SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT

FY 2012/2013
RESEARCH PLAN

Approved by SCCWRP Commission

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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. SCCWRP's primary mission is to enhance scientific understanding of linkages among human activities, natural events, and the health of the Southern California coastal environment; to communicate this understanding to decision makers and other stakeholders; and to suggest strategies for protecting the coastal environment for this and future generations.

Each year, SCCWRP prepares a Research Plan describing anticipated research activities for the upcoming fiscal year. The Plan provides an overview of SCCWRP's research foci, as well as details of specific projects. SCCWRP's quarterly Director's Report provides updates on research objectives and reports project benchmarks as related to the Research Plan. . Both the Research Plan and the Director's Reports can be accessed year-round on the SCCWRP website (www.sccwrp.org).

The Research Plan is organized by project purpose, with research activities falling into three main areas: development of new environmental assessment methodologies and tools, science to support management or regulatory programs, and regional monitoring programs to assess status and trends in ecosystem conditions. Projects are next grouped by scientific disciplines or habitats. Although some projects may be representative of more than one category, reflecting the interdisciplinary nature of SCCWRP research, each appears only once. Project descriptions detail goals, current status, collaborators, funders, and lead investigator contact information for each project. Readers are encouraged to contact lead investigators for additional project information and research insights.

A. ENVIRONMENTAL ASSESSMENT METHOD/TOOL DEVELOPMENT

One of the main functions of SCCWRP's research is to investigate, test, refine, validate, and transfer new environmental assessment technologies to California's water quality management community. SCCWRP is consistently on the leading edge of environmental assessment method and/or tool development for Southern California, and in some cases, for the state, national, and international scientific community. Method/tool development is often initiated in response to a particular problem or need, morphing novel scientific techniques into usable and reliable applications. SCCWRP's emphasis is on not only discovering new ways of understanding the environment, but on leveraging its management community linkage to transition new methods and tools to real-world applications.

In support of this function, many of SCCWRP's current research activities in take advantage of recent advances in molecular biology and genetic technology, which offer a new way of examining the diversity of aquatic life and how chemicals interact with biological systems. These methods offer potential advantages in time, cost, accuracy, reproducibility, and detection ranges. Additionally, new methods and tools are needed to more fully understand previously unstudied contaminant classes and specific needs of California's ecosystems.

1. Chemistry Assessment

a. Analytical Methods for Toxaphene

Traditional analytical methods determine the bulk amount of a particular target chemical in an environmental sample. Approved measurement methods have been developed for most historic environmental contaminants of concern. However, many of these measurements are obtained simultaneously using a single, non-specific method that are inadequate for individual, difficult to detect compounds (e.g., toxaphene).

This project involves development of analytical methods for quantifying toxaphene residue in environmental sample extracts using a relatively new technique known as negative ion mass spectrometry. Toxaphene is the generic name of a complex organochlorine pesticide mixture that was used extensively during the last half of the 20th century. Banned in the 1980s, toxaphene residue raises concern due to its persistence, bioaccumulation, and potential for toxic effects. Method development associated with this project is in late stages, and efforts this year will focus on coordinating laboratory intercalibration exercises for the newly developed toxaphene sample processing protocols.

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

Collaborators: Ashland Chemical (Tim Hassett), CSU Long Beach (Richard Gossett), National Institute of Standards and Technology (Dr. John Kucklick), Test America (Betsy Beauchamp)

External Funding Support: Ashland Chemical

New Project

b. **Non-targeted Analysis**

Approved measurement methods have been developed for many historic environmental contaminants, but these methods are inadequate for investigating chemical constituents of more recent concern, impeding monitoring and management for these constituents. This project seeks to develop analytical methods for contaminants of emerging concern (CECs). CECs are a large group of chemicals not commonly monitored or regulated in the environment. CECs number in the thousands and include pharmaceuticals and personal care products, current-use pesticides, natural and/or synthetic hormones, and industrial and commercial chemicals.

This project uses two dimensional gas chromatography and time-of-flight-mass spectrometry (GCxGC-TOF-MS) to identify, in a non-targeted manner, multiple classes of CECs in tissue, sediment, and water samples from selected receiving water environments. Non-targeted analysis may serve as a useful periodic screening tool for directing the targeted analytical methods used in regional monitoring projects. Also, the comparison of non-targeted "fingerprints" may be useful in distinguishing the suite of source contaminants, such as treated wastewater effluent and storm water, from naturally occurring contaminants.

Lead Investigator: Nathan Dodder (nathand@sccwrp.org)

Collaborators: CSU San Diego (Dr. Euhna Hoh), National Institute of Standards and Technology (Dr. John Kucklick), Orange County Sanitation District (Dr. Jeff Armstrong), San Francisco Estuary Institute (Dr. Susan Klosterhaus)

External Funding Support: None at this time.

c. Passive Samplers

Multiple line of evidence approaches to assess contaminated sediments typically measure total (bulk) contaminants. However, in many instances, bulk sediment chemistry does not reflect the pool of contaminants ultimately available to organisms, resulting in a lack of concordance between observed chemistry and biological impact data. Attempts to improve contaminant partitioning estimates by modifying conventional measurements and/or parameters (e.g., total organic carbon normalization or toxic unit estimation) have met with limited success. In contrast, passive sampling methods (PSMs), including solid phase

microextraction and polyethylene sediment porewater samplers previously developed at SCCWRP, have shown great promise in quantifying the bioavailable contaminant pool for both sediment-associated organic constituents and metals. Further testing is needed to determine if PSMs can predict the amount of uptake and bioaccumulation by sentinel test species, such as fish and benthic invertebrates, and thus the contaminants' potential toxic impacts.

The purpose of this project is to evaluate whether PSMs can be used to better predict bioaccumulation and observed sediment toxicity in sediments from coastal water bodies. This year, a technical workshop will be convened to identify the salient issues surrounding the use of PSMs for sediment assessment. In the next few years, experiments and field studies will be performed using PSMs to quantify the bioavailable fraction of high priority sediment contaminants (e.g., pyrethroids, fipronil, PBDEs) in conjunction with efforts to characterize toxicity parameters (i.e., LC_{50}) and bioaccumulation profiles for the same model compounds.

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

External Collaborators: Chinese Academy of Sciences (Dr. Jing You), Exxon-Mobil (Dr. Tom Parkerton), National Oceanic and Atmospheric Administration (Dr. Peter Landrum, ret.), State Water Resources Control Board (Chris Beegan), Loyola Marymount University (Dr. Rachel Adams), USC (Dr. Jim Haw), US Environmental Protection Agency (Dr. Robert Burgess)

External Funding Support: USC Sea Grant

d. Bioanalytical Screening Tools

Given the large number of CECs, it would be impractical to develop and implement a traditional chemically specific approach for monitoring each individually, particularly as chemical production and use is continually changing. The State of California's Science Advisory Panel for CECs has encouraged development of bioanalytical screening techniques to meet this challenge. Because these screening techniques are designed to integrate a response to multiple chemicals, they can account for unknown chemicals and elucidate the cumulative potency of complex mixtures. If successful, adaptation of methods recently developed by the US Environmental Protection Agency and National Institute of Environmental Health Sciences would serve to screen for exposure to known, regularly occurring chemicals that act with a similar modes of action, such as estrogenicity, androgenicity, thyroid activity, or carcinogenicity.

The purpose of this study is to evaluate whether selected bioanalytical methods can be used as monitoring tools for recycled water and ambient waters receiving treated

wastewater effluent and stormwater discharges. This year, linkages between candidate bioassay response and higher order impacts to human health will be established. Appropriate statewide monitoring for recycled water will be defined for methods exhibiting acceptable performance. In subsequent years, the most promising bioassays relevant to ecosystem protection (receiving waters) will be selected and optimized.

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

Collaborators: BDS-Calux (Dr. Peter Benisch), Griffith University (Dr. Fred Leusch), Life Technologies Inc. (Gerry Pelanek), SwitchGear Genomics (Dr. Shelley Aldred), UC Riverside (Dr. Daniel Schlenk), University of Arizona (Dr. Shane Snyder), University of Florida (Dr. Nancy Denslow), University of Queensland (Dr. Beate Escher), University of South Florida (Dr. Sandy Westerheide)

External Funding Support: State Water Resources Control Board, Water Reuse Research Foundation

2. Toxicity Assessment

a. Traditional Toxicity Identification Evaluation Methods

Identifying the specific constituents responsible for responses in sediment toxicity tests is a complex task, but one that is important to supporting management actions such as site remediation, sediment quality objective compliance, and Total Maximum Daily Load establishment. Most environmental samples contain mixtures of contaminants, and conventional chemical analyses are rarely sufficient to identify the individual constituents. A more effective approach to contaminant assessment involves use of Toxicity Identification Evaluation (TIE), which is a sequence of laboratory investigations that first characterize the general classes of toxicants present (e.g., metals) and then confirm the specific constituents (e.g., copper) causing environmental effects. 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 will involve method development studies with spiked samples and application to field sites. The focus for this year will be on refining sediment TIE thresholds for pyrethroids (commonly found in household insecticides) and developing TIE methods for additional current use pesticides (e.g., fipronil).

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

Collaborators: San Francisco Estuary Institute (Sarah Lowe), UC Davis Marine Pollution Studies Laboratory (Bryn Phillips)

External Funding Support: City of Los Angeles

b. Molecular Tools for Toxicity Identification Evaluation

The Toxic Identification Evaluation (TIE) process uses a variety of chemical/physical separation methods and treatments to remove one or more toxicant class, coupled with toxicity testing following each manipulation. Although helpful in identifying contaminant classes of greatest concern, traditional TIE methods have several drawbacks including cost, chemical specificity, and omission of low-level sublethal toxic effects and synergistic or antagonist effects associated with contaminant mixtures. Recent advances in molecular biotechnology may allow development and application of improved methods based on genomics (e.g., analysis of gene expression or protein production). Gene microarrays, particularly when linked to higher level effects on the test organism (e.g., growth, reproduction), have the potential to simultaneously measure effects on multiple physiological systems, providing a sensitive measure of a contaminant's or sample's toxicological effects.

The goal of this project is to develop a new suite of TIE tools. This will involve microarray development for sentinel organisms (including marine fish and invertebrates), documentation of gene expression profiles for target contaminants, and comparison of the microarray results to conventional TIE methods. Research this year will include a) developing a work plan for a new mussel (*Mytilus galloprovincialis*) microarray, b) examining gene expression patterns in fish exposed to contaminants in the field and laboratory, and c) refining data analysis methods by conducting interlaboratory comparisons for the marine amphipod microarray.

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

Collaborators: CSU Long Beach (Dr. Kevin Kelley), Environment Canada (Graham Van Agglen), Los Angeles County Sanitation Districts, UC Berkeley (Dr. Chris Vulpe), UC Davis Marine Pollution Studies Laboratory (Brian Anderson), UC Riverside (Dr. Daniel Schlenk), University of Southern California (Dr. Andrew Gracey)

External Funding Support: Environment Canada, Los Angeles County Sanitation Districts, Los Angeles Regional Water Quality Control Board, San Francisco Estuary Institute

3. Biological Assessment

New Project

a. Rocky Reefs

Rocky reefs, most easily identified by their forests of giant kelp (*Macrocystis*), are amongst the most productive marine ecosystems on earth. Rocky reef habitats span at least one-quarter of the southern California coastline, but are sensitive to water quality stress, suffer from fishing pressure, and respond dynamically to natural fluctuations such as temperature and wave climate. There are a number of programs that manage these habitats and their associated biota, but lack standardized assessment tools that can be used to score sites, define status, and evaluate trends. This lack of standardization has limited communication of the complex biological information to environmental managers in a simple, straightforward manner.

The goal of this project is to begin developing a rocky reef assessment index. This project will bring together two dozen of the nation's experts in rocky reef ecology. Requisite biological and physical data with location and stressor levels redacted to eliminate bias regarding perceived condition will be made available to each expert. Their challenge will be to gain consensus on the attributes commonly used for ranking each site's biological condition.

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

Collaborators: Occidental College (Dr. Dan Pondella), UC Santa Barbara (Dr. Jenn Casselle)

External Funding Support: South Orange County Water District

b. Periphyton

As primary producers, algae occupy the base of aquatic ecosystem food webs and represent a crucial component of healthy, highly functional streams. Diverse factors, such as exposure to light, water temperature, current speed, water chemistry, presence of grazers, substrate types, and channel morphology, control algal growth, distribution, and community composition. Many southern California streams are channelized, exhibit modified hydrology, and have anthropogenic nutrient inputs. These and other factors can contribute to excessive algal growth, which may impact beneficial uses. Along with information from physical and chemical monitoring, algal community assessment can be used as a biological indicator to interpret stream condition and/or beneficial use status.

This project aims to produce tools that utilize benthic soft-bodied algae and diatom assemblages for biological assessment of stream condition, anthropogenic disturbance, and nutrient levels. Data on algal assemblages, water chemistry, physical habitat, and landscape parameters have been compiled for southern California coastal streams across condition gradients, and are being used to develop a Periphyton Index of Biotic Integrity (IBI). This year activities will be focused on refining the IBI and preparing user support materials (written documentation and tools) for technology transfer to managers and

practitioners. SCCWRP will also help to facilitate training workshops.

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

Collaborators: University of Colorado (Dr. Patrick Kociolek), CSU San Marcos (Dr. Robert Sheath), CSU Monterey Bay (Dr. Marc Los Huertos)

External Funding Support: State Water Resources Control Board

c. DNA Barcoding

Species assemblages are often used as indicators of environmental condition; however, traditional methods for identifying and quantifying organisms can be time-consuming and labor-intensive. This project explores the efficacy of DNA barcoding, in which a short gene sequence from a standardized position in the genome is measured, as an alternative tool for rapidly identifying species. 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. Species composition can then be translated to correspond with existing indices of biological integrity. Additionally, barcode speciation data could reveal instances where reassessment of taxonomy is warranted.

The goal of this project is to assess the efficacy of barcoding for rapidly identifying benthic invertebrate and algal species in marine and freshwater samples from the Southern California Bight. Aspects of the project include: a) establish a DNA barcode reference library of voucher specimens that have been identified using traditional taxonomic methods and genetically sequenced to record their unique genetic barcode; b) develop protocols for sample processing, including suitable fixatives that do not degrade genetic material; and c) determine how to correlate barcode data with existing quantitative indices.

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

Collaborators: Canadian Centre for DNA Barcoding (Dr. Peter Miller), SCCWRP member agencies, Stroud Water Research Center (Dr. Bernard Sweeney), US Environmental Protection Agency (Dr. Erik Pilgrim).

External Funding Support: None at this time

d. Cyanobacteria

Cyanobacteria blooms are a global problem and have been found throughout California in fresh water and brackish habitats. Cyanobacteria produce toxins that can cause wildlife

mortality and are associated with liver cancer and tumors in humans. Cyanotoxins in coastal runoff also impact marine ecosystems, causing mortality in California sea otters. A preliminary study of 40 southern California lakes, depressional wetlands and coastal lagoons found that >95% were dominated by cyanobacteria, with toxin levels exceeding WHO standards in 10%. Early studies by the Stormwater Monitoring Coalition found toxicity in a number of stream reaches, including those in undeveloped catchments. Follow-up pilot studies have documented detectable cyanotoxin concentrations in streams. The potential for benthic cyanobacteria to produce toxins in wadeable streams is of great importance not only because of the likely effect on aquatic life use, but also because of the possibility that presence of cyanotoxins can depress BMI IBI scores. Despite the health risks associated with cyanotoxins, insufficient data is available on the prevalence of cyanobacterial blooms and cyanotoxins concentrations in southern California water bodies. Better understanding is needed on the temporal patterns and environmental drivers for bloom occurrence and toxin production.

The goals of this project are to: 1) document the prevalence of cyanobacterial blooms and toxin concentrations in a variety of fresh and brackish water habitats in southern California, 2) document the temporal patterns of bloom occurrence and toxin concentrations and pilot novel methods of monitoring cyanotoxins, with the objective of recommending ways of optimizing monitoring, and 3) increase understanding of environmental drivers for cyanobacterial bloom occurrence and toxin production.

This year, researchers will continue documenting the prevalence of cyanobacteria in aquatic habitats by collecting samples from depressional wetlands via the regional depressional wetland assessment (see 3b. Depressional Wetlands) and from wadeable streams via the SMC regional monitoring program. Sampling in streams will focus on reference and open-space sites with few known sources of anthropogenic inputs. Results of the cyanotoxin analysis will be compared to results of standard toxicity tests and benthic macroinvertebrate analysis to begin exploring potential effects of cyanotoxicity.

Lead Investigators: Betty Fetscher (bettyf@sccwrp.org), Meredith Howard (merdithh@sccwrp.org)

Collaborators: UC Santa Cruz (Dr. Raphael Kudela)

External Funding Support: None at this time

4. Microbiological Assessment

a. Rapid Water Quality Indicators

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 18- to 24-hour sample incubation periods, during which the public may be exposed to contaminated water. Correspondingly, beaches may have posted warnings or advisories for a day longer than necessary simply because of methodological lags in obtaining results. In 2010 and 2011, pilot projects were conducted at Orange County and LA County beaches demonstrating how a rapid bacterial indicator measurement method (quantitative polymerase chain reaction or qPCR) could be used for beach monitoring with same-day results. Several logistic and technological challenges remain, including method modification to address inhibition of the rapid reaction that occurs when inhibitory substances are present in water samples. Such interference poses a concern because it can cause underestimation of pathogen levels. In addition, there remain opportunities for speeding the monitoring process through assay automation.

The goal of this project is to continue development of rapid methods that can augment or replace existing methods for indicator bacteria at high risk beaches. This year, SCCWRP will work to resolve inhibition issues, support technology transition in southern California, share findings with the US Environmental Protection Agency as they move toward approving a rapid beach monitoring method nationally, and further develop automated sample processing technology. Studies to address inhibition will include evaluating alternative qPCR reagents, sample purification procedures, and predictive factors for the occurrence of inhibition. An automated environmental sample processor being developed and intercalibrated by SCCWRP and partners will be deployed on piers or moorings in southern California and other parts of the state to test the processor's ability to collect and analyze indicator bacteria in situ and telemeter data back to shore.

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

Collaborators: Stanford University (Dr. Ali Boehm), Monterey Bay Aquarium Research Institute (Dr. Chris Scholin), USEPA (Dr. Richard Hoagland), City of Los Angeles, NOAA (Dr. Kelly Goodwin)

External Funding Support: None at this time

b. Microbial Source Tracking and Identification

The State of California enacted the Clean Beaches Initiative (CBI) Grant Program in 2001 with the aim of restoring and protecting coastal beach water quality. The CBI has helped to improve water quality at many beaches by funding nearly $100M in management measures, such as diverting storm drains to reduce runoff flows, repairing aging sewer lines, and creating natural filtration areas. Despite these successes, a number of beaches with poor water quality remain, primarily because the source of contamination is unknown. A variety of molecular methods designed to distinguish among fecal sources have been developed over the last several years, but the last comprehensive examination of such source-tracking methods was conducted nearly a decade ago. Thus, water quality managers are unsure about which methods are most reliable for their specific application, forestalling mitigation efforts.

The goal of this project is to create a source identification manual, implement selected protocols at several beaches of high interest to the State, and transition source identification capabilities to local laboratories to ensure their continuing use after the project is completed. These efforts are part of the Source Identification Protocol Project, and site-specific studies will be conducted this year at Dog Beach in San Diego and Doheny Beach in Dana Point.

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

Collaborators: Stanford University (Dr. Ali Boehm), UC Santa Barbara (Dr. Patricia Holden), UCLA (Dr. Jennifer Jay), Virginia Tech (Dr. Charles Hagedorn)

External Funding Support: State of California Water Resources Control Board, County of San Diego

New Project

c. Quantitative Microbial Risk Assessment

Current fecal indicator bacteria (FIB) criteria are based on epidemiological studies that found health risks to swimmers were associated with FIB concentrations. These studies were largely conducted at beaches dominated by human sources of fecal inputs (sewage pollution), but many beaches, including those in southern California, are subject to inputs of fecal pollution from non-human sources. Because of differences in associated pathogen loading, health risks associated with non-human FIB levels may differ from that associated with human fecal inputs. To address situations where non-human sources of fecal input predominate, the EPA is considering the use of quantitative microbial risk assessment (QMRA) to determine site-specific objectives. QMRA models human health risks associated with non-human sources of fecal pollution based on source strength and pathogen load. However, very few QMRA's have been conducted globally, and none have been conducted at marine beaches in the US.

The goal of this project is to conduct a QMRA demonstration project at a southern California marine beach and will involve: a) identifying sources in detail to ensure no or few human pathogen inputs exist; b) sampling fresh fecal material from identified non-human sources for pathogen analysis; c) characterizing swimmer exposure by modeling transport and fate of non-human source inputs, and d) quantifying the level of illness in the swimming population. This project will test the QMRA framework, evaluate the assumptions associated with the modeling, and identify data gaps where research can improve QMRA as a future management tool.

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

Collaborators: Soller Environmental (Jeffrey Soller), USEPA (Dr. Nick Ashbolt, John Ravenscroft)

External Funding Support: Los Angeles Regional Water Quality Control Board, US Environmental Protection Agency, Ventura County Watershed Protection District

5. Biogeochemical Cycling Assessment

a. Coastal Hypoxia

New Project

Hypoxia, or lack of dissolved oxygen (DO), is an escalating threat to global coastal waters, with several time-series studies highlighting recent declines in ocean DO concentrations. In addition to this large-scale trend, short-term acute hypoxic events in shallow, coastal locations are of special concern because they impact the coastal ecosystems that support important economic sectors like fishing, shellfish hatcheries, and tourism. Traditionally, hypoxia has been thought to result from nutrient runoff fueling increased productivity. However, more recent work suggests that many coastal hypoxic events on the west coast result from shoaling of deeper oceanic water which is becoming increasingly hypoxic due to a climate-change induced strengthening of the thermocline layer. The purpose of this project is to use existing monitoring data to investigate trends in oxygen conditions in southern California waters and assess the relative importance of oceanic versus anthropogenic drivers for those trends. Additional goals for this project during the first few years will include identifying data gaps and defining future research directions in this area.

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

Collaborators: Center for Ocean Solutions (Dr. Fio Micheli)

External Funding Support: None at this time.

New Project

b. Harmful Algal Blooms

Blooms of harmful and toxic algae have increased in frequency and severity along the US West Coast in recent years. Although several harmful algal bloom (HAB) organisms have been identified, the toxic diatom *Pseudo-nitzschia* is the most prevalent, and has been linked to many detrimental impacts on commercial fisheries, tourism, and marine birds and mammals. Still, scientists lack understanding about how bloom dynamics change in response to shifting environmental conditions and why certain "hot spots" are frequently impacted. Research into the ecophysiological factors driving *Pseudo-nitzschia* blooms will support improved monitoring, predictive modeling, and management approaches.

The primary goal of this study is to develop a better understanding of the conditions leading to bloom and toxin initiation for *Pseudo-nitzschia* by simultaneously comparing two hot spots: Monterey Bay and San Pedro, California. A combination of field work and modeling will be used to determine the relative sensitivity of bloom and toxin initiation to a variety of factors. This will include several years of intensive field sampling in each region using ship-based surveys, autonomous underwater vehicles (gliders), automated environmental sample processors, and satellite imagery in combination with physical and statistical modeling.

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

Collaborators: Monterey Bay Aquarium Research Institute (Dr. Chris Scholin), Moss Landing Marine Laboratories (Dr. Jason Smith), National Oceanic and Atmospheric Administration (Dr. Greg Doucette), UCLA (Dr. Yi Chao), UC Santa Cruz (Dr. Raphael Kudela), University of Southern California (Dr. David Caron)

External Funding Support: National Oceanic and Atmospheric Administration

New Project

c. Microbial Response to Environmental Gradients in Streams

Urban development and agricultural activity has seriously altered hydrology and increased contaminant loading into streams and rivers, threatening a wide range of essential and economically valuable ecosystem services provided by these aquatic systems. While monitoring chemical and physical parameters provides information about contaminant levels, bioassessment is needed to diagnose adverse biological effects and link contaminant concentrations to ecosystem health. However, current bioassessment tools rely on labor-intensive and time-consuming taxonomical identification of benthic invertebrate and algae communities, while the potential to use microbial community analysis for bioassessment remains relatively unexplored. Microbes are primary players in the biogeochemical cycling that is fundamental to ecosystem services. Microbial community composition (i.e., microbe types and quantities) and function have been shown to be sensitive and respond rapidly to

environmental changes. Mature and rapidly developing molecular technologies already exist for microbial community analysis.

The goal of this project is to evaluate the efficacy of using microbial community analysis as a bioassessment tool. Because pristine and impacted environments may select for different phylogenetic groups of microorganisms and/or different microbial functions, such as denitrification, nitrification, or metal metabolism, community analysis technologies that characterize both phylogenetic and functional community composition will be employed. Researchers will perform simple microbiological measurements and high-throughput phylogenetic sequencing and functional microarray microbial community analysis; sample selection will be based on hydrological, physical, and chemical parameters. Subsequent analytical results will be used to relate microbial community phylogenetic attributes and functional composition to nutrient levels, algae extent, and benthic invertebrate bioassessments. Ultimately, a customized microarray will be constructed as a bioassessment tool for a particular effect or array of effects.

Lead Investigator: Yiping Cao (yipingc@sccwrp.org)

Collaborators: University of Oklahoma (Dr. Jizhong Zhou)

External Funding Support: None at this time

B. TECHNICAL SUPPORT FOR MANAGEMENT/REGULATORY PROGRAMS

A second major function of SCCWRP's research is to integrate the body of available scientific knowledge and new studies to build a technical foundation for effective management and regulatory programs. California's environmental management programs often shape the development of national programs, and SCCWRP is uniquely positioned at the interface of science and management on both levels. As a result, SCCWRP is often called upon to serve as one of a handful of organizations offering expertise to discern the best scientific approaches for achieving environmental policy goals. This type of service is usually requested when environmental issues are widely acknowledged and well documented, but support is needed to develop effective, practicable management.

SCCWRP's research activities in this area are intended to guide the unbiased development of the best available methods for tracking progress and for ultimately achieving environmental management goals. While the goals themselves are set by policy and management agencies, SCCWRP helps to interpret and transition scientific methods to support program implementation.

a. Nutrient Objectives in Streams

The California State Water Resources Control Board (SWRCB) is working to protect California waterbodies from eutrophication (i.e., accumulation of organic matter, typically from nutrient enrichment) by developing nutrient objectives. These nutrient objectives will be narrative, with guidance to establish thresholds for eutrophication indicators such as algal biomass and dissolved oxygen. These thresholds can be used in a nutrient numeric endpoint (NNE) framework. The NNE consists of two components: 1) an assessment framework which specifies how to use monitoring data to determine waterbody condition and 2) one of several available nutrient-response models that can be used to link response indicators to nutrients and other management controls (e.g., hydrology) on a waterbody-specific basis.

For streams, NNE thresholds for algal biomass were chosen by consensus of best professional judgment as determined by a team of national and international experts; as such, these thresholds may be reflective of the team's collective experience with streams in conditions atypical of those found in California (i.e., heavily forested ecosystems). To date, no work has been done to explicitly identify tipping points from increased nutrients and algal biomass on indicators of aquatic life use (e.g., community structure of algae and benthic macroinvertebrates). There is a need to continue research on alternative or complimentary indicators (e.g., percent cover), and optimize monitoring protocols. In addition, more work is needed on nutrient-response models, including: statistical models, simple mechanistic (spreadsheet) models, and calibrated dynamic models. To help meet

this need, the SWRCB is offering "benthic biomass spreadsheet models" as scoping tools that relate ambient nutrient concentrations to algal biomass while accounting for physical factors such as stream flow velocity and canopy cover. Additional work is needed to validate these spreadsheet tools, conduct mechanistic studies, generate calibrated dynamic simulation models of nutrient-response in arid Mediterranean streams, and develop guidance on the use of modeling tools in regulatory applications.

The goals of this project are to: 1) investigate relationships between nutrient concentrations, algal biomass, and indicators of biotic communities (algae and benthic macroinvertebrates, 2) research alternative or complimentary indicators and optimize monitoring protocols, 3) conduct mechanistic studies on nutrient cycling in the Santa Margarita River, 4) validate the benthic biomass nutrient-algal response spreadsheet models, and 5) develop and validate a calibrated dynamic simulation model of nutrient-algal response in the Santa Margarita River.

Initially, researchers will analyze existing stream bioassessment data to investigate relationships between nutrient concentrations, algal biomass, and algae and benthic macroinvertebrate taxonomy. These data will also be used to validate the benthic biomass spreadsheet tool and investigate sources of model error. Subsequently, a river monitoring plan will be implemented in the Santa Margarita River, and data will be collected to develop a calibrated dynamic simulation model.

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

Collaborators: US Environmental Protection Agency (Dr. Naomi Dettenbeck), Space and Naval Warfare Systems Command (Dr. PF Wang), TetraTech Inc (Dr. Jon Butcher).

External Funding Support: County of San Diego, State Water Resources Control Board, US Environmental Protection Agency

b. Nutrient Objectives in Estuaries

SCCWRP is providing support to develop the technical foundation for nutrient objectives in California estuaries. As with streams and lakes (see project B.a above), the State Water Resources Control Board approach consists of: 1) utilization of NNE assessment frameworks to establish how to use monitoring data on indicators of algae and dissolved oxygen to categorize waterbody condition with respect to eutrophication, and 2) development of nutrient-algal response models to link the NNE targets to nutrients and estuarine condition. California has variety of estuarine classes and habitat types (intertidal flats, seagrass, unvegetated subtidal) for which the numeric endpoints and nutrient-algal response models would be expected to be different. Because the San Francisco Bay represents approximately 75% of the State's estuarine habitat and differs in properties

from the many small estuaries in the State, a site-specific NNE assessment framework and nutrient algal-response model will be developed for San Francisco Bay.

The goals of this project are to: 1) develop NNE assessment frameworks for the range of habitat types and estuarine classes through a combination of new studies, existing data, and best professional judgment, and 2) develop nutrient algal-response models for California estuaries. NNE assessment frameworks will be developed for: 1) Macroalgae intertidal flats, shallow subtidal habitat, macroalgae and phytoplankton in seagrass habitats, and phytoplankton in unvegetated subtidal habitat within estuaries where inlets are "open" to tidal exchange; 2) Macroalgae and phytoplankton in "bar-built" estuaries "closed" to tidal exchange; and 3) Dissolved oxygen across all habitat types. Work on nutrient-algal response models will consist of: 1) refinement of statistical models, 2) development of "pilot" mechanistic models for southern California Bight estuaries, and 3) development of calibrated dynamic simulation models for individual estuaries (e.g., Loma Alta Slough, Santa Margarita River estuary), and 4) development of a conceptual model and modeling strategy for the San Francisco Bay.

Initially, this project inventoried California estuaries, reviewed candidate indicators and science supporting decisions on assessment framework thresholds for algae and dissolved oxygen, developed a work plan to proceed with assessment framework and nutrient-response model development for the State's estuaries, and conducted experiments to document the threshold for effects of macroalgae on intertidal flats in open estuaries. This year, researchers will: 1) conduct experiments to determine the threshold for effects of macroalgae in seagrass habitat, 2) develop the NNE assessment framework for macroalgae in intertidal flats and seagrass, 3) develop a work plan for a study of background levels of macroalgae and phytoplankton in reference "closed" estuaries, 4) synthesize existing data and develop a conceptual model governing NNE assessment and nutrient-response modeling in San Francisco Bay, 5) complete a calibrated dynamic response model in Loma Alta Slough, and 6) begin development of a calibrated dynamic simulation model in Santa Margarita River estuary.

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

Collaborators: San Francisco Estuary Institute (Dr. Dave Senn), UCLA (Dr. Peggy Fong), UC Santa Cruz (Dr. Raphael Kudela), US Geological Survey (Dr. Jim Cloern), UC Davis/Bodega Bay Marine Laboratory (Dr. John Largier), Elkhorn Slough National Estuarine Research Reserve (Dr. Kirsten Wassen), Morro Bay National Estuary Program (Adrienne Harris).

External Funding Support: State Water Resources Control Board, Bay Area Clean Water Agencies, San Francisco Regional Water Quality Control Board, San Francisco Estuary Institute Regional Monitoring Program

c. Biological Objectives

Direct measures of biological condition are increasingly preferred as assessment endpoints because they are most closely linked to the beneficial uses or functions that are the focus of environmental protection and management. In contrast, traditional 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. As a result, the California State Water Resources Control Board is working to develop biological objectives (bio-objectives) for perennial streams and rivers. Benthic macroinvertebrates will be used as a primary bioindicator in streams because of their well-studied life histories, relatively sessile nature, available taxonomy, and relative ease of collection and identification. In addition, other metrics such as rapid ecosystem assessment and numeric flow criteria could provide powerful tools for use in regulatory programs like bio-objectives. Altered hydrology is one of the primary factors that directly or indirectly affect the health of in-stream benthic communities. Although a basic understanding of the relationship between flow alteration and ecological response exists, few studies have provided the mechanistic evidence on how specific ecological metrics respond to various degrees of flow alteration.

The goal of this project is to develop the technical foundation for bio-objectives. Focusing on perennial wadeable streams and their associated riverine/riparian wetlands, assessments will include benthic macroinvertebrate indicators, the California Rapid Assessment Method (CRAM), and in-stream flow requirements. Ultimately, the bio-objectives framework will include an approach for integrating multiple biological indicators and waterbody types. This will require producing maps of the stream and wetland resources that currently exist, identifying and quantifying reference conditions, creating or enhancing biological assessment tools, defining a stressor gradient to identify biological expectations for the mapped resources, and setting thresholds of concern for biological condition. This year's activities will involve refining the benthic assessment tool and conducting a statewide test application of proposed bio-objective thresholds. In addition, researchers will conduct three case studies using assessment tools to identify specific stressors that cause biological impacts.

Lead Investigators: Ken Schiff (kens@sccwrp.org), Eric Stein (erics@sccwrp.org)

Collaborators: California Coastal Commission (Ross Clark), California Department of Fish and Game (Dr. Peter Ode), Southern California Stormwater Monitoring Coalition, State Water Resources Control Board, US Environmental Protection Agency, US Geological Survey (Dr. Jason May, Dr. Larry Brown)

External Funding Support: US Environmental Protection Agency and State Water Resources Control Board

d. Sediment Quality Objectives

Sediment quality objectives (SQOs) have been recently approved for use in California enclosed bays and estuaries. SCCWRP helped develop and validate the assessment framework and data analysis tools needed to interpret sediment quality in the context of the SQOs. Regulatory agencies are in the process of incorporating SQOs into monitoring programs, permitting processes, and cleanup actions, which raises continuing technical questions about sampling designs, results interpretation, and stressor identification. SCCWRP is also assisting with technical support to investigate indirect relationships between sediment contamination and potential impacts on organisms (e.g., marine birds, predatory fish, and humans) through the food chain. Bioaccumulation in organisms consumed by humans and wildlife is often a driving factor in ecological risk assessments, especially with respect to DDTs, PCBs, and mercury. Still, the assessment of indirect effects due to sediment contamination is more complex than direct effects and requires a different conceptual approach. The potential for indirect effects on an organism is influenced by numerous factors, including the fraction of sediment contaminants biologically available to prey species, complexity of the food web, movements of the receptor organisms, food consumption rate, and species-specific variations in chemical sensitivity.

The goal of this project is to: a) develop an assessment framework based on multiple indicators for evaluating the indirect effects of sediment contamination on human health, and b) provide technical support for assessment and management activities associated with incorporating the approved SQOs into monitoring and cleanup activities. For indirect effects guidance, SCCWRP will revise technical support documents this year in response to public comments and prepare journal publications. The primary focus of SCCWRP's support will be assistance with study design, training, and review of reports.

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

Collaborators: San Francisco Estuary Institute (Ben Greenfield), State Water Resources Control Board

External Funding Support: San Diego Regional Water Quality Control Board, State Water Resources Control Board

e. Hydromodification Assessment and Management

Southern California is home to several highly urbanized regions. The process of urbanization affects stream courses directly through channel engineering, and indirectly

through altered watershed hydrology (hydromodification). Hydromodification can have adverse effects on stream habitat, surface water quality, and water supply, while associated stream erosion may threaten infrastructure, homes, and businesses. To address this issue, state and local agencies are developing standards and management approaches to control and/or mitigate hydromodification effects on natural and semi-natural stream courses. To support these programs, science-based tools are needed to understand causal factors and susceptibility to hydromodification effects.

The goal of this project is to develop a series of support tools for hydromodification management measures that can be used to better protect the physical, chemical, and biological integrity of streams and their associated beneficial uses. Tools will be targeted to address several questions: a) which streams are at the greatest risk of hydromodification effects? b) what are the anticipated effects in terms of increased erosion, sedimentation, or habitat loss with increases in impervious cover? c) what are some potential management measures that could be implemented to offset hydromodification effects? and d) how effective are they likely to be? This year, researchers will focus on reporting and technology transfer for the screening and predictive model-based tools developed by this project.

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

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

External Funding Support: State Water Resources Control Board, County of San Diego

C. REGIONAL MONITORING

Monitoring is a cornerstone of environmental management, providing stakeholders with information about changes in ecosystem condition and the effectiveness of management programs. SCCWRP's research focus on monitoring programs helps guide implementation of problem-driven investigations and sustained tracking. In the early stages, these efforts are focused on defining clear monitoring questions and appropriate sampling designs to answer those questions. Subsequently, there is a need for standardization of approaches and assessment methodologies across multiple monitoring agencies from a regional perspective. At the later stages, SCCWRP supports the data management and quality assurance needs of ongoing monitoring efforts.

SCCWRP began conducting regional surveys in the 1970s and continues to be well-known for coordinating the Southern California Bight Regional Monitoring Program, which monitors waters from the shoreline to the coastal shelf in five-year cycles. SCCWRP also maintains extensive pollutant emissions data from the many dischargers to the Southern California Bight at periodic intervals dating back to 1971. More recent efforts involve development of monitoring solutions for other habitats, including streams, wetlands, and Areas of Special Biological Significance.

1. Regional Marine Monitoring

a. Southern California Bight Regional Monitoring Program

The Southern California Bight Regional Monitoring Program is currently conducted in five-year cycles and has involved over 100 different stakeholder organizations. This program has been useful in monitoring trends over time, as well as establishing regional reference conditions, developing new environmental assessment tools, standardizing data collection approaches in southern California, and providing a support network for special studies. The most recent survey, Bight '08, examined six major research areas, including: Coastal Ecology (sediment condition), Water Quality (water column condition), Microbiology (beach condition), Rocky Reefs (kelp bed condition), Estuarine Eutrophication (nutrient over-enrichment), and Areas of Special Biological Significance (Condition of marine protected areas).

The goal of this project is to plan for the 2013 Regional Monitoring Program (Bight '13). This year's activities will be focused on identifying the best structure for the Bight '13 program based on planning discussions with stakeholders. Prior to initiation of sample collection, committees will be formed to define monitoring questions, prepare study designs, set quality assurance expectations, and develop an information management system to be shared among participants.

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

Collaborators: Numerous participating organizations

External funding support: None at this time

b. Pollutant Sources Data Cataloguing

Mass emission estimates enable comparisons among different pollution sources to assess relative risk and track trends over time. SCCWRP has estimated mass emissions from large publicly owned treatment works (POTWs) annually for the last 38 years, and from other sources (such as small POTWs, industrial dischargers, dredged material disposal, urban runoff, oil platforms, vessel discharges, and aerial deposition) about every five years. Pollutant mass emissions from the four largest southern California POTWs have declined by more than 95% over the last 40 years as a result of increased effluent treatment, source control, industrial pretreatment, and reclamation. At the same time, nonpoint source discharges (such as stormwater runoff) have become a proportionately greater contributor to overall pollutant loading to the ocean. Regulated stormwater agencies have recently begun to standardize monitoring approaches and methods in order to estimate concentrations and loads; however, these agencies still lack an integrated data management system for compiling monitoring data.

The primary goal this year is to estimate mass emissions from stormwater, industrial dischargers, power generating stations, large POTWs to the southern California Bight. In addition to being used for status and trends tracking, the stormwater data will be transferred to the California Environmental Data Exchange Network for use in statewide water quality assessments.

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

Collaborators: City of Los Angeles, City of San Diego, Los Angeles County Sanitation Districts, Orange County Sanitation District, Southern California Stormwater Monitoring Coalition

External Funding Support: None.

c. Mussel Watch

To characterize the spatial extent and temporal trends in coastal contaminant levels nationwide, the National Oceanic and Atmospheric Administration (NOAA) Mussel Watch Program has collected and analyzed bivalve species since 1986. Representative samples of locally abundant species are collected from fixed sites in order to assess long-term temporal trends in trace metal and organic contaminant levels. The program includes 21

Mussel Watch sites in the Southern California Bight (SCB), with most located along the open coast. This dataset has provided unparalleled information on the declines in 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 provides a point of comparison between the SCB and the rest of the country. The sentinel sites in California have also provided a mechanism to begin monitoring the fate of contaminants of emerging concern (CECs). SCCWRP has also worked with NOAA to intensify the number of sampling sites in the SCB.

The goals of this study are to assist NOAA in implementation and further development of the Mussel Watch Program in the southern California region, including: 1) expanded sampling in Areas of Special Biological Significance and Marine Protected Areas; 2) compare bivalve accumulation measurements with results from passive sampling devices; 3) identify priority CECs that warrant inclusion in the national Mussel Watch program; and 4) develop alternative bioindicators for future assessment. Initial pilot monitoring for CECs has been completed, and upcoming years will focus on the development and evaluation of bioindicators that characterize integrated exposure to environmental stressors for bivalves and other sentinel coastal species.

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

Collaborators: Multi-Agency Rocky Intertidal Network (Dr. Jack Engle), National Oceanic and Atmospheric Administration (Gunnar Lauenstein), San Francisco Estuary Institute (Dr. Susan Klosterhaus), State Water Resources Control Board (Dominic Gregorio), University of Southern California (Dr. Andrew Gracey), US Geological Survey (Dr. Ed Furlong, Dr. David Alvarez)

External Funding Support: None at this time

d. Areas of Special Biological Significance

Areas of Special Biological Significance (ASBS) are water quality protected areas in California where the discharge of waste is prohibited. There are 34 ASBS throughout the state, and about half are located in southern California. Mapping studies conducted in 2003 identified nearly 1,700 outfalls that discharge into ASBS statewide, and in 2006, voters approved a $5.4 million water bond with a portion of the funds dedicated to reducing pollutant inputs into ASBS. To date, 14 grants totaling $1.3 million have been authorized by the State Water Resources Control Board (SWRCB) to ASBS regulated parties. While the SWRCB requires monitoring for each grant, there is no coordination among grantees with respect to monitoring questions, study designs, measurement indicators, or methods. This makes it difficult to assess the overall effectiveness of the Proposition 84 grant program.

The goal of this project is to provide technical support for coordinating Proposition 84 grantee monitoring. The monitoring program should determine: a) the mass of pollutants removed from ASBS discharges as a result of Proposition 84 grants, and b) the condition of ASBS receiving waters, especially near grant implementation sites. Earlier work focused on reviewing and improving grantee monitoring plans and quality assurance project plans. This year's activities will focus on data compilation from initial grantee monitoring.

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

Collaborators: None at this time

External funding support: State Water Resources Control Board

2. Regional Watershed Monitoring

a. Stormwater Monitoring Coalition Regional Watershed Monitoring

In-stream bioassessment monitoring in southern California is currently conducted by more than a dozen different organizations. In the past, each of these organizations had disparate programs varying in design, frequency, and indicators selected for measurement. Even where designs were similar, field techniques, laboratory methods, and quality assurance requirements often diverged, making cumulative assessments impossible. To address these issues, a comprehensive and integrated monitoring program was designed by the southern California Stormwater Monitoring Coalition (SMC). This program mirrors SCCWRP's Southern California Bight Regional Monitoring Program, wherein each participating group assesses its local geography and contributes a small portion to the whole regional assessment. The SMC program plans to establish comparability in the field and the laboratory, performance-based quality assurance guidelines, and an information management system for sharing data. In this way, it can address large-scale management needs and provide answers to the public about the overall health of southern California's streams and rivers. The SMC program also provides an opportunity to investigate novel issues and/or monitoring parameters.

The goal of this project is to support implementation of the SMC's regional watershed monitoring program for southern California's coastal streams and rivers. The program intends to initiate summer sampling in 2012 and sample a total of 450 sites over five years. SCCWRP will continue providing support for data compilation and interpretation to guide the future directions of the program. In addition, SCCWRP will continue developing a methodology for multi-indicator assessment of riparian wetland ecosystem condition in California. This requires integration of existing biological assessment tools, including benthic macroinvertebrate and algal indices of biotic integrity, physical habitat assessment

(PHAB), and the California Rapid Assessment Method (CRAM), to provide an overall ecosystem assessment for riverine wetlands.

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

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

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

New Project

b. Background Concentrations of Contaminants in San Diego Reference Streams

The streams and rivers found in Orange and San Diego County watersheds have become increasingly urbanized, which brings increased wet and dry weather runoff to streams, resulting in increased loads of bacteria, nutrients, heavy metals and other contaminants. Management of these water quality issues in the San Diego Regional Water Quality Control Board's region is currently hampered by the lack of a consistent set of scientifically-defensible numeric targets for streams. Existing standards do not account for natural sources of constituents. One approach to developing numeric targets that account for "natural sources" involves quantifying concentrations in, or loads from, streams in a minimally disturbed or "reference" condition.

The goal of this project is to collect the data necessary to derive reasonable and accurate wet and dry weather numeric targets for bacteria, nutrients, and heavy metals, based on a reference approach. This project provides an opportunity to demonstrate the use of new bioassessment approaches to identify reference conditions, including: 1) use of new molecular microbial source tracking tools for bacteria community fingerprinting (see *Microbial Communities Analysis as a Bioassessment Tool* proposal); 2) use of stream algal bio-objectives to establish the biomass, cover, and taxonomic composition of algae associated with reference streams; and 3) investigations of sources of toxicity to invertebrates using newly developed molecular toxicity identification evaluations, including potential cyanobacteria and associated toxins.

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

Collaborators: None at this time

External Funding Support: City of San Diego, Counties of Orange and San Diego and their co-permittees

c. Atmospheric Deposition of Nutrients to Coastal Watersheds

Recent data from the Storm Water Monitoring Coalition Regional Stream Monitoring Program indicate that heavy algal cover (>30%) occurs even at sites with predominantly undisturbed catchments, suggesting that atmospheric deposition may be a significant source of nutrients to streams. Previous SCCWRP research found that atmospheric deposition can be a significant source of trace metals to southern California watersheds, but only limited data exists on atmospheric deposition of nutrients and its contribution to water quality in this region. A lack of standardized techniques for direct measurement of atmospheric nutrient deposition is one reason for such limited data. Inferential methods, which have been frequently used in other regions, are both costly and time-consuming. Surrogate surfaces offer a simple, cost-effective method for direct measurement of atmospheric nutrient deposition, but surrogates have not been tested in the semi-arid conditions of southern California.

The goals of this project are to: 1) provide reliable measurement techniques for atmospheric nutrient deposition in southern California and 2) to estimate rates of atmospheric nutrient deposition in selected sites in Southern California. The combination of the most successful methods (static surface samplers versus conventional denuders) and isotope tracking methods will be used to measure rates of wet and dry atmospheric at 6 regional stream bioassessment reference sites in southern California 5 times over an annual cycle, capturing gradients in natural land cover type (forested, chaparral, etc.).

Lead Investigator: Karen McLaughlin (karenm@sccwrp.org)

Collaborators: US Forest Service (Dr. Pamela Padgett)

External Funding Support: County of San Diego, US Environmental Protection Agency

3. Regional Wetland Monitoring

a. Wetlands Status and Trends

Billions of dollars have been invested over the last 20 years for the protection and restoration of California's wetlands and riparian areas. However, the effectiveness of these investments is uncertain due to a lack of systematic monitoring. At a national level, the US Fish and Wildlife Service National Wetland Inventory has adopted a probability-based survey approach to assess trends in wetland acreage and produce status and trends plots. The new design is currently being incorporated into the EPA's 2011 National Wetland Condition Assessment (NWCA). Within the state, the California Wetlands Monitoring Workgroup (CWMW) has developed and is working to implement a statewide Wetland and Riparian Area Monitoring Program (WRAMP). The goal of the WRAMP is to produce regular reports on trends in wetland extent and condition, and to relate these trends to

management actions, climate change, and other natural and anthropogenic factors, in order to inform future decisions. In addition, to track and evaluate the success of wetland restoration programs, SCCWRP is developing performance curves to forecast how the beneficial uses and functional capacity of restoration projects should increase over time. These new tools for mitigation and restoration planning will help ensure that projects contribute to an overall net gain or no net loss in wetland extent and condition throughout the state.

The goals of this project are to help build a framework for wetland and riparian monitoring and assessment by participating in the CWMW, supporting implementation of the NWCA and WRAMP, and to provide new technical tools for wetland tracking. Activities in the current year will focus on: a) development of standard definition, classification, and mapping procedures for wetland status and trend plots; b) support and population of the State's recently launched Wetlands Portal and wetland project tracking system; c) support for WRAMP implementation through several large infrastructure projects such as solar energy and high speed rail; d) implementation of the Stormwater Monitoring Coalition's (SMC) riverine wetland regional monitoring program; and e) creation of a statewide strategy for monitoring wetland extent using census and probability-based approaches. In addition, performance curves based on the California Rapid Assessment Method (CRAM) will be developed for perennial estuarine and coastal riverine wetlands, and regional reference sites will be incorporated to evaluate the curves with respect to best achievable condition.

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

Collaborators: California Department of Fish and Game, San Francisco Estuary Institute (Dr. Josh Collins), CSU Northridge (Dr. Shauna Dark), US Environmental Protection Agency, US Fish and Wildlife Service National Wetlands Inventory, California Wetlands Monitoring Workgroup

External Funding Support: US Environmental Protection Agency, California Coastal Conservancy, California Resources Agency via the Coastal Impact Assistance Program

b. Depressional Wetlands

Freshwater depressional wetlands are the state's most diverse wetland class and comprise approximately 45% of California's 3.6 million wetland acres. This class includes vernal pools, freshwater marshes, and wet meadows, and may have near-persistent to intermittent surface water flows that connect them to other surface waters. Depressional wetlands may be natural, actively maintained manmade features, or abandoned manmade features. While they perform the entire range of functions typically associated with wetlands, depressional wetlands are particularly important as seasonal refugia and

breeding areas in dry habitats. Cumulatively, they contribute to groundwater recharge, water purification, and attenuation of surface runoff, thus reducing the impact of excessive flow to streams, lentic water bodies, and coastal environments downstream. To date, the state's Surface Water Ambient Monitoring Program has focused almost entirely on wadeable streams; most monitoring and assessment of depressional wetlands is associated with specific impact or mitigation projects. As a result, the available monitoring data is limited in space and time, and there is little knowledge about the overall extent and condition of depressional wetlands.

The goal of this project is to establish a foundation for a statewide ambient monitoring program for depressional wetlands by a) developing, modifying, and testing assessment tools; b) creating a monitoring design; and c) demonstrating the monitoring program through pilot implementation at a subset of depressional wetland types in southern California. The study design and indicators might then be adopted or modified for other regions of the State.

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

Collaborators: CSU San Marcos (Dr. Robert Sheath), UC Berkeley (Kevin Lunde)

External Funding Support: California Resources Agency via the Coastal Impact Assistance Program; San Diego, Los Angeles, and Santa Ana Regional Water Quality Control Boards; US Environmental Protection Agency

New Project

c. Eelgrass

Eelgrass is considered a "foundation", or habitat forming species that creates unique biological, physical, and chemical values and environments. In addition, eelgrass provides many important services that contribute to a healthy ecosystem, such as trapping and removing suspended particulates, improving water clarity, and reducing erosion by stabilizing the sediment. Within southern California, four species of eelgrass are known to occur; however, the two species, narrow-bladed eelgrass (*Zostera marina*) and wide-bladed eelgrass (*Z. pacifica*), are likely the most dominant in the region and have been the subject of resource management for many years.

Despite the obvious value of eelgrass and other seagrasses, nearly a quarter million acre loss has been documented throughout the world over the last three decades. Given its location in bays, estuaries, and nearshore environments, the continued pressures of

shoreline development and influences from coastal processes have the potential to significantly affect its distribution and abundance in southern California.

California currently lacks a system for tracking eelgrass data that would allow determination of the resource extent and compliance with the Southern California Eelgrass Mitigation Policy. Having consistent and comparable monitoring data on eelgrass distribution, extent, and condition throughout the southern California Bight will provide more complete information to management agencies about the overall status of this resource and trends in its condition, thus providing an overall regional context for making more informed decisions at the local and project scales. The goal of this project is to develop a process to facilitate the incorporation of eelgrass maps, existing regionwide survey data, and mitigation projects into the California Wetlands Portal (www.CaliforniaWetlands.net.). This information will enable individuals and resource managers to more effectively predict, track, and manage the impacts of specific projects in the region.

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

Collaborators: National Marine Fisheries Service (Bryant Chesney), San Francisco Estuary Institute (Meredith Williams)

External Funding Support: National Marine Fisheries Service, Habitat Conservation Division

d. Historical Ecology

Historical ecology, mapping the historical extent and distribution of natural resources, is a valuable environmental management tool. For example, knowledge of the streams and wetlands in southern California's coastal watersheds circa 1870 provides environmental managers, scientists, and the public answers to a range of key questions about the restoration potential of contemporary watersheds, such as where to leave streams accessible to daylight, or how to lay out a landscaping palette of native vegetation for restoration projects. Historical ecology requires the acquisition, georeferencing, digitizing, and interpretation of historic coastal topographic maps (t-sheets). However, much more information is needed to help fill in data gaps, cross-reference facts, and make estimations for interim time periods. Specifically, information on wetland and riparian habitat must be gathered, 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. Previously, the project has examined distribution of wetland and riparian habitat in the San Gabriel River, lower Ventura River, lower Santa Clara River, and Ballona Creek watersheds. Presently, it is focused on the historical ecology of several north San Diego Lagoons. In addition to creating summary reports, the project has developed several online tools to host products and metadata including digitized coastal t-sheets.

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

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

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

D. INFORMATION MANAGEMENT AND ANALYSIS

Turning data into usable information is an ongoing challenge for environmental monitoring and management efforts. Monitoring data is collected by many different agencies and organizations with a wide range of methods for collecting, labeling, storing, and sharing data. However, this data is only meaningful in forms that can be easily accessed and compared to other datasets. To this end, SCCWRP has played a primary role in helping member agencies and others produce comparable data products that maximize value and usability.

Over the past decade, SCCWRP has done a great deal of work developing standardized data transfer formats, which led to its role in leading the California Environmental Data Exchange Network (CEDEN), and serving as CEDEN's Southern California Regional Data Center. More recently, SCCWRP research has focused on the development of cutting edge tools that make it easier to process complex data and display it visually in a meaningful way.

a. Database Management

SCCWRP is currently overseeing development and management of two large water quality databases in California, the California Environmental Data Exchange Network (CEDEN) and the Beach Watch database. CEDEN facilitates data access and sharing among a network of federal, state, county, and private organizations. This data is primarily used by the State of California to report prepare the 303(d) list of impaired water bodies to the US Environmental Protection Agency (EPA) in compliance with the Clean Water Act. To facilitate participation by a rapidly growing number of agencies, CEDEN receives data via four regional data centers, including the Southern California Regional Data Center housed at SCCWRP. The goal of CEDEN is to improve data sharing among existing monitoring programs and provide a platform for effective and efficient statewide water quality assessments. SCCWRP's current efforts are focused on recruiting and training regional data providers, developing visualization and extraction tools, providing user-friendly web-based data access and documentation, and connecting CEDEN with other state and EPA data servers.

The Beach Watch program assists the State comply with its requirements to compile and report beach water quality data collected by county environmental health departments and other entities. This is accomplished through development of a standardized data transfer system and a SCCWRP-designed and implemented web-based data submission system. SCCWRP also assists the State by transferring this data to EPA databases and to the public through the California Water Quality Monitoring Council's website. The goal of Beach

Watch is to ensure successful storage of beach water quality data and submission to the EPA.

Lead Investigator: Steve Steinberg (steves@sccwrp.org)

Collaborators: Moss Landing Marine Laboratories (Rusty Fairey), San Francisco Estuary Institute (Meredith Williams), State Water Resources Control Board, Dr. Michael Johnson

External Funding Support: State Water Resources Control Board

New Project

b. Dynamic Data Processing and Visualization

SCCWRP has historically focused on data consistency and storage. However, as large data bases become increasingly available, the next challenge is to find ways to ensure that available data that is intuitive and visual for effective use with analytical tools (e.g., index computation, environmental models) or to support management decisions. Data visualization provides valuable insights into understanding data relationships and interactions. For analysis across diverse geographic regions, geovisualization enables the analysis and display of data in a map-based context. With the advent of more sophisticated scientific and spatial modeling tools and capabilities, there are important opportunities for SCCWRP to extend capabilities in data modeling and visualization, particularly within a geospatial framework.

The goal of this project is to develop visualization and geovisualization capabilities to support projects across SCCWRP's research portfolio and to enhance options for reporting, presentation, web-based visualization, and animation. This year's focus will be on developing the ability to dynamically process data streams via web-based applications, including complex computations that are not otherwise available to the broader scientific and management communities. In particular, SCCWRP will complete work on a web-based computation and visualization tool for benthic index data based on the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) taxonomic listings.

Lead Investigator: Steve Steinberg (steves@sccwrp.org)

Collaborators: None at this time

External Funding Support: None at this time

E. MEMBER AGENCY SUPPORT

In addition to research-oriented activities, SCCWRP provides ongoing on-call support for its member agencies. In particular, this year two of SCCWRP's member agencies (Orange County Sanitation District and City of Los Angeles Bureau of Sanitation) are planning temporary diversion of their ocean outfalls as part of maintenance activities, and SCCWRP will provide support by monitoring the effects of discharges to shallower locations that rarely receive such inputs.

New Project

a. General Support

SCCWRP staff provide periodic support to the member agencies in the form of training, quality-assurance audits, field and laboratory assistance, monitoring guidance, administrative support, technical review, and communication to their Governing Boards.

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

b. Quality Assurance for Offshore Monitoring

The State Water Resources Control Board recently prepared an amendment to the California Ocean Plan that requires quality assurance (QA) procedures for ocean monitoring paralleling the State's previous efforts to establish QA protocols for freshwater monitoring. Some of the existing QA guidelines for freshwater are directly applicable to ocean monitoring, but others need to be retooled for application within a marine context. One of the most challenging adaptations will involve biological monitoring of benthic infauna, where thousands of organisms comprising hundreds of species can live within one square meter of the seabed.

The goal of this project is to prepare method quality objectives (MQOs) for ocean monitoring that the State can integrate into its Quality Assurance Program Plan. This process will require consideration of several different science-based approaches and facilitation of cooperative decision-making among stakeholders.

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

Collaborators: The SCCWRP member agencies, Central Coast Regional Monitoring participants (CCLEAN), Southern California Association of Marine Invertebrate Taxonomist (SCAMIT)

External Funding Support: None at this time

New Project

c. Pilot Monitoring with Autonomous Underwater Vehicle

Ocean monitoring surveys are currently conducted several times a year by the municipal wastewater dischargers in southern California. These rely on ship-based data collection using a CTD (conductivity, temperature, and depth) measurement device, supplemented by periodic grab sampling of water for further laboratory analysis. Some water quality tests (e.g., bacterial and nutrient measurements) can only be collected with grab samples, limiting the spatial coverage of this type of data. In addition, ship-based data can only be collected during favorable weather conditions and time periods when agency personnel are available. The National Oceanic and Atmospheric Administration and others are developing automated ocean monitoring technology that would allow pre-programmed continuous monitoring along specified transects. These autonomous underwater vehicles (AUVs) could potentially provide better spatial and temporal coverage while reducing monitoring costs.

The goal of this project is to test application of an AUV (glider) in southern California through a collaborative effort with SCCWRP member agencies. The glider will be deployed at four locations (near the City of Los Angeles, Los Angeles County, Orange County, and City of San Diego outfalls) in conjunction with a comparable traditional survey. Objectives are to identify and address potential logistic challenges, compare data collected using the two methods, and determine if AUV technology offers advantages to local agencies.

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

Collaborators: City of Los Angeles, City of San Diego, Los Angeles County Sanitation Districts, National Oceanic and Atmospheric Administration, Orange County Sanitation District, Southern California Coastal Ocean Observing System

External Funding Support: None at this time

New Project

d. Effects of Ocean Outfall Diversion on Nutrient Cycling

The relative influence of anthropogenic versus natural factors in regulating nitrogen cycling and primary productivity in the Southern California Bight has not been well established. One challenge is isolating the effect of individual factors, such as wastewater effluent input. This fall, the Orange County Sanitation District (OCSD) plans to divert discharge from its main ocean outfall to a pipe that that will discharge effluent closer to shore and in shallower water. This diversion will present an opportunity to observe the effect of wastewater on dominant pathways of nitrogen cycling and primary production before and after the area receives effluent input.

The goal of this project is to assess changes in the Newport Coast nearshore waters as a result of the OCSD diversion. The project will include the use of gliders to track the effluent

plume and ship-based sampling to monitor the any detrimental environmental impacts, such as the potential for increased algal blooms. SCCWRP's involvement in this project also provides an opportunity to assess the applicability of emerging technologies to detect the effects of anthropogenic sources of nutrients in coastal waters. Activities will include bacteria community fingerprinting, experiments to assess the relative effects of nitrogen form on growth of phytoplankton species, and assessment of relative rates of nitrification and denitrification associated with any algal blooms that might develop.

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

Collaborators: Orange County Sanitation District, University of Southern California (Dr. David Caron), National Oceanic and Atmospheric Administration (Dr. Greg Doucette).

External Funding Support: None at this time.

New Project

e. Newport Bay Watershed Model Monitoring

The Newport Bay Watershed is a valuable Orange County resource, with the upper Newport Bay being one of the region's largest estuaries. The Newport Bay Watershed is subject to a complex mix of regulatory requirements resulting in a series of unlinked monitoring programs for wastewater, stormwater, and total maximum daily load (TMDL) compliance. Like many urban watersheds, the results from independently developed monitoring programs are not synthesized; consequently, many basic questions about status, trends, or knowledge gaps remain unanswered.

The goal of this project is to facilitate a critical review of, and develop a potential redesign of, current watershed monitoring efforts to improve effectiveness and cost-efficiency of making management decisions. Tasks include defining and prioritizing monitoring questions, inventorying existing efforts, evaluating current monitoring designs, and recommending changes to the design for program improvement.

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

Collaborators: Santa Ana Regional Water Quality Control Board, Orange County Public Works

External Funding Support: Santa Ana Regional Water Quality Control Board