SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT

FY 2010/2011 RESEARCH PLAN

First Draft to CTAG

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CONTENTS

INTRODUCTION

The Southern California Coastal Water Research Project Authority (SCCWRP) is a research institute studying the coastal ecosystems of southern California, from watersheds to the ocean. Each year, a Research Plan is prepared for the SCCWRP Commission (SCCWRP's governing board) detailing anticipated research activities for the upcoming fiscal year. The Research Plan provides an overview of SCCWRP's various focus areas, as well as project descriptions, goals, expected outcomes, and collaborators. In addition, SCCWRP releases a Director's Report on a quarterly basis, which contains updates on the current status and progress toward completing each project. Both the Research Plan and Director's Report can be accessed year-round on the SCCWRP website (www.sccwrp.org).

Since SCCWRP was formed in 1969, its main foci historically are Regional Monitoring and Contaminants. Over the past few decades, the research thematic areas of Wetlands, Beach Water Quality, Stormwater, and Nutrients have developed as new environmental management needs have arisen. SCCWRP is widely known and respected for their work in all of these areas, not only in terms of scientific investigations, but also in their ability to develop consensus among diverse stakeholders, pilot new technologies, and transition science into effective management applications. In addition, SCCWRP is a leader in the field of environmental data management, supporting a number of collaborative data compilations and sharing efforts across the State.

Much of SCCWRP's research is interdisciplinary, reflecting the inherent interconnectedness of environmental systems. This Plan is organized by research themes, grouping together projects that answer similar questions. Some projects have characteristics of more than one research theme; however, each is placed under the theme with which it is most closely tied. Contact information for the lead scientist on each project is provided, and communication with SCCWRP scientists is encouraged for obtaining more details about any of the listed projects.

A. CONTAMINANTS

Extensive population expansion and urban development over the past 150 years has placed increasing stress on the marine and aquatic environments of southern California, partly through an increase in the number of pollution sources. Some pollution sources are closely controlled and tracked through mechanisms such as the National Pollutant Discharge Elimination System (NPDES) permitting system. However, many of the more diffuse “non-point” sources are monitored little or not at all. Even where sources are well monitored, there is less information about the transport and fate of these pollutants once they enter the environment. Additionally, there are new pollutants continually emerging for which the environmental occurrence, fate, and risk of biological effects are not well understood. These issues challenge the development of effective management programs to steward southern California’s marine and aquatic natural resources.

Over its history, SCCWRP has undertaken a number of projects that quantify sources, fates and effects of contaminants in southern California’s marine and aquatic environments. These include studies of mass emissions and historical contaminant deposition around outfalls. They have also developed and refined many new laboratory and sampling methods. For example, source identification and toxicity identification methodologies were recently developed to address the presence of multiple comingled contaminants in environmental samples. Other methodologies assess the impacts of pollutants on native aquatic life. A standardized framework for assessing sediment quality was recently developed, which integrates chemistry, toxicity, and biological community data.

In this section, the first group of projects deals with combining data sources to track relative contributions and total mass emissions of contaminants to the Southern California Bight (SCB). The second group focuses on accurately examining receptors of contamination. The third integrates the study of pollutant fate and effects within the context of sediment quality assessment. The fourth group of studies is centered on improving knowledge of emerging contaminant occurrence and effects. These research topics cumulatively produce a more complete picture of the pollution stressors affecting southern California’s ecosystems.

1. Sources

SCCWRP's Southern California Bight (SCB) mass emissions database is one of the longest-running continuous databases in the United States that addresses pollutant sources to the coastal ocean. SCCWRP has been compiling effluent data on most major point sources of pollution to the SCB since 1970, including publicly owned treatment works (POTWs), industrial discharges, oil platforms, power generating stations, and dredged material disposal. These data have been used to estimate relative pollutant loading from various sources and to assess trends in pollutant emissions relative to changes in regulations and management practices over time.

This year's Research Plan includes three ongoing projects focused on estimating contaminant sources to the SCB. The first project updates analysis of mass emissions from large POTWs, where regular effluent monitoring is performed. The second project was begun recently to estimate nonpoint stormwater mass emissions to the SCB. The third project continues to update and analyze data on emissions from other (smaller) point source dischargers.

a. Characteristics of Effluents from Large Municipal Wastewater Treatment Facilities

Pollutant mass emissions from the four largest publicly owned treatment works (POTWs) have historically been the largest source of contaminant input to the SCB. However, contaminant loads from these sources have declined by more than 95% over the last 40 years as a result of increased effluent treatment, source control, industrial pretreatment, and reclamation.

For this project, each POTW's effluent is characterized based on their discharge monitoring reports, and then mass emission estimates are calculated. These calculations continue the time series of annual mass emission estimates dating back to 1972.

This is an ongoing project. This year staff will compile the annual monitoring reports from 2008-09, update SCCWRP's existing database, and then investigate emerging and ongoing trends in the data.

Lead Investigator: Eric Stein (erics@sccwrp.org)

Collaborators: City of Los Angeles, Sanitation Districts of Los Angeles County, Orange County Sanitation District, City of San Diego

External Funding Support: None at this time

b. Characteristics of Stormwater Mass Emissions to the SCB

Point source discharges, such as those from treated wastewater or industrial discharge facilities, have historically been the focus of water quality management activities. Over the past 35 years, improved source control and treatment practices have dramatically reduced mass emissions from point sources. As a result, nonpoint source discharges (such as stormwater runoff) have become a proportionately greater contributor to overall pollutant loading to the ocean. Stormwater runoff, especially in wet years, may likely be the predominant source of many coastal pollutants. Stormwater entails large discharge volumes accumulated over diffuse spatial scales, making the ability to critically assess inputs relatively coarse. Empirical estimates are also challenging because there is no standard regional approach for measuring and reporting data on pollutant loadings from stormwater. Estimating the status and trends for stormwater emissions to the SCB requires compilation of monitoring data from numerous municipal agencies that manage river discharge to the ocean.

The goal of this project is to compile, standardize, and analyze stormwater loading data from major rivers that discharge to the SCB. These steps will facilitate transfer of the data to the California Environmental Data Exchange Network (see project *Southern California Regional Data Center*), and allow for assessment of status and trends in both point and nonpoint source discharges to the SCB.

This is an ongoing project.

Lead Investigator: Eric Stein (erics@sccwrp.org)

Collaborators: Southern California Stormwater Monitoring Coalition

External Funding Support: None at this time

c. Comparative Mass Emissions to the Southern California Bight

One tool used to estimate the risk of environmental impairment is estimation of mass emissions for constituents of concern. Mass emission estimates enable comparisons among different sources to assess relative risk. Comparison of mass emissions over time from a single source helps assess whether discharges are increasing or decreasing. SCCWRP has conducted mass emission comparisons from a variety of sources at periodic intervals dating back to 1970. Estimates of mass emissions from large publicly owned treatment works (POTWs) have been made annually for the last 38 years. Estimates from other sources (such as small POTWs, industrial dischargers, dredged material disposal, urban runoff, oil platforms, vessel discharges, and aerial deposition) have been conducted at frequencies of about every five years. SCCWRP's last effort to comprehensively characterize all sources occurred in 2000.

The goal of the current project is to once again estimate mass emissions from all sources for the 2005-2006 time period in order to determine: 1) combined mass emissions; 2) relative contribution of each source; and 3) trends in mass emissions from each source over the last 38 years.

This is an ongoing project. This year will focus on compilation of discharge data from industrial dischargers, and power generating stations.

Lead Investigator: Eric Stein (erics@sccwrp.org)

Collaborators: None at this time

External Funding Support: None at this time

2. Measurement, Fate, and Bioavailability

Regulatory controls on environmental contaminants are often intended to protect the potential receptors of contamination, including wildlife and humans. Thus, to understand the full range of pollutant effects, contaminant levels need to be measured not only at the source, but also in the environment and within organisms. Since its inception, SCCWRP has been developing contaminant measurement methodologies for quantifying trace constituents (e.g., DDT, PAH, lead, mercury and copper) at low levels in hard-to-analyze media (e.g. seawater, sediments, tissues). Analytical protocols developed and/or improved at SCCWRP have frequently become the “standard method” used in routine monitoring laboratories throughout the SCB. One recent example of this technology development is the use of *in situ* passive water column sampling devices based on solid phase microextraction (SPME). SPMEs enable cost-effective measurement of trace organic contaminants at ultra-low levels.

This year’s Research Plan highlights three projects that follow the theme of research-grade method development for ultra-trace level organic pollutants. The first project focuses on practical applications of the new SPME technology. The second project develops analytical methods for toxaphene. The third, a new project, will help the State to refine a methodology for monitoring the combined effects of toxicants in water bodies.

a. In situ Measurement of Toxic Organic Compounds in Sediment Pore Water

While bulk sediments may contain measurable quantities of toxic hydrophobic organic contaminants (HOCs) like PAHs, PCBs, and chlorinated pesticides, it is the bioavailable fraction freely dissolved in sediment pore water that is most likely to stress biological organisms. Quantification of the bioavailable fraction of HOCs with current technology is extremely difficult. Concentrations found by traditional methods often lack the sensitivity to assess impairment to aquatic life, while non-target compounds often interfere with accurate and reliable measurements. Passive sampling devices that measure freely dissolved HOCs in sediment pore water offer clear advantages over traditional *ex situ* techniques, but have not yet been optimized and/or tested for this application. SCCWRP’s recently developed *in situ* SPME sampler may represent the simple, inexpensive, and sensitive method needed to assess the potential for biological impacts.

The goal of this study is to develop and test an *in situ* sediment pore water sampler based on SPME technology that will more accurately quantify exposure of sediment dwelling organisms to HOCs. This project consists of three major tasks: 1) selection and calibration of SPME fibers for a wide range of regulated HOCs; 2) optimization and performance evaluation of prototype samplers under controlled laboratory conditions; and 3) *in situ* testing of the most promising sampler configuration.

This is the third year of a three-year study. Calibration of SPME fibers with different sorbent coating thicknesses for PAHs, PCBs, DDTs and chlordanes was accomplished in the first year. The sampler's capability to mimic bioavailability of HOCs to benthic invertebrates under controlled laboratory conditions was demonstrated in the second year. In year three, the successful sampler design will be deployed *in situ* at several field locations representing a wide range of sediment quality conditions. SPME measurements will be compared with multiple chemical and biological effects endpoints in year four.

Lead Investigator: Keith Maruya (keithm@sccwrp.org)

Collaborators: Chinese Academy of Sciences (Dr. Eddy Zeng), SPAWAR Systems Center (Dr. Bart Chadwick), US Environmental Protection Agency (Dr. Bruce Duncan), Texas A&M (Dr. Kirby Donnelly, Dr. Thomas McDonald), Tijuana River National Estuarine Research Reserve (Dr. Jeff Crooks), City of Los Angeles (Dr. Shokoufe Marashi)

External Funding Support: Cooperative Institute of Coastal and Estuarine Environmental Technology (CICEET), City of Los Angeles

b. Development of Analytical Methods for Toxaphene

Toxaphene is the generic name of a complex organochlorine pesticide mixture that was used extensively during the last half of the 20^{th} century. Banned in the 1980s, residues of toxaphene are of concern due to their persistence, bioaccumulation, and potential for toxic effects. However, the environmental fate and behavior of toxaphene is complex and poorly understood, even though it is named as a cause for impairment to several 303(d) listed waterbodies within California. The standard analytical methods used to generate environmental toxaphene data (e.g., US EPA Method 8081) suffer from poor selectivity and specificity for toxaphene. The utility of approved methods is further compromised by profound changes in residue congener profiles in the environment. In recent years, the application of new instrumental techniques and the availability of purified standards have allowed analysts to better characterize toxaphene contamination. Development and acceptance of these updated methods is crucial for confirming reports of toxaphene contamination in impaired waterways.

The purpose of this study is to evaluate a new determinative method for identification and quantification of toxaphene residues in organic extracts of environmental samples. Matrices of interest for this method include natural waters, aquatic sediments, and biological tissue.

This is the third year of a three-year study. In the first year, analytical protocols for processing and analyzing environmental samples (including fish tissue) for residues of toxaphene were developed, validated, and documented. In the second year, SCCWRP focused on the preparation of control materials for laboratory intercalibration of proposed analytical protocols. In year three, researchers will coordinate and participate in the aforementioned laboratory intercalibration exercise.

Lead Investigator: Keith Maruya (keithm@sccwrp.org)

Collaborators: US Environmental Protection Agency (Dr. Shen-Yi Yang), National Institute of Standards and Technology (Dr. John Kucklick), Ashland Chemical (Tim Hassett)

External Funding Support: Ashland Chemical

New Project

c. Development of Whole Effluent Toxicity Implementation Guidance

Whole Effluent Toxicity (WET) tests are used to monitor the aggregate effects of toxicants through the exposure of sensitive aquatic organisms to wastewater effluent or receiving waters. These tests estimate the potential effects of discharge on the survival, growth and reproduction of endemic species and are used to determine compliance with the toxicity objectives established in the California's Regional Water Quality Control Plans (Basin Plans). The State Water Resources Control Board (SWRCB) is currently revising the toxicity control provisions established in the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (SIP). The proposed changes include statewide numeric objectives, and further standardization of WET provisions for National Pollutant Discharge Elimination System (NPDES) permittees and other applicable dischargers. Implementation of the new toxicity control provisions will require several types of technical support, such as adaptation of data analysis methods to west coast test species.

The goal of this project is to assist the SWRCB in developing training and technical guidance materials to support implementation of the revised WET policy. The project includes four main objectives: 1) obtain test performance data for WET species; 2) develop implementation guidance for application to stormwater discharge permits; 3) provide technical review of implementation documents; 4) assist with training on the new implementation methods.

This is the first year of a two-year project. The first year will include compilation of California test species data to support data analysis, method refinement, and the development of guidance for stormwater testing/implementation in coordination with the Stormwater Monitoring Coalition. Document review and training assistance will also be provided as needed.

Lead Investigator: Steve Bay (steveb@sccwrp.org)

External Funding Support: State Water Resources Control Board, Southern California Stormwater Monitoring Coalition (SMC)

3. Sediment Quality

Many chemical contaminants that enter coastal waters are deposited in sediment where they can accumulate to harmful concentrations and may adversely impact sediment-dwelling organisms, as well as fish and wildlife that consume contaminated prey. The assessment and management of sediment quality is an important component of many monitoring and regulatory programs. Because a number of complex sediment processes influence the bioavailability of contaminants to marine life, a multifaceted approach is needed to assess their impact on ecosystems and human and wildlife health. SCCWRP develops tools for the assessment of three key components that influence sediment quality: sediment chemistry, sediment toxicity, and benthic macrofauna community condition. This work has resulted in the development of new approaches for the interpretation of sediment quality data. For example, SCCWRP research led to inclusion of a three-part assessment framework in the State Water Resources Control Board's adoption of sediment quality objectives (SQOs), which are the first such criteria to be developed for any state in the nation.

The first three projects in this section of the Research Plan seek to provide guidance for the State on a multifaceted framework for assessing both the direct and indirect effects of sediment contamination in marine bays and estuaries. The next two will develop improved methods for identifying the cause of sediment toxicity. The last two relate to development of innovative techniques for sediment quality assessment through analysis of benthic communities.

a. Guidance for Implementation of a Sediment Quality Assessment Framework for Marine Bays

Marine bays in southern California are highly developed regions that support many uses, including recreation, commerce and shipping. These uses and their proximity to urban areas permit a wide variety of contaminant inputs, sometimes resulting in contaminated sediment. Environmental managers often need to evaluate the significance of sediment contamination as part of water quality assessments or sediment cleanup activities. Historically, those assessments have differed from project to project in which parameters were used and which thresholds were meaningful for each parameter. The State of California recently adopted sediment quality objectives (SQOs) for marine bays based largely on SCCWRP research. The SQO assessment framework integrates multiple lines of evidence (i.e., sediment chemistry, toxicity, and benthic infauna) to provide a stronger scientific foundation than only a single line of evidence would offer.

The State now faces the challenge of providing the training and guidance necessary for successful implementation of the SQO assessment framework. The goal of this project is to assist the State in developing such guidance materials.

This is the fourth year of a four-year project. The first three years focused on production of publications that provided the underlying scientific foundation for the SQOs. Several data analysis tools and workshops were also developed to provide training in use of the SQO methods. The fourth year will see continued activities to assist users of the SQO methodology, by providing additional training on assessment and stressor identification, and refinement of data analysis tools.

Lead Investigator: Steve Bay (steveb@sccwrp.org)

Collaborators: State Water Resources Control Board (Chris Beegan); numerous regulated, regulatory and non-governmental organizations

External Funding Support: State Water Resources Control Board

b. Development of a Sediment Quality Assessment Framework for Estuaries

Estuaries represent the interface between marine and freshwater habitats, adding a layer of physical complexity to sediment assessments. Sediment quality assessment tools developed for marine bay habitats may not be appropriate in estuaries for many reasons, such as different biological communities, salinity differences that affect the chemical form or bioavailability of contaminants, different types of contaminants, and different methods to measure toxicity. There has also been less sediment quality monitoring of estuaries as compared to marine bays. As a result, there is currently insufficient information available to support development of assessment tools. Such tools are needed, though, because the State of California intends to develop sediment quality objectives (SQOs) for estuaries.

The goal of this project is to develop a framework for assessing sediment quality in California's estuaries. The project consists of four major elements: 1) compiling data on estuarine sediment quality; 2) developing and calibrating methods for evaluating sediment contaminant exposure, toxicity, and benthic community alterations; 3) developing a framework for data integration and interpretation; and 4) developing guidance and tools to assist managers in conducting estuarine sediment quality assessments.

This is the sixth year of a six-year project. Previous work included the compilation of existing sediment quality data and analyses to identify the characteristics of estuarine benthic assemblages. This research also involved new surveys of sediment quality in the Sacramento and San Joaquin River Delta. Research during the fifth year focused on additional data analysis and development of methods for chemistry, toxicity, and benthic community data in two estuarine habitat types: the Sacramento and San Joaquin River Delta and the mesohaline portion of San Francisco Bay. Activities during the sixth year will include potential revisions of the SQO data integration framework to accommodate the new assessment tools, and development of user guidance and journal publications that describe the technical aspects of the methods.

Lead Investigator: Steve Bay (steveb@sccwrp.org)

Collaborators: State Water Resources Control Board (Chris Beegan), San Francisco Estuary Institute, numerous regulated, regulatory and non-governmental organizations

External Funding Support: State Water Resources Control Board

c. Framework to Assess Impacts from Sediment Contaminant Bioaccumulation

Sediment quality assessment tools developed to date by SCCWRP have focused on effects on organisms living in the sediment. Sediment contamination can also indirectly impact organisms that do not reside in sediments when they are exposed to sediment contamination through the food chain. Key targets for these effects are marine birds, fish, and humans. Bioaccumulation impacts to organisms consumed by humans and wildlife are often a driving factor in ecological risk assessments, especially with respect to impacts from DDTs, PCBs, and mercury. Still, the assessment of indirect effects due to sediment contamination is more complex and requires a different conceptual approach than that used to assess direct effects on benthic communities. The potential for indirect effects on an organism is influenced by several factors, including the fraction of sediment contaminants that are biologically available to prey species, the complexity of the food web, movements of the receptor organisms, food consumption rate, and species-specific variations in chemical sensitivity. No consistent framework exists among California's environmental management agencies to assess sediment quality with respect to these indirect impacts, limiting the ability of managers to fully and fairly evaluate sediment quality data.

The goal of this project is to develop an assessment framework based on a multiple line of evidence approach for evaluating the indirect effects of sediment contamination on human health. The project consists of three major elements: 1) developing a conceptual framework for data integration and interpretation; 2) developing bioaccumulation models and other tools for data analysis; and 3) evaluating the assessment framework for various case scenarios that represent a range of applications.

This is the fifth year of a six-year project. The development of a work plan and draft conceptual approach for the project, establishment of advisory and steering committees, and examination of case studies were conducted during the first three years. The fourth year focused on development of data analysis tools and evaluation of the framework and tools within selected scenarios. Research during the fifth year will include refinement of data analysis tools in response to external review, and preparation of guidance documents and journal publications that provide a technical foundation for the assessment methods.

Lead Investigator: Steve Bay (steveb@sccwrp.org)

Collaborators: State Water Resources Control Board (Chris Beegan), San Francisco Estuary Institute (Ben Greenfield), numerous regulated, regulatory and non-governmental organizations

External Funding Support: State Water Resources Control Board

d. Development of Toxicity Identification Methods for Current Use Pesticides

Identifying the specific constituents responsible for the toxicity observed in sediment toxicity tests is a complex task. Because most environmental samples contain mixtures of contaminants, conventional chemical analyses are rarely sufficient to identify the culpable constituents. Identification of the constituents responsible for toxicity is an important management endpoint for activities like site remediation, sediment quality objective compliance, and total maximum daily load establishment. Toxicity identification evaluation (TIE) refers to a sequence of laboratory investigations used to help determine the cause of toxicity. This sequence includes laboratory methods to first characterize the general classes of toxicants present (e.g., metals), then identify and confirm the specific constituents causing the effects (e.g., copper). Standardized characterization and identification methods are available for water samples, but fewer methods are available for sediments. Moreover, reliability and specificity of the sediment methods are poorly understood.

The goal of this project is to develop and refine toxicity identification methods for current use pesticides in marine sediments. This goal will be addressed through three types of activities: 1) method development studies with spiked water and sediment samples; 2) application of the methods to field sites containing toxic sediments; and 3) collaborative studies with other research institutions.

This is the fourth year of a four-year study. The first and second years focused on adapting existing methods for freshwater sediments and surface water to marine samples and investigate the utility of the methods with field samples. The third year included spiked sediment and water experiments to define threshold effect levels for legacy and current use pesticides, further refinement of TIE treatments for pesticides, and establishment of a statewide workgroup to improve collaboration and coordination of TIE development activities among research organizations. Research during the fourth year will include development of effect thresholds for additional contaminants, investigation of TIE methods for additional pesticides (e.g., fipronil), and development of guidance for stressor identification in marine sediments.

Lead Investigator: Steve Bay (steveb@sccwrp.org)

Collaborators: City of Los Angeles (Dr. Shokoufe Marashi, Dr. Gerald McGowen), San Francisco Estuary Institute (Sarah Lowe), and UC Davis Marine Pollution Studies Laboratory (Bryn Phillips)

External Funding Support: City of Los Angeles

e. Molecular Tools for Toxicity Identification Evaluation

The toxicity identification evaluation (TIE) process is used to determine the causal agents in sediment samples found to be toxic in laboratory tests. This process uses a variety of chemical/physical separation methods and treatments to remove one or more toxicant classes, coupled with toxicity testing following each manipulation. The time and cost associated with conducting a TIE in this manner can be substantial. These approaches have generally been successful in differentiating broad classes of toxicants in sediments, but less successful for identifying individual pollutants. Because sediment TIE approaches rely on acute toxicity testing, they are not applicable to sediments with low-level toxicity that causes sublethal effects. In addition, separation approaches cannot consider synergistic or antagonist effects associated with contaminant mixtures. For all these reasons, sediment TIEs (or other toxicant identification methods) are often not implemented, forcing environmental managers to rely on incomplete or inaccurate information to determine the constituents responsible for impaired sediment quality. Improved TIE methods are needed that can cost-effectively provide more detailed information applicable to a variety of contaminant types and concentrations. Recent advances in molecular biotechnology may allow development and application of such methods.

The goal of this project is to develop a new suite of TIE tools based on genomics (e.g., analysis of gene expression or protein production). This goal will be addressed through three types of activities: 1) gene sequencing and microarray development for marine invertebrates; 2) development of gene expression profiles for target contaminants; and 3) comparison of toxicant identification based on gene expression results to conventional TIE methods.

This is the second year of a five-year study. The first year completed preliminary sequencing of RNA from marine amphipods exposed to a variety of contaminant stressors, and developed a prototype microarray. Research in the second year will include development of a gene expression profiles for selected contaminants, and evaluation of the ability of gene expression analysis to correctly identify the type of toxicant in sediment samples.

Lead Investigator: Steve Bay (steveb@sccwrp.org)

Collaborators: Los Angeles County Sanitation Districts (Josh Westfall), San Francisco Estuary Institute, UC Davis (Brian Anderson), UC Berkeley (Dr. Chris Vulpe)

External Funding Support: Environment Canada, San Francisco Estuary Institute

f. Sediment Profile Imaging for Evaluating Benthic Community Condition

Benthic infauna are used extensively as indicators of sediment quality. However, traditional benthic assessments involve identifying and counting organisms, which is time-consuming and labor intensive. There is a shortage of trained taxonomists who identify and count benthic organisms, even as the demand increases because of regulatory programs like the State of California's Sediment Quality Objectives. Fewer new taxonomists are being trained, while many current taxonomists approach retirement.

The goal of this project is to investigate an alternate method of measuring benthic community condition: sediment profile imagery (SPI). The SPI is a field-deployed digital camera that captures cross-sectional images of soft-bottom environments. These images reveal important benthic morphology such as burrows, tubes of infaunal organisms, and the redox potential discontinuity.

This is the third year of a four-year study. The first year focused on data collection. Side-by-side comparisons between SPI and traditional benthic assessments were taken at 74 sites in Los Angeles Harbor, Long Beach Harbor, and San Diego Bay in coordination with the Bight '08 Regional Marine Monitoring Program. To assess the ability of SPI to track known gradients of impact, images were also collected at 39 sites near the mouth of Chollas Creek, an urban watershed in San Diego Bay that is the subject of contaminated sediment TMDL. During the second and third years, the images will be processed and the infaunal samples will be identified. The fourth year will focus on evaluating SPI performance.

Lead Investigator: Ananda Ranasinghe (anandar@sccwrp.org)

Collaborators: US EPA Office of Research and Development (Giancarlo Cicchetti), Bight '08 participating laboratories

External Funding Support: None at this time

g. DNA Barcoding for Assessing Benthic Infauna Communities

Assemblages of benthic species are used to assess environmental conditions. However, traditional methods for identifying and counting benthic infauna as indicators of sediment quality can be time-consuming and labor-intensive. This project addresses that challenge by examining a new molecular tool for rapidly identifying species within benthic community assemblages. DNA barcoding espouses the idea that all biological species can be identified using a short gene sequence from a standardized position in the genome – a "DNA barcode" – analogous to the black stripes of the Universal Product Code used to distinguish commercial products. The first step to barcoding is building a library of sequences from known reference specimens. After that, unknown specimens can be identified by 'looking up' their sequences in the reference library. Thus, building a library of benthic invertebrate species barcodes may enable rapid assessment of the species composition for benthic infauna samples, which can be interpreted to correspond with other benthic indices. Additionally, examination of barcode data will potentially reveal instances where a reassessment of morphologically-defined species is warranted, thus helping to clarify the catalog of benthic marine invertebrate species taxonomy for southern California.

The goal of our DNA barcoding project is to assess the efficacy of barcoding for rapidly identifying benthic invertebrate species in samples from the Southern California Bight. The project will involve three steps: 1) establish a DNA barcode reference library of vouchered reference specimens that have been identified using traditional taxonomic methods and have also been genetically sequenced to identify their unique genetic barcode; 2) develop protocols for sample processing, including suitable fixatives that do not degrade genetic material; and 3) determine how to correlate barcode data with quantitative environmental indices.

This is the second year of a three-year study. During the first year, partnerships were established with the Canadian Centre for DNA Barcoding (CCDB) and the USEPA to perform barcoding molecular analyses on voucher specimens provided by SCCWRP. Protocols were developed for sample collection, voucher specimen handling, molecular analysis, and data recording in the Barcode of Life Database (BOLD). During the second year we will focus on establishing the barcode reference library for benthic marine invertebrate species in the SCB.

Lead Investigator: Peter Miller (peterm@sccwrp.org)

Collaborators: US Environmental Protection Agency (Dr. Erik Pilgrim), Los Angeles County Sanitation District, Orange County Sanitation District, City of San Diego, Canadian Centre for DNA Barcoding

External Funding Support: None at this time

4. Emerging Contaminants

During the first three decades of SCCWRP's existence, much was learned about priority legacy pollutants such as DDT, PCBs, mercury and lead. Less is currently known about the sources, fates, and effects of newly developed chemicals, particularly those only recently manufactured and used in a widespread manner. These so-called "contaminants of emerging concern" (CECs) number in the thousands and can be classified into four major categories: pharmaceuticals and personal care products (PPCPs), current use pesticides (CUPs), natural and/or synthetic hormones, and industrial and commercial chemicals (ICCs). Examples of emerging contaminants are oxybenzone (active ingredient in sunscreen), fipronil (an insecticide used to combat termites and fire ants), ethinyl estradiol (active ingredient in birth control pills), and PBDEs (a flame retarding additive in electronics and clothing). Presence of these chemicals in the environment has not been extensively evaluated, often due to the lack of available measurement methods, and therefore the risk they pose is unknown. Limited studies suggest that some emerging contaminants can exert toxic effects at relatively low concentrations.

This year's Research Plan contains five continuing projects geared toward developing a better understanding of the occurrence and effects of emerging contaminants. Two of the projects are focused on development and application of CEC measurements while another two projects are focused on effects of CECs on resident biota. The last project helps provide technical guidance to managers on CEC issues for policy development.

a. Analytical Methods for Emerging Contaminants

The list of contaminants of emerging concern (CECs) is long and increasing. In most cases, though, levels of CECs found in the environment are very low (e.g., parts per billion or less). While existing analytical methods may be appropriate for some target compounds, standardized intercalibrated methods are not yet available for the vast majority of emerging contaminants. Another complicating factor is that a myriad of environmental toxicants are likely to co-occur in the environment. Sampling and analysis of these multiple chemical classes currently requires substantial expertise, cost, and labor. As a result, little to no effort has been taken to measure these constituents, or to match chemical concentrations with biological effects data.

The goal of this project is to develop and evaluate analytical methods for detection and quantification of specific classes of emerging contaminants in various matrices (e.g., water, sediment, and biological tissues) at environmentally relevant levels. The initial focus of this study will be on the more hydrophobic contaminant classes that accumulate in sediment and biological tissues, including pyrethroid pesticides and PBDEs. A secondary objective is to incorporate cost-effective passive sampling devices (PSDs) into these methodologies.

This is the third year of a five-year study. The first year resulted in the development and validation of analytical methods for pyrethroid pesticides and PBDEs in sediment and tissue samples. The second year resulted in the successful calibration of passive sampling devices for selected emerging contaminants, including pyrethroid pesticides. The third year will validate the developed methods via laboratory intercalibration comparisons and field trials, and will also evaluate the feasibility of incorporating additional analytical techniques, like advanced PSDs, to further improve the methods. One example might be supplementing SPME with electron capture negative ion mass spectrometry (ECNI-MS). Methods for additional classes of emerging contaminants will be developed during years four and five.

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Collaborators: United States Geological Survey (Kelly Smalling), Southern Illinois University (Dr. Michael Lydy), Loyola Marymount University (Dr. Rachel Adams), University of Southern California (Dr. James Haw), California State University Long Beach (Richard Gossett), National Institute of Standards and Technology (Dr. John Kucklick), San Francisco Estuary Institute (Dr. Susan Klosterhaus)

External Support: USC Sea Grant

b. Occurrence and Fate of Emerging Contaminants in Coastal Habitats

Recent studies have suggested that emerging contaminants in coastal regions of the SCB may affect wildlife. Sediment toxicity in embayments has been linked to the occurrence of current use pesticides (see *Development of Toxicity Identification Methods for Current Use Pesticides*), while levels of brominated flame retardants found in SCB wildlife are among the highest in the nation. Initial efforts to determine likely sources and/or causative chemical agents in each of these cases, though, have focused on regulated, “legacy” contaminants and have been largely inconclusive. A variety of factors have prevented measurement of these constituents in SCB ecosystems, particularly where they are matched with biological effects data (see *Analytical Methods for Emerging Contaminants*).

The goal of this project is to assess the input, occurrence, and levels of emerging contaminants throughout the SCB. This project will identify those classes of emerging contaminants that are being discharged into the marine environment, as well as those that persist and accumulate in sediments and biota. SCCWRP aims to gain a better understanding of the occurrence, relative source input, and potential for chemically mediated effects due to emerging contaminants in the SCB.

This is the fourth year of a five-year study. The first year identified and measured several classes of emerging contaminants in POTW effluent, receiving seawater, marine sediment and fish. The second year documented levels of PBDEs in marine mammal tissue collected from coastal locations throughout the SCB. The third year focused on documenting PBDE levels in sediment and fish tissue throughout the SCB. The fourth and fifth years will focus on targeted evaluation of the occurrence of high priority CECs, and examine the input history of emerging contaminants. This includes examination of alternative brominated flame retardants (BFRs) in dated sediment cores from the Palos Verdes Shelf and more recent contamination in surface sediments collected for the 2008 Bight Regional Monitoring Program.

Lead Investigator: Keith Maruya (keithm@sccwrp.org)

Collaborators: National Oceanic and Atmospheric Administration (Gunnar Lauenstein, Tony Pait, John Christensen), United States Geological Survey (Dr. Edward Furlong), University of California Riverside (Dr. Daniel Schlenk), California State University Long Beach (Richard Gossett), Southern Nevada Water Authority (Dr. Shane Snyder), Mississippi State Chemistry Lab (Dr. Kevin Armbrust), Bight'08 Regional Monitoring participants

External Funding Support: State Water Resources Control Board, David and Lucile Packard Foundation

c. Emerging Contaminant Effects on Coastal Fish

A variety of CECs have been found on the coastal shelf and in embayments of the Southern California Bight. Some CECs can disrupt the endocrine system of non-target organisms after being released to the environment, since they mimic or interfere with the action of reproductive hormones such as estrogen or testosterone. In the SCB, indicators of estrogen exposure such as egg yolk protein production and egg development in male flatfish on the coastal shelf have been observed, but the cause and significance of these effects is unknown. Virtually no information is available on endocrine disruption in embayment and/or wetland fish species. Moreover, little is known about the background levels and natural variability of these biological responses, making it difficult to determine the environmental significance of endocrine disruption due to emerging contaminants.

The goals of this project are to: 1) determine which groups of emerging contaminants fish are exposed to; 2) determine whether coastal and wetland fish show evidence of endocrine disruption or other impacts associated with emerging contaminant exposure; and 3) determine whether effects on fish are associated with POTW effluent or nonpoint source discharges.

This is the sixth year of a six-year study. In the first four years, methods were developed to assess endocrine disruption and other biological effects by measuring vitellogenin, hormones, and gonad condition. Preliminary experiments were also conducted to construct and validate a gene microarray (see also *Molecular Tools for Assessing Contaminant Exposure and Effects*) and field studies were initiated to measure the effects of endocrine response in flatfish living near POTW outfalls. Laboratory exposures of fish to POTW effluent were conducted. Field sampling to determine baseline conditions in reference flatfish and to investigate CEC effects in wetlands were also conducted.

Sample and data analyses from a coastal shelf field study were completed in the fifth year. Research in the sixth year will focus on data analyses to compare responses among habitats and species, along with publication of findings.

Lead Investigator: Steve Bay (steveb@sccwrp.org)

Collaborators: Sanitation Districts of Los Angeles County (Joe Gully), Orange County Sanitation District (Dr. Jeff Armstrong), City of San Diego (Dr. Tim Stebbins), City of Los Angeles (Curtis Cash), City of Oxnard (Scott Johnson), University of California San Diego (Dr. Michael Baker), University of California Riverside (Dr. Dan Schlenk), University of California Davis (Dr. Gary Cherr), California State University Long Beach (Dr. Kevin Kelley), Ocean Institute, 2008 Bight Regional Monitoring participants

External Funding Support: Sanitation Districts of Los Angeles County, Orange County Sanitation District, City of San Diego, City of Los Angeles, EPA Region IX, Regional Water Quality Control Board 8, State Water Resources Control Board

d. Molecular Tools for Assessing Contaminant Exposure and Effects

Several indicators of endocrine disruption, including elevated vitellogenin and atypical hormone concentrations, have been detected in male fish collected from areas near large POTWs (see project *Emerging Contaminant Effects on Coastal Fish*). However, it is not known whether the observed effects are caused by legacy contamination, ongoing effluent and/or nonpoint discharges of emerging contaminants, other factors, or a combination thereof. Both the source and identity of the endocrine disrupting compounds (EDCs) need to be determined before appropriate management actions can be taken. Unfortunately, the tools for determining the nature and source of contaminant exposure are limited and expensive. Rapid advances in biotechnology have resulted in new tools that have the potential to measure changes in gene expression using microarray technology to investigate the response of organisms to environmental stressors. These gene microarrays may provide a rapid and comprehensive evaluation of an organism's response to contaminants.

The goal of this project is to develop and apply a gene microarray tool for investigating contaminant exposure and identifying impacts on sentinel organisms in the coastal marine environment. This project is comprised of four tasks: 1) develop and refine microarrays for use with southern California fish species; 2) compare gene expression measurements to other environmental assessment methods; 3) investigate the correspondence between molecular changes (e.g., gene expression, endocrine disruption) in fish to exposure from POTW effluent or nonpoint (runoff) discharges; and 4) develop molecular tools for other sentinel species.

This is the fourth year of a five-year study. Research in the first three years focused on developing a targeted gene microarray for use with multiple species of fish. This microarray was used to analyze liver gene expression in fish collected from offshore POTW-influenced sites, wetlands, reference sites, and also fish exposed to POTW effluent in the laboratory. Research in the fourth year will continue data analysis of the gene expression results in order to compare results between species, exposure types, and biological endpoints. Development of a more comprehensive high density microarray for flatfish will also be initiated.

Lead Investigator: Steve Bay (steveb@sccwrp.org)

Collaborators: UC San Diego (Dr. Michael Baker), UC Riverside (Dr. Dan Schlenk), UC Davis (Dr. Gary Cherr), CSU Long Beach (Dr. Kevin Kelley), Sanitation Districts of Los Angeles County (Joe Gully), Orange County Sanitation District (Dr. Jeff Armstrong), City of San Diego (Dr. Tim Stebbins), City of Los Angeles (Curtis Cash)

External Funding Support: EPA Region IX, Regional Water Quality Control Board 8, Regional Water Quality Control Board 4, Sanitation Districts of Los Angeles County, Orange County Sanitation District, City of San Diego, City of Los Angeles

e. Science Advisory Panel for the State of California

In early 2009, the State Water Resources Control Board adopted their Recycled Water Policy, part of which addresses constituents/contaminants of emerging concern (CECs). Since regulatory requirements for protection of human and ecological health must be based on the best available peer-reviewed science, the Policy mandated the convening of an expert advisory panel to assess the current state of scientific knowledge regarding CEC risks to the general public and the environment. Among the specific issues to be addressed by the panel are questions such as: “what are the appropriate constituents to be monitored in recycled water?”, “what toxicological information is available for these constituents?”, and “what levels of CECs should trigger enhanced monitoring in recycled, ground, or surface waters?” Recommendations by the expert panel will be used by the Water Board and the California Department of Public Health (CDPH) to make informed policy decisions on CEC issues. Since many of the same questions are germane to coastal and marine waters that receive treated wastewater effluent and stormwater discharges, a similar approach was initiated in late 2009 to inform future management decisions for the ambient environment.

The goal of this project is to recruit, convene, and support a panel of scientific experts that can provide the State with recommendations for addressing CEC issues associated with recycled water applications, as well as coastal and marine systems. To accomplish this, the panel will utilize state-of-the-science information to make recommendations. SCCWRP will collate and synthesize these for the Water Board, CDPH, and the California Ocean Protection Council in two written reports (one each for the Recycled Water Policy and Coastal and Marine Ecosystems) and will address and respond to comments from peer reviewers and the public.

This is the second year of a three-year project. The first year focused on engaging the panel members in a series of meetings to introduce and address the Recycled Water Policy and ambient environment issues. The second year will focus on formulation and documentation of the Panel recommendations for the Recycled Water Policy. The third year will focus on formulation and documentation of recommendations for coastal and marine ecosystems.

Lead Investigator: Keith Maruya (keithm@sccwrp.org)

Collaborators: State Water Resources Control Board (John Bishop, Frederick Moss), Ocean Protection Council (Dr. Amber Mace), David & Lucile Packard Foundation (Dr. Kai Lee), and the panel members: NOAA (Dr. Tracy Collier), University of Florida (Dr. Nancy Denslow), Colorado School of Mines (Dr. Jörg Drewes), EOA, Inc. (Dr. Adam Olivieri), UC Riverside (Dr. Daniel Schlenk), AMEC Earth and Environmental (Dr. Paul Anderson), Total Environmental Solutions, Inc. (Dr. Shane Snyder)

External Funding Support: State Water Resources Control Board, David & Lucile Packard Foundation

B. NUTRIENTS

Nutrient over-enrichment is one of the leading causes of impairment to water bodies in the United States. Excessive nutrient loading causes eutrophication, which is an increase in the production of organic matter in the form of algae and aquatic plants. The direct effects of eutrophication may include harmful algal blooms, a decrease in aquatic species diversity, hypoxia (low dissolved oxygen levels), poor aesthetics, odor, altered food webs, and loss of critical habitat. In coastal areas, the upstream ecological changes caused by nutrient enrichment can have far-reaching consequences downstream, such as lowered fishery production, loss or degradation of seagrass and kelp beds, smothering of benthic organisms, nuisance odors, and impacts on human and marine mammal health. Though eutrophication may create significant economic and social costs, the extent and magnitude of eutrophication has not been well characterized in southern California aquatic ecosystems. Data gaps exist with respect to identification and estimation of nutrient loads from various sources. Unlike most sediment contaminants that transform slowly, nutrients are dynamic, changing forms rapidly and transferring between media (i.e., sediments, water, air) with numerous mechanisms for active biological uptake and release. Likewise, the factors that control the biological response to high nutrient loads are not well understood.

SCCWRP has developed a research agenda that addresses these data gaps by studying both nutrient dynamics and algal responses, as well as developing assessment tools and models to improve eutrophication management. In addition, research on the extent of eutrophication and its causal factors will help define critical pathways that regulators can use for controlling nutrient-related impacts. Ultimately, this research should aid policy-makers in developing critical nutrient threshold levels for restoring and maintaining healthy ecosystems.

This portion of the Research Plan features five projects. The first looks at nutrient-algae relationships in streams, while the second focuses on understanding eutrophication processes in lagoons. The third project addresses nutrient loading contributions from atmospheric deposition in southern California. The fourth is targeted at developing a new assessment tool for judging the degree of eutrophication based on periphyton communities. The last involves science to support regulatory nutrient criteria.

a. Technical Support for Development of Nutrient Numeric Endpoints in California Estuaries

The California State Water Resources Control Board (SWRCB), EPA Region IX, and SCCWRP previously finalized a technical approach and framework for developing numeric nutrient endpoints (NNEs) for California estuaries. This approach is based on two fundamental principles: 1) biological response indicators provide a more direct risk-based linkage to beneficial uses than nutrient concentrations alone; and 2) a weight of evidence approach with multiple indicators will produce NNEs with greater scientific validity. Current candidate indicators for numeric endpoint development include dissolved oxygen, a range of primary producer variables, such as macroalgal and microalgal biomass, nuisance submerged aquatic vegetation, toxin-forming harmful algal blooms, and general indicators such as water clarity, poor aesthetics and/or odors. While this conceptual approach provides a sound platform for achieving NNEs, there are several data gaps that need to be filled before NNEs become a reality. Most importantly, scientists need to define the linkage between nutrient loading, primary production, and impacts to the management endpoints of concern. Without the knowledge of linkages between the major stressor-response components of estuaries at risk for eutrophication, it is impossible to develop the predictive tools necessary to manage and regulate water quality.

The goal of this project is to address the data gaps that preclude a better understanding of nutrient loading and biogeochemical cycling, as well as primary producer extent and distribution in California estuaries. This research will: 1) support the development of consistent statewide standards; 2) provide clear linkages between science-based criteria and impacted estuarine beneficial uses; and 3) provide regionally-specific data for better-performing models to help manage eutrophication.

This is the third year of a four-year study. The first year focused on creating technical teams, initiating stakeholder advisory groups, reviewing the conceptual framework and work plan, and developing detailed study plans to guide technical support activities, including support of the Bight '08 Eutrophication Assessment. Year two focused on identifying a target population of estuaries, proposing a classification scheme, conceptual model development, and conducting reviews of literature to support indicator selection. Year three will be dedicated to synthesizing information to create an assessment framework, conducting a study to quantify the impacts of macroalgae on benthic infauna, and summarizing available information (i.e., numeric endpoints for dissolved oxygen and other indicators) for the SWRCB and advisory groups to review and select.

Lead Investigator: Martha Sutula (marthas@sccwrp.org)

Collaborators: State Water Resources Control Board, EPA Region IX, UC Davis (Dr. John Largier), UCLA (Dr. Peggy Fong), EPA Office of Research and Development (Dr. Naomi Dettenbeck, Dr. Jim Kaldy), 2nd Nature (Dr. Nicole Beck), Entrix Corp. (Dr. Camm Swift), San Francisco Estuary Institute (Dr. Lester McKee)

External Funding Support: State Water Resources Control Board

b. Development of a Periphyton Bioassessment Tool for Southern California Streams

As primary producers, algae occupy the base of aquatic ecosystem food webs and are therefore a crucial component of healthy, highly functional streams. There are many factors that control algal growth, distribution, and community composition, such as exposure to light, water temperature, current speed, water chemistry, presence of grazers, substrate types, and channel morphology. Therefore, changes to a multitude of anthropogenic and natural factors can affect streams, as mediated through algae. Many southern California streams exhibit modified hydrology, are channelized, and are devoid of natural canopy. Such factors can contribute to excessive algal growth that, in turn, may impact many beneficial uses. Because of complex factors that influence algal growth in the variety of stream types and environmental conditions in California, causal relationships among these factors are not fully understood. An enhanced knowledge of stream algal dynamics can help with developing the tools necessary to determine when algal communities transition from their role as important components of a healthy ecosystem to that of a threat to beneficial uses.

The goal of this project is to produce tools utilizing benthic soft-bodied algae and diatom (collectively called “periphyton”) assemblages for bioassessment of stream condition, anthropogenic disturbance, and nutrient impairment. This will be accomplished by: 1) compiling a data set of algal assemblage, water chemistry, physical habitat, and landscape parameters for southern California coastal streams across condition gradients; and 2) using this dataset to develop a Periphyton Index of Biotic Integrity (PIBI). Ultimately, the PIBI will be transferred to managers and practitioners through release of the user support materials, training workshops, and demonstration of its application in a watershed survey.

This is the third year of a three-year project. The first and second years were focused on developing protocols for periphyton collection, field sampling, and laboratory processing to begin creating a robust nutrient/periphyton reference dataset. In addition, during the second year, work began on developing comprehensive taxonomic resources for PIBI end-users, including a guide to regional flora of diatoms and soft-bodied algae, a georeferenced photo-library of specimens, and taxonomic keys. The third year will focus on developing and screening candidate metrics and testing combinations into a draft PIBI.

Lead Investigator: Betty Fetscher (bettyf@sccwrp.org)

Collaborators: University of Colorado (Dr. Patrick Kociolek), California State Universities at San Marcos (Dr. Robert Sheath) and Monterey Bay (Dr. Marc Los Huertos)

External Funding Support: State Water Resources Control Board

c. Investigation of Algal Nuisance and Relationships with Nutrient Sources in Rainbow Creek and the Santa Margarita River Watershed

The presence of nuisance algae in Southern California streams can alter water chemistry parameters such as dissolved oxygen and pH, and also lead to taste/odor problems and the production of algal toxins. All of these factors can adversely affect stream biota, impact aquatic life, and affect recreational beneficial uses. Management of eutrophication and nuisance algae requires an understanding of the factors controlling algal response to nutrient loads. While algal biomass is limited by nitrogen and/or phosphorus, it is also influenced by light availability, recent scour, and herbivory. To account for the relationships between ambient nutrient concentrations and algal nuisance, the US EPA has begun creating a Nutrient Numeric Endpoint (NNE) framework. The NNE framework utilizes “benthic biomass spreadsheet tools” relating ambient nutrient concentrations to algal biomass, while accounting for stream physical factors such as flow velocity and canopy cover. However, opportunities to validate the benthic biomass spreadsheet tool have been limited, particularly in arid regions such as southern California. Another important component of addressing nuisance algae is identifying and tracing specific nutrient sources to impaired waterbodies. In any given system, there can be multiple point and non-point sources of nutrients; nutrients may also be cycled *in situ*. Stable isotopes of key elements, such as ^{14}N and ^{15}N, show promise as a means to track nutrient sources and cycling. Different substrates (e.g., soil nitrogen, atmospheric nitrogen, chemical fertilizers, manure, and sewage) have unique isotopic signatures, much like fingerprints, that can potentially be used to identify the sources of nutrients to aquatic systems.

The Santa Margarita River watershed provides a valuable opportunity to study relationships between nutrient sources and algae. Rainbow Creek, in particular, contains a variety of land-use types including agriculture, residential development, nurseries, and golf courses. Data from this study will provide a means of validating the NNE spreadsheet tool in our region, and will also shed light on the utility of stable isotope geochemistry tools for nutrient source tracking and TMDL development, refinement, and implementation. The goals of this project are to: 1) establish a reference data set of nutrient concentration-algal response for Rainbow Creek and selected other reaches within the Santa Margarita River (SMR) watershed, 2) validate the NNE spreadsheet tool against this and related datasets, and 3) identify the isotopic composition of nitrate, ammonium, and phosphate sources into the sampling reaches for this study and begin to trace sources and transformation processes.

This is the first year of a three-year project. The first year will focus on developing a project study design, identifying sites, and initiating field sampling.

Lead Investigator: Betty Fetscher (bettyf@sccwrp.org)

Collaborators: UC Santa Cruz Institute of Marine Sciences (Dr. Adina Paytan)

External Funding Support: County of San Diego

d. Quantifying the Role of Sediments in Nutrient Cycling in Southern California Lagoons

Southern California estuaries and lagoons are heavily influenced by their urbanized watersheds. Watershed runoff, coupled with reduced tidal influence from restricted inlets, has resulted in nutrient-related impairments in many systems, like excessive algal growth and low dissolved oxygen. Most existing management strategies focus on nutrient inputs during the growing season (i.e., summer dry weather inputs) because that is when eutrophication effects are most noticeable. Recent SCCWRP research, however, has indicated that sediments represent an important (sometimes primary) nutrient loading input during the growing season. Sediment nutrients are deposited following storm events and re-suspended during the summer, providing a continuous nutrient source for algal blooms. This two-part cycle that disconnects inputs from effects is just one example of several potential pathways that complicate management of southern California estuaries (see project *Technical Support for Development of Nutrient Numeric Endpoints in California Estuaries*).

The goal of this project is to further understand the mechanisms and processes that control nutrient cycling in southern California lagoons. While previous SCCWRP research has indicated that sediment can be a particularly important pathway in some systems, differences in inputs, hydrology, and estuarine morphology preclude extrapolation to all estuaries. Ultimately, the goal is to extend this research to build dynamic computer simulation models that will link various sources of nutrients (including sediments) with algal growth, algal biomass, and dissolved oxygen within lagoons.

This is the fourth year of a four-year project. The first year focused on development of a conceptual framework to guide the collection of monitoring and special studies data. Year two focused on field sampling and data analysis. The third year focused on interpretation of data for model development. The fourth year will involved final reporting, facilitation of a stakeholder group discussion identifying important management endpoints, and technical support for model development in the Loma Alta Slough TMDL.

Lead Investigators: Martha Sutula (marthas@sccwrp.org)

Collaborators: University of California Los Angeles (Dr. Peggy Fong), Louisiana State University (Dr. Jaye Cable)

External Funding Support: San Diego Regional Water Quality Control Board

e. Validation of Measurement Techniques for Quantifying Atmospheric Nutrient Deposition

While previous SCCWRP research has shown that atmospheric deposition can be a large source of trace metals to southern California watersheds, virtually no data exists on atmospheric deposition of nutrients and its contribution to water quality impairments in this region. One reason for the lack of data is that there are no standardized techniques for direct measurement of atmospheric nutrient deposition. Inferential methods, which have been frequently used in other regions, are both expensive and time-consuming. Surrogate surfaces offer a simple, inexpensive method for direct measurement of atmospheric nutrient deposition, but they have not been tested in the semi-arid conditions of southern California.

The goal of this project is to provide a reliable measurement technique for atmospheric nutrient deposition in southern California. Establishing sound measurement techniques is a first step to characterizing and understanding the impact of atmospheric nutrient deposition on water quality in southern California. This will be accomplished by refinement and comparison of surrogate surface methods against more standardized inferential methods to estimate atmospheric nutrient deposition.

This is the second year of a two-year project. The first year focused on method development and validation in order to refine surrogate surface sampling techniques for atmospheric nutrient deposition, especially as it applies to our semi-arid climate. The second year will focus on filling data gaps by measuring atmospheric nutrient deposition in multiple locations in southern California, in order to estimate the annual load to critical waterbodies of southern California.

Lead Investigator: Ken Schiff (kens@sccwrp.org)

Collaborators: Bight'08 Water Quality participants

External Funding Support: San Diego Regional Water Quality Control Board

C. STORMWATER

Watershed development can affect urban runoff, and ultimately receiving waters, in many ways. Some of this effect can be attributed to hydromodification, where increased watershed imperviousness results in increased runoff volume and higher peak flows. Hydromodification can cause stream bank erosion, alteration of aquatic habitats, and impacts to stream biota. Urbanization also tends to introduce a greater number of potential pollutant sources to the watershed, which are more easily introduced into waterways since impervious surfaces inhibit filtering of the accumulated pollutants through soils.

Dynamic computer simulation models are often used by stormwater managers to evaluate potential control strategies, including TMDL development and BMP implementation. These models rely on an understanding of the mechanisms that affect stormwater hydrology and the associated constituent loading. Knowledge of these factors helps managers pinpoint the most effective control strategies for the locations and times periods of greatest risk. SCCWRP has placed great emphasis over the last decade on sampling stormwater runoff from dozens of sites over a variety of storm conditions. These data have been used to calibrate and validate watershed models, while other studies have helped to quantify factors such as erosion potential for different stream types, pollutant build-up and wash off, and particle size distributions and pollutant fractionation in runoff. The goal of SCCWRP's stormwater research program is to enhance understanding of the processes associated with stormwater runoff, and to develop tools that can be used by managers to guide decisions about stormwater management.

This year's Research Plan contains three areas of emphasis. These projects deal with the effect of particle sizes on pollutant transport, the effects of fires on storm runoff, and development of tools to characterize hydromodification risk for management purposes.

a. Dynamics and Partitioning of Stormwater Particles

Stormwater is known to contain high levels of several contaminants of concern, including metals and organic compounds. Most of these constituents are preferentially associated with specific particle size fractions. Moreover, particle density and size distribution can change dramatically over the course of a storm. The dynamics of metal and organic contaminants associated with various particle sizes over the course of a storm have not been well described in southern California or elsewhere. Such information would allow managers to link particle-associated contaminant sources to estuaries, where they may settle out and degrade sediment quality. It also promotes development of watershed models that accurately predict particle loading and associated contaminants for use in BMP design.

The objective of this project is to characterize the particle size distribution within stormwater discharge and to quantify the differential partitioning of pollutants of concern to various particle size fractions.

This is the fourth year of a four-year project. During the first year, SCCWRP scientists focused on developing and testing methods for continuous quantification of particle size distributions in stormwater. During the second year, the method was finalized and field-validated. During the third year, the methods were applied to begin evaluating stormwater particle dynamics and pollutant partitioning to specific particle size fractions. This effort will conclude this year with additional field sampling and analysis.

Lead Investigator: Eric Stein (erics@sccwrp.org)

Collaborators: Loyola Marymount University (Dr. John Dorsey), California State University Long Beach (Richard Gossett)

External Funding Support: None at this time

b. Effects of Regionwide Fires on Deposition, Runoff, and Emissions to the SCB

Fire is a natural component of Mediterranean ecosystems, such as those found in southern California. Due to loss of plant cover, severe burns have been shown to increase runoff and sediment generation to downstream areas. Constituents associated with the increased runoff have the potential to affect water quality in downstream receiving waters and the near-shore coastal environment. This may be especially problematic for streams that are already impaired. Most research on post-fire water quality has focused on nutrient and sediment enrichment in relatively natural areas. However, post-fire runoff also has the potential to increase loadings of carbon, organic compounds such as PAHs, and trace metals. Constituent loadings may occur by several mechanisms over a range of spatial and temporal scales. Potential loading mechanisms include direct runoff, debris flows, or atmospheric deposition of ash followed by storm runoff. Investigating the magnitude and duration of fire effects in downstream and/or adjacent watersheds is critical to accounting for its influence on cumulative water quality impacts and attaining water quality standards.

This goal of this project is to investigate the fate of water quality constituents resulting from southern California wildfires in order to quantify the effects of post-fire runoff on downstream metals and organic constituent concentrations and loads. Both direct effects of runoff from burn areas and indirect effects associated with ash fallout will be investigated as part of this project.

This is the third year of a three-year project. The first year focused on monitoring of burned and unburned watersheds to begin assessing the relative contribution of post-fire runoff to downstream constituent loading. During the second year, a workshop was convened to synthesize the science on contaminant loading associated with fires, and to develop a regional post-fire water quality response plan. This year’s work will include additional data collection and initial implementation of the post-fire water quality monitoring program.

Lead Investigator: Eric Stein (erics@sccwrp.org)

Collaborators: Southern California Stormwater Monitoring Coalition, Los Angeles County Flood Control District

External Funding Support: None at this time

c. Assessment and Management of Hydromodification Effects

The process of urbanization has the potential to affect stream courses by altering watershed hydrology. Development and redevelopment can increase the amount of impervious surfaces on formerly undeveloped landscapes. This reduces the capacity of the remaining pervious surfaces to capture and infiltrate rainfall so that, as a result, a larger percentage of rainfall becomes runoff during any given storm. In addition, runoff reaches the stream channel much more efficiently, so peak discharge rates post-development are higher compared to pre-development for an equivalent rainfall event. This phenomenon is termed hydromodification.

The goal of this project is to develop a series of tools supporting implementation of hydromodification management measures that could be used to better protect the physical, chemical, and biological integrity of streams and their associated beneficial uses. This project will provide tools to answer the following questions: 1) Which streams are at the greatest risk of hydromodification effects? 2) What are the anticipated effects in terms of increased erosion, sedimentation, or habitat loss with increases in impervious cover? 3) What are some potential management measures that could be implemented to offset hydromodification effects and how effective are they likely to be?

This is the fourth year of a five-year project. The first two years focused on collection of geomorphic data from a range of stream sites. During the third year screening tools were developed to rank the relative susceptibility of streams to hydromodification effects. This year will focus on development of predictive model-based tools to assess expected stream channel response to hydromodification, and development of a framework for regional monitoring and assessment of hydromodification management efforts.

Lead Investigator: Eric Stein (erics@sccwrp.org)

Collaborators: Colorado State University Fort Collins (Dr. Brian Bledsoe), Southern California Stormwater Monitoring Coalition (SMC), Stillwater Sciences (Dr. Derek Booth)

External Funding Support: State Water Resources Control Board

D. WETLANDS

Southern California's wetland and riparian areas have experienced dramatic losses over the last two hundred years, estimated at greater than 90% of the historical extent. As a result, approximately 19 state and federal agencies, as well as many local and non-profit organizations, sponsor programs aimed at conserving and managing wetlands. Implementation and coordination of these programs, though, is complicated by lack of basic information on the extent, distribution, and condition of both historical and contemporary wetlands. Further barriers are presented by the lack of standardized mapping and assessment tools that are necessary to compile such data.

SCCWRP's wetlands research has included efforts to map the present extent and condition of wetlands throughout California, allowing managers to both assess the degree of wetland loss or impairment and monitor future changes. Along these same lines, SCCWRP scientists have examined historical data in order to aid managers in designing of effective wetland restoration strategies. Research into scientific modeling applications uses an understanding of wetland processes to model and predict the effects of future changes in variables like climate forcing. Models can be used to design approaches for current wetland protection and to prevent future wetland loss.

The first part of this section investigates historical and future coastal wetland condition. The second element focuses on wetland regional monitoring to provide the information needed to track wetland conditions on a large scale and support management efforts.

1. Wetland Ecology

Successful protection and management of southern California's wetlands relies on a scientific understanding of wetland conditions. Some of the key tools used to fill this need include standardized condition assessment protocols, mapping, and project tracking. In addition, wetland studies that look at both past conditions and likely future conditions provide valuable context for effective wetland management planning. Historical analyses allow managers to recognize the mechanisms of past wetland decline, illuminate potential landscape constraints, and provide templates for future restoration. Investigation into future conditions helps to ensure that the resources spent on wetland restoration and conservation will not be misdirected.

SCCWRP's current wetland ecology research includes two continuing projects. The first deals with historical examination of wetland areas in coastal watersheds, and the second looks toward the future, asking how climate forcing will affect southern California's coastal wetlands.

a. Historical Ecology of Coastal Watersheds

The overall goal of this project is to provide new understanding about baseline conditions of streams and wetlands in the Ballona Creek, Ventura River, and Santa Clara River watersheds based on information from the mid- to late-19th century through the early 20th century. This information is not readily accessible to environmental managers, scientists, and the public at present, but could answer a range of key questions about the restoration potential of each watershed, such as where to leave streams accessible to daylight, or how to lay out a landscaping palette of native vegetation for restoration projects. This project requires the acquisition, georeferencing, digitizing, and interpretation of historic coastal topographic maps (t-sheets). However, much more information is also gathered to help fill in data gaps, cross-reference facts, and make estimations for interim time periods. Specifically, information on wetland and riparian habitat is needed, especially in relation to natural events and management activities within the watershed, such as floods, fires, agriculture, channel modifications, and water diversions and impoundments.

The goals of this project are to develop a framework and infrastructure for compiling sentinel data sets on historic condition, and to use these data to evaluate how the distribution of wetlands has changed over time, specifically in response to key changes in land use or stream management. The changes to be examined include distribution of wetland and riparian habitat in the watershed during the period from 1850-1910, structure and composition of riparian habitat, riparian structure of the floodplain in wet vs. dry years, and spatial distribution of wetland and riparian vegetation community types and wildlife species.

This is the third year of an ongoing watershed historical ecology program. Previously, a historical analysis was completed for the San Gabriel River. This year will focus on the lower Ventura River, lower Santa Clara River, and Ballona Creek watersheds.

Lead Investigator: Eric Stein (erics@sccwrp.org)

Collaborators: San Francisco Estuary Institute (Robin Grossinger), California State University Northridge (Dr. Shauna Dark), University of Southern California (Dr. Travis Longcore), Santa Monica Bay Restoration Commission (Dr. Shelley Luce), Stillwater Sciences (Dr. Peter Downs)

External Funding Support: Santa Monica Bay Restoration Commission, Coastal Conservancy, US Fish and Wildlife Service

b. Effect of Climate Change on Coastal Wetland Extent and Distribution

The 2007 Intergovernmental Panel on Climate Change Assessment Report estimates that mean temperatures will increase by 2-4°C over the next 100 years. Associated with this temperature rise, increases in mean sea level between 20 and 60 cm are expected. The US Geological Survey (USGS) estimates that the area between Point Conception and the Mexican Border is at high to very high risk of adverse effects of sea level rise. In addition to sea level rise, global warming is also expected to affect rainfall-runoff patterns, with trends toward increased annual river runoff in the wintertime. Concern over the expected effects of global climate change and resultant sea level rise have led coastal countries and states, including California, to begin developing management plans to address expected future changes. Almost all of these planning efforts focus on an assessment of risks to populations and infrastructure associated with erosion and flooding from sea level rise. However, relatively little attention has been paid to the effects of global climate change on the extent and distribution of coastal wetlands. This gap is particularly noteworthy given the large investment, both past and planned, in coastal wetland restoration.

The goal of this project is to address the anticipated effects of global climate change on the extent and distribution of southern California's coastal wetlands. Specifically, SCCWRP will assess how climatic forcing from both the ocean and terrestrial side of coastal wetlands may affect a range of wetland types that exist in a variety of physiographic and development settings. This project will build on previous work on global climate change by USGS, US Global Change Research Program, Synthesis and Upscaling of Sea-Level Rise Vulnerability Assessment Studies, and the Federal Emergency Management Agency. In addition, it will leverage studies of historic and contemporary wetland extent by SCCWRP and the San Francisco Estuary Institute to provide ecological context for assessing change. Although focused on southern California, the long-term objective of this study is to develop an approach that can be expanded to answer similar questions about expected change in coastal wetlands throughout California.

This is the second year of a two-year project. The first year focused on summarizing the literature and developing the initial framework for the watershed and estuary models. The second year will focus on application of the models to assess several potential future climate scenarios.

Lead Investigator: Eric Stein (erics@sccwrp.org)

Collaborators: University of California Los Angeles (Dr. Terry Hogue), NOAA Center for Coastal Ocean Research (Carol Auer), Southern California Wetland Recovery Project

External Funding Support: State Water Resources Control Board

2. Regional Wetland Assessments

SCCWRP collaborates with a number of different organizations to improve regional wetland assessment in southern California. Monitoring programs are essential to provide an understanding of current wetland extent and condition, as well as trends over time. Another benefit of monitoring is the ability to evaluate the efficacy of changing management activities. In 1997, several agencies involved with wetland stewardship formed the Southern California Wetland Recovery Project (WRP) with a goal of increasing regional coordination of wetland preservation, restoration and management. The WRP (working in concert with local governments, environmental organizations, and scientists from SCCWRP and other agencies) aims to develop and implement a comprehensive plan for preserving and restoring the region's wetlands.

The current research agenda focuses on application of recently developed wetland assessment tools to various wetland monitoring programs. The first project will improve systematic monitoring of wetlands across the state. The second project under this section focuses on southern California. The last seeks to develop a network of reference sites for targeted classes of coastal wetlands. Reference sites are often used as a component of monitoring programs, offering a valuable point of comparison to distinguish natural from anthropogenic effects.

a. Status and Trends in the Extent of California's Wetlands

Billions of dollars have been invested over the last 20 years into the protection and restoration of wetlands and riparian areas in California. The effectiveness of these investments is uncertain, though, because California's wetlands are not systematically monitored. The existing State Wetland Inventory system is inadequate for several reasons: 1) patchwork base imagery dates and resolutions, 2) inaccuracy of mapping with limited ground-truthing, and 3) cost of comprehensively mapping the state with sufficient frequency to provide an up-to-date analysis of trends. Acknowledging these difficulties, the US Fish and Wildlife Service National Wetland Inventory (NWI) adopted a probability-based survey approach to assess trends in wetland acreage on a national level. According to the new system, wetlands within a statistically sampled four square-mile grid will be mapped with remote sensing data in combination with an adequate degree of ground-truthing, in order to determine the degree of recent wetland change (presented as "status and trends (S&T) plots"). Because of improved resolution in mapping, trends in wetland change can be detected earlier. The new S&T design is currently being incorporated into the EPA's 2011 National Wetland Condition Assessment (NWCA). The 2011 NWCA presents an opportunity for California to further the investment in probability-based assessments of wetland extent and condition by: 1) intensifying the number of S&T plots in California, and 2) conducting an intensification of assessment of wetland condition consistent with NWCA methodologies.

The goal of this project is to increase state capacity for implementing a probability-based approach for monitoring the status and trends in wetland extent and condition. Specific tasks include: 1) create a statewide strategy for how to monitor the extent of California wetlands, which incorporates the use of census and probability-based approaches; 2) develop a probability-based design, standard operating procedures, and costs for wetland extent S&T mapping; 3) train and inter-calibrate regional mapping center partners in mapping methods; 4) remap/reclassify existing NWI S&T plots to set up a basic California S&T system; and 5) demonstrate a probability-based assessment of wetland extent and condition. This project will provide a way for state and federal agencies to assess the net effect of their policies and programs on wetland extent.

This is the first year of the three-year project. The first year will focus on creating the statewide strategy and developing a sampling design for the S&T assessment.

Lead Investigator: Martha Sutula (marthas@sccwrp.org)

Collaborators: California Resources Agency, California Department of Fish and Game, San Francisco Estuary Institute, California State University Northridge, US Environmental Protection Agency, and US Fish and Wildlife Service National Wetlands Inventory

External Funding Support: US Environmental Protection Agency

b. Regional Monitoring/Assessment Program for Southern California Wetlands

Wetland monitoring most often occurs at the project/site scale in response to regulatory or permit requirements. In any given year, hundreds of individual wetland projects may be monitored. Nevertheless, it is difficult to compile results from these projects to provide an overall regional assessment of wetland condition. The main obstacles to such an assessment have been the lack of consistent assessment tools and the lack of an integrated regional monitoring framework. Over the past several years, SCCWRP and the Wetlands Recovery Project Science Advisory Panel (WRP SAP) have developed both the tools and the regional framework for wetland assessment. To date, monitoring frameworks have been completed for estuaries, coastal lagoons, and riverine wetlands. More recently, SCCWRP and other statewide partners have facilitated formation of the California Wetlands Monitoring Workgroup (CWMW). The CWMW functions as a subcommittee of the State Water Quality Monitoring Council and is focused on developing approaches and infrastructure for statewide wetland monitoring assessment and data dissemination.

The objective of this project is to work with the WRP and the CWMW to implement a regional wetland assessment program. This program will involve updating resource inventories, developing and validating landscape assessment and rapid assessment methodologies, guiding the selection of appropriate monitoring indicators, and exploring partnerships with other organizations interested in monitoring southern California wetlands.

This is an ongoing project. Activities in the current year will focus on development and population of the State's wetland information portal and wetland project tracking system and on initial development of an ambient monitoring program for depressional wetlands. Implementation of the riverine wetland regional monitoring program began last year as an element of the Stormwater Monitoring Coalition's (SMC) regional assessment for wadeable streams (see *Regional Watershed Monitoring*); this effort will continue this year. Finally, tools to support ambient and project monitoring (e.g., protocols, quality assurance procedures, standard reporting procedures) will be developed in concert with existing interagency workgroups.

Lead Investigator: Eric Stein (erics@sccwrp.org)

Collaborators: Southern California Wetland Recovery Project, California Wetlands Monitoring Workgroup

External funding support: California Coastal Conservancy, California Natural Resources Agency via the Coastal Impact Assistance Program (CIAP)

c. Development of a Statewide Network of Reference Wetlands for California

Interpretation of regional monitoring data requires context to better understand status and trends information, as well as the relationship of specific sites or projects to regional conditions. Reference sites can provide such context. Defining reference conditions provides a scientifically defensible basis upon which to measure the inherent natural variability of wetlands. Reference wetlands can also help define appropriate expectations or targets for management actions that affect wetland condition, including restoration and mitigation projects. This project represents an important first step toward the development of a wetland reference network for California, which currently does not exist.

The goals of this project are to: 1) establish a conceptual approach to the development of a statewide network of reference wetlands; and 2) to select reference sites for targeted wetland classes in selected regions (e.g., Sacramento and San Joaquin Valleys, Sierra bioregions) using the California Rapid Assessment Method (CRAM). This project will also help to establish a formal process for refinement of CRAM training and quality assurance practices via a network of regional audit teams. These audit teams will support CRAM implementation within state and federal monitoring and regulatory programs.

This is the second year of a three-year project. The first year focused on drafting a concept white paper about how a reference wetland network will be developed for California. The second year will focus on site selection and assembling audit teams for the Central Valley and Sierra bioregions. The third year will focus on implementation of base statewide assessments with selected bioregion intensification.

Lead Investigator: Chris Solek (chriss@sccwrp.org)

Collaborators: San Francisco Estuary Institute (Dr. Josh Collins), Humboldt Bay Harbor Recreation and Conservation District (Dr. Chad Roberts), Moss Landing Marine Laboratories (Ross Clark)

External Funding Support: US Environmental Protection Agency

E. BEACH WATER QUALITY

California's beaches are among the most popular and the most extensively monitored coastal waters in the world. Each year, tens of millions of people visit the state's beaches while many thousands of water quality measurements are taken to prevent exposure to pathogens. A great deal of expense goes into these monitoring efforts, but the existing system is not optimal for several reasons. First, monitoring programs typically use bacterial enumeration methods that require 24 hours to obtain results, precluding same-day warnings in the event of poor water quality. Second, standard bacterial measurement methods are unable to differentiate among sources of bacteria, including whether the sources are natural or anthropogenic. Currently in California, the predominant sources of bacteria to beaches are from diffuse nonpoint (and possibly nonhuman) sources, rather than the predominately sewage sources for which the indicators were originally developed. Because of this, standard bacterial indicators are not always well-correlated with human pathogen concentrations in receiving waters.

SCCWRP research has helped recent advances in molecular biology and immunochemistry produce new candidate methods for measuring microbial water quality. These may provide beach monitoring programs with tools that more accurately assess public health risk in a timely manner. New testing methods can also enable the user to track fecal bacteria to a source organism and determine if it came from wildlife, pet waste, or a sewage spill, for example. A variety of indicators are being tested in comparison with older methods to determine which provide the best correlation with human epidemiology. Efforts to record extensive epidemiological information in conjunction with water quality testing will provide improved insight as to the health risk associated with specific bacterial indicator levels. SCCWRP's coordination of these research efforts, training of end users, and data management activities build a means of communication among various stakeholders.

The Beach Water Quality section of the Research Plan draws together studies on indicator method development, beach epidemiology surveys, bacterial source tracking and source identification, bacterial standards for shellfish harvesting areas, and data sharing.

a. Rapid Bacterial Indicator Development

Current growth-based methods used to enumerate indicator bacteria (i.e., multiple tube fermentation, membrane filtration, and chromogenic substrate) are too slow to effectively evaluate risk of swimmers' exposure to waterborne pathogens. These methods require an 18-24 hour period for laboratory incubation of samples, during which time the public may be exposed to contaminated water. This time lag also makes it difficult to track sources of microbiological contamination. Since most sources of contamination are intermittent and last less than a day. Lacking a more rapid method, investigators are unable to follow the trail of contamination back to its origin. Rapid measurement techniques would allow for near-real time tracking of sewage spills and speed the reopening of non-contaminated beaches.

The goal of this project is to develop rapid methods that can augment or replace the existing methods for one or more types of indicator bacteria. The objective is to develop a method that will detect and quantify viable indicator organisms (or a molecular substructure of the organism) in less than two hours.

This is the third year of a three-year project. The first year included side-by-side testing of rapid methods and traditional growth-based methods for over 400 environmental samples. The second year focused on method performance testing, including identification of locations, times, and substances that lead to problematic issues such as inhibition. The method performance evaluation will be completed in the third year with publication of a Standard Operating Procedure. SCCWRP staff will also assist with technical transfer by training staff at beach monitoring laboratories to conduct rapid indicator analyses.

Lead Investigator: Steve Weisberg (stevew@sccwrp.org)

Collaborators: Orange County Sanitation District, University of North Carolina (Dr. Rachel Noble)

External Funding Support: State Water Resources Control Board

b. Epidemiology of Nonpoint Source Impacted Beaches

Epidemiology studies are used at beaches to determine whether swimmers are at risk of developing illnesses based on water contact recreation. Over the last 40 years, there have been roughly three dozen such studies around the world. Of these, less than half were conducted at marine beaches and virtually all were at beaches with known human fecal contamination sources. Current beach pollution in southern California, though, is predominantly associated with nonpoint sources of unknown, and at least partly nonhuman, origin. Previous epidemiology studies have demonstrated that when human point sources exist, quantifiable relationships between the frequency of illness and levels of fecal indicator bacteria (e.g., *Enterococcus*, total coliforms, fecal coliforms and *E. coli*). However, some studies have documented that relationships between fecal indicator bacteria and human pathogens are not well-correlated at beaches impacted by nonpoint sources.

The goal of this project is to conduct epidemiological studies to assess the risk of swimming-related illness following exposure to nonpoint source contaminated waters. If the risk of illness increases at nonpoint source impacted beaches, then SCCWRP will examine whether traditional fecal indicator bacteria are predictive of illness. Finally, staff will also examine whether nontraditional methods of microbial detection, including human specific markers and pathogens, are better predictors of illness than the traditional indicator bacteria.

This is the fourth year of a five-year study. The first three years targeted data collection at three different beaches; Doheny State Beach, Malibu Surfrider Beach, and Avalon Bay. More than 4,000 sample analyses were conducted incorporating 36 different measurement methods across 24 different laboratories. In addition, over 24,000 beachgoers were recruited into the study to quantify the frequency of health effects in the swimming population. The fourth and fifth years will focus on data analysis and reporting. Based on all of the data collected, more than 175,000 different indicator-swimmer combinations exist and this extensive data set requires careful interpretation before conclusions can be reached. The findings of this study will be presented to both the US EPA and the State of California for use in the development of new beach water quality standards.

Lead Investigator: Ken Schiff (kens@sccwrp.org)

Collaborators: University of California Berkeley (Dr. Jack Colford), the Orange County Sanitation Districts (Charles McGee), Heal the Bay (Dr. Mark Gold), US Environmental Protection Agency, City of Avalon, City of Dana Point

External Funding Support: US Environmental Protection Agency, National Institutes of Health, State Water Resources Control Board, Cooperative Institute of Coastal and Estuarine Environmental Technology, City of Dana Point, Los Angeles County Department of Public Works

c. Bacterial Source Tracking in Upper Santa Monica Bay

Beaches at the mouths of many watersheds in Southern California have fecal indicator bacteria levels that exceed ocean water quality (AB411) standards. Recent TMDL programs have required management efforts in watersheds to reduce bacteria levels at the ocean shoreline. As a prelude to remediation in a watershed, bacteria sources need to be tracked and problematic sites identified. However, approaches to bacteria source tracking to date have been piecemeal, with an agreed-upon approach lacking. A common approach is needed so that environmental managers can understand the extent of contamination sources and cost of remediation in order to develop priorities at a regional scale.

The goal of this project is to develop a source tracking protocol that can be used to identify whether surface runoff is the primary bacteria source to impacted beaches throughout southern California. Ramirez Creek (RC) and Escondido Creek (EC) watersheds, located in the City of Malibu, Los Angeles County, are two of many watersheds that stretch from the hills above Santa Monica Bay to the ocean. Beaches at the mouth of RC and EC have continued to show high indicator bacteria counts for three out of four years since a bacteria TMDL was put into effect in 2005. The source tracking protocol will be tested at RC and EC and, if these creeks are impacting their downstream beaches, then additional protocols will be tested for identifying the primary bacterial sources upstream.

This is the fourth year of a four-year study. The first year focused on determining the spatial and temporal patterns in fecal indicator bacteria, optical brighteners, and human fecal markers. The second and third year increased sampling intensity in areas of concern and initiated more detailed bacterial analysis. Year four will focus on confirmation of contamination sources.

Lead Investigator: Steve Weisberg (stevew@sccwrp.org)

Collaborators: Los Angeles County Department of Public Works, Heal the Bay

External Funding Support: Los Angeles County Department of Public Works

d. Shellfish Beneficial Use

Shellfish harvesting is one of the beneficial uses designated in the California Ocean Plan. The current definition of shellfish harvesting used by the Regional Water Quality Control Boards (RWQCBs) is broad, encompassing recreational harvesting for consumption, harvesting for bait, and commercial aquaculture. The breadth of this definition reduces flexibility to apply the most appropriate water quality standards for each of these applications in specific areas. The current regulations also do not allow for exclusions to regulatory threshold exceedences caused by natural sources of contaminants at commercial or recreational shellfish harvesting areas. Without a more focused definition of the “shellfish harvesting” beneficial use, management efforts could be misdirected.

The purpose of this project is to collect the information necessary for the State to consider re-evaluating bacteria standards at recreational shellfish harvesting areas, based on natural reference conditions. The objectives are to: 1) identify commercial and recreational shellfish harvesting areas on the coast and in enclosed bays/estuaries of California; and 2) characterize the frequency of shellfish harvesting water quality exceedences at reference beaches.

This is the third year of a three-year study. Tasks in this year will include identifying currently used and historical shellfish beds, as well as providing refinements to the analyses requested by the State.

Lead Investigator: Steve Weisberg (stevew@sccwrp.org)

External Funding Support: State Water Resources Control Board

e. BeachWatch Data Management

Historically, storage of data collected by county environmental health departments in California for beach water quality has been disparate and unconnected. To maximize consistency of data used to determine compliance with AB411 requirements, the State

Water Resources Control Board (SWRCB) enlisted SCCWRP's assistance in creating a standardized data transfer system. From 1999 through 2001, SCCWRP created and implemented a database system designed to make data transfer from California county health agencies to the SWRCB simple and consistent. In addition, special features were included in the database system to make data easier to input, and to allow for simple data analysis and reporting. This system was initially deployed for southern California county health departments, but its successful use in southern California led to its implementation in the rest of California by 2006. Due to the success of this project, the State Water Resources Control Board decided to enlist SCCWRP's assistance in all aspects of data management for beach water quality programs in California. In addition to providing database support, SCCWRP designed and implemented a new web-based data submission system over the course of the next year for all California coastal environmental health agencies. Data submitted to SCCWRP's system will then be made available through the Water Quality Monitoring Council's website (see project *Clean Beach Initiative Website*).

The goal of this project is for SCCWRP to provide continued database support to coastal environmental health departments and data management to the State Water Resources Control Board, in order to ensure successful submission and storage of beach water quality data.

This is an ongoing project. SCCWRP will be developing a new web portal system for data submissions, as well as continuing to assist environmental health agencies with data submissions, maintaining their local databases, and fulfilling unique data requests (e.g., creating specialized data reports).

Lead Investigator: Shelly Moore (shellym@sccwrp.org)

Collaborators: City of Long Beach, 15 coastal county health departments

External Funding Support: State Water Resources Control Board

F. REGIONAL MONITORING

A variety of environmental agencies and stakeholder groups in southern California collectively spend over $30 million annually to assess the status of streams, estuaries, beaches, and marine environments in southern California. Approximately three-quarters of this amount are spent by regulated parties to comply with National Pollutant Discharge Elimination System (NPDES) permits. However, the NPDES program focuses on monitoring near permitted discharges, leading to a lack of spatial coverage and regional data integration. Thus, less than 7% of the southern California marine environment is actually monitored through that mechanism on an ongoing basis. A complete monitoring approach for southern California must encompass not only compliance, but also regional and investigative monitoring.

Conducting large-scale regional assessments has many benefits to regulatory and regulated agencies alike. Regulated agencies benefit by gaining a regional perspective; rather than making comparisons to a small number of control sites that may or may not be similar to their discharge site, they are able to compare local results to the entire breadth of natural variability inherent to the ecosystem, also known as the regional reference condition. Regulatory agencies benefit by being able to compare the relative impacts of various dischargers and assess the effects of cumulative emissions. These types of comparisons allow regulators to target resources where management actions are most needed.

Since the 1990s, SCCWRP's regional monitoring research has centered on the Southern California Bight Regional Monitoring Program, and it accordingly forms the first component of this section. The next components are related to marine, shoreline, and watershed monitoring. Another of SCCWRP's major research foci, marine debris, is discussed in the last component.

1. Southern California Bight Regional Monitoring Program

Regional marine monitoring programs have been a focal point of SCCWRP's activities since the 1970s. Originating with the 60-m survey conducted in 1977, then the reference surveys of the 1980s, and finally the Bight Pilot Project in 1994, SCCWRP has committed to understanding large-scale impacts to the ocean environment. SCCWRP currently coordinates a bi-decadal Bight Regional Monitoring Program that, in total, involves nearly 100 different stakeholder organizations. The Bight programs have been especially useful in establishing regional reference conditions, developing new environmental assessment tools, and standardizing data collection approaches in southern California.

This section of the Research Plan describes the six components of the 2008 Regional Monitoring Program (Bight '08). Three of them, Coastal Ecology, Offshore Water Quality, and Shoreline Microbiology, were also a part of past Bight Programs. The other three, Rocky Subtidal Habitat, Areas of Special Biological Significance, and Estuaries and Coastal Wetlands, were added in 2008.

a. Bight '08 Coastal Ecology

Bight ’08 is an integrated and collaborative regional monitoring program that follows a line of regional monitoring programs taking place approximately every five years since 1994. Bight ’08 is conducted by a consortium of 65 local organizations working together, each contributing a small part toward a condition assessment of the whole southern California Bight (SCB). In this way, no single agency controls the fate of the program, but instead it is fed by interaction and communication. The result is a regional program that has widespread appeal, serves the needs of local agencies, and delivers information directly to managers for improved decision making.

The Coastal Ecology portion of Bight’08 addresses three primary questions: 1) what are the extent and magnitude of impacts in the SCB (and how does this impact vary by habitat)? 2) what are the trends in SCB environmental condition? and 3) what are the levels of contaminants in organisms that may be harvested for seafood? These questions are addressed by measuring numerous indicators of environmental condition (e.g., habitat quality, sediment contamination, toxicity, infaunal communities, fish communities) at nearly 400 sites spread across 13 different habitats ranging from estuaries to the deep ocean basins.

This is the fourth year of a five-year study. The first year was spent planning and conducting QA exercises to ensure data comparability among participating agencies. The second and third years were spent sampling and conducting analyses. The fourth and fifth years will be spent analyzing data, making Bight-wide assessments, and completing reports.

Lead Investigator: Ken Schiff (kens@sccwrp.org)

Collaborators: 65 participating organizations

b. Bight’08 Offshore Water Quality

The Offshore Water Quality component of the Southern California Bight (SCB) Regional Monitoring Program focuses on assessing the condition of waters in the coastal ocean. This was one of the original elements of the Bight Regional Monitoring Program, initially implemented as part of the 1994 Pilot Project. The Pilot Project led to formation of the Central Bight Water Quality group, a collection of four large wastewater treatment agencies that now coordinate conductivity, temperature, and depth (CTD) surveys between Ventura and Orange Counties on a quarterly basis. SCCWRP’s Bight Regional Monitoring Program, conducted once every five years, builds from this existing collaboration by bringing in new partners, and expanding the variety of parameters measured and questions addressed. New components of this year’s investigation are nutrient source characterization and harmful algal blooms (HABs). HABs are a potentially serious consequence of nutrient over-enrichment in the coastal ocean, which can cause water column hypoxia, fish kills, or release of planktonic neurotoxins like domoic acid.

The overall goals of this study are to: 1) quantify the major nutrient sources to the Southern California Bight; and 2) characterize the extent, magnitude, and ecological characteristics of algal blooms, with an emphasis on HABs. It will involve three primary tasks: 1) establishing the relative nutrient contributions (nitrogen, phosphorus, silica) of four major sources to the SCB (upwelling, POTW discharge, atmospheric deposition, terrestrial coastal runoff) and estimating anthropogenic versus natural nutrient loading to the SCB; 2) characterizing the spatial and temporal patterns of algal blooms, as well as the effects of these blooms, with an emphasis on HABs and specifically *Pseudo-nitzschia* and domoic acid; and (3) identifying the specific water quality conditions associated with bloom events. Nutrient loading data will be used to assess the timing and magnitude of nutrient delivery to the coastal ocean relative to remotely-sensed and field observations of algal blooms. Ultimately, these relationships will help to discern the mechanisms and conditions that lead to both nearshore and offshore algal blooms and HABs.

This is the third fourth year of a five-year study. The first year was spent planning and conducting QA exercises to ensure data comparability among participating agencies. The second through fourth years are to be spent sampling and conducting analyses. The fifth year will be spent analyzing data, making Bight-wide assessments, and completing reports.

Lead Investigator: Meredith Howard (meredithh@sccwrp.org)

Collaborators: 24 participating organizations

c. Bight'08 Shoreline Microbiology

Previous regional surveys found that 95% of southern California beaches meet the State's quality standards for water contact recreation. The remaining 5% are mostly located near urban runoff outlets. Several studies have suggested that some of the indicator bacteria emanating from these outlets may come from re-growth within the drain systems, rather than human fecal sources.

The goal of the Bight '08 Shoreline Microbiology Component is to identify the principal sources of fecal indicator bacteria at chronically problematic beaches in the Southern California Bight. The first task will be to determine what percentage of chronically problematic beaches has human sources of fecal indicator bacteria. At those beaches without human sources, the second task will be to identify the non-human sources of fecal indicator bacteria. Non-human sources may include sloughing of storm drain biofilms, or re-growth on beach wrack, beach sand, or sediment. These sources will be quantified using traditional fecal indicator bacteria, speciation of enterococcus, and new measurement technologies including those that differentiate between human and nonhuman sources of fecal contamination. Another key element in this study will be the development of new methods. This will involve developing standardized protocols for measuring fecal indicator bacteria in sand and beach wrack.

This is the fourth year of a five-year study. The first year was used to design the regional program. The second year was used for development of measurement protocols for fecal indicator bacteria in sand. The third year featured a pilot study to test the protocols with sand from Surfrider Beach in Malibu and to develop measurement methods for bacteria in storm drain biofilms. The fourth year will involve sampling and analysis at more than 15 different problematic beaches. Beach wrack as a source of bacteria and re-growth of bacteria in sand will be evaluated during this multi-beach sampling effort. The fifth year will be used for data assessment and interpretation.

Lead Investigator: John Griffith (johng@sccwrp.org)

Collaborators: 18 participating organizations

d. Bight'08 Areas of Special Biological Significance

Areas of Special Biological Significance (ASBS) are state Marine Protected Areas (MPAs) where the discharge of waste is prohibited. There are 34 ASBS throughout the State of California; 14 are located in southern California. Nearly 1,700 outfalls have been identified in ASBS statewide that could carry waste from nonpoint sources, especially in wet weather. Since zero waste discharge is allowed to ASBS, typical regulatory limits (i.e., effluent limits) do not apply. Instead, state regulatory statute stipulates the maintenance of "natural water quality." Maintaining this objective is challenging due to the mix of natural and anthropogenic wastes during wet weather events, compounded by the large variability in natural contributions due to changing hydrologic and geologic conditions, among other factors. Thus, little information exists on what constitutes "natural water quality" in ASBS.

The goal of this study is to answer three questions: 1) what is the range of natural water quality at reference locations? 2) how does water quality along ASBS coastlines compare to natural water quality at reference locations? and 3) how does the extent of natural quality compare among ASBS with and without discharges? The first question will produce reference thresholds, while the third question will examine the status of ASBS regionally to determine if these marine protected areas are impacted and, if so, the extent of the impact relative to non-ASBS areas.

This is the fourth year of a five-year study. The first year was used to design the regional program. The second and third years were used for sampling and analysis. Nearly 400 samples were collected by over 10 different organizations during the 2008-09 wet season. An additional two-dozen intertidal sites were quantitatively sampled for biological assemblages. The third and fourth years are being used for data analysis, assessments, and reporting.

Lead Investigator: Ken Schiff (kens@sccwrp.org)

Collaborators: State Water Resources Control Board, Regional Water Quality Control Boards 4, 8 and 9, ASBS regulated stakeholders

e. Bight'08 Rocky Subtidal Habitat

Rocky habitat provides some of the SCB's most spectacular underwater scenery. Giant forests of the kelp *Macrocystis pyrifera* represent some of the most productive marine habitats on earth. California's Marine Life Protection Act calls for an interrelated regional network of Marine Protected Areas that would preserve these habitats. However, no unified maps of hard bottom habitat currently exist; nor do regional assessments of fish, invertebrate, and macro-algal densities in these habitats. Despite some intensive rocky habitat/kelp forest monitoring programs, there is little data integration among researchers.

The goal of the Bight'08 Rocky Habitat component is to answer three questions: 1) what is the distribution of hard bottom habitats in the SCB? 2) what is the range of natural biological conditions in these reef assemblages? and 3) how do these conditions overlay or correlate with anthropogenic factors? A reef index of health will be developed in response to the third question, as this is critical to various resource management concerns and needs.

This is the fourth year of a five-year study. The first year was used to design the regional program, and the second year was used for sampling and analysis. Fifteen organizations sampled more than 60 reefs from San Diego to Point Conception, including the Channel Islands. The third and fourth years will be used for data analysis, assessments, and reporting.

Lead Investigator: Ken Schiff (kens@sccwrp.org)

Collaborators: 15 participating organizations

f. Bight '08 Estuaries and Coastal Wetlands

Eutrophication is the increased production of organic matter through excessive aquatic algae and plant growth, caused in part by increased nutrient loading to coastal waters. The effects of nutrient loading on estuaries and coastal waters have not been well monitored in California, with the notable exception of San Francisco Bay. California lacks consistent, statewide water quality standards to manage the effects of nutrient over-enrichment and eutrophication in estuaries. One fundamental data gap is better articulation of regional differences in biological response to nutrient loads.

The Estuaries and Coastal Wetlands portion of Bight '08 will address three major questions: 1) what is the extent and magnitude of eutrophication in SCB estuaries? 2) do differences exist between estuarine classes (e.g., protected embayments, perennially tidal lagoons, seasonally tidal lagoons, non-tidal lagoons, river mouth estuaries) with respect to their biological response to nutrient loads? and 3) how does muting of the tidal forcing within an estuary impact the biological response to nutrient loads? These questions will be answered through an assessment of eutrophication status at 30 sites in 25 estuaries.

This is the fourth year of a five-year study. The first year was spent planning and conducting QA exercises to ensure comparability among participating agencies. The second year was spent sampling and conducting analyses. The third and fourth years are to be spent analyzing data and completing reports.

Lead Investigator: Martha Sutula (marthas@sccwrp.org)

Collaborators: 41 participating agencies

2. Regional Marine Assessments

Beyond the Bight Regional Monitoring Program, SCCWRP is involved in a number of other regional-scale assessments. To characterize coastal contaminant levels nationwide, the National Oceanic and Atmospheric Administration's (NOAA's) National Status and Trends (NS&T) Program collects and analyzes bivalve species as part of their Mussel Watch program. SCCWRP has set up a partnership with NOAA to sample additional sites in southern California, and is also working with NOAA to begin assessing contaminants of emerging concern (CECs) through the Mussel Watch program. They have likewise become involved in an effort to standardize regional approaches to determining compliance of outfall plumes with the California Ocean Plan.

The first project in this section discusses the Southern California Mussel Watch. The second, initiated by some of SCCWRP's member agencies, involves a collaborative examination of the offshore conductivity, temperature, and depth (CTD) data used to define outfall plumes from wastewater treatment facilities.

a. Southern California Mussel Watch

To characterize the spatial extent and temporal trends in coastal contaminant levels nationwide, the NOAA Mussel Watch Program has collected and analyzed bivalve species since 1986. Representative samples of locally abundant species are collected from fixed sites during the winter in order to assess long-term temporal trends in trace metal and organic contaminant levels. The program established 21 "Mussel Watch" sites in the SCB, with most located along the open coast. This data set has provided unparalleled information on the declines of biological exposure to contaminants associated with source control and increased effluent treatment over the last 20 years. It has also demonstrated that local hot spots still exist in the SCB and it provides a point of comparison between the SCB and the rest of the country. Finally, as new chemicals are released to the environment, the NS&T sentinel sites provide a mechanism to monitor the fate of these potential contaminants.

The goals of this study are to: 1) increase spatial coverage of NOAA's NS&T Program in the Southern California region; 2) provide Mussel Watch contaminant data at Areas of Special Biological Significance and Marine Protected Areas; 3) compare results of passive sampling devices (PSDs) with bivalve accumulation; and 4) identify contaminants of emerging concern (CECs) that warrant inclusion in the NS&T program. To achieve these goals, an additional 13 sites have been established in the SCB. Local agencies collect the bivalves and then contaminant burdens are measured at NOAA's analytical laboratory. A collaborative effort to select priority CECs for future assessment is also planned as a part of this project.

This is the fourth year of a five-year project. The first year was devoted to establishing new sites and conducting sampling activities. Bivalve and SPME samples were collected and analyzed for trace constituents in year two. The third year focused on (1) a second round of bivalve collection; and (2) planning for a pilot evaluation of CEC analytes and co-deployment of PSDs to measure the occurrence of CECs in the water column. The fourth and fifth years will be devoted to sample and data analysis for CECs in bivalve tissue samples and PSDs collected in the pilot study. It will also involve refining the list of CECs to be included in future NS&T cycles.

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Collaborators: National Oceanic and Atmospheric Administration (Gunnar Lauenstein), State Water Resources Control Board (Dominic Gregorio), Multi-Agency Rocky Intertidal Network (Dr. Jack Engle), United States Geological Survey (Kelly Smalling, Dr. David Alvarez), San Francisco Estuary Institute (Dr. Susan Klosterhaus, Dr. Jay Davis)

b. Water Quality Compliance Assessment

Compliance with water quality objectives must be based on a standardized, scientifically-grounded approach to collecting and interpreting data. In southern California, publically owned treatment works (POTWs) that discharge treated effluent via offshore outfalls are required to assess whether their discharge results in deviation from water quality objectives as stated in California's Ocean Plan. While the POTWs in southern California have collaborated effectively over the last thirty years to implement a regional monitoring program that provides the data necessary to make these assessments, they have not yet developed a shared approach for interpreting whether these monitoring data demonstrate compliance with the Plan. The regional monitoring program consists of extensive quarterly surveys that measure water quality parameters both near discharges and at farfield reference areas. These surveys provide depth-continuous measurements of conductivity, temperature, depth, dissolved oxygen, pH, transmissivity, and chlorophyll and colored dissolved organic matter (CDOM) fluorescence, collectively known as CTD+. CTD+ measurements are also coupled with static water sampling at a subset of sites for parameters not measured by the CTD sampling device (e.g., nutrients, enteric bacteria).

The goal of this project is to provide a scientific foundation for development of a shared compliance assessment framework for coastal southern California POTWs. The project consists of three tasks. The first is to determine the extent to which CTD+ parameters can be used to define the spatial extent of outfall plumes. Currently, plume extent is derived from parameters measured by static water sampling, which is costly and spatially limited. More promising methods involve continuous measurement by CTD+ casts of CDOM fluorescence in combination with other parameters. On the basis of these data, a multi-metric index will be developed and compared to traditional methods. The second task involves quantifying instrument-related variability associated with the parameters of interest. To accomplish this, field-based experiments and statistical analysis of the existing dataset will be carried out to quantify variability associated with instrument calibration, post-calibration drift, and small-scale spatial variability. The third task seeks to define "reference" conditions, in which a reference envelope will be developed in the context of spatial (e.g., cross-shelf, along-shelf, depth) and temporal (e.g., seasonal, interannual) variability.

This is the second year of a two-year project. The first year consisted of project planning and preliminary data analysis. The second year will be spent answering the proposed questions directly.

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Collaborators: City of Los Angeles, Los Angeles County Sanitation District, Orange County Sanitation District, City of San Diego, State Water Resources Control Board

3. Regional Freshwater Assessments

Southern California's burgeoning population imparts a large number of potential stressors to coastal watersheds, rivers, and streams. Habitat alteration, hydromodification, flood control measures, water diversion, discharge of treated wastewaters, and pollutants in urban runoff can all result in impairments to aquatic beneficial uses. There are a number of monitoring agencies to assess the health of southern California's rivers and streams, but most of this effort is located near in-stream discharges where monitoring is required by NPDES permits to assess discharge effects. These programs cover only 29% of the stream miles in southern California and present a biased picture of aquatic health because the sites are located near known areas of concern. Like Bight Regional Monitoring, regional assessments of freshwater systems are valuable tools for assessing the spatial extent of cumulative effects, providing comparative reference values, standardizing monitoring approaches, and promoting data sharing.

This year's Research Plan highlights three regional monitoring projects for freshwater in-stream habitats. The first focuses on integrating existing monitoring efforts into a comprehensive regional program that parallels the Bight programs. The second extends the monitoring program to include an assessment of non-perennial streams (streams that flow for only a portion of the year), which are presently unmonitored. The third project will develop biological assessment tools that can be used to interpret data from these monitoring programs.

a. Regional Watershed Monitoring

In-stream bioassessment monitoring in southern California is currently conducted by over a dozen different organizations. Each of these organizations has disparate programs that vary in design, frequency, and the indicators selected for measurement. Even where designs are similar, the field techniques, laboratory methods, and quality assurance requirements are often not comparable, making cumulative assessments impossible. Another challenge is the lack of an integrated information management system that allows data sharing among programs.

The goal of this project is to implement a large-scale regional monitoring program for southern California's coastal streams and rivers. A comprehensive monitoring plan that integrates elements of several individualized monitoring programs was designed by the southern California Stormwater Monitoring Coalition (SMC). The plan establishes comparability in the field and the laboratory, performance-based quality assurance guidelines, and an information management system for sharing data. This integrated regional monitoring program is collaborative, so that each participating group can assess its local geography, and then contribute a small portion to the whole regional assessment. In this way, the program can address large-scale management needs and provide answers to the public about the health of southern California's streams and rivers.

This is the third year of a five-year study. The first year involved the development of the monitoring infrastructure including comparability and QA evaluations. The next years will focus on sampling, laboratory analysis, and assessment reports.

Lead Investigator: Ken Schiff (kens@sccwrp.org)

Collaborators: Southern California Stormwater Monitoring Coalition, State Water Resources Control Board's Surface Water Ambient Monitoring Program, Regional Water Quality Control Boards 4, 8 and 9

b. Non-perennial Stream Assessment

Non-perennial streams in southern California that do not have year-round flow are often overlooked as a beneficial use resource, even though they make up two-thirds of the stream miles throughout southern California. Moreover, assessment tools to determine if biological communities are healthy or impaired have been developed almost exclusively in perennial streams; their applicability in non-perennial streams has not been calibrated or validated.

The goal of this project is to adapt bioassessment techniques to non-perennial stream conditions. This will require overcoming several barriers, including identifying the locations of non-perennial streams, quantifying successional changes in the benthic Macroinvertebrate (BMI) fauna in non-perennial streams, documenting the performance of existing bioassessment tools (IBIs and OE models) in non-perennial streams, and determining whether there are anthropogenic stressors specific to intermittent streams over the yearly cycle of flooding and drying. Ultimately, an attempt will be made to identify the factors, such as critical flow conditions, that most influence BMI communities in non-perennial streams.

This is the fourth year of a four-year study. The first year focused on mapping non-perennial stream reaches and saw a GIS map produced. The second and third years involved intensive temporal sampling of non-perennial stream reaches beginning at the conclusion of the wet season and continuing into the summer drying cycle. Tasks in the fourth year will include data analysis, assessment tool evaluation, and reporting.

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Collaborators: California Department of Fish and Game (Dr. Pete Ode), Southern California Stormwater Monitoring Coalition

External Funding Support: San Diego Regional Water Quality Control Board

c. Developing a Technical Foundation for Freshwater Biological Objectives

California's streams are regulated through a variety of programs across multiple State and Federal agencies. A common element of every program is the need for objective assessment endpoints that can be used to gauge success or compliance. Direct measures of biological condition are increasingly preferred as assessment endpoints because they are more closely linked to the beneficial uses or functions that are the focus of protection and management. In contrast, chemistry- or toxicity-based assessment endpoints require inferences about their relationship with the ecological integrity of natural systems. Biological indicators have the added advantage of integrating condition over space and time, thus providing a more comprehensive assessment than traditional indicators.

The goal of this project is to develop the technical foundation for biologically-based thresholds or bio-objectives. The technical foundation will require at least five tasks before bio-objectives can be created. These tasks include creating maps of the stream and wetland resources that currently exist, identifying and quantifying reference condition, creating or enhancing biological assessment tools such as indices of biological integrity (IBI), defining a stressor gradient to identify biological expectations for the mapped resources, and setting thresholds of concern for biological condition. This project will begin by focusing on biological objectives for California's perennial wadeable streams and their associated riverine/riparian wetlands. Similarly, the project will initially focus on benthic macroinvertebrates (BMI) and the California Rapid Assessment Method (CRAM) since data for BMIs and CRAM currently exist for much of the state. Ultimately, the project will develop an approach for integrating multiple biological indicators like benthic algae and physical habitat assessment.

This is the first year of a five-year project. The first year will focus on developing a detailed study approach and initial data collection.

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External Funding Support: U.S. Environmental Protection Agency, State Water Resources Control Board

4. Regional Debris Assessments

The mid-20th century saw the introduction of many new materials and products that resist oxidative and bacteriological decay. Since these materials (mostly plastics) do not easily biodegrade, they have resulted in a build-up of debris over time, with negative aesthetic and ecological consequences. SCCWRP has previously been involved in a number of pioneering studies to quantify and characterize marine debris on beaches, along the ocean shelf, and in the North Pacific gyre. Based in part on these studies, the State of California and numerous municipalities have begun to take management steps aimed at reducing debris. SCCWRP has more recently entered into plastic pellet and debris assessments in collaboration with the State to monitor the current status of debris along California's shoreline, and keep track of changing debris levels over time.

This section of the Research Plan describes a regional monitoring study to assess the distribution of plastic pellets and other types of marine debris on California beaches.

a. Distribution and Amount of Plastic Pellets on Beaches in California

Marine debris is often thought of as large items, found floating in the ocean or strewn along the beaches. However, smaller plastic items (<5 mm) may present a larger problem to the health of marine organisms. A 1998 SCCWRP study estimated that there are over 100 million plastic pellets on beaches in Orange County, California. Around one quadrillion of these plastic pellets (60 billion pounds) are produced in the United States annually and transported via railways, trucks and ships to manufacturers who then mold them into a final product. Many of these pellets are accidentally lost or dropped during transport and find their way via stormwater drains and rivers into the ocean and ultimately onto beaches. The State Water Resources Control Board (SWRCB) and the Regional Water Quality Control Boards are required by AB 258 to implement a program for the control of discharges of preproduction plastic pellets from point and nonpoint sources. Knowledge of the distribution and amount of plastic pellets on beaches in California is crucial to implementing a plan to control and reduce the discharges of plastic pellets. In addition, a baseline study will prove useful when later assessing the effectiveness of any programs and controls adopted by the SWRCB.

The goal of this project is to provide baseline information on the distribution and amount of plastic pellets on beaches throughout the state of California.

This is the second year of a two-year project. Sampling for this project has been completed and data analysis begun.

Lead Investigator: Shelly Moore (shellym@sccwrp.org)

Collaborators: State Water Resources Control Board (Dominic Gregorio, Emily Siegel), California State University Fullerton (Sarice Friedman)

External Funding Support: State Water Resources Control Board

G. INFORMATION AND DATA CENTER

A major ongoing challenge for environmental assessments is attempting to collate and standardize various monitoring data sets. These data sets, which may be large in number, often exist in multiple forms including paper, spreadsheets, reports, and databases. Even for those datasets that are stored electronically, there are a multitude of formats for access, export, and analysis. Many of SCCWRP's projects, such as the Bight program, have spurred the development of standardized data transfer formats that enable collation of large data sets. This and other SCCWRP projects have provided a model for successful data sharing. Other tools for statistical analysis of monitoring designs and improved spatial mapping techniques have also come out of planning for regional monitoring programs.

This year's Research Plan first includes two data management projects that strengthen SCCWRP's role as a regional data center in southern California. These seek to involve more participants in data-sharing and make SCCWRP's data more accessible for use by partners. The next two projects strive to improve SCCWRP and partner agencies' abilities to cost-efficiently achieve meaningful monitoring results via statistical analysis of monitoring designs. The last project will consolidate and improve accessibility of statewide data on beach water quality.

a. Southern California Regional Data Center

The State of California and the US EPA are charged with evaluating the status of beneficial uses for waterbodies within the State of California every three years. One important component of this assessment is the creation of the 303(d) list, or list of impaired waterbodies. This assessment is also the foundation for reports to legislature on the status of water quality and success of water quality management programs. One method of obtaining data for these assessments is through the State's Surface Water Ambient Monitoring Program (SWAMP), one of the largest ambient monitoring data repositories in the State of California. However, this database is growing rapidly and the old centralized system cannot keep up with the demands of data users. The State is attempting to overcome these challenges through use of the California Environmental Data Exchange Network (CEDEN). CEDEN is a network of federal, state, county, and private organizations interested in the exchange and sharing of water quality and other environmental data from California. To facilitate participation by a rapidly growing number of agencies, CEDEN will be fed data via a system of distributed data centers. The Southern California Regional Data Center (SCRDC) will be housed at SCCWRP.

The overall goal of creating the distributed data center model is to improve data sharing between existing monitoring programs and CEDEN in order to effectively and efficiently provide data for assessment of waterbodies statewide. Over the next year, three objectives will be targeted: 1) continuation of support for the Stormwater Monitoring Coalition in loading their data to the system, as well as recruiting other NPDES permit holders to participate; 2) recruiting and assisting citizen monitoring groups in submitting and sharing their water quality monitoring data; and 3) adding SCCWRP historical data to CEDEN. Specifically, SCCWRP will offer users technical assistance with a web-based data submission tool, and will work to provide web-based access to SWAMP data by creating user-friendly queries to extract data and other information.

This is an ongoing project. In the next year, SCCWRP will collaborate with CEDEN and other Data Center partners to develop data visualization and extraction tools. In addition, staff will work on the technical task of connecting the SCRDC to the CEDEN server.

Lead Investigator: Shelly Moore (shellym@sccwrp.org)

Collaborators: Moss Landing Marine Laboratories (Rusty Fairey, Mark Pranger), State Water Resources Control Board (Val Connor, Karl Jacobs), San Francisco Estuary Institute (Dr. John Oram, Cristina Grosso), University of California Davis (Dr. Michael Johnson, Melissa Turner), Southern California Stormwater Monitoring Coalition, and a number of citizen-monitoring groups

External Funding Support: State Water Resources Control Board

b. Web Data Services

SCCWRP provides the scientific community public access to its data sets and associated metadata through the SCCWRP website. Although the data is available, it is stored and served to the data user on a by-project basis, typically in compressed text files. Many users would prefer to download data across projects and have the option of different formats to view the data. New sophisticated web-based tools for downloading and viewing data have been developed that allow users to access data more easily and efficiently. Geographic Information Systems (GIS) coupled with relational databases permit drag and drop or preformatted queries for extracting data by location, time, and/or constituent. The queries might generate thematic maps, tables, and graphs, or download the portions of data sets of specific interest to the user. New tools have also been developed to allow users to make “on the fly” graphics to view the data.

The goal of this project is to develop and maintain browser-based data discovery and visualization tools that will be available over the SCCWRP website. These tools will allow for customized data extraction, data analysis, and presentation.

This is an ongoing project. SCCWRP is currently in the process of investigating many new data visualization tools. Over the next year, staff will begin developing and implementing these tools.

Lead Investigator: Shelly Moore (shellym@sccwrp.org)

Collaborators: None at this time

c. Spatial Sampling Designs for Mapping

Maps are useful tools for understanding the marine environment. Using maps, resource managers can quickly locate disturbances, evaluate cumulative effects resulting from multiple sources or types of disturbance, weigh risks to neighboring areas, and assess the relative magnitude and spatial extent of contamination. Perhaps most importantly, maps are an effective and efficient media for communicating information to the public. Despite these benefits, there has been little success in developing statistically-defensible maps of environmental quality and aquatic resources in coastal regions. Sparse sampling grids and simple interpolation methods may not reliably predict environmental conditions at non-sampled locations, and do not provide estimates of precision.

The goal of this project is to provide general guidelines to monitoring programs on how to capture the necessary spatial information for constructing scientifically-defensible maps of environmental impact. This project will apply the kriging method of interpolation to predict chemical and biological parameters associated with non-sampled locations. SCCWRP will also investigate practical and cost-efficient sampling strategies for augmenting existing monitoring designs, with a focus on estimating spatial correlation and building sound predictions. In particular, a variogram will be used to model spatial variability and to translate this information into cost-efficiency curves (prediction error vs. sampling density) for enhancing future surveys. Such curves will allow resource managers to weigh the relative benefit in increased accuracy from contributing additional samples to the map.

This is the fourth year of a five year project. Previously, SCCWRP helped develop a sophisticated monitoring design, implement sampling, and apply intensive iterative analysis using robust spatial statistics surrounding San Diego's two ocean discharge sites. Last year, a similar mapping study was initiated a similar study with the Orange County Sanitation District (OCSD). The fourth and fifth years will focus on sampling near OCSD's ocean outfall, variogram modeling, cost-efficiency analysis for monitoring approaches, and creation of statistically defensible maps of the continental shelf.

Lead Investigator: Kerry Ritter (kerryr@sccwrp.org)

Collaborators: City of San Diego, Colorado State University (Dr. Scott Uruqhart), Orange County Sanitation District

External Funding Support: Orange County Sanitation District

d. Improving Probabilistic Surveys of Environmental Condition to Include Trend Detection

Most regulatory-based environmental monitoring programs focus on going to the same sites repeatedly over time. While this type of sampling design provides tremendous information about temporal trends, it provides little information on the condition of the area beyond those sites. Over the last 15 years, SCCWRP has led an effort to integrate probability-based survey designs into the Southern California Bight Regional Monitoring Programs. Probability-based designs provide invaluable information about the spatial extent of environmental condition, such as "how many acres of marine habitat are impacted?" or "how many stream miles are impaired?" Still, they are not optimized for trend detection.

The goal of this project is to create a survey design that can be used to effectively describe both spatial extent and temporal trends. This should address the needs of environmental decision-makers to detect increases (or decreases) in the magnitude of disturbance over time. While some work has been conducted to optimize spatial extent and trends in a single sampling design, this has rarely been done in southern California, particularly in marine ecosystems. This project will focus on estimating the variability between sites and sampling periods (up to 10 years), as well as the magnitude of change. This information will be used to perform a cost-efficiency analysis to optimize allocation of sampling effort.

This is the second year of a three-year project. The first and second years will focus on estimating the temporal components of variability relative to the overall variability for Bight '08 data. In the third year, the temporal variability estimates will be used to confirm trends in spatial extent as well as optimizing different sampling allocations across time/space for assessing trends in future Bight Regional Monitoring Programs.

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Collaborators: Bight'08 Regional Monitoring participants, Southern California Stormwater Monitoring Coalition, State Water Resources Control Board's Surface Water Ambient Monitoring Program

e. Clean Beach Initiative Website

Beach water quality data collected by coastal county environmental health agencies in California is reported to the State Water Resources Control Board (SWRCB) as part of AB411 monitoring requirements. In many cases, each county provides access to its beach water quality monitoring data through its own website; therefore, no central location to find and view all of the data for California exists. Because it is not easily available or viewable, this data cannot be used to its full advantage for answering questions posed by other organizations and the public about beach safety. Consequently, the California Water Quality Monitoring Council is developing a website that will provide a centralized location to find AB411 data and information. SCCWRP staff will work with the SWRCB to develop a system for displaying and viewing this data. The website will focus on answering the question "Is it safe to swim?"

The goal of this project is for SCCWRP to provide an interface for users of California's Water Quality Monitoring Council's website to view and download beach water quality monitoring data. In addition, SCCWRP will process the SWRCB's data to create linked summary reports that describe the displayed information.

This is the first year of a one-year project. SCCWRP will work with Beach Watch partners (see project *Beach Watch Data Management*) to develop a mechanism for retrieving and displaying data through the new Water Quality Monitoring Council website.

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Collaborators: SWRCB Water Quality Monitoring Council

External Funding Support: California Department of Health Services