SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT AUTHORITY

FY 2015-2016
RESEARCH PLAN
EXECUTIVE SUMMARY

Approved by the Commission

June 2015

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 45 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. **Sediment Quality**
3. **Contaminants of Emerging Concern**
4. **Eutrophication**
5. **Microbial Water Quality**
6. **Flow Ecology**
7. **Wetlands**
8. **Regional Monitoring**
9. **Information Technology and Visualization**

Furthermore, SCCWRP is invested in additional research through its ongoing exploration and pursuit of **New Initiatives** (e.g., Climate Change and Recycled Water), which could one day become codified in SCCWRP's core research agenda. Finally, SCCWRP conducts special research projects and initiatives in its role providing ongoing **Member Agency Support**.

Research Planning Process

SCCWRP staff works in partnership with the 14 members of CTAG to develop and continuously update a 10- to 15-year research vision for each of SCCWRP's major thematic research areas. Written for knowledgeable scientists working in each particular field, these comprehensive technical reports are living documents that are updated in real time, as new projects and partnership opportunities emerge. CTAG and SCCWRP staff collaborate in all-day research planning workshops to flesh out and update these long-range research visions and identify broadly supported priorities for research. CTAG also reviews the written documents to check for technical accuracy, ensure SCCWRP's research agenda remains relevant to member agency needs, and 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 its management-level audience 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 also serves as SCCWRP's Research Plan and Budget, which the SCCWRP Commission is required to approve annually. Accordingly, this document contains two portions: a series of two-page summaries of SCCWRP's research directions within each research theme, and financial information for the organization 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 as the organisms move through an ecosystem. 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 nearshore marine environments that rely primarily on evaluating the health of benthic invertebrates and algae. SCCWRP's goal is to develop bioassessment tools for all aquatic habitats using a 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 standard evaluation frameworks and 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 ecology 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 combat the negligible role that biological data have historically

relegated to in key management decisions, including in designation of new conservation areas and selection of sites requiring restoration.

This year, SCCWRP is continuing 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 2015-16 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. The goal is that assessment tools based on invertebrates, algae, vertebrates or molecular indicators could be applied streams, wetlands, and/or coastal lagoons. This year, SCCWRP is focused on developing condition indices for perennial wadeable streams that will be eventually expanded to development and/or validation of indices for other water body types (e.g., nonperennial streams, episodic rivers, depressional wetlands and bar-built estuaries) and development of new indicators (e.g., fish, amphibians and riparian birds). To guide these expansions, SCCWRP will develop a framework that can link beneficial uses to different indicators of attainment.
- **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 include development of report cards and other data synthesis methods, decision support tools to help locate high-value areas for protection and to prioritize management actions, and screening tools to help evaluate the restoration potential of degraded water bodies and establish appropriate management targets.

Sediment Quality

The quality of sediment that underlies water bodies is a sentinel indicator of the health of marine ecosystems. Pollutants flushed down drains and discharged from 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 carefully calibrated, rigorously vetted assessment framework that gauges the impacts of sediment contamination on the bottom-dwelling organisms that come into contact with it. 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 advanced its research agenda to investigate the flip side of sediment contamination, developing sophisticated mathematical models that quantify how contamination from sediment moves through the food web and bioaccumulates in seafood consumed by humans.

At SCCWRP, researchers are studying the two main ways that organisms become exposed to sediment contamination: direct exposure, where bottom-dwelling marine life come into contact with and ingest contamination in sediment, and indirect exposure, where predators accumulate toxins in their bodies as they consume contaminated prey. Each exposure route requires 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 ultimate 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 2015-16 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 analyze data from the 2013 cycle of the Southern California Bight Regional Monitoring Program to assess the spatial extent of and temporal changes to 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 new Sediment Quality Objectives program 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

Contaminants of emerging concern (CECs) refer to the tens of thousands of chemicals – ranging from pesticides to personal care products – that may be introduced to receiving waters through human activity that environmental managers are working to detect, understand and monitor. Although the knowledge base is limited, scientists are continually learning more about CECs' sources, pervasiveness and effects. With so many chemicals to triage, the traditional approach of monitoring and regulating individual chemicals has become unwieldy. Moreover, ongoing changes in human activity have made CECs a moving target, with new chemicals continually being substituted for ones being phased out. Recognizing the need for a new approach to monitoring and assessment of environmental contaminants, SCCWRP has been working to develop novel methods to more widely and efficiently screen for CECs. The agency also is invested in building models to predict the impacts of high-priority CECs, to characterize key exposure routes, and to connect screening-level monitoring data to higher-level biological responses.

Unlike with many historically regulated chemicals, the potential for CEC impacts occurs at much lower levels and is manifested over longer periods of time. Consequently, SCCWRP has pursued development of a suite of chemical and biological tools to improve CEC monitoring. Chemical monitoring methods are necessary in characterizing the likelihood that humans and aquatic life will be exposed to harmful substances in the aquatic environment. Biological monitoring methods, meanwhile, are key to determining whether existing levels of chemical exposure are causing adverse impacts to wildlife and humans. SCCWRP's biological-monitoring focus is on adapting bioanalytical tools – which employ state-of-the-art engineered cell biology techniques – to screen receiving water bodies for thousands of chemicals at the same time; the goal is to make monitoring more efficient, relevant and comprehensive than the status quo (i.e. a chemical-by-chemical approach). To interpret biological-monitoring results, SCCWRP is pursuing development of chemical techniques that can identify the CECs responsible for exerting toxicity, a process known as non-targeted chemical

analysis. Integration of these tools into a tiered monitoring framework will allow managers to make informed decisions concerning the level of treatment, discharge, occurrence and impacts of CECs.

This year, SCCWRP is focused on investigating the quantitative linkage between cellular, or "bioscreening," assay responses and observed effects on organisms from endocrine disrupting CECs (EDCs) exposure. SCCWRP also is developing non-targeted chemical methods for identifying bioaccumulative and bioactive CECs. Finally, SCCWRP is launching pilot testing with these new monitoring tools in selected watersheds across California to understand how they interact in a tiered framework. SCCWRP's focus for 2015-16 will be on:

- **Bioanalytical screening methods**: To determine bioscreening's effectiveness in guarding against reproductive impacts to wildlife exposed to EDCs, SCCWRP is employing freshwater and estuarine/marine fish species (e.g. fathead minnow, inland silverside) to look for concordance between bioscreening results for EDCs and the degree of reproductive harm observed in test fish. In these laboratory experiments, SCCWRP is 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 SCCWRP's regional catalog of bioaccumulative CECs, SCCWRP is using non-targeted chemical analysis to analyze blubber samples of various marine mammal species that frequent the Southern California Bight. 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 WWTP discharge.
- **Pilot testing of the CEC monitoring framework**: SCCWRP is beginning to test the validity and utility of a tiered CEC monitoring framework in multiple watersheds across the State, including systems that receive CECs from both WWTP 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.

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 acidification (low pH) 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 is continuing 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 2015-16 will be on:

- **Establishing nutrient and eutrophication targets for California's streams, lakes and estuaries**: 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 assisting the San Francisco Estuary Institute in completing science supporting policy decisions on chlorophyll a numeric targets, and undertaking a review of the science supporting dissolved oxygen objectives in South San Francisco Bay.

- **Biogeochemical effects of nutrients in wastewater effluent on the Southern California Bight**: SCCWRP is working to develop coupled physical and biogeochemical models that can ascertain the relationship between coastal hypoxia/acidification conditions and potential regional management actions. Several management actions, such as nutrient load reduction, have been suggested to improve local water quality, but the extent of change achieved from nutrient discharge reductions may be small, given that the primary drivers for coastal hypoxia and acidification are processes that operate at a global scale. Coupled biogeochemical and physical circulation models, which presently don't exist for near coastal environments, are needed to evaluate the extent to which anthropogenic nutrients are affecting trends in oxygen and acidification conditions.
- **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 and associated phenomena (hypoxia and acidification), (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 – recognized as a potential threat to human and ecosystem health – SCCWRP is leading a statewide group that will develop California's cyanobacteria monitoring strategy and create protocols for routine nutrient and cyanobacteria ambient lake assessments.

Microbial Water Quality

With more than 125 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 for 24 hours 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 is continuing 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.

- **Rapid assessment methods:** To improve real-time, in-field detection of fecal indicators and 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 tracing bacterial contamination to its source. By allowing field staff to make nearly instantaneous 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 on SCCWRP's pioneering work to develop laboratory-based rapid methods for measuring microbes in beach and storm water.
- **Source identification:** For environmental managers to be able to use a suite of source-associated genetic markers that have been 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 for 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. But these genetic markers cannot yet be used by managers because management decisions are made based on levels of fecal indicator bacteria (FIB) and/or pathogens, not on source-associated markers.
- **Assessing health impacts:** To model health impacts on ocean bathers from rainfall that flows through storm drains to the ocean, SCCWRP is conducting an epidemiology study to assess whether stormwater runoff contains microbial contaminants that are making surfers ill. The surfer health study builds upon previously published epidemiology work that focused on ocean bathers during summer months; this study is the first to assess illness rates associated with stormwater runoff during the rainy winter months. Surfer health data, combined with the microbial data, 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's modeling approach will serve as the basis for future epidemiological studies assessing health impacts on Southern California ocean bathers during dry weather.

Flow Ecology

Flow ecology, the study of how changes in the flow of water can impact ecosystems, has historically focused on understanding the role that moving water plays in transporting and depositing pollutants. But the magnitude, duration and persistence of runoff from land surfaces can also trigger stream erosion and deposition, causing permanent physical and hydrologic changes that affect the ability of streams or wetlands to support desired plant and animal communities. These changes, referred to as hydromodification, can result from both direct manipulation (e.g., diversion, impoundment, or discharge) and indirect effects (e.g., changes in land use). Traditional approaches to studying the volume and timing of flow have 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 alterations to how biological communities respond to them. As regulatory programs increasingly rely on these biological endpoints to assess compliance and the effectiveness of mitigation efforts, as well as to decide if and how to divert flows, SCCWRP has been 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 physical impacts) and ecosystem health. Better tools will better inform management actions for reducing and mitigating the impacts of flow alteration.

SCCWRP's flow ecology research is driven by three major objectives: (1) Develop tools to evaluate the relationship between changes in flow and related physical and biological responses in streams or wetlands. These tools may be in the form of statistical or deterministic models; separate tools are necessary to predict physical and biological effects. (2) Evaluate the effectiveness of various management actions (e.g., BMPs) and other efforts to reduce or mitigate the impacts of flow modification, which result from anthropogenic activities and climate change. This evaluation must include mechanisms that enhance performance and that improve understanding of how multiple BMPs can work together across broad areas to improve the condition of receiving waters. (3) Develop improved decision-support and data-visualization tools that can help translate complex hydro-physical-biological relationships into data that environmental managers can readily understand and use.

This year, SCCWRP is continuing to focus on developing tools that can be used to predict how changes in flow translate to changes in physical structure and to biological communities – changes that are associated with ecosystem health. From this work, SCCWRP is developing tools and approaches to facilitate implementation of BMPs that can achieve physical and biological targets. SCCWRP's focus for 2015-16 will be on:

- **Development of flow ecology relationships**: To link changes in flow to physical and biological changes associated with ecosystem health, SCCWRP is working to develop an approach for establishing the instream environmental flow requirements necessary to meet ecological benchmarks, as defined by measures of benthic macroinvertebrate and algae community composition and structure. These requirements can be used to help establish

criteria for use in hydromodification management, nutrient numeric endpoints, and freshwater bioobjectives. Because changes in flow are one of the key determinants of the health of instream biological communities, understanding these relationships are crucial for establishing biological-based targets for stream condition and for informing decisions about water reuse. 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 strategies 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 development of 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.

Wetlands

Prior to passage of the federal Clean Water Act in 1971, government policies considered wetlands to be “wastelands” and subsidized their conversion to agricultural or urban land uses. Contemporary federal and state policies have recognized that wetlands are one of the most diverse and ubiquitous habitats in California, and today there are a host of state and federal programs and regulations aimed at protecting and restoring them. Defined as the transitional area between aquatic and terrestrial habitats, wetlands are integrated into most landscape settings and occur in a wide range of sizes and types, from small freshwater systems to larger brackish areas along the coast. Wetlands may exist as relatively isolated resources or be associated with other water body types, such as lakes, streams, or estuaries. Their unique position between wet and dry areas allows them to support distinctive plant and animal communities that provide a broad set of ecological functions and services for society, including habitat for sensitive species, flood attenuation, groundwater recharge, coastal protection,

and recreational and aesthetic opportunities. However, wetland management and protection are challenging goals for California because the state lacks comprehensive programs for mapping and assessing wetland extent and condition and for evaluating the relative vulnerability of wetlands to various stressors.

SCCWRP's wetlands research is organized around addressing four broad issues important to management and protection of wetlands: (1) Assessment, which involves improving understanding of the historical and contemporary extent and condition of wetlands. For this area, SCCWRP is working alongside the California Wetland Monitoring Workgroup – the state agency charged with coordinating wetland monitoring and assessment – to develop an integrated set of tools and approaches that can be used across agency programs to inform decisions about wetland management and make wetland information broadly accessible to agencies and the public. (2) Vulnerability, which focuses on understanding how both short- and long-term changes can potentially impact wetlands; it includes gaining understanding of short-term impacts from factors such as land-use changes, hydrologic modification, and contaminant input to wetlands, as well as long-term effects associated with climate change. (3) Management, which is focused on understanding how wetlands can provide a broad suite of functions, services and beneficial uses to society, and how various actions by the environmental-management community affect this capacity. (4) Planning, which revolves around establishing goals or targets for regulatory and management programs and evaluating the effectiveness of those actions.

This year, SCCWRP is continuing to pursue development of a comprehensive strategy to effectively protect, restore and optimize utilization of wetlands across Southern California and beyond. SCCWRP's focus for 2015-16 will be on:

- **Assessing wetland extent and condition**: SCCWRP is developing and refining tools to assess wetland extent and condition using the three-tiered U.S. EPA assessment framework: mapping (Level 1), general condition assessment (Level 2), and intensive diagnostic assessment (Level 3). Level 1 studies include analysis of historical wetland extent and distribution, as well as developing new mapping methodologies, including model-based mapping approaches. Level 2 studies consist of developing new modules for the California Rapid Assessment Methods (CRAM), validating existing models, and helping to transition completed models to implementation. Level 3 studies focus on expanding assessment tools to new wetland types where tools don't exist, and improving the sensitivity and resolution of assessment tools through incorporation of direct measures of ecosystem function. SCCWRP, which is focused on integration across tool type as well as space and time, is developing approaches for assessing ecosystem services provided by coastal wetlands – both ecological condition and function, as well as services important to humans. While global methods exist for evaluating ecological services, these assessments have never been conducted in Southern California. Understanding the level of service provided by a wetland is important for informing restoration and management priorities and for relating condition to beneficial use. Existing approaches and those that show the most promise will be evaluated for applicability and tested through pilot application to Southern California wetlands.

- **Understanding vulnerability**: Because wetland condition can be affected by a broad range of landscape-scale and local perturbations, SCCWRP is studying wetland stressors at three separate but interrelated scales: At the local scale, SCCWRP is addressing water-quality effects of contaminant loading and wetlands' assimilative capacity to various pollutants. At the intermediate scale, SCCWRP is investigating how hydrologic changes associated with land use and/or drought affect the biological communities found in wetlands. At the global scale, SCCWRP is looking at long-term effects associated with climate change. Sea level rise in particular is expected to be one of the largest factors influencing coastal wetland restoration over the next 50-100 years, even as different wetland types are expected to respond differently based on structure, position, and influence of adjacent infrastructure. SCCWRP is interested in designing evaluation tools that can account for these effects, both in terms of restoration design and expected needs and costs for long-term management. SCCWRP is starting the process by 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. From the findings of this evaluation, a decision support tool will be developed to assist wetland managers in understanding potential effects and in selecting the most appropriate tools and strategies for incorporation into local wetland restoration plans.
- **Informing strategic planning**: Because wetlands restoration and management requires integrated, comprehensive planning efforts that account for wetlands' interaction with their surroundings and the influence of multiple management actions on desired targets or endpoints, a combination of technical, social and economic tools must be used to evaluate tradeoffs among options and to prioritize actions. SCCWRP is developing frameworks and tools that synthesize information on past actions, evaluate their efficacy, and apply this understanding to predict implications of potential future actions. SCCWRP is working with the Southern California Wetlands Recovery Project – a consortium of state and federal wetland agencies with wetland protection or management responsibilities – to pilot this approach by developing a regional strategy for coastal wetland restoration that is intended to provide a roadmap to inform local projects. The goal is that this strategy can support a larger vision of an integrated set of coastal wetlands that collectively support regional functions and services. The lack of a regional strategy and associated goals has often been cited as one of the major impediments to effective restoration of Southern California coastal wetlands.

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 2008 to monitor an area that stretches from the Ventura River in Ventura County to the Tijuana River near 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 is culminating multiple elements of its most recent coastal monitoring effort (Bight '13). Additionally, as the Bight regional monitoring program winds down its 2013 cycle, the regional watershed monitoring is re-emerging as it enters its second, five-year phase with new questions, new designs and new indicators. SCCWRP's focus for 2015-16 will be on:

- **Regional marine monitoring (Bight '13)**: The 2013 cycle of the Southern California Bight Regional Monitoring program, a hallmark marine monitoring project 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 effects. All five elements have at least one still-unanswered monitoring question focused on the extent and magnitude of anthropogenic impacts, and on the range of natural variability upon which scientists judge these impacts.
    - The sediment contamination element (also called contaminant impact assessment) is completing the last of the laboratory analyses from nearly 400 sites collected in more than 12 different habitats, ranging from the region's shallowest depths (estuaries) to its deepest depths (ocean basins). Once analysis is completed, the data from sediment chemistry, sediment toxicity, benthic infauna, and benthic fish will be used to create a weight of evidence to assess not only the extent of sediment contamination, but also whether this contamination is improving or degrading since early surveys in the 1990s.

- The trash and debris element is finalizing compilation of monitoring data from watersheds, streams, and the ocean to link plastic and other trash to both land-based inputs and ocean-based effects.
- The shoreline microbiology element is examining how many beaches are influenced by human sources of bacteria. This year, SCCWRP and its partners are wrapping up sampling and analyzing bacteria at beaches and ocean discharges from San Diego to Ventura County. One of the analyses focuses on the 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 the local monitoring laboratories throughout the region in genetic testing.
- The nutrient element is addressing questions about the potential impacts of nutrient sources 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 see 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 leading a multi-agency effort to launch the second, five-year cycle of the Southern California Stormwater Monitoring Coalition Regional Watershed Monitoring Program. SCCWRP coordinated the first regional monitoring survey of streams from 2008 to 2013 to assess the health of Southern California's approximately 4,300 miles of streams in its coastal watersheds. Based upon more than 500 sites surveyed across all 17 major watersheds between the Ventura and Tijuana Rivers, the majority of stream-miles showed impact to invertebrates, algae, and/or riparian habitat. The monitoring questions in the 2015 cycle are similar to the initial 2008 cycle: (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 builds upon the initial five-year survey by adding several important components, including examining non-perennial streams, which is a habitat that comprises nearly three-quarters of all stream-miles in the region. Additional novel components include new biological indicators (amphibians), the physical effects of hydromodification, and impacts due to 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 ways to visualize 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 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 is continuing 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 2015-16 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 at SCCWRP, 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) and the Beachwatch ocean water-quality 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, including the algaeMetrics calculator, 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.

Additional Research

New Initiatives

SCCWRP continually assesses whether it should broaden and expand its research agenda to meet the needs of its member agencies and the greater environmental management community. New and emerging SCCWRP initiatives being considered for inclusion in the agency's core research agenda include:

Climate Change: As the atmosphere and ocean warm and trigger more climate extremes and global changes to the water cycle, scientists must work to identify, evaluate, refine and implement effective mitigation and preparedness measures. SCCWRP already is contributing to these efforts by looking at improved methods for monitoring ocean acidification, a phenomenon caused primarily by oceanic assimilation of atmospheric carbon dioxide. SCCWRP also is looking at how to plan for the impacts of sea-level rise on wetland areas. In the future, SCCWRP might expand its climate-change monitoring efforts, initiate new planning efforts focused on vulnerability assessment and adaptation, evaluate the robustness and potential modification of bioassessment strategies for determining ecosystem health, and examine how to effectively sequester and store atmospheric carbon dioxide in wetlands over extended periods, a concept known as carbon sequestration.

Recycled Water: As the State of California moves aggressively into the recycled water research arena, SCCWRP is poised to help provide technical studies that will be needed to support eventual development of policies and objectives for a comprehensive state recycled water program. SCCWRP's pilot study to understand the impacts of CECs on water bodies statewide has already positioned SCCWRP to pursue this research in greater depth, as has SCCWRP's extensive work on how alterations to stream flows and discharges trigger ambient effects.

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.

This year, SCCWRP's work to support its member agencies includes facilitation of the Expert Review Panel for the State's Environmental Laboratory Accreditation Program (ELAP), creation of member agency working groups for data acquisition and analysis, support for the City of Los Angele's upcoming temporary outfall diversion, and synthesis of scientific findings from Orange County's recent temporary outfall diversion into a dedicated issue of a scientific journal.