# SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT AUTHORITY

## FY 2018-2019
## RESEARCH PLAN
## EXECUTIVE SUMMARY

**Approved by the SCCWRP Commission**
**June 1, 2018**

# 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 approximately 45 researchers 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 principles to monitor and assess the condition of aquatic ecosystems, with an overarching goal to solve significant 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 five science departments – Toxicology, Chemistry, Biogeochemistry, Biology, and Microbiology – 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**

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 periodically 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 SCCWRP's 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 includes 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 chemical-based monitoring, which provides only limited information about a relatively narrow set of environmental stressors at a discrete point in time, bioassessment integrates exposure of living organisms to multiple chemicals and other stressors (such as altered habitats and changes in life-sustaining water-flow patterns) over extended time periods. Consequently, bioassessment provides a more comprehensive reflection of the condition of an aquatic ecosystem; bioassessment also is more closely tied to environmental managers' focus on ecosystem protection. 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 vulnerabilities to healthy resources, and (3) using the data to support management activities, such as prioritization and effectiveness assessments. To assess condition, SCCWRP develops standardized sampling protocols, characterizes reference conditions, and develops assessment tools that transform complex biological data into simple measures of condition. Additionally, SCCWRP focuses on creating appropriate interpretive frameworks for understanding bioassessment outcomes, 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 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 decisions aimed at improving overall condition, SCCWRP develops synthesis and integration tools that can translate assessment results to actionable information. In this way, SCCWRP products can be used to protect healthy waterbodies and 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, refine and expand its capacity to conduct both condition assessments and causal assessments, as well as pursue development of guidance and decision support tools to inform management actions. SCCWRP's focus for 2018-19 will be on:

- **Condition assessment:** 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 finalizing a statewide stream condition index for algae, a critical bioassessment indicator for evaluating impacts from nutrients, flow, temperature and habitat alteration. The new algal index, known as the Algal Stream Condition Index (ASCI), will directly incorporate molecular data into the index development process for the first time. SCCWRP is also continuing its development work on bioindicators for ephemeral streams (i.e., streams that flow for short durations immediately following rain events), where a lack of tools precludes assessment. SCCWRP is also exploring how to develop additional species, including freshwater fish and ichthyoplankton (larval marine fishes), as new bioindicators of water body condition. Ichthyoplankton holds tremendous promise because of next-generation measurement methods, including genetic barcoding, that are allowing scientists to link water quality and natural resources to the California Cooperative Fisheries Investigation (CalCOFI), one of the longest-running fish monitoring programs in the nation. Additional work will be started this year to develop environmental DNA (eDNA) methods for vertebrate monitoring and for assessing biological communities associated with eelgrass beds.

- **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 continue to work toward developing an integrated and tiered approach to causal assessment. Rapid causal screening tools are being tested to achieve a streamlined approach for identifying major classes of stressors (e.g., flow vs. habitat alteration vs. contaminants). This will be followed by development of stressor-specific metrics based primarily on life history traits and molecular assessment tools, as appropriate, that are designed to improve diagnostic ability. This framework is being demonstrated through ongoing case studies that provide roadmaps for broader implementation of the tools throughout the region and state.

- **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 (1) tools that will allow for the development of report cards and similar data synthesis methods, (2) decision support tools that help locate high-value areas for protection and prioritize management actions, and (3) 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 2018-19 will be on:

- **Development of statewide framework for evaluating in-stream flow needs**: SCCWRP has facilitated formation of a statewide workgroup under the California Water Quality Monitoring Council that is developing a tiered framework for assessing in-stream flow needs across California. The workgroup, which features partners from UC Berkeley, UC Davis, U.S. Geological Survey and The Nature Conservancy, is developing an environmental flows management framework that includes statewide hydrologic and geomorphic classification, coarse-level flow requirements for each hydrologic class in the state, and a framework for selecting the most appropriate site-specific tool based on consideration of stream type, biological endpoint, and management needs. The framework will be applied to support several needs related to flow management, including dam management, agricultural water withdrawals, and urban stormwater management.

- **Application of flow-ecology to water resources management**: Past SCCWRP research has produced flow-ecology relationships that linked changes in flow to changes in stream condition as indicated by benthic macroinvertebrate community composition. SCCWRP is now pursuing development of flow targets based on algal communities, freshwater fish and riparian habitats. This broader suite of tools will be applied to support applications that include urban stormwater management, evaluation of climate change effects, and evaluation of water use and reuse proposals.

- **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 is partnering 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

Excess nutrients introduced to aquatic habitats through human activity (i.e., nitrogen and phosphorus) – combined with other changes such as modifications to hydrology, temperature and light – can trigger eutrophication, which is 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 that can trigger declines in fishery harvests and in diversity of aquatic life. However, determining the nutrient load a water body can 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 and other waterbody conditions that can exacerbate eutrophication. SCCWRP has been at the forefront of eutrophication research efforts in both freshwater and coastal-ocean systems, working to build a foundational body of science for 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 combined biostimulatory (nutrients) and biointegrity 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 California Current ecosystem are contributing to eutrophication, particularly with respect to increasing algal blooms and declines in dissolved oxygen and pH.

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, such as habitat and hydromodification, 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 a knowledge base and 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 2018-19 will be on:

- **Building the technical foundation for nutrient targets for California water bodies**: SCCWRP is pursuing a multi-pronged approach toward building the technical foundation upon which policy decisions regarding biointegrity, nutrient and eutrophication targets for California's wadeable streams, lakes and estuaries will be based:
  - SCCWRP is developing an Algal Stream Condition Index (ASCI) to support biointegrity assessments and to link algal and benthic macroinvertebrate community composition to pathways of eutrophication impacts.
  - SCCWRP is using the consensus of wadeable stream experts to calibrate the range of scores for ASCI and the benthic macroinvertebrate-based California Stream Condition Index (CSCI) that correspond to levels of ecological condition and function, from high to low. This information will support decisions regarding biological goals for CSCI and ASCI by helping to relate these targets back to levels of beneficial-use protection.
  - SCCWRP is working toward development of statistical models that relate standardized stream bioassessment indices to nutrient concentrations and eutrophication indicators. Such models may provide the approach used by the statewide biostimulatory/biointegrity policy on how to make decisions on nutrient targets.
  - SCCWRP is continuing to demonstrate how science can inform a combined biostimulatory/biointegrity approach to watershed management. Through the Santa Margarita River Nutrient Management Initiative, SCCWRP is supporting stakeholders by collecting monitoring data and developing statistical and mechanistic process models to establish watershed-specific nutrient targets for the Santa Margarita River's estuary and main stem, based on biointegrity goals.

- **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) supporting partners to pinpoint which HAB organisms are present and which toxins are being produced to better characterize the extent of the problem, including through DNA barcoding, which is being coupled with rigorous analyses of toxin presence to more fundamentally characterize lakes, streams and estuaries, (2) conducting studies to understand the drivers for HABs proliferation and toxin production, including nutrients, temperature and hydromodification, and (3) supporting the State Water Board's efforts to develop chlorophyll-a and cyanotoxin targets for lakes, and (4) playing a role in unifying the HABs 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 supporting a statewide group that is working to implement a statewide cyanobacteria monitoring strategy.

- **Biogeochemical effects of anthropogenic nutrients and carbon in the Southern California Bight**: SCCWRP is working with partners to couple biogeochemical models with physical oceanographic models to ascertain the relationship between coastal hypoxia and acidification conditions as sources of land-based nutrient inputs enter the Bight and other locations along the North American West Coast. 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 coastal hypoxia and acidification may be driven primarily by climate change and thus operate at a global scale. Coupled biogeochemical and physical circulation models, which 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

The science community has invested heavily in understanding how climate change will manifest in the coming decades. Researchers have developed sophisticated monitoring programs to document carbon dioxide emissions in the atmosphere, track changes in air and water temperature, and measure acidity of the ocean. Similarly, researchers are using state-of-the-art computer models to predict how weather and rainfall patterns will be altered, how sea levels will rise over the next century, and the uncertainty and nuances that necessarily accompany multi-decade predictions. These detailed analyses are beginning to answer pressing societal questions about what the ways that global climate change will play out in local communities, and starting to drive long-term planning and priority setting by state, federal and local governments. Most climate change research focuses on physical changes in the ocean and terrestrial ecosystems, such as sea level rise and temperature. To effectively protect aquatic environments in the face of global climate change, water-quality managers also must know how animals, plants and entire ecosystems will respond to this changing physical environment. Just as importantly, managers need to know which strategies, tools and approaches are viable, cost-effective and optimized to help mitigate ecosystem impacts and how responses to climate change (e.g., seawalls, channel armoring, water diversion) may translate to secondary impacts to aquatic resources.

Toward that end, SCCWRP's climate change research is focused on connecting rapidly growing knowledge about the physical aspects of climate change with assessments and prediction of how aquatic ecosystems will respond. SCCWRP is working to understand biotic response to four climate change stressors: (1) how changing rainfall and runoff patterns will influence California's efforts to protect the environmental flows that sustain aquatic ecosystems, and how the state's water resources management community can improve and better coordinate its approaches to protecting these flows, (2) how biological communities that live in low-lying coastal wetland environments will be impacted by rising sea levels in the coming decades, and how coastal resources managers can use this information to chart courses of action that maximize opportunities for these ecological resources to adapt, (3) how warming waters affect distribution of biota, including nuisance species such as cyanobacterial blooms, and (4) how rising ocean acidity affects the health of marine food webs. SCCWRP invests in creating and strengthening monitoring programs that evaluate the biological impacts of these changing environmental conditions, as well as building sophisticated computer simulations of how climate change will affect the health, distribution and resiliency of sentinel aquatic species.

This year, SCCWRP will continue to focus on understanding biotic responses to the stressors of climate change. SCCWRP's focus for 2018-19 will be on:

- **Assessment of acidification and its impacts:** Among SCCWRP's top priorities are developing a scientific understanding of ocean acidification, a phenomenon caused by oceanic assimilation of atmospheric carbon dioxide. This ocean acidification research compasses several topical areas, including: (1) developing and applying a coupled physical-biogeochemical model to estimate the current and future extent of acidification and hypoxia under climate change (see Eutrophication research theme) and to investigate the contribution of local pollution inputs to acidification and hypoxia, (2) defining biological endpoints affected by acidification and the chemical thresholds at which those effects manifest; this includes laboratory and field experiments, as well as workshops with leading experts to synthesize the effects of acidification on selected marine taxa, and (3) mining historical data to assess the extent to which acidification may have already manifested; SCCWRP is working with its member agencies to digitize and analyze historical data sets dating back 50 years or more, with the intent to examine possible local trends in acidification.

- **Evaluation of coastal adaptation strategies to sea level rise**: While prior SCCWRP research has focused on evaluating the susceptibility of coastal wetlands to the effects of sea level rise, SCCWRP will continue its work to evaluate adaptation strategies aimed at helping wetlands persist in the face of expected dramatic increases in mean sea level and storm surge. Computer modeling suggests that coastal California may experience several meters of sea level rise by the turn of the century. To understand how coastal wetlands might accommodate these changes, SCCWRP and its partners are developing linked physical and biological models that can be used to evaluate adaptation planning. These models are being used to evaluate how strategies such as augmenting accretion, management of mouth dynamics, and facilitating transgression can help reduce anticipated wetland losses associated with sea level rise.

- **Evaluation of climate change and water resources management effects on southern California streams**: Because climate change complicates decisions regarding how to balance competing ecological and human demands for in-stream flows, and because changing precipitation patterns and warmer temperatures are likely to reduce summer baseflows and increase the variability of winter storm flows, SCCWRP is working to help managers manage environmental flows to maintain desired biological endpoints in the context of changing runoff patterns and water management practices. SCCWRP is incorporating local downscaled predictions of changing temperature and rainfall patterns into flow ecology models to evaluate how climate change may affect decisions regarding in-stream flow management. This, in turn, will be used to inform deliberations regarding setting flow targets aimed at ensuring healthy biological communities, within the context of other demands on water supply.

# 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. SCCWRP and its collaborators have 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 is developing an additional assessment framework that applies sophisticated mathematical models to 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 reflect the two main routes by which 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 pollutants 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 2018-19 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 biological assessment arena, SCCWRP is evaluating how to use DNA barcoding to rapidly assess the condition of marine benthic invertebrate communities, and is also adapting benthic indices for use in low-salinity environments. Research is also underway to develop a rapid causal assessment framework for macrofaunal community impacts in embayments. In the toxicology arena, SCCWRP is investigating the impact of ocean acidification on contaminant bioavailability and sediment toxicity.

- **Indirect effects on sediment quality**: To assess sediment contamination's health risks for humans and wildlife, SCCWRP is continuing to refine bioaccumulation models and assessment frameworks that integrate chemical exposure and sediment contaminant linkage indicators. In the sediment linkage arena, SCCWRP is using passive sampling and tissue contamination measurements to improve the ability of bioaccumulation models to address the influence of dissolved contamination in the water column on food web contaminant transfer.

- **Sediment quality objectives implementation**: To support implementation of new evaluation tools for assessing sediment quality impacts on human health, SCCWRP is continuing to update its technical support resources and guidance documents.

# 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 tens of thousands of chemicals to triage, making the traditional chemical-by-chemical approach to monitoring and regulation unwieldy. 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 when compared with chemicals already being regulated, which has presented additional challenges for their detection and assessment. As a result, a new approach to monitoring and assessment of aquatic contaminants is needed.

SCCWRP is developing three 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 ("targeted" and "non-targeted" chemical analysis) will provide a means for interpreting biological monitoring results. Tools that concentrate chemicals directly from the environment ("passive sampling methods") will make sampling and collection of CECs more efficient and relevant. 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 continue investigating new bioanalytical tools that screen for CECs responsible for non-endocrine modes of action, while continuing to assess the quantitative linkage between cellular ("bioscreening") assay responses and effects to organisms for endocrine-disrupting CECs ("EDCs"). SCCWRP will also continue developing and applying targeted and non-targeted chemical methods for identifying water-soluble CECs and biotoxins. Finally, SCCWRP will test different passive sampling materials that can efficiently sample and concentrate CECs, including biotoxins, from the environment. SCCWRP's focus for 2018-19 will be on:

- **Bioanalytical screening methods**: To expand the current bioanalytical toolbox, SCCWRP is using high-throughput cellular assays to screen for a wider variety of CECs, including those identified as bioactive using chemical analysis. These assays are being evaluated using known chemicals and mixtures thereof, as well as on real (field-collected) samples. This year, SCCWRP will employ those tools for the first time on a large scale as part of the Southern California Bight 2018 Regional Monitoring Program (see Regional Monitoring research theme). In parallel, SCCWRP is extending the scope of linkage testing using freshwater and estuarine/marine fish species (e.g., fathead minnow, inland silverside) to look for concordance between bioscreening results and the degree of both lethal and non-lethal harm for fish exposed in the lab and in the field. To accomplish the latter, researchers will develop reliable sublethal toxicity endpoints as measures of aquatic health (e.g., gene biomarkers, developmental and behavioral endpoints).

- **Analytical methods for identification of problematic CECs and fingerprinting**: To identify CECs that exhibit bioactivity and/or toxicity, SCCWRP is developing targeted and non-targeted analytical methods for environmental matrices of interest (e.g., water, sediment, tissue). Researchers are also developing non-targeted methods for these matrices to distinguish among sources of contamination (e.g., for receiving environments subject to stormwater and/or wastewater discharge).

- **Passive sampling of CECs**: SCCWRP is applying and developing passive sampling methods to more efficiently collect CECs of interest that occur at low concentrations in water and sediment. Passive samplers have the potential to facilitate sampling of CECs (e.g., pharmaceuticals, current use pesticides and biotoxins) as well as persistent pollutants in a form that represents a more relevant parameter of chemical exposure to target.

# 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) developing methods to provide same-day health warnings to ocean bathers, (2) improving the approaches used to identify sources of microbial contamination, and (3) understanding 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 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 examine the prevalence of antibiotic-resistant bacteria and the genes that confer resistance in wastewater treatment plants and discharges. 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. SCCWRP's focus for 2018-19 will be on:

- **Evaluating antibiotic-resistant bacteria and genes in wastewater:** SCCWRP is collaborating with its wastewater treatment member agencies to quantify the prevalence of antibiotic-resistant bacteria in wastewater treatment plants and their discharges. The study was prompted by media reports that potentially pathogenic antibiotic-resistant bacteria and antibiotic resistance genes may persist and even multiply during the wastewater treatment process before being discharged into the environment with treated effluent. The purpose of the study is to gain information about the type and prevalence of antibiotic-resistant bacteria and antibiotic resistance genes in southern California wastewater treatment plants and their discharges.

- **Tracking microbial biofilm communities in sewer pipes**: SCCWRP and collaborators are investigating whether the microbial community growing on the inner surfaces of public sewer pipes is unique to this type of infrastructure, a finding that could provide insights into the origins of human fecal contamination found in aquatic systems across Southern California. Researchers are using microbial source tracking methods to determine whether leaking sewer pipes could be responsible for the fecal contamination of Southern California waterways, or whether the contamination is coming from other sources, such as direct deposition of fecal matter into storm drain channels. The biofilm community that lines the insides of sewer pipes is theorized to be the product of unique environmental factors, including temperature, moisture, darkness and a rich nutrient supply.

- **Assessing health effects on swimmers**: SCCWRP and collaborators are continuing to work toward determining the appropriateness of setting site-specific objectives for water-quality criteria at Southern California beaches via Quantitative Microbial Risk Assessment (QMRA). A QMRA analysis is ongoing at Inner Cabrillo Beach, a popular swimming spot in the Los Angeles Harbor area where fecal indicator bacteria concentrations frequently exceed water-quality guidelines. As part of this effort, SCCWRP will be advancing the use of genetic methods to more accurately and rapidly measure the viral pathogens that are the illness vectors.

# 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 is that most monitoring is focused on addressing relatively compact areas that surround specific outfalls – monitoring that is required under state and federal laws. Even when scientists compile this compliance-based monitoring data from dozens of agencies, the resulting regional picture is incomplete. Recognizing this challenge, SCCWRP helps coordinate 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 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 Southern California Bight Regional Monitoring Program, conducted every five years since the mid-1990s. The ongoing 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 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 begin field sampling for the next five-year cycle of the Southern California Bight Regional Monitoring Program, known as Bight '18. Additionally, the SMC Regional Watershed Monitoring Program is in the middle of its second cycle that started in 2014. SCCWRP's focus for 2018-19 will be on:

- **Regional marine monitoring (Bight '18)**: The Southern California Bight Regional Monitoring Program, an integrated collaborative regional monitoring initiative, has developed five major study elements for the program's sixth cycle, known as Bight '18: Sediment Quality, Ocean Acidification, Harmful Algal Blooms, Trash and Microbiology. Dating back to 1994, the Bight program provides holistic answers to questions regarding the extent and magnitude of anthropogenic impacts and the range of natural variability upon which scientists evaluate these impacts. The Bight program covers approximately 1,500 square miles of near-coastal ocean and has sampled over 2,000 sites. For Bight '18, more than 80 collaborating agencies will track trends in ecosystem health, including new habitats not previously monitored. Bight '18 also will provide a platform for testing new monitoring technology, including new sampling techniques, new pollutants, and new ecosystem response assessment tools. Finally, Bight '18 will examine emerging developments in water-quality management, including the success of previous management actions.

- **Regional watershed monitoring**: SCCWRP is facilitating the second cycle of the Southern California Stormwater Monitoring Coalition (SMC) Regional Watershed Monitoring Program, which kicked off in 2014 and runs through 2019. The program assesses the health of approximately 4,300 miles of streams in coastal Southern California watersheds. The regional stream survey is among the largest in the country, with sampling at more than 500 sites across all 17 major watersheds between the Ventura and Tijuana Rivers. Data being collected encompass water quality, physical habitat and riparian condition, and biological communities, including benthic invertebrates and algae. The monitoring questions for the second five-year cycle 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?

# Emerging Research and Member Agency Support

SCCWRP provides support for its member agencies in a number of ways, including 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.

SCCWRP also conducts research in areas that have not yet grown into a thematic focus area, though have the potential to do so in future years. Key among those in SCCWRP's 2018-2019 research agenda are:

- **Trash pollution**: Development of reliable, repeatable trash-surveying capabilities is crucial as California and its municipalities seek to document the effectiveness of aggressive, next-generation trash reduction and control programs being rolled out statewide. SCCWRP and its partners are working to establish cost-effective, repeatable methods for quantifying trash levels and types in various settings (e.g., roadways, stream banks). Through Bight '18, researchers also are continuing to track the extent of trash on the Bight seafloor, enabling managers to establish temporal trends.

- **Stormwater and urban runoff treatment strategies**: As Southern California stormwater managers install best management practices (BMPs) to improve the quality of stormwater and urban runoff, there is a need to optimize their design and application to improve outcomes. SCCWRP and its partners are evaluating the efficacy of various BMPs to remove pathogens, indicator bacteria, nutrients, metals and other contaminants from runoff. SCCWRP is also researching ways to improve current BMP performance by developing and testing new BMP technology, such as bioretention soil media.