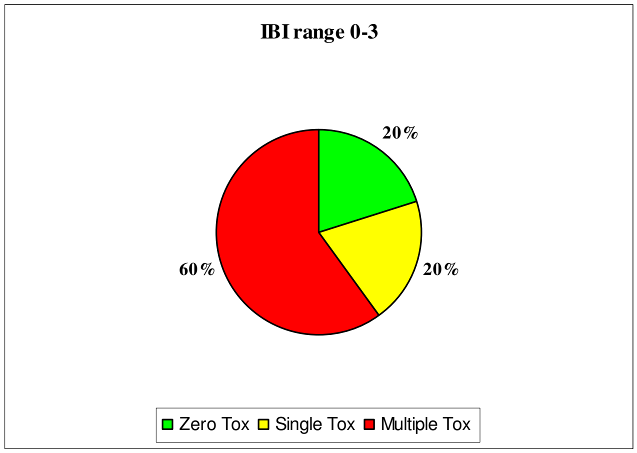
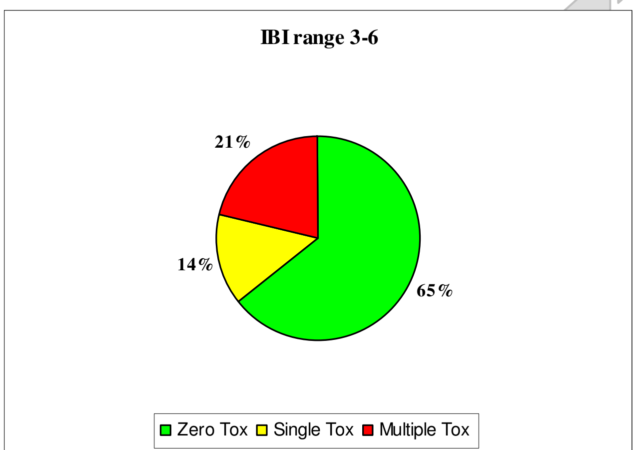
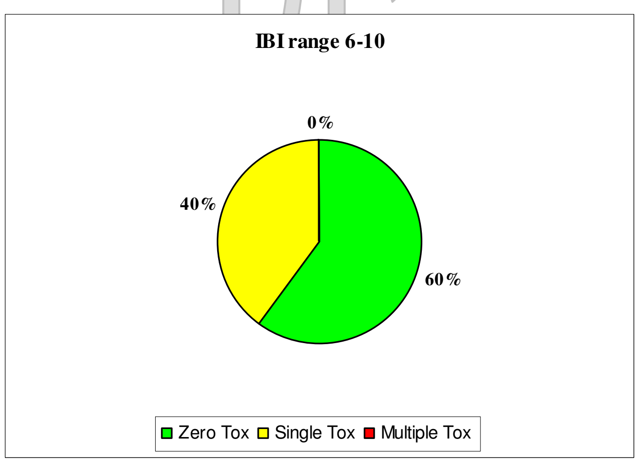


Figure B.2. Regression of Southern California Index of Biotic Integrity scores against Central Coast Ambient Monitoring Program Index of Biotic Integrity scores for the Central Coast Region.



Lowest IBI quartile scores





Highest IBI quartile scores

Figure B.3. Percent of sites showing zero toxicity, a single toxic result or multiple toxic results, according to CCAMP-IBI quartile scores.