SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT

FY 2014/2015
RESEARCH PLAN

Commission Approved

June 2014

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 works closely with its member agencies, among them dischargers, watershed managers, and regulators, to provide the scientific foundation for ambient water quality management in the region.

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 about specific projects. Many of these projects and project areas remain consistent from year to year due to their alignment with multi-year strategic efforts. SCCWRP's quarterly Director's Report provides more frequent updates on research objectives and individual projects 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 the goals, current status, collaborators, funders, and lead investigator contact information for each project. Readers are encouraged to contact the project's lead investigator(s) for additional information.

A. ENVIRONMENTAL ASSESSMENT METHOD/TOOL DEVELOPMENT

One of SCCWRP's main research functions is to investigate, test, refine, validate, and transfer new environmental assessment technologies to Southern California's water quality management community. SCCWRP is consistently on the leading edge of environmental assessment method and/or tool development for the region, 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 not only on discovering new ways of understanding the environment, but also on leveraging the organization's linkage to the management community to transition new methods and tools into real-world applications.

In support of this function, many of SCCWRP's current research activities 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 being developed to more fully understand previously unstudied contaminant classes and needs specific to California's ecosystems.

1. Chemistry Assessment

a. Emerging Contaminant Prioritization

Contaminants of emerging concern (CECs) encompass a vast number of largely unregulated compounds that lack data on occurrence and potential toxicity in the environment. A wide variety of substances including pharmaceuticals, flame retardants, contemporary pesticides, and even food additives are considered CECs. Many CECs have been present in the environment for years or even decades but were not previously detectable using available analytical methods. Recent technological advances have improved capabilities for CEC detection and quantification in environmental media, leading to increased attention on determining their potential hazards. Traditionally, identifying CECs with the highest risk to ecological and human health requires knowledge of their fate once discharged into the environment, as well as high quality exposure (occurrence) and toxicological data to support threshold development. The State of California previously sponsored an expert Science Advisory Panel for CECs to develop a prioritization approach to help guide permit monitoring programs. However, the expert panel was challenged by the limited amount of occurrence data available.

The purpose of this project is to enhance the availability of CEC occurrence data. This data will enable the state and advisory panel to continue prioritizing the CECs of greatest concern. SCCWRP will collect occurrence data in sediments at regional scales utilizing the Bight Regional Monitoring Program (see project C1a). A more spatially focused effort will also target potential CEC sources near Los Angeles. Tissue screening for CECs will be accomplished via a partnership with the National Oceanic and Atmospheric Administration's Mussel Watch program. Finally, SCCWRP will help develop a statewide monitoring study design and associated implementation plan for incorporating CECs into California's Surface Water Ambient Monitoring Program.

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

Collaborators: Los Angeles Regional Water Quality Board (J. Michael Lyons), Los Angeles County Sanitation Districts (Joe Gully, Ann Heil), participants in the Bight '13 Regional Monitoring Program, Colorado School of Mines (Dr. Jorg Drewes), National Oceanic and Atmospheric Administration, State Water Resources Control Board

External Funding Support: State Water Resources Control Board, Los Angeles Regional Water Quality Control Board

b. Bioanalytical Screening Tools

While new chemical methods and environmental occurrence data can help prioritize monitoring and assessment efforts in the short term, the large number of potential CECs (in the tens of thousands of chemicals) makes it impractical to implement a traditional chemical-specific monitoring approach. The State of California's Science Advisory Panel for CECs encouraged development of bioanalytical screening techniques to meet this challenge. Bioanalytical screening techniques elicit cellular responses such as estrogenicity, androgenicity, or carcinogenicity after exposure to toxic compounds. These techniques can integrate measurement of multiple chemicals, account for unknown chemicals, and elucidate the cumulative potency of complex chemical mixtures.

This study evaluates whether selected bioanalytical methods can be used as monitoring tools for recycled water and ambient waters receiving treated wastewater effluent and stormwater discharge. Many bioanalytical screening tools adapt methods recently developed by the US Environmental Protection Agency and National Institute of Environmental Health Sciences for other, sometimes nonaquatic, exposure scenarios. This project will test and evaluate different methods to isolate the best performing bioanalytical screening tools for regional recycled water and ecosystem health applications. The best performing assays will be applied within the Bight '13 Regional Marine Monitoring Program (see project C1a) and as part of the Stormwater Monitoring Coalition's 5-year strategic plan to evaluate the tools' relevance to ecosystem protection where stressors (i.e., contaminant chemistry) and biological response (i.e., sediment toxicity tests and biological communities) are being measured synoptically. The new bioassays will also be evaluated on extracts from marine environmental samples (e.g., sediment, tissue) collected throughout the Southern California Bight.

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

Collaborators: Griffith University (Dr. Fred Leusch), Life Technologies Inc. (Mr. John Printen), 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), San Diego Regional Water Quality Control Board (Dr. Lilian Busse), Scripps Institution of Oceanography (Dr. Lihini Aluwihare), San Diego State University (Dr. Eunha Hoh).

External Funding Support: State Water Resources Control Board; Scripps Center for Oceans and Human Health

c. Non-targeted Analysis

Approved measurement methods have been developed for many historic environmental contaminants, but CECs number in the thousands and include a wide range of pharmaceuticals and personal care products, current-use pesticides, natural and/or synthetic hormones, and industrial and commercial chemicals. Measurement methods are available for only a handful of these and it is impractical to develop methods beyond those that are prioritized as markers for recycled and ambient waters. This creates a need for non-targeted analysis methods that can be used when bioanalytical screening reveals a sample of concern for which the unknown chemicals causing the response must be determined.

This project seeks to develop analytical methods for all CECs, including unknowns. It 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 or as guidance for selecting appropriate targeted analytical methods in regional monitoring projects. In addition, the comparison of non-targeted "fingerprints" may be useful in distinguishing source contaminants, such as those found in treated wastewater effluent and storm water, from naturally occurring contaminants. Work this year will focus on expanding the mass spectral library (chemical "fingerprints") representing sediment and biological tissue samples (e.g., bivalves, marine mammals, bird eggs) from coastal California as well as other regions.

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

Collaborators: CSU San Diego (Dr. Eunha Hoh), National Institute of Standards and Technology (Dr. John Kucklick), San Francisco Estuary Institute (Margaret Sedlak), University of Hohenheim (Dr. Walter Vetter)

External Funding Support: Scripps Center for Oceans and Human Health, University of Hohenheim

d. Analytical Methods for Emerging Contaminants

Traditional analytical methods determine the bulk amount of individual target chemicals in an environmental sample. Approved measurement methods have been developed for most historic environmental contaminants (e.g., DDTs, PCBs); however, these methods do not perform well for many classes of contaminants of emerging concern (CECs). Thus, new methods are needed for robust measurement of priority CECs, such as consumer and commercial chemicals that have a high probability for occurrence in potable and receiving waters at levels that pose a potential environmental threat.

This project involves developing analytical methods for priority CEC analytes such as alkylphenols (e.g., nonylphenol), synthetic musks used as fragrances in consumer products, and high production flame retarding chemicals. CEC residues will be quantified in environmental samples using accelerated solvent extraction and single quadrapole mass spectrometry. Method development will consist of optimizing extraction and determinative protocols for each targeted CEC class, followed by method performance validation in collaboration with other laboratories.

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

Collaborators: University of Arizona (Dr. Shane Snyder), US Geological Survey (Dr. James Gray), Duke University (Dr. Lee Ferguson), Virginia Institute of Marine Science (Dr. Mark LaGuardia), CSU Long Beach (Richard Gossett), National Institute of Standards and Technology (Dr. John Kucklick), University of California, Riverside (Dr. Dan Schlenk)

External Funding Support: Los Angeles Regional Water Quality Control Board

e. Passive Samplers

Multiple line of evidence approaches to assessing sediment and water column contaminants typically measure total (bulk) contaminants. However, in many instances, bulk chemistry does not reflect the pool of contaminants 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 samplers previously developed at SCCWRP, have shown great promise in quantifying the bioavailable contaminant pool for sediment- and water-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 therefore the contaminants' potential toxic impacts.

This project will evaluate whether PSMs can better predict exposure, bioaccumulation, and observed sediment toxicity in coastal water bodies. Experiments and field studies will be performed using PSMs to quantify the bioavailable fraction of high priority water column and sediment contaminants (e.g., DDTs, pyrethroids, fipronil, PBDEs). They will take place in conjunction with efforts to characterize toxicity parameters (i.e., LC_{50}) and bioaccumulation profiles for the same model compounds. The extent of equilibrium for passive samplers will also be determined using preloaded performance reference compounds.

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

External Collaborators: 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), US Environmental Protection Agency (Dr. Robert Burgess, Judy Huang), University of California, Riverside (Dr. Jay Gan), Applied Marine Sciences (Jay Johnson)

External Funding Support: University of California, Riverside, ITSI-Gilbane

2. Toxicity Assessment

a. Molecular Tools for Toxicity Identification Evaluation

The Toxicity Identification Evaluation (TIE) 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. Although helpful in identifying the contaminant classes of greatest concern, traditional TIE methods have several drawbacks including cost, poor chemical specificity, poor sensitivity to low-level toxic effects, and limited applicability to field exposure situations. Recent advances in molecular biotechnology may allow development and application of improved methods based on genomics (e.g., gene expression or protein production analysis). 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.

This project will develop a new suite of TIE tools for both laboratory and field applications. This involves gene expression microarray development for sentinel organisms (including marine and freshwater fish and invertebrates), documentation of gene expression profiles for target contaminants, and comparison of the microarray results to conventional toxicity test and TIE methods. Models will be developed for toxicant identification based on amphipod gene expression, applying gene expression microarrays to investigate hornyhead turbot gene expression responses to legacy contaminants and CECs, and examining linkages between gene expression changes and higher order effects (protein production, histopathology, reproductive effects) in fathead minnows exposed to endocrine disrupting compounds.

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

Collaborators: 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 Florida (Dr. Nancy Denslow), University of North Carolina (Dr. Susanne Brander)

External Funding Support: Environment Canada, Los Angeles County Sanitation Districts, San Francisco Estuary Institute

3. Biological Assessment

a. Rocky Reefs

Rocky reefs, most easily identified by forests of giant kelp (*Macrocystis*), are among the most productive marine ecosystems on earth. These 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 wind and wave climates. A number of programs manage rocky reef habitats and 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 complex biological information to environmental managers in a simple, straightforward manner.

This project will develop a rocky reef assessment index. Previously held workshops built consensus among the state's rocky reef ecology experts about attributes used for ranking biological condition. This information will be used to implement status assessments and stressor responses via the Southern California Bight Regional Monitoring Program (see project C1a) and monitoring of the region's Marine Protected Areas, established in 2011.

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

Collaborators: Occidental College (Dr. Dan Pondella), UC Santa Barbara (Dr. Jenn Casselle), Marine Protected Area Monitoring Enterprise

External Funding Support: South Orange County Water District

b. 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 Southern California. Aspects to this project include: a) establishing a DNA barcode reference library of voucher specimens identified both using traditional taxonomic methods and a genetically sequenced barcode; b) developing protocols for sample processing, including suitable fixatives that do not degrade genetic material; c) determining how to correlate barcode data with existing quantitative indices; and d) working toward next-generation sequencing methods to analyze composite DNA samples. This year's efforts will focus on leveraging the Bight Regional Monitoring Program (see project C1a) to enhance the barcoding library for the marine environment, analyzing the effect of increased taxonomic resolution from barcoding on sensitivity of existing freshwater biological indices, and evaluating the ability to determine invertebrate community composition from environmental DNA (eDNA; a composite of free-floating DNA extracted directly from the water column).

Lead Investigator: Dr. 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

c. Cyanobacteria

Cyanobacteria blooms are a global problem and have been found throughout California in freshwater and brackish habitats. Cyanobacteria produce toxins that can cause wildlife mortality and are associated with liver cancer and tumors in humans. Cyanotoxins transported in coastal runoff can also affect marine ecosystems, causing mortality in California sea otters. Despite the health risks associated with cyanotoxins, insufficient data is available on the prevalence of cyanobacterial blooms and cyanotoxin concentrations in Southern California water bodies. A better understanding of the temporal patterns and environmental drivers for bloom occurrence and toxin production is needed before effective regulatory or remediation actions can be implemented.

The goals of this project are to a) document the prevalence of cyanobacterial blooms and toxin concentrations in a variety of fresh and brackish water habitats in Southern California, b) document temporal patterns of bloom occurrence and toxin concentrations by pilot-testing novel cyanotoxin monitoring methods, c) increase understanding of environmental drivers for cyanobacterial bloom occurrence and toxin production, and d) recommend ways to optimize monitoring. Habitats for cyanobacteria prevalence measurements will include depressional wetlands (see project C3b) and reference streams in the San Diego region (see project C2b).

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

Collaborators: UC Santa Cruz (Dr. Raphael Kudela)

External Funding Support: None at this time

d. Non-perennial Streams

More than 100 samples are collected from perennial wadeable streams each year in an effort to assess biological condition. The State Water Resources Control Board is developing biological objectives to create a regulatory framework for protecting highly functional streams and restoring impacted streams. However, only about one-third of the stream-miles in southern California coastal watersheds are perennial (have year-round flow). The majority of stream miles are non-perennial, and most of these are located in lightly developed watersheds susceptible to future urban growth. Ecosystem management and protection efforts for non-perennial streams will require development or adaptation of monitoring tools and assessment mechanisms.

This project will evaluate applicability of current biological assessment tools originally created for perennial streams in non-perennial systems. It has four components including

a) identifying reference sites with a range of non-perennial flow characteristics; b) sampling flow, biology, and a variety of physical and chemical parameters throughout wetting and drying cycles; c) calculating biological objective scores to identify critical flow conditions for biological communities; and d) comparing results across a host of non-perennial and perennial sites with a range of anthropogenic stress exposure. If existing scoring tools prove untenable, new scoring tools that better reflect the natural variability of non-perennial ecosystems must be evaluated.

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

Collaborators: California Department of Fish and Wildlife (Dr. Peter Ode), San Diego Regional Water Quality Control Board (Dr. Lilian Busse)

External Funding Support: State Water Resources Control Board

e. Soft-bottom Benthos

Benthic community assessment is a cornerstone of marine monitoring and has become a central element of regulatory programs, such as the California's Sediment Quality Objectives for bays and estuaries. To date, SCCWRP researchers have calibrated and validated benthic indices for two nearshore habitats: Southern California marine bays and polyhaline (high salinity) portions of San Francisco Bay. There is still need for index development in other habitats, such as the low salinity mesohaline and tidal freshwater environments. These habitats are particularly challenging because the natural salinity stress leads to the community having a lesser number of, and more stress tolerant, organisms than in higher salinity habitats.

The objective of this project is to develop and calibrate benthic indices for the mesohaline environment of San Francisco Bay. The process will rely on an expert panel to define reference conditions prior to application of several index approaches, including the Index of Biotic Integrity, the Benthic Response Index and the AMBI.

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

Collaborators: None at this time

External Funding Support: San Francisco Estuary Institute

4. Microbiological Assessment

a. Rapid Water Quality Indicators

Traditional 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 post warnings or advisories for a day longer than necessary simply because of methodological lags in obtaining new results. In 2010 and 2011, pilot projects conducted at Orange County and LA County beaches demonstrated how a rapid bacterial indicator measurement method (quantitative polymerase chain reaction or qPCR) could be used for beach monitoring with same-day results. Several logistical and technological challenges remain, including method modification to address inhibition of the rapid reaction due to natural substances in environmental water samples. Such interference poses a concern because it can cause underestimation of pathogen levels. In addition, opportunities remain for speeding the monitoring process through assay automation.

This project continues development of rapid methods to augment or replace existing indicator bacteria methods. This year, SCCWRP will work to resolve inhibition issues, support technology transition in Southern California, and work with the Monterey Bay Aquarium Research Institute to develop an automated portable digital PCR platform capable of processing samples in the field and telemetering results back to the laboratory and public health agencies.

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

Collaborators: Stanford University (Dr. Ali Boehm), Monterey Bay Aquarium Research Institute (Dr. Chris Scholin), Arizona State University (Dr. Cody Youngbull)

External Funding Support: State Water Resources Control Board

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 $100 million 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 remain with poor water quality, 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. A comprehensive examination of source-tracking methods in 2012 identified a suite of bacterial source identification markers suitable for use in California, leading to production of a standard guidance manual in 2013. However, it remains unclear how bacterial degradation in the environment compares to degradation of pathogens or fecal indicator bacteria (FIB) currently used for regulatory purposes. Thus, a knowledge gap exists regarding how to interpret results from source identification markers to inform mitigation efforts.

This project aims to discern how DNA-based bacterial fecal markers used to detect feces from various sources (e.g., bird, cow, human) undergo changes in freshwater, ocean water, and beach sands/sediments over time. SCCWRP will design and implement a study that tracks the relative degradation of DNA-based fecal markers, FIB, and pathogens in the environment. Ultimately, this research seeks to produce a model to inform decisions about mitigation efforts when DNA-based source identification markers are found in the environment.

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

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

External Funding Support: State Water Resources Control Board

c. Wet Weather Epidemiology

Reducing fecal indicator bacteria (FIB) concentrations during wet weather may be one of the most difficult environmental challenges of current times. While few problematic beaches can be found in dry weather, wet weather FIB concentrations are so ubiquitously high that most Health Departments routinely post blanket warnings at beaches from San Diego to Santa Barbara to stay out of the ocean for the three days following rainfall without collecting a single sample. This has led to a number of regulatory options, including total maximum daily loads (TMDL) that mandates FIB reductions during wet weather. Managers remain perplexed, however, since many FIB sources in wet weather are non-human and the risk of illness from these non-human sources may not justify the radically expensive measures that will be required for wet weather FIB reductions.

The goal of this project is to conduct an epidemiological study to assess the risk of water contact illness following exposure to wet weather contaminated marine beach waters. Specifically, we will examine illness in surfers, the most chronically exposed population of ocean users in the winter months. If the risk of illness increases at wet weather impacted beaches, then SCCWRP will examine whether traditional FIB are predictive of illness. These data will be supplemented with information on human and non-human markers of fecal host sources. If there are little to no human fecal sources, and the FIB:risk relationship is different (less risk) than those used to establish current water quality objectives for FIB, then managers may consider the option of developing site specific water quality objectives for wet weather based on this empirical health information.

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

Collaborators: University of California Berkeley (Dr. Jack Colford), Surfrider International

External Funding Support: County of San Diego, City of San Diego

d. Quantitative Microbial Risk Assessment

Current fecal indicator bacteria (FIB) criteria are based on epidemiological studies that tied swimmer health risk to 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 fecal pollution inputs from non-human sources. Due to differences in associated pathogen loading, health risks associated with non-human FIB levels may differ from those associated with human fecal inputs. To address situations where non-human fecal sources predominate, the EPA is considering the use of quantitative microbial risk assessment (QMRA) to develop 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 QMRAs have been conducted globally, and none have been conducted at marine beaches in the US.

This project seeks to conduct a QMRA demonstration project at a Southern California marine beach. It 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 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 (Dr. Jeffrey Soller), US Environmental Protection Agency (Dr. Nick Ashbolt, John Ravenscroft)

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

5. Biogeochemical Cycling Assessment

a. Harmful Algal Blooms

Harmful algal blooms (HABs) have increased in frequency and severity along the US West Coast in recent years. They are linked to detrimental effects on commercial fisheries, tourism, and marine animals. In other parts of the world, anthropogenic nutrient inputs overwhelm most natural sources and are often a significant factor contributing to the increase in HABs. In contrast, large quantities of nutrients from the deep ocean rise to the surface of the nearshore zone in upwelling-dominated ecosystems such as the California Current, making the relative influence of local anthropogenic nutrients discharges on HAB development less clear. Scientists lack understanding about how bloom dynamics change in response to shifting environmental conditions and why certain "hot spots" are frequently impacted by harmful or toxic blooms.

The goal of this project is to understand the ecophysiological factors driving HABs in order to support improved monitoring, predictive modeling, and management approaches. This research will a) evaluate existing data to characterize trends in HABs and related phenomenon (hypoxia and acidification), b) conduct studies to understand the fate of anthropogenic nutrients in the SCB as well as the linkage between anthropogenic nutrients and algal bloom development, and c) maintain SCCWRP's relationship with the California Harmful Algal Bloom Monitoring and Alert Program (HABMAP).

Lead Investigator: Dr. 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

b. Ocean Acidification

Ocean acidification (OA) is the reduction of seawater pH associated with increasing global oceanic uptake of atmospheric carbon dioxide (CO_2). When CO_2 dissolves in seawater, it reduces the concentration of free carbonate ions. Waters undersaturated with carbonate can become corrosive to organisms that produce carbonate exoskeletons (such as shellfish, corals, and some species of plankton). Ocean monitoring programs have measured significant OA-related changes in ocean chemistry at a faster-then-expected rate with continuing acceleration. The US West Coast is particularly susceptible to OA due to seasonal upwelling, which brings waters high in nutrients, low in dissolved oxygen, and low in pH onto the coastal shelf. In response to this knowledge, scientists, managers, regulators, and industries affected by OA began meeting in 2010 and are collaborating to develop a coordinated OA measurement network through the West Coast-wide California Current Acidification Network (C-CAN).

Goals of this research are to a) take a leadership role in C-CAN, b) assist the West Coast Governors Alliance for Ocean Health (WCGA) in developing a West Coast-wide strategy for addressing OA issues, and c) work with member agencies to determine the feasibility of upgrading existing monitoring programs to incorporate OA measurements into routine surveys. C-CAN is currently developing explicit guidance on monitoring program development (parameters, technology development, quality assurance, information management). Work in collaboration with the WCGA will include a) inventorying existing and potential assets and a plan to incorporate them into a West Coast-wide OA monitoring network, b) defining the science and policy questions most relevant to addressing stakeholder needs, and c) developing a prioritized research agenda based on these collective policy questions.

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

Collaborators: C-CAN Steering Committee, SCCWRP member agencies

External Funding Support: None at this time.

c. Coastal Ocean Nutrient Modeling

Many of the documented hypoxic and acidification events on the West Coast result from shoaling of deep nutrient-rich ocean waters. However, local nutrient additions (e.g., from municipal treated wastewater plumes) have the potential to exacerbate hypoxia and acidification by stimulating algal growth, which affects the carbon cycle through rapid blooming and senescence. The relative contribution of local anthropogenic inputs to these processes is presently unknown, but is vital to understanding the potential benefits of management controls on local inputs. Calculating the relative importance of local anthropogenic nutrient inputs in hypoxic and acidification events requires a complex coupling of biogeochemical models. These models describe nutrient uptake and biological processing in conjunction with physical circulation models. They can help determine whether biogeochemical processes occur rapidly enough for the local inputs to generate effects while waters from land-based sources remain in the coastal zone.

This project facilitates development of complex causal models. SCCWRP hosted a modeling workshop convening coastal managers, scientists, and modelers in 2013 to a) distill which critical, unanswered questions and potential management scenarios the models should address; b) define the relevant temporal and spatial scales in which the models need to operate; c) determine which models should be used; and d) identify the data required for model calibration and validation. SCCWRP will next conduct field and laboratory studies recommended by workshop participants to generate key data sets necessary to parameterize and validate the model, including a) nutrient inputs (stormwater, treated wastewater, and atmospheric deposition), b) rate processes (productivity, respiration, nutrient uptake and nutrient transformation) and how they change as a function of time and proximity to anthropogenic inputs, and c) validation data sets (CTDs, ocean moorings, gliders). Modeling results will be distilled into regional budgets to help discern the major causes of hypoxia and acidification changes over time.

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

Collaborators: Center for Ocean Solutions (Dr. Fiorenza Micheli), UCLA (Dr. Mark Gold, Dr. Jim McWilliams), University of Washington (Dr. Curtis Deutsch), University of Georgia (Dr. Brock Woodson), SCCWRP member agencies

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.

1. Nutrient Objectives

a. Nutrient Objectives in Streams and Lakes

Many aquatic environments in California experience accelerated accumulation of organic matter and plant overgrowth due to excess nutrient enrichment. Consequences of this overgrowth may include harmful algal blooms, hypoxia, altered aquatic food webs, or degradation of critical habitat. The California State Water Resources Control Board (SWRCB) is working to develop scientifically based statewide water quality objectives that relate these endpoints to management controls. Their nutrient numeric endpoint (NNE) framework will consist of narrative nutrient objectives accompanied by numeric guidance. The NNE framework has two components: a) response indicators and regulatory endpoints that specify how to assess water body condition, and b) nutrient-response models that can be used to link response indicators to nutrients and other management controls (e.g., hydrology) on a water body-specific basis. To overcome challenges associated with a best professional judgment approach, the SWRCB preliminarily offered "benthic biomass spreadsheet models" as scoping tools to relate ambient nutrient concentrations to algal biomass while accounting for physical factors such as stream flow velocity and canopy cover. However, early validation efforts indicated these spreadsheet tools require refinement. Stakeholders also need technical assistance in working through how to implement the NNE in management programs such as Total Maximum Daily Loads, 303(d) listing, and discharge permits.

This project will provide a scientific foundation for NNEs in streams and lakes. Five primary tasks for streams include a) documenting statistical thresholds in the dose-response relationships between proposed NNE indicators and metrics of aquatic life use in streams (algae and benthic macroinvertebrate indices of biological integrity); b) documenting "reference levels" of proposed NNE indicators and the percent of stream miles exceeding statistical or proposed regulatory thresholds; c) validating stream NNE spreadsheet models, identifying sources of error, and proposing refinements to NNE scoping tools; d) developing calibrated, site-specific, dynamic models to better understand factors controlling algal responses to nutrients; and e) using tools and data to assist with decisions about how to implement the NNE to set watershed-based nutrient targets. Given the diversity of lakes in California, model validation requires compilation of a substantial data set reflecting the range of conditions. To address these needs, researchers will a) compile existing data on phytoplankton biomass, nutrient concentrations, cyanobacterial dominance, and cyanotoxins in California lakes; and b) validate the NNE spreadsheet model for lakes, identifying sources of error and proposed refinements.

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

Collaborators: US Environmental Protection Agency (Dr. Naomi Dettenbeck), Tetra Tech (Dr. Jon Butcher), San Francisco Estuary Institute (Dr. Thomas Jabusch), UC Santa Cruz (Dr. Raphael Kudela)

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

b. Nutrient Objectives in Estuaries

California has a variety of estuarine classes and habitat types (i.e., intertidal flats, seagrass, unvegetated subtidal) for which numeric endpoints and nutrient-algal response models would be expected to differ. 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 perennially tidal estuaries. Because the San Francisco Bay-Delta encompasses approximately 80% of the state's estuarine habitat, but differs from many small estuaries in other areas of California, a site-specific NNE assessment framework and nutrient algal-response model will be developed for San Francisco Bay and for the Delta.

To address the technical needs for nutrient objectives in estuaries, SCCWRP will help develop indicators, conduct dose-response studies, and hold expert workshops to support selection of regulatory endpoints for intertidal flats, seagrass habitats, and unvegetated subtidal habitat across the range of estuarine classes in the state. In addition, SCCWRP will develop nutrient-algal response models including statistical stress-response models, "pilot" mechanistic models for Southern California Bight estuaries, calibrate dynamic simulation models for individual estuaries, and a conceptual model/modeling strategy for the San Francisco Bay.

Lead Investigator: Dr. 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), Elkhorn Slough National Estuarine Research Reserve (Dr. Kirsten Wassen), Morro Bay National Estuary Program (Adrienne Harris)

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

2. Sediment Quality Objectives

Sediment quality objectives (SQOs) were recently approved for use in California's enclosed marine bays and estuaries. SCCWRP helped to develop and validate the assessment framework and data analysis tools needed to interpret sediment quality in the context of SQOs. Regulatory agencies are currently in the process of incorporating SQOs into monitoring programs, permitting processes, and cleanup actions, raising continuing technical questions about study design and data interpretation, applicability in new habitats, and stressor identification. A second phase of SQO is also under development 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 common Southern California contaminants like 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, movement of receptor organisms, food consumption rates, and species-specific variations in chemical sensitivity.

This project has three primary goals. For indirect effects assessment, SCCWRP will refine a framework for evaluating sediment contamination risks to human and ecosystem health based on multiple indicators. This will include incorporation of new information on bioaccumulation pathways in California food webs and development of tools for data analysis. For direct effects, SCCWRP will develop guidance for toxicity stressor identification and develop biological assessment tools for new habitats such as mesohaline estuaries. Finally, SCCWRP will provide technical support to regulatory agencies and the Ports of Los Angeles and Long Beach to develop guidance for implementing the SQOs into regulatory programs such as TMDLs.

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

Collaborators: State Water Resources Control Board, Ports of Los Angeles and Long Beach

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

3. Flow Criteria

Southern California is one of the most urbanized regions in the country. 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 and implementing standards and policies in an attempt to control and/or mitigate hydromodification effects on natural and semi-natural stream courses. SCCWRP has spent many years developing support tools to assist managers by a) mapping the streams most at risk from hydromodification; b) estimating the magnitude of hydromodification effects such as erosion, sedimentation, and habitat loss based on increases in impervious land cover; and c) identifying a suite of the most effective management measures to offset hydromodification effects. Although additional work is needed to improve capacity for predicting hydrological and physical effects of hydromodification, some of the biggest unanswered questions relate to the relationships between these physical changes and biological responses, which is a core endpoint of management concern.

This project will define the relationship between stream flow and biological community impacts as measured by benthic macroinvertebrate communities. It involves a) identifying reference sites (defined by lack of human influence), b) developing flow models to estimate hydrologic conditions in unmodified streams, c) establishing the natural variation in stream flow versus biological community relationships at reference sites, and d) comparing these reference relationships to stream flow/biological condition relationships in hydromodified streams.

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

Collaborators: California Department of Fish and Wildlife (Dr. Peter Ode), Colorado State University (Dr. Brian Bledsoe), US Geological Survey (Dr. Darren Carlisle)

External Funding Support: State Water Resources Control Board, US Geological Survey

4. Modeling

a. Modeling of Best Management Practices

As watersheds urbanize, stormwater best management practices (BMPs) are increasingly being used to mitigate the adverse effects of hydromodification and contaminant loading. However, the effectiveness of BMPs for achieving stream water quality and biological objectives is rarely tested, despite increasing regulatory requirements for their installation that greatly increase the costs of stormwater management. In particular, a key management need is identifying the optimal placement, type, and numbers of BMPs to achieve sufficient hydraulic detention/capture and desired management endpoints. Because of site-specific variability in BMP effectiveness and the need to integrate effects at a watershed scale, the most efficient means to address this management need is modeling. Models including mechanistic BMP models, watershed hydrology and chemical loading models, and biological stress response models have been developed and used on an individual basis. However, they have not been coupled on a watershed scale to examine the effects of BMP implementation on the watershed hydrology and receiving water chemical and biological responses. Experimental data have documented the effects of BMPs on a treatment catchment in Melbourne, Australia, monitoring the effects on hydrology, water chemistry, and biology over a ten-year period and providing a unique opportunity to calibrate linked models for Southern California.

The goal of this project is to develop a toolkit of linked models that will optimize BMP density, type, and location at a watershed scale. It will include a) mechanistically modeling BMP performance at a site scale; b) modeling effects of implemented BMPs on watershed hydrology and water quality for wet and dry weather; c) developing mechanistic stress-response models to link BMP performance, watershed hydrology, and water quality to biological endpoints; and d) using the tools in tandem to optimize the placement, type, and density/size of BMPs within the watershed. Models of BMP performance will be calibrated as a function of intrinsic factors such as geology, soil type, and slope using existing Southern California BMP performance data.

Lead Investigator: Dr. Ashmita Sengupta (ashmitas@sccwrp.org)

Collaborators: UC Irvine (Dr. Stanley Grant, Dr. Brett Sanders, Dr. Jean-Daniel Saphores), University of Melbourne (Dr. Tim Fletcher)

External Funding Support: National Science Foundation

b. Stressor Response Modeling

The linkage between management actions and the recovery of receiving water bodies is often obscure. This is most obvious in Southern California estuaries, located at the terminus of urbanized watersheds and subjected to the adverse effects of hydromodification and contaminant loading. Complicating factors in the linkage between management actions in the watershed and downstream changes in estuaries include the high degree of variability in freshwater flow and contaminant concentrations, the large diversity of estuarine ecotypes, temporal and spatial patterns in estuarine hydrology that affects the transport and biological fate of pollutants, and the ultimate interaction between water quality and biology. Because of the complexity of these site-specific factors, scientists turn to mechanistic stressor-response models to better understand and predict the linkage between management actions and the fate and effects of contaminants in estuaries. Unfortunately, these mechanistic models are rare in Southern California largely due to the significant effort required. As a result, managers lack the confidence needed for implementing management actions in the watershed to protect downstream estuarine resources.

This project will begin developing linked stressor-response models that managers can routinely use for managing estuaries. Developing linked stressor-response models begins with developing simple hydrodynamic models for various estuarine ecotypes. The base hydrodynamic model will include a) advection and dispersion, b) interaction of freshwater inflow with saline ocean waters, and c) residence times in the estuaries. The hydrodynamic model will then be coupled with either a biological response model for nutrients or a chemical fate model for contaminants of emerging concern (CECs). The biological response model for nutrients will include eutrophication processes such as predicting biomass and dissolved oxygen concentrations. The fate model for CECs will include contaminant dependent processes, such as sorption/desorption and transformation. The simple model will be calibrated and validated with regional monitoring data (see project C1a) and compared to model output from existing, more complex three-dimensional mechanistic models.

Lead Investigator: Dr. Ashmita Sengupta (ashmitas@sccwrp.org)

Collaborators: University of Massachusetts (Dr. Mi-Hyun Park), University of Rhode Island (Dr. Christopher Kinkaid), Space and Naval Warfare Systems Command (Dr. P.F. Wang), Mississippi State University (Dr. James Martin)

External Funding Support: None at this time

5. Freshwater Biological Objectives

a. Analysis of Biological Thresholds

Direct measures of biological condition are increasingly preferred as assessment endpoints because they link most closely to water body beneficial uses or other functions relevant to 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 conditions 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. Currently, the State is focused on benthic macroinvertebrates as a primary stream bioindicator because of their well-studied life histories, comparatively sessile nature, readily available taxonomy, and relative ease of collection. However, there are number of other potential bioindicators that could be used for bio-objectives other than benthic invertebrates, such as upper trophic level organisms (i.e., fish, amphibians, birds) that link to beneficial uses including wildlife habitat, cold water habitat, warm water habitat, or the ability to support rare species. Ultimately, the State Board would like to include an approach for integrating multiple biological indicators across many trophic levels to support the bio-objectives framework.

This project will continue developing the technical foundation for bio-objectives. SCCWRP previously helped develop the technical foundation for biological objectives based on benthic macroinvertebrate indicators. This year, technical support will include refining bioassessment tools for a variety of "modified" stream types throughout the state, investigating approaches to establishing thresholds, and assessing the relationship between benthic macroinvertebrates and higher trophic level organisms such as amphibians, fish, and birds.

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

Collaborators: 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. Robert Fisher)

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

b. Causal Assessment

Only a fraction of the streams in California will achieve a desired condition based on an assessment of biological condition. For those streams that fail to achieve a desired “biological objective,” the next step involves diagnosing the likely causative factors affecting the biology so that appropriate management actions can be determined. Scientists exploit the complexity of biological communities and their differential response to various stressors to decipher the responsible stressor(s). This is an inexact science that relies largely on a "weight-of-evidence" approach to either diagnose or refute a stressor. No single assessment tool or measurement device can provide an answer, but many tools used in combination help build a case towards identifying the responsible stressor(s). The most commonly used and best-developed approach to causal assessment is the US Environmental Protection Agency’s Causal Analysis/Diagnosis Decision Information System (CADDIS), an online decision support system to help scientists identify the stressors responsible for undesirable biological conditions in aquatic systems (http://www.epa.gov/caddis). Earlier work demonstrated the use of CADDIS in California through four case studies, the results of which were used to produce a CADDIS guidance manual.

This work will build on the foundation provided in the CADDIS guidance manual by developing additional assessment tools that can be used to more definitively identify causes, separate anthropogenic effects from natural patterns, and inform ultimate management responses. The project will develop a case study in San Diego through development of additional diagnostic and assessment tools.

Lead Investigators: David Gillett (davidg@sccwrp.org), Eric Stein (erics@sccwrp.org)

Collaborators: Southern California Stormwater Monitoring Coalition, San Diego Regional Resources Control Board, US Environmental Protection Agency, Tetra Tech

External Funding Support: County of San Diego, San Diego Regional Water Quality Control Board

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 ongoing status tracking efforts. In the early stages, these efforts focus on defining clear monitoring questions and appropriate sampling designs to answer questions. Subsequently, approaches and assessment methodologies must be standardized across multiple monitoring agencies from a regional perspective. At later stages, SCCWRP supports the data management and quality assurance needs of ongoing monitoring efforts.

SCCWRP began conducting regional surveys in the 1970s. The agency continues to coordinate 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 many dischargers to the Southern California Bight dating back to 1971. Recently initiated 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 next iteration of the regional monitoring program began in 2013 (Bight '13). The Bight '13 survey has five components: coastal impact assessment (offshore sediment condition), nutrient impact (water column condition), microbiology (beach water quality condition), marine protected areas (rocky reef condition), and debris assessment (especially plastics).

This project will coordinate sampling and conduct data analyses, assessments, and reporting for Bight '13 Regional Monitoring Program. Project planning steps including study design, sampling and analysis preparation, and pre-survey quality assurance activities occurred in 2012. In 2013, sampling and laboratory analyses were completed for approximately 400 sites, and results submitted through an integrated data system (see project D2). Hundreds of indicators were measured including sediment chemistry and toxicity; benthic infauna, fish, and invertebrates; contaminant bioaccumulation in bird eggs; trash and debris; physical water column characteristics; nutrients and algae; fecal indicator bacteria; and human pathogens. The focus of the current year is to create consensus-based assessments from the results of the regional survey data.

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

Collaborators: Numerous participating organizations

External funding support: In-kind contributions from participating organizations

b. Pollutant Sources Data Cataloguing

Mass emission estimates enable comparisons among different pollution sources to assess relative risks 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 due to 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.

This project aims to estimate mass emissions from stormwater, industrial dischargers, power generating stations, and 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: Dr. Eric Stein (erics@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 at this time

c. Areas of Special Biological Significance

Areas of Special Biological Significance (ASBS) are water quality protected areas in California where the waste discharge 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) for 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.

This project provides 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. Current efforts focus on data compilation and analysis from 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, sampling frequency, and measured indicators. 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 regional assessment. The SMC program establishes 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.

This project supports ongoing implementation and development of the SMC's regional watershed monitoring program for Southern California's coastal streams and rivers. The program's first five-year cycle is near completion. SCCWRP will continue providing support for data compilation and interpretation, including special studies from the 2014 summer sampling season, and guiding the future directions of the program for the next five-year cycle to begin in 2015. 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

b. Background Concentrations of Contaminants in San Diego Reference Streams

The streams and rivers in Orange and San Diego County watersheds have become increasingly urbanized in recent decades. Urbanization brings additional 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 region is currently hampered by the lack of a consistent set of scientifically defensible numeric targets for in-stream water quality. Further, standards must 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 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 also provides an opportunity to demonstrate the use of new bioassessment approaches to identify reference conditions by a) establishing the biomass, cover, and taxonomic composition of algae associated with reference streams; and

b) investigating toxicity sources to invertebrates using newly developed molecular Toxicity Identification Evaluations (see project A2a).

Lead Investigator: Dr. 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 Stormwater 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 frequently been 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 extensively tested in the semi-arid conditions of Southern California.

The goals of this project are to a) provide reliable measurement techniques for atmospheric nutrient deposition in Southern California, and b) 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 are being used to measure rates of wet and dry atmospheric at six regional stream bioassessment reference sites in Southern California across an annual cycle, to capture natural gradients in land cover type (e.g., forested, chaparral).

Lead Investigator: Dr. 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 program has adopted a probability-based survey approach to assess trends in wetland acreage and produce status and trends plots. The new design was also incorporated into the EPA's 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, new tools to track and evaluate the success of wetland restoration programs are needed, such as performance curves that forecast how beneficial uses and functional capacity of restoration projects should improve over time. These new tools for mitigation and restoration planning will help ensure individual projects contribute to an overall net gain (or no net loss) in wetland extent and condition throughout California.

This project will help build a framework for wetland and riparian monitoring and assessment through participation in the CWMW, support for implementing the NWCA and WRAMP, and development of new technical tools for wetland tracking. Current efforts include identifying ways to refine the technical approach, reduce sample error, and evaluate proposed change assessment methodologies. SCCWRP participates in an interagency team to develop a long-term implementation and funding strategies for wetland monitoring. In addition, performance curves based on the California Rapid Assessment Method (CRAM) are being developed for perennial estuarine and coastal riverine wetlands, using regional reference sites to evaluate the curves with respect to best achievable condition.

Lead Investigator: Dr. 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 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 refuges and breeding areas in dry habitats. They also 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.

This project will 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 approach through pilot implementation at a subset of depressional wetland types in Southern California. It will also test the Periphyton Index of Biotic Integrity, originally developed for streams, for potential application in depressional wetlands. Repeated measurement of seasonal wetlands will help evaluate the influence of drying on invertebrate communities and refine appropriate monitoring periods.

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

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

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

D. INFORMATION MANAGEMENT AND ANALYSIS

The scale of data collection grows exponentially as new technologies and techniques become available. Regional data can be obtained via large-scale monitoring programs or satellite or aerial imaging. Lab analysis for a variety of chemical and biological data types, especially for emerging molecular methods and DNA barcoding, also generate extremely large datasets. In addition, new automated technologies have data collection methodologies that bypass human intervention. With these changes, new approaches are needed to collect, store, manage, and analyze these large datasets in a manner that effectively serves the needs of the scientific community and environmental managers. Emerging methods for data storage, including cloud databases, require further research and development applied to environmental data storage and access. Further, new tools are needed to process data sets for various applications (e.g., index computation, environmental models) and produce information in useful formats like scores, charts, graphs, maps, animations, and other types of visualizations.

SCCWRP has historically played a primary role in helping member agencies and others produce comparable data products that maximize value and usability among the environmental management community. The essential next step is developing mechanisms to more effectively collect, manage, and share data, as well as to deliver analytical results.

1. Mobile Data Acquisition Technologies

Mobile technologies offer vast new opportunities for onsite data collection. SCCWRP is dedicated to developing field data tools that can be implemented on everyday mobile devices such as smart phones and tablet computers. By leveraging built-in capabilities such as GPS receivers, cameras, and wireless connectivity, newer mobile devices can capture nearly limitless types of monitoring information. Users can also take advantage of communication networks to record information, either automatically or with human input, and directly transfer that data from the field to the office. Moreover, mobile applications can be used to ensure data is collected and structured consistently with quality checks, handled instantaneously at the point of collection, before scientists leave the site.

This project explores rapidly evolving mobile technologies to further extend the capabilities of field sampling programs. Capabilities currently under investigation include a) mobile (smart phone/tablet-based) applications to capture sample event data including location, station occupation observations, site descriptions and images, and then transfer data to cloud-based databases; b) survey applications to collect interview and participant-supplied data; c) image capture devices, including cell-phone cameras, as microscopes to optically identify species in the field; and d) wireless environmental sensors that communicate with mobile devices to aid in data acquisition, sensor testing and maintenance, and real-time adaptive monitoring capabilities.

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

Collaborators: UC Berkeley

External Funding Support: None at this time

2. Seamless Data Sharing

Data are essential to environmental management and planning on a variety of levels. When data are not readily accessible, it impedes many of the decision-making processes that depend on current, reliable, and high quality data. When data sharing is ineffective, it increases lost opportunities and the potential for making suboptimal management decisions. The benefits of additional information include context, for example the ability to consider data from adjacent areas or view a time-series to provide perspective. Modern data sharing tools provide opportunities for rapid and accurate data sharing. These tools enable managers and the public to have transparent access to understandable environmental information. SCCWRP previously helped develop and support the California Environmental Data Exchange Network (CEDEN), which is utilized by the State Water Resources Control Board to prepare the 303(d) list of impaired water bodies. SCCWRP also designed, developed, and maintained the Beach Watch database, which serves as the central repository for beach water quality monitoring information statewide.

This research a) facilitates collection and submission of data to a consistently accessible data server, and b) facilitates access to data and analytical results needed by the scientific and management community. SCCWRP is currently redesigning and updating the Beach Watch database to a modernized cloud-based system, which serves as the central repository for beach water quality monitoring information statewide. This new system will provide rapid data availability to managers and the public and, when complete, will integrate with CEDEN. Other current efforts focus on recruiting and training regional data providers, developing data visualization and extraction tools, providing user-friendly web-based data access and documentation, and connecting CEDEN with other state and US Environmental Protection Agency (EPA) data servers. These databases will serve managers and the public through the California Water Quality Monitoring Council's website (see project D3) and a number of other applications that are "powered by CEDEN."

Lead Investigator: Dr. 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 L. Johnson, LLC.

External Funding Support: State Water Resources Control Board

3. Dynamic Data Processing and Visualization

Data visualization provides valuable insights into understanding data relationships and interactions. Visualization includes ways to effectively convert data into information, as well as ways to present information using visualization techniques such as index computation and integration of dynamically generated charts, maps, and animations. With the advent of more sophisticated scientific and spatial modeling tools and capabilities, important opportunities have arisen to extend capabilities for environmental data modeling and visualization, particularly within a geospatial framework. For data visualization to be useful, however, it must be driven by development and validation of scientifically appropriate and robust analytical techniques.

This project focuses on enhancing options for reporting and presenting real-time statistical data analysis as well as visualization techniques for data output to the web or mobile device. Three areas of current research include a) assisting the State Water Board in making monitoring data and data interpretations accessible to the public through water quality portals (http://www.waterboards.ca.gov/mywaterquality/); b) creating a web-based prototype "dashboard" for stormwater managers and regulators to track program effectiveness, which track progress towards both programmatic and technical goals; and c) developing approaches that infer ecosystem condition from spatial data or track changes over time under different management scenarios, in order to integrate past, present, and future management approaches to achieve specific recovery goals in Southern California watersheds (e.g., Tijuana River Valley).

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

Collaborators: California Department of Public Health (Mark Emmerson), Water Education Foundation, Tijuana River National Estuarine Research Reserve (Jeff Crooks), Sacramento State University (David Ceppos and Brian Currier), San Francisco Estuary Institute (Robin Grossinger), California Coastal Conservancy (Greg Gauthier), State Water Resources Control Board (Greg Gearhardt)

External Funding Support: State Water Resources Control Board, National Estuarine Research Reserve System Science Collaborative (NERRS)

4. San Diego Integrated Water Resource Data Management System

Water data in San Diego County is collected, managed, accessed and assessed by a variety of government agencies for both regulatory and management as well as tribal, academic, NGO and consultant communities. Traditionally, given a variety of disparate data systems, accessing these data in a consistent and comparable manner is difficult.

Building upon SCCWRP's history and expertise in data management systems, the IM&A Department, in collaboration with The Center for Collaborative Policy, a program of California State University Sacramento, will develop recommendations and specifications to serve as a basis for the future development of a web-based water data management system for the San Diego County region.

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

Collaborators: San Diego IRWM, Sacramento State University, Center for Collaborative Policy

External Funding Support: County of San Diego.

E. MEMBER AGENCY SUPPORT

SCCWRP research is generally applicable to collective environmental management concerns. To ensure scientific resources are communicated to and used by the core network of end users (SCCWRP's 14 member agencies), attention is also devoted to supporting individual member agency activities and sub-groups of member agencies facing similar questions. SCCWRP provides ongoing on-call support for these organizations.

1. General Support

This project encompasses a variety of forms in which SCCWRP provides periodic assistance to member agencies, such as training, quality-assurance audits, field and laboratory services, method or document review, monitoring guidance, administrative support, meeting organization, data processing, technical advice, memo or fact sheet preparation, response to media requests, and communication/presentations to the member agencies' governing boards.

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

2. Effects of Ocean Outfall Diversion on Nutrient Cycling

The relative influence of anthropogenic versus natural factors in regulating nitrogen cycling and primary productivity has not been well established in the Southern California Bight. One challenge is isolating the effect of individual factors, such as wastewater effluent input, from the other factors at play. In 2012, the Orange County Sanitation District diverted discharge from its main ocean outfall to a pipe that discharged effluent closer to shore in shallower water. This diversion presented an opportunity to observe the effect of wastewater on dominant pathways of nitrogen cycling and primary production before and after the area received effluent input. Similarly, in 2013 the City of Los Angeles Hyperion Treatment Plant diverted their outfall to conduct routine maintenance, providing a further opportunity to continue gathering information. SCCWRP joined a team of researchers using gliders and ship-based sampling to track the effluent plume during the diversions to monitor for any detrimental environmental impacts, such as increased algal growth.

This project a) compares rates of nitrification and denitrification between reference areas and sites near the temporary effluent discharge before and after diversions, and b) monitors phytoplankton productivity and species composition changes during the diversion. Field sampling will continue in 2014. Researchers are also reporting earlier results in a special issue of the journal *Estuarine, Coastal and Shelf Science*.

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

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

External Funding Support: None at this time