SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT AUTHORITY

FY 2016-2017
RESEARCH PLAN
EXECUTIVE SUMMARY

Approved by the SCCWRP Commission

June 2016

Introduction

The Southern California Coastal Water Research Project Authority, or SCCWRP, is a leading U.S. environmental research institute that develops a scientific foundation for informed water-quality management in Southern California and beyond. Since its founding as a public agency in 1969, SCCWRP has been a champion of sound interdisciplinary approaches to solving complex water-management challenges. SCCWRP's staff of 41 researchers – about half of whom hold Ph.D.s – investigates not only how to more effectively monitor and protect watersheds and coastal waters, but also how to bridge the gap between water-quality research and the management community that relies on this science. Through a 14-member governing board – known as the SCCWRP Commission and made up of senior managers from Southern California's largest wastewater treatment, stormwater management and water-quality regulatory agencies – SCCWRP builds consensus and develops real-world management solutions, paving the way for collaborators and stakeholders to coalesce around shared, long-range research goals.

Mission

SCCWRP's mission is to enhance the scientific foundation for management of Southern California's ocean and coastal watershed resources. The SCCWRP Commission's vision is that the effective transfer of science from SCCWRP to member agencies and other stakeholders will lead to implementation of appropriate, viable management strategies that protect the ocean and coastal watershed resources for present and future generations. To achieve this mission and vision, SCCWRP is guided by four goals:

1. Undertake and participate in scientific investigations to understand ecological systems in the coastal waters and associated watersheds, in order to document relationships between these systems and human activities relevant to SCCWRP member agencies.
2. Serve as a respected source of unbiased coastal water quality science.
3. Develop scientific consensus on issues relevant to management decisions and application of science by member agencies.
4. Stimulate conversion of science to action.

Research Vision

SCCWRP scientists apply biological, chemical, toxicological, biogeochemical, and microbiological and information-technology principles to monitor and assess the condition of aquatic ecosystems, with an overarching goal to solve significant identified challenges in public water management. SCCWRP leverages its direct connections to the water-quality management community to set a comprehensive, independent research agenda that guides its priorities and directions. This research vision is conceptualized and advanced through collaborative planning with the SCCWRP Commission's Technical Advisory Group (CTAG), which is the scientific advisory panel formed by the lead scientists and managers from each of SCCWRP's 14 member agencies. While SCCWRP conducts basic research, it does so within a strategic context of transitioning this science into real-world applications. Accordingly, the agency's research vision spans multiple years and transcends individual projects. As SCCWRP staff weighs taking on specific projects and works to balance competing demands, CTAG and SCCWRP staff work together to ensure that all projects remain integrated into – and integral to – the shared master vision.

Research Areas

SCCWRP consists of six science departments – Toxicology, Chemistry, Biogeochemistry, Biology, Microbiology, and Information Management & Analysis – that work in an interdisciplinary, interconnected fashion across SCCWRP's major research areas:

1. **Bioassessment**
2. **Ecohydrology**
3. **Eutrophication**
4. **Climate Change**
5. **Sediment Quality**
6. **Contaminants of Emerging Concern**
7. **Microbial Water Quality**
8. **Regional Monitoring**
9. **Information Technology and Visualization**

2016-17 update:

For 2016-17, Climate Change has replaced the Wetlands thematic area. SCCWRP's wetlands-related research has been moved into SCCWRP's other thematic areas, including Bioassessment, Ecohydrology, and Climate Change.

Furthermore, SCCWRP conducts new and emerging research that have yet to grow into a thematic focus area, as well as research that addresses topics of immediate interest to member agencies but that may not grow into a full-scale research program. This area is known as **Emerging Research and Member Agency Support**.

Research Planning Process

SCCWRP staff works in partnership with the agency's 14 CTAG representatives to develop and continuously update a 10-year research vision for each of SCCWRP's major thematic research areas. Written for knowledgeable scientists working in each particular field, these comprehensive technical publications provide an overview of how SCCWRP conceptually approaches each research theme and how our multi-faceted research strategy fits together. The detailed documents also identify broadly supported priorities for research. CTAG and SCCWRP staff collaborate in all-day research planning workshops to flesh out and periodically update these living documents. CTAG's goal is to ensure SCCWRP's research agenda remains relevant to member agency needs, and to help identify opportunities to transfer SCCWRP's research to application. The detailed technical documents are available on SCCWRP's website.

Separately, SCCWRP annually prepares this document – the Research Plan Executive Summary – for the SCCWRP Commission to convey the broad thematic areas around which SCCWRP research is focused, and to provide an overview of the major projects being worked on to advance those thematic areas. This document, written for a management-level audience, also serves as the research plan budget, which the SCCWRP Commission is required to approve annually. Accordingly, this document contains two portions: a series of concise summaries of SCCWRP's research directions within each research theme, and the corresponding financial information for the upcoming fiscal year.

Bioassessment

Biological assessment, or bioassessment, is the science of evaluating the health of an ecosystem by assessing the organisms that live within it. In aquatic ecosystems, algae and invertebrates serve as particularly useful indicators of ecosystem health because they are relatively sessile and live along bottom habitats where chemical and other stressors tend to be concentrated. Unlike traditional chemistry-based monitoring, which provides only limited information about a relatively narrow portion of the environment at a discrete point in time, bioassessment can account for living organisms exposed to multiple chemicals and other stressors (such as altered habitats and changes in life-sustaining water-flow patterns) over extended time periods. Consequently, bioassessment has the potential to provide a more integrated reflection of the condition of an aquatic ecosystem; bioassessment also is more closely tied to environmental managers' end-goal focus on ecosystem protection and serves as an important way to monitor and protect the populations of endangered species and fisheries. SCCWRP is focused on developing an overall bioassessment framework (e.g. survey design, interpretation methods) and associated tools that environmental managers can use to assess the health of aquatic ecosystems and inform regulatory and management decisions. SCCWRP has made considerable progress on developing bioassessment tools for streams, wetlands and marine environments for a subset of organisms including benthic invertebrates, fish and algae. SCCWRP's goal is to develop bioassessment tools for all aquatic habitats using a wide variety of organisms, as different organisms are uniquely suited to evaluate specific habitats.

SCCWRP's bioassessment work revolves around three main research areas: (1) assessing the condition of different water body types using multiple indicators, (2) identifying potential causes of poor condition, and (3) using the data to support management activities, such as prioritization and effectiveness assessments. To assess condition, SCCWRP creates assessment tools that can identify and characterize reference conditions, as well as develops sampling protocols and indices that can transform complex biological data into simple measures of condition. Additionally, SCCWRP focuses on creating appropriate interpretive frameworks for understanding bioassessment data, including connections to beneficial uses, and for incorporating multiple indicators into integrative assessments. To identify potential causes of degraded condition, SCCWRP uses causal assessment, a process that relies on upgrading standard evaluation frameworks and creating rigorous evaluation procedures to understand the relationships between stressors and condition. The goals of SCCWRP's causal assessment research are to: (1) develop causal assessment diagnostic indicators via traits-based analysis and molecular methods, (2) improve stressor measurements such as habitat condition indices, (3) explore relationships between stressors and biological responses, such as flow and nutrient responses, and (4) investigate the relative constraints on biological condition that come from different natural and anthropogenic sources. To ensure condition and causal assessments are used to guide management decision aimed at improving overall condition, SCCWRP develops synthesis and integration tools that can translate assessment results to actionable information. In this way, SCCWRP is able to effectively reverse the historically negligible role that biological data have played in informing key management decisions, such as designation of new conservation areas and selection of sites for restoration.

This year, SCCWRP will continue its work to develop and expand its protocols and processes for both condition assessments and causal assessments, as well as pursuing development of guidance and decision support tools to inform management actions. SCCWRP's focus for 2016-17 will be on:

- **Condition assessment:** To assess the condition of Southern California's full range of aquatic resource types, SCCWRP is working to develop a broad suite of condition assessment tools,

with a long-term goal of having bioassessment tools based on invertebrates, algae, vertebrates or molecular indicators that can be applied in streams, wetlands, coastal lagoons, and/or ocean ecosystems. This year, SCCWRP will focus on developing statewide condition indices for algae, a critical bioassessment indicator for evaluating impacts from nutrients, flow, temperature, and habitat alteration. SCCWRP is also piloting new indicators, including amphibians and ichthyoplankton (larval marine fishes). The ichthyoplankton holds tremendous promise because new measurement methods, such as genetic barcoding, are allowing scientists to link water quality and natural resources to one of the longest-running fish monitoring programs in the country, the California Cooperative Fisheries Investigation (CalCOFI).

- **Causal assessment**: To identify potential causes of degraded condition, SCCWRP applies and adapts the U.S. EPA's Causal Analysis/Diagnosis Decision Information System (CADDIS) framework. This year, SCCWRP will focus on (1) improving the ability to measure a variety of pervasive, complex stressors, including physical habitat degradation, altered hydrology, and nutrient enrichment, (2) developing diagnostic indicators based primarily on life history traits and molecular assessment tools, as appropriate, to identify stressor-specific responses in biological indicators, (3) adapting the causal assessment tools developed by the EPA for Southern California's unique settings, which includes development of comparator site selection tools that incorporate rich regional data sets, and (4) exploring how multiple stressors interact to constrain biological condition for different indicators, with particular focus on channelized streams.
- **Integration and implementation:** Although SCCWRP's research on condition and causal assessment provides the technical foundation to support management decisions, this technical foundation must be informed by the development of guidance and decision support tools. SCCWRP is conceptualizing tools that will allow for the development of report cards and similar data synthesis methods, decision support tools that help locate high-value areas for protection and prioritize management actions, and screening tools that help evaluate the restoration potential of degraded water bodies and establish appropriate management targets.

Ecohydrology

Ecohydrology is the study of how changes in the frequency, magnitude, and duration of flow affect ecosystem structure and composition. As water runs off land surfaces with varying frequency, magnitude, and duration, these flows can not only directly affect biological communities, but also trigger erosion and deposition that alters the physical structure of water bodies, which, in turn, affects the ability of aquatic systems to support desired plant and animal communities. Past SCCWRP research has focused on predicting changes in water chemistry in response to specific anthropogenic actions, and on developing management measures – including best management practices (BMPs) – aimed at offsetting the effects of these chemical changes. Substantially less effort has been devoted to relating hydrologic and physical (or geomorphic) alterations to how biological communities respond to these alterations. As regulatory programs increasingly rely on biological endpoints to assess compliance and the effectiveness of mitigation efforts, SCCWRP is working to develop and improve tools that can help environmental managers better understand and ultimately predict the relationship between flow (and its associated hydrologic and geomorphic impacts) and ecosystem health. Better tools will better inform management actions aimed at reducing and mitigating the impacts of flow alterations, especially human-induced alterations associated with flood control, stormwater capture, and water reuse practices.

SCCWRP's ecohydrology research is driven by three major objectives: (1) Understand and predict patterns in key drivers of hydrologic change (e.g., land use, climate change, water use practices), (2) develop tools including statistical and deterministic models to evaluate the relationship between key drivers and changes in flow and related physical and biological responses in the stream, and (3) evaluate the effectiveness of various management actions (e.g., BMPs) and other efforts to reduce or mitigate the impacts of flow modification. Evaluating possible management actions includes developing mechanisms that enhance performance and that improve understanding of how multiple BMPs can work synergistically across broad areas to improve the condition of receiving waters.

This year, SCCWRP will continue to focus on developing tools that can be used to predict how changes in flow translate to changes in physical structure and in biological community composition – changes that are ultimately linked to ecosystem health. SCCWRP's focus for 2016-17 will be on:

- **Development of flow-ecology relationships**: To link changes in flow to the physical and biological changes associated with ecosystem health, SCCWRP is developing an approach for establishing the in-stream environmental flow requirements necessary to meet ecological benchmarks across Southern California, as defined by measures of the composition and structure of benthic macroinvertebrate and algae communities. Because changes in flow are one of the key determinants of the health of in-stream biological communities, understanding these relationships are crucial for establishing biological-based targets for stream condition, as well as informing decisions about water reuse, or supporting criteria for hydromodification management, nutrient numeric endpoints, and freshwater biointegrity. From this research will come answers to several key questions: (1) How should streams be classified for the purposes of establishing environmental flow requirements? (2) What are the key hydrologic variables that should be used for environmental flow requirements? (3) What are the key biological response variables that should be used when establishing environmental flow requirements? (4) What is the appropriate framework for setting actual flow requirements for specific stream types?
- **Development of site-specific and watershed-scale BMPs**: To facilitate BMP implementation to achieve physical and biological targets, SCCWRP is focusing on a combination of local and watershed-scale strategies, both of which are required for effective flow management. SCCWRP has partnered with members of the Southern California Stormwater Monitoring Coalition (SMC) to investigate performance of low-impact development (LID) practices under a range of design and implementation scenarios, including developing recommendations for standard monitoring and data management approaches. LID practices, which are one of the main tools used to meet stormwater runoff, hydromodification, and water-quality requirements, operate by capturing, retaining, detaining, or infiltrating runoff from developed land uses. LID performance can be affected by a variety of factors, such as influent concentrations, rainfall intensity, design attributes, and maintenance history. The results of this work will ultimately be used to support development of mechanistic models of LID performance. Separately, SCCWRP is working with local partners on developing technical approaches to determine optimal placement of hydromodification and water-quality management measures to achieve agreed-upon, watershed-scale objectives. These approaches include helping to develop a system that can determine appropriate offsets between BMPs and impacts along different portions of a watershed.

Eutrophication

While not inherently harmful, excess nutrients introduced to aquatic habitats through human activity (i.e., nitrogen and phosphorus) can trigger eutrophication, the accelerated accumulation of organic matter from overgrowth of aquatic plants and algae. These aquatic blooms can be unsightly and, in some cases, produce toxins and noxious odors. They also can lead to low dissolved-oxygen levels, which trigger declines in fishery harvests and in diversity of aquatic life. However, determining the nutrient load a water body can sustainably assimilate is challenging because, unlike with contaminants, some level of nutrient input is necessary to sustain life. Consequently, environmental managers must work to control the deleterious impacts of excessive nutrients. SCCWRP has been at the forefront of eutrophication research efforts in both freshwater and coastal-ocean systems, working to build a rigorous body of science capable of diagnosing eutrophication, identifying appropriate nutrient targets for California's water bodies, and tracking where nutrients are coming from and what is happening to them. In inland waters, SCCWRP is serving as the technical lead on a multi-year effort by the State Water Board to develop a nutrient objectives policy to protect all of California's wadeable streams, lakes and estuaries. In coastal waters, SCCWRP is studying if and how anthropogenic nutrient inputs to the Southern California Bight are contributing to eutrophication, particularly with respect to increasing algal blooms and declines in dissolved oxygen.

While the symptoms of eutrophication vary by water body type, the conceptual approach to developing tools to diagnose eutrophication and identify nutrient targets is similar for all water bodies. The first step is to build consensus around a conceptual model that identifies symptoms of eutrophication (e.g., altered dissolved oxygen concentrations, increased algal abundance) and their link to both nutrient loads and other contributing water body factors. The second step is to design a framework for assessing the condition of a water body, one that focuses on eutrophication symptoms instead of nutrients themselves. An important element of this framework is to identify thresholds for each symptom that equate to protection of human and ecosystem values and avoidance of adverse impacts. The third step is to build statistical and mechanistic models that link eutrophication symptoms to nutrients and other factors to examine environmental-management scenarios that might prevent an ecosystem impact. An important element of mechanistic model development is conducting process studies that document the fate of nutrients as they are cycled through an aquatic habitat. The final step is to assist in transferring this technology to environmental managers.

This year, SCCWRP will continue its work to incrementally build the knowledge base and the technical foundation that will allow nutrient inputs to be more effectively monitored and managed in California, both in fresh and marine waters. SCCWRP's focus for 2016-17 will be on:

- **Building the Technical Foundation for nutrient targets in California water bodies**: SCCWRP is pursuing a multi-pronged approach toward building the technical foundation upon which policy decisions regarding nutrient and eutrophication targets for California's wadeable streams, lakes and estuaries will be based:
    - SCCWRP is using the consensus of wadeable stream experts to establish the range of eutrophication indicator values that correspond to levels of ecological condition, from high to low, of stream algal community composition. This information will help relate these targets back to levels of beneficial use protection. SCCWRP also is working toward development of statistical models that relate eutrophication indicators to nutrient concentrations and other site-specific factors by major classes of California streams. Such models may provide an alternative approach to setting nutrient targets based on site-

specific factors (e.g., canopy cover, hydrology) that control the ecological response to nutrients.
    - SCCWRP is continuing to work toward derivation of alternative nutrient and eutrophication targets (in lieu of statewide "default" targets) for two major watersheds: Santa Margarita River watershed and San Francisco Bay estuary. For the Santa Margarita River watershed program, which will demonstrate how to establish watershed-specific nutrient targets by developing mechanistic models of wadeable stream and estuarine hydrology and water quality, SCCWRP is conducting process studies and monitoring ambient field conditions to support model development in the lower Santa Margarita River. In San Francisco Bay, SCCWRP is helping to develop the science that will support policy decisions on chlorophyll-a numeric targets, and undertaking a review of the science supporting dissolved oxygen objectives in South San Francisco Bay.
- **Assessments of harmful algal blooms (HABs)**: To understand the magnitude and spatial extent of harmful algal blooms across marine, estuarine and fresh water systems, SCCWRP is studying the ecophysiological factors that drive HABs development and proliferation. SCCWRP is focused on: (1) evaluating existing data to characterize trends in HAB proliferation, (2) conducting studies to understand the fate of anthropogenic nutrients and their linkage with algal boom proliferation, and (3) playing a role in unifying the monitoring and research efforts taking place in freshwater habitats and the coastal zone. To understand the prevalence of cyanobacterial blooms and toxins in California lakes and streams – which can pose a potential threat to human and ecosystem health – SCCWRP is leading a statewide group that is working to implement a statewide cyanobacteria monitoring strategy, including development of statewide protocols for routine nutrient and cyanobacteria ambient lake assessments.
- **Biogeochemical effects of nutrients in the Southern California Bight**: SCCWRP is working to couple biogeochemical models with physical oceanographic models to ascertain the relationship between coastal hypoxia and acidification conditions with sources of land-based nutrient inputs entering the Bight. Management actions, including nutrient load reduction, have been suggested as a strategy for improving local water quality, but the extent of change achieved from nutrient load reductions are uncertain, given that the primary drivers for coastal hypoxia and acidification may be processes that operate at a global scale due to climate change. Coupled biogeochemical and physical circulation models, which presently don't exist for near coastal environments, will be used to evaluate the extent to which anthropogenic nutrients are affecting trends in oxygen and acidification conditions.

Climate Change

Global climate change will fundamentally alter how aquatic systems are managed. As anthropogenic carbon dioxide emissions drive increasingly severe changes to ocean temperature and chemistry, water-quality managers will be tasked with developing long-term strategies and management responses that match the scale and scope of this global phenomenon. Although climate change drivers operate primarily at a global scale, the impacts will be managed at a local scale. To that end, managers must be prepared to confront the local impacts of climate change, including how climate change will fundamentally alter biological communities, how it will disrupt sensitive ecological areas along the coast, and how it will shift societal attitudes about how aquatic resources should be managed. SCCWRP is helping Southern California water-quality managers pursue a multi-pronged

research agenda aimed at developing next-generation solutions for monitoring, mitigating and offsetting the local impacts of global climate change.

SCCWRP's research is focused on identifying, evaluating, refining and implementing viable mitigation and preparedness options that will position aquatic systems to optimally cope with the impacts of rising atmospheric carbon dioxide emissions. SCCWRP is primarily invested in advancing scientific understanding of ocean acidification, a phenomenon caused by oceanic assimilation of atmospheric carbon dioxide. This ocean acidification research is wide-ranging and encompasses disparate areas, including: (1) how to differentiate the changing distribution of organisms with temperature relative to existing biological monitoring programs, (2) advancing the state of the science on acidification impacts by moving beyond dissolution of calcium carbonate in shelled organisms to more subtle, but potentially more far-reaching, chronic sub-lethal impacts, and (3) developing predictive models for ecosystem transitions in streams, wetlands, lagoons and estuaries. Meanwhile, as climate change drives rising sea levels and increased storm surge, as well as fundamental shifts in weather patterns and increases in seawater temperatures, SCCWRP also will seek to understand these impacts and evaluate the effectiveness of possible management actions.

This year, SCCWRP will work toward improving managers' ability to monitor ocean acidification and to assess its impacts on the Southern California Bight, and assess the vulnerability of coastal areas to sea level rise and storm surge. SCCWRP's focus for 2016-17 will be on:

- **Assessment of acidification and its impacts:** SCCWRP is developing new technologies and approaches to assess the changing chemistry of seawater, as well as conducting research to assess how ocean acidification may already be impacting the water quality and biota in the Southern California Bight.
    - SCCWRP is improving the ability to monitor potentially acidifying waters in three main ways: (1) SCCWRP is working with its member agencies to collect high-accuracy, static samples contemporaneously with existing pH monitoring technology to better quantify the existing error rate and define the circumstances under which that error rate is most pronounced, (2) SCCWRP is evaluating strategies for improving existing technology through alternative calibration approaches, and (3) SCCWRP and its member agencies are evaluating pH sensor prototypes developed through an international XPRIZE competition side-by-side with existing technology to determine whether these new technologies are appropriate for compliance assessment applications. Traditional water quality profiling instruments use pH sensors that are based on glass electrode technology that has measurement variability about twice that of the allowable deviation in the California Ocean Plan.
    - To assess possible effects of acidification that have already manifested, SCCWRP is working with its member agencies to digitize and analyze historical Bight data sets dating back 50 years or more, with the intent to examine possible local trends in acidification. Those analyses are focused on assessing possible changes to pH, which is a direct measure for changes in water quality, and assessing condition of benthic infauna, which allows for assessment of the potential biological response to changing water quality exposure. The benthic infaunal analysis will examine whether there have been any faunal shifts in the biota over the 40+-year data record and whether any changes can logically be associated with acidification stress, such as the ratio or spatial distribution of shelled vs. non-shelled organisms.
- **Evaluation of sea level rise vulnerabilities**: SCCWRP is in the beginning stages of designing evaluation tools that can synthesize information about wetland structure, position

and surrounding infrastructure to predict how a vulnerable coastal zone will respond to sea level rise and storm surge. The goal is to be able to inform restoration design and expected needs and costs for long-term management of vulnerable coastal areas, as sea level rise is expected to be one of the largest factors influencing coastal wetland restoration over the next 50 to 100 years. SCCWRP is evaluating an existing set of sea level rise prediction models – in terms of their applicability to the various wetland types found along the Southern California coast – to provide a preliminary evaluation of sea level rise effects on the habitat and biological communities that currently reside there. From the findings of this evaluation, a decision support tool will be developed to assist wetland managers in predicting potential biological alterations, and in selecting the most appropriate tools and strategies for incorporation into local wetland restoration plans.

Sediment Quality

The quality of sediment that underlies water bodies is a sentinel indicator of the health of marine ecosystems. Pollutants discharged from wastewater treatment plants and urban watersheds have led to sediment contamination along California's coastline, with contamination levels most acute in bays and estuaries, where slower-flowing waters promote settling of contaminant-laden particles. SCCWRP has been at the forefront of efforts to quantify, monitor and develop solutions to remediate contaminated sediment. In partnership with its collaborators, SCCWRP has advanced sediment-quality science into the regulatory arena through the development of a widely applicable sediment quality assessment framework designed to gauge the impacts of sediment contamination on bottom-dwelling organisms. In California, this assessment framework has become the technical foundation for implementing the state's Sediment Quality Objectives program that went into effect in 2009. SCCWRP also has begun developing sophisticated mathematical models that quantify how contamination from sediment moves through the food web and bioaccumulates in wildlife and humans.

SCCWRP's research falls into two main categories that organisms become exposed to sediment contamination: direct exposure, where bottom-dwelling marine life come into contact with and/or ingests contamination in sediment, and indirect exposure, where predators accumulate toxins in their bodies as they consume contaminated prey. Each exposure route calls for a different conceptual approach to build a comprehensive assessment framework that can accurately measure and estimate the impacts of sediment contamination on the organisms exposed to it, including humans. SCCWRP's goal is to build a common, agreed-upon technical foundation for assessing sediment quality to help water-quality managers make better-informed decisions about sediment remediation and clean-up activities.

This year, SCCWRP is continuing its work across both the direct and indirect exposure arenas, as well as pursuing case studies that can assist in translating sediment science to application by environmental managers. SCCWRP's focus for 2016-17 will be on:

- **Direct effects on sediment quality**: To build upon research focusing on the impacts of direct exposure to contaminated sediment, SCCWRP is pursuing projects across all three lines of evidence used in sediment quality assessments. In the chemistry arena, SCCWRP is studying how to accurately measure the freely dissolved concentration of sediment contamination by a technique known as passive sampling. In the toxicity arena, SCCWRP is continuing to test sediment quality in embayments, which were identified as some of the most impacted sediments from Bight regional monitoring surveys, to assess spatial and temporal variability

in sediment toxicity. In the biological assessment arena, SCCWRP is evaluating if and how to use DNA barcoding to rapidly assess the condition of marine benthic invertebrate communities. In the toxicity identification evaluation (TIE) arena, SCCWRP is developing guidance documents for traditional TIE methods and also studying how molecular TIE methods could be adapted to sediment toxicity testing.

- **Indirect effects on sediment quality**: To assess sediment contamination's health risks for humans and wildlife, SCCWRP is pursuing development of bioaccumulation models and assessment frameworks that integrate consumption risk and sediment linkage indicators. In the sediment linkage arena, SCCWRP is working to assess the utility of bioaccumulation models to predict sediment contamination transfer through food webs in multiple habitats. In the consumption risk arena, SCCWRP is conducting a San Diego Bay fish consumption study to understand how socio-spatial factors influence consumption rates of local seafood. And in the assessment framework arena, SCCWRP is drafting a multi-tiered sediment quality objectives framework for human health, as well as evaluating the framework's utility and designing a decision support tool to complement the framework.
- **Case studies to evaluate California's sediment quality objectives**: To support implementation of new evaluation tools for sediment quality monitoring initiatives, SCCWRP is partnering with local agencies to use California's Sediment Quality Objectives program for protection of benthic infauna to implement toxics TMDLs (total maximum daily loads) for the Los Angeles/Long Beach Harbor and Marina del Rey Harbor, as well as develop sediment remediation plans for San Diego Bay contamination hotspots. SCCWRP also is working to develop methodologies for determining sediment clean-up targets that improve upon the empirical sediment quality guidelines presently in use.

Contaminants of Emerging Concern

Managers are challenged with addressing contaminants of emerging concern (CECs) in the face of a limited, but rapidly growing knowledge base about their sources, pervasiveness, and effects. There are literally tens of thousands of chemicals to triage, making the traditional chemical-by-chemical approach to monitoring and regulation unwieldy and obsolete. Moreover, CECs are a "moving target" as new chemicals are substituted for ones that are being phased out. In some cases, their potential for impact occurs at much lower levels and is manifested over longer periods of time compared with chemicals already being regulated. As a result, a new approach to monitoring and assessment of aquatic contaminants is needed.

SCCWRP is developing two types of tools for sampling and measurement of chemical and biological parameters that will best inform whether CECs associated with permitted discharges are negatively impacting aquatic systems in California. Methods that employ state-of-the-art engineered cell biology ("bioanalytical tools") can screen for many chemicals at the same time, making monitoring more efficient, relevant and comprehensive than the status quo. New chemical techniques that identify CECs responsible for exerting toxicity and that accumulate in wildlife ("non-targeted chemical analysis") will provide a means for interpreting biological monitoring results. Integration of these tools with diagnostic toxicity testing and monitoring for CEC impacts *in situ* using a tiered monitoring framework will allow managers to make informed decisions concerning the level of treatment, discharge and occurrence of CECs.

This year, SCCWRP will investigate the quantitative linkage between cellular (or "bioscreening") assay responses and effects to organisms for endocrine disrupting CECs (or "EDCs"), and develop

and apply non-targeted chemical methods for identifying bioaccumulative and bioactive CECs. In addition, SCCWRP will continue pilot testing these new monitoring tools and how they interact in a tiered framework in selected watersheds across California. SCCWRP's focus for 2016-17 will be on:

- **Bioanalytical screening methods**: To determine how effective bioscreening can be in guarding against reproductive impacts to wildlife exposed to EDCs, SCCWRP is using freshwater and estuarine/marine fish species (e.g., fathead minnow, inland silverside) to look for concordance between EDC bioscreening results and the degree of reproductive harm observed in test fish. These laboratory experiments are testing water spiked with known EDCs, as well as with more complex mixtures that better represent receiving waters. In parallel, SCCWRP is extending the scope of standard toxicity tests to include endpoints of interest for EDCs, e.g., gonadal development, sexual differentiation and reproductive success in these same test fish species.
- **Non-targeted identification of bioaccumulative and bioactive CECs**: To identify appropriate sentinel species and to expand the regional catalog of bioaccumulative CECs, SCCWRP is analyzing blubber samples of various marine mammal species that frequent the Southern California Bight using non-targeted chemical analysis. SCCWRP also is developing non-targeted methods to identify bioactive chemicals in water and sediment, and applying these methods to samples from receiving environments subject to stormwater and treated wastewater discharge.
- **Pilot testing of the CEC monitoring framework**: SCCWRP is continuing to test the validity and utility of a tiered framework for monitoring CECs in multiple watersheds across California, including aquatic systems that receive CECs from both treated wastewater and stormwater discharge. In Tier I, bioscreening and targeted chemical analysis are being performed on receiving water samples. Where bioactivity cannot be explained by screening analyses, non-targeted chemical analysis is being "triggered" to identify previously unknown bioactive chemicals (Tier II). Occurrence data for CECs with established thresholds (e.g., selected pharmaceuticals, hormones and pesticides) are being assessed in these watersheds to determine if future monitoring is warranted.

Microbial Water Quality

With more than 233 million visits per year, Southern California's beaches are a precious natural resource and a major economic driver for the state and region. As such, protecting beachgoers from waterborne microbes that come from a disparate array of sources is vital to maintaining the economic benefits and perception of healthful living associated with California beach culture. Although California runs the nation's most comprehensive beach water monitoring program, the public can benefit greatly from continuing advances in how microbial water contamination is monitored. Existing methods take 24 hours or more to yield results, which isn't fast enough to provide same-day warnings to beachgoers. Moreover, when environmental managers find fecal indicator bacteria that may be associated with potentially pathogenic microbes in water, they want to identify where the contamination is coming from to stop it at the source. Given that waterborne microbes can travel long distances, remain infectious for extended periods (as in the case of some viruses), leave behind genetic material long after being rendered non-viable via disinfection treatment processes, and come from any combination of human and animal feces, the process of identifying sources of microbial water contamination and their associated health risks can be challenging and complex – an area for which the technology is still evolving. SCCWRP has been at the forefront of efforts to more rapidly detect beach microbial contamination and to advance the breadth and accuracy of emerging source-

identification technologies. Working with its collaborators, SCCWRP has evaluated methods for identifying fecal sources, created a tiered framework for investigating sources of fecal bacteria at beaches, and developed and evaluated multiple assays designed to measure pathogens in both fresh and marine water. SCCWRP also is actively involved in applying these methodologies to epidemiology and modeling studies to characterize the risk of water-contact illness.

SCCWRP's microbial water quality research is focused around three major objectives: (1) Develop methods to provide same-day health warnings to ocean bathers, (2) improve the approaches used to identify sources of microbial contamination, and (3) understand the relationships between contamination measurements and observed impacts on human health. The first two areas revolve around transitioning from decades-old culture-based analyses – in which microbes must grow overnight in a lab – to genetic methods capable of rapidly detecting and quantifying microbes via the presence of their genetic material (DNA or RNA). This genetic technology also has the potential to provide important information about the source of fecal contamination, as specific genetic targets are diagnostic of different fecal sources (e.g., humans, dogs, cows, birds). Given the trove of data that these emerging technologies can yield, SCCWRP is working to incorporate these methods into epidemiological studies that can help environmental managers better understand the health risks associated with various beaches and fecal sources. SCCWRP's ultimate goal is to provide managers with real-time information on sources of fecal contamination and commensurate risk to public health.

This year, SCCWRP will continue to pursue development of new technology to autonomously and rapidly assess beach water quality in the field. SCCWRP also is examining the utility of source-associated markers to identify microbial water pollution, and assessing the health effects of contaminated ocean water on swimmers and surfers. SCCWRP's focus for 2016-17 will be on:

- **Rapid assessment methods:** To improve real-time, in-field detection of fecal indicators and host markers at the beach, SCCWRP is playing a key role in the development of a field-deployable instrument capable of detecting and quantifying fecal indicator bacteria (FIB) and source-associated fecal markers. With this field method, technicians will be able to conduct microbial source tracking by following the relative concentrations among samples and tracking bacterial contamination to its source. By allowing field staff to make near real-time measurements on the beach, rather than being forced to wait while the samples are transported to a central processing laboratory, warnings can be issued sooner to protect ocean bathers from exposure to waterborne pathogens. This project builds upon SCCWRP's pioneering work to develop laboratory-based rapid methods for measuring microbes in beach and storm waters.
- **Source identification:** For environmental managers to be able to use a suite of source-associated genetic markers shown to detect and quantify sources of aquatic fecal contamination, managers must know the environmental decay rates of these source-associated markers relative to the decay rates and viability of the FIB and pathogens presently being monitored. SCCWRP is working to help characterize the relative decay rates of source-associated markers, fecal indicator bacteria (FIB), and pathogens in fresh, brackish, and marine water and sediment. The study builds upon previous SCCWRP research that identified a suite of source-associated genetic markers that were deemed both sensitive and specific for detection and quantification of aquatic fecal contamination sources.
- **Assessing human health impacts**: SCCWRP and collaborators are conducting an epidemiology study to assess whether stormwater runoff are making surfers ill. The surfer health study builds upon previously published epidemiology work that focused on ocean bathers during summer months, and is the first to assess illness rates associated with

stormwater runoff during the rainy winter months. Surfer health data, combined with the microbial data on FIB and pathogens, is being used to determine whether the water-quality standards developed for dry-weather summer conditions are also the most appropriate for rainy winter conditions. SCCWRP is also conducting a Quantitative Microbial Risk Assessment, or QMRA, to determine the appropriateness of setting site-specific objectives for water quality criteria. No QMRA has been conducted at a marine beach, especially in California, making it an important case study.

Regional Monitoring

Southern California environmental managers and scientists spend an estimated $50 million every year on monitoring aquatic environments, but have struggled to answer the big-picture questions being asked by the public: "Is it safe to swim in the ocean?" "Are locally caught fish safe to eat?" and "Are local ecosystems adequately protected?" The reason? Most of this money is allocated to keep tabs on the relatively compact areas that surround specific outfalls – monitoring that is required under state and federal laws. Consequently, when scientists compile this compliance-based monitoring data from dozens of agencies, the resulting regional picture is incomplete. Recognizing this challenge, SCCWRP has stepped in to coordinate and facilitate wide-scale regional monitoring programs across a variety of habitats, including streams, wetlands, estuaries, beaches and coastal waters. For each monitoring program, SCCWRP works with up to 100 local and regional agencies to standardize data collection and coordinate analysis efforts, leveraging the limited resources of many to obtain comprehensive data on some of the region's most pressing environmental challenges. These programs are among the top regional monitoring programs in the nation and have served as models for developing similar programs internationally.

SCCWRP's best-known monitoring program is the ongoing Southern California Bight Regional Monitoring Program, conducted every five years since the mid-1990s. The program mobilizes participating agencies to collect data from across a much greater expanse than just their outfall zones, allowing environmental managers to paint a comprehensive picture of the health of coastal waters that stretch from Point Conception in Santa Barbara County to just south of the U.S.-Mexico border. The Bight program's freshwater counterpart, the Southern California Stormwater Monitoring Coalition Regional Watershed Monitoring Program, was launched in 2009 to monitor an area that stretches from the Ventura River in Ventura County to the Tijuana River straddling the U.S.-Mexico border. The key to success in developing integrated monitoring designs is SCCWRP's ability to bring all parties to the table – from local and regional agencies to state and national entities – to work toward agreement on goals, study design and data interpretation. Not only do the comprehensive data sets help environmental managers establish appropriate priorities and goals for addressing big-picture challenges, but regional monitoring also fosters productive interactions among dischargers and regulators as they develop and collaboratively interpret monitoring information and implement findings. Regional monitoring also provides an important launching platform for SCCWRP's member agencies and research collaborators to test new technologies and assessment tools.

This year, SCCWRP will culminate several elements of its most recent coastal monitoring effort (Bight '13). Additionally, as the Bight regional monitoring program winds down its 2013 cycle, the SMC regional watershed monitoring program is pursuing new questions, new designs and new indicators following the launch of its second cycle in 2014. SCCWRP's focus for 2016-17 will be on:

- **Regional marine monitoring (Bight '13)**: The 2013 cycle of the Southern California Bight Regional Monitoring program, a hallmark marine monitoring initiative encompassing five

design elements and nearly 100 collaborating agencies, is continuing to provide answers to key monitoring questions in the areas of sediment contamination, trash and debris, shoreline microbiology, marine protected areas, and nutrient impacts. All five elements are focused on answering questions regarding the extent and magnitude of anthropogenic impacts, and the range of natural variability upon which scientists judge these impacts. The status of each element as of the start of 2016-17 is as follows:

- The sediment contamination element (also called contaminant impact assessment) is performing a final assessment of integrated condition using sediment chemistry, sediment toxicity, benthic infauna, and benthic fish data. This weight-of-evidence approach to assessment is based on nearly 400 sites collected in more than 12 different habitats, ranging from the region's shallowest depths (estuaries) to its deepest depths (ocean basins). The condition as of Bight '13 will be compared to comparable surveys dating back to 1994.
- The trash and debris element has completed a final assessment of monitoring data from watersheds and the coastal ocean, linking plastic and other trash from land-based inputs to ocean-based effects.
- The shoreline microbiology element is examining how many beaches are influenced by human sources of bacteria. After spending three years sampling and analyzing bacteria at beaches and ocean discharges from San Diego to Ventura County, this element is focusing on genetic signatures of the bacteria's source, or "host," to answer a key question: Is the host human (i.e., sewage or septic), or is the host another, less pathogenic organism? Not only will this information help prioritize and rank beaches for future remediation, but SCCWRP is using the opportunity to train and validate local monitoring laboratories throughout the region in genetic testing.
- The nutrient element is addressing questions about the potential impacts of nutrient loading on algal blooms, hypoxia, and ocean acidification. Isolated studies have hinted at the potential for these effects, but never before has so much effort been expended at such a large spatial scale in Southern California. Several platforms, including boats, moorings, autonomous underwater vehicles, and satellites, are being used to measure ocean responses to nutrients. Ultimately, a complex computer model will be developed to assess the interaction between global-scale processes (i.e., CO_2), regional-scale processes (i.e., upwelling), and local-scale processes (i.e., POTWs and river runoff).

- **Regional watershed monitoring**: SCCWRP is facilitating the second iteration of the Southern California Stormwater Monitoring Coalition (SMC) Regional Watershed Monitoring Program. After successfully facilitating the first regional monitoring survey of streams from 2009 to 2014, SCCWRP helped the SMC assess the health of Southern California's approximately 4,300 miles of streams in its coastal watersheds. The regional stream survey is among the largest in country, with sampling at more than 500 sites across all 17 major watersheds between the Ventura and Tijuana Rivers. Data being collected encompasses water quality, physical habitat and riparian condition, and biological communities, including benthic invertebrates and algae. The monitoring questions for the second five-year cycle, which runs through 2019, include: (1) What are the extent and magnitude of impact in Southern California's streams? (2) Are the extent and magnitude getting better or worse? (3) What are the stressors responsible for the impacts observed? The 2015 survey also addresses several special study components, including assessing non-perennial streams, which is a habitat that comprises nearly three-quarters of all stream-miles in the region. Additional novel components include integrating new biological indicators

(amphibians), evaluating the physical effects of hydromodification, and assessing the impacts of contaminants of emerging concern (CECs).

Information Technology and Visualization

Monitoring, assessment and management of aquatic ecosystems is a data-driven process, with millions of dollars spent every year in Southern California on the collection of monitoring data. To effectively use data, the methods used to acquire, manage and assess data must be well-documented. The goal is to generate data that are reproducible, consistent and comparable. Increasingly, environmental managers are seeking sophisticated approaches to visualizing data to effectively communicate big-picture ideas and complex findings; these visualization tools include data dashboards, map-based tools and virtual-reality simulations that can examine what-if scenarios by altering hypothetical conditions and decisions. SCCWRP is at the forefront of efforts to develop and standardize data management across Southern California, beginning with an ocean-monitoring pilot study in 1994 that has evolved into the ongoing Southern California Bight Regional Monitoring Program. Development of standardized data collection and management protocols through the Bight program and others has greatly improved data quality and comparability throughout the region, offering environmental managers comprehensive, detailed snapshots of the changing condition of coastal waters in Southern California and beyond. Signature data-collection initiatives such as the Bight program also serve as national models for effective environmental-monitoring design.

As SCCWRP advances its research agenda to leverage emerging information technologies in data acquisition and analysis, the agency evaluates opportunities to use new and emerging technologies to improve the data workflow. This workflow falls into three main stages: (1) data acquisition, (2) data management, and (3) processing and interpretation of results. To improve quality, consistency and speed of data collection, SCCWRP is pursuing a number of emerging technologies for field data acquisition. To allow environmental researchers and managers to evaluate potential outcomes based on various assumptions and hypothetical courses of action, SCCWRP is pursuing development of environmental index and statistical calculators, data dashboard and visualization products, and scenario tools. SCCWRP's goal is to provide environmental managers and the public with consistent and transparent analytical methods and outputs, so the science developed by SCCWRP and its collaborators can be effectively used to inform management action.

This year, SCCWRP will continue its work to further enhance data acquisition technologies, refine its data management processes and protocols, and build and test next-generation data processing and interpretation tools. SCCWRP's focus for 2016-17 will be on:

- **Data acquisition**: To improve scientists' ability to gather environmental data and field measurements, SCCWRP is working to expand and improve its field computing tools, including the utility and capabilities of mobile apps to support data collection, and the use of real-time web data services to more effectively integrate data collection. SCCWRP also is working to adapt the capabilities of remote sensors, especially satellites and unmanned aerial systems (UAS), to allow for collection of richer, more data-intensive imagery. Finally, SCCWRP is pursuing ways to use device appendages – ranging from environmental sensor probes to a portable field microscope appended to a smartphone – to enhance the utility of data acquisition tools. Across all of these data acquisition platforms, SCCWRP is exploring opportunities to effectively automate the analysis of image data being collected.
- **Data management**: Although not a formal research area, data management remains a pivotal role for SCCWRP. SCCWRP is continuing to support agencies that prepare and transmit

environmental data to the State of California Environmental Data Exchange Network (CEDEN) database. More broadly, SCCWRP is continuing its investment in cost-effective and open-source technologies, developing next-generation web-based data submission tools with integrated data-quality checkers, updating databases to optimize functionality and ensure utility, providing support for efforts to identify and prioritize non-digitized historical data, and maintaining updated databases as nomenclature and the state of the science evolve.

- **Data processing and interpretation**: To simplify the laborious, highly technical tasks associated with data crunching and analysis, SCCWRP is working to transfer its environmental index calculators to the end-user community. To improve managers' ability to visualize and analyze fully integrated data sets, SCCWRP is building a stormwater dashboard that can pull from multiple data sources, and a 3D visualization tool prototype customized for the Tijuana River National Estuarine Research Reserve that can aid in restoration and recovery planning of ecologically sensitive areas. To pave the way for virtual- and augmented-reality scenario planning, SCCWRP is moving aggressively into the "what if" planning arena via a newly forged partnership with Esri, a leading commercial GIS software company.

Emerging Research and Member Agency Support

SCCWRP provides support for its member agencies in a number of ways, ranging from field support, methodological training, quality assurance, serving on expert panels, expert panel facilitation, data analysis and integration, and producing documents such as the SCCWRP Annual Report. In addition, SCCWRP also provides presentations to member agencies upon request and hosts a biennial Symposium for the staff of member agencies to learn about SCCWRP research.