SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT AUTHORITY

FY 2021-2022
RESEARCH PLAN
EXECUTIVE SUMMARY

Approved by the SCCWRP Commission
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Contents

Introduction

The Southern California Coastal Water Research Project (SCCWRP) is a public research agency that develops and applies next-generation science to improve management of aquatic systems in Southern California and beyond. Since its founding in 1969, SCCWRP has focused on developing strategies, tools and technologies that the region's water-quality management community relies on to effectively protect and enhance the ecological health of Southern California's coastal ocean and watersheds. SCCWRP's reputation is built on conducting scientific research and translating it into actionable guidance that informs management decision-making and policy development. SCCWRP science has served as the basis for discharge permits and watershed basin plans, runoff requirements for development, biological objectives for aquatic life, sediment quality criteria, and microbial contamination standards for beach ocean water. SCCWRP also plays a key role in developing and facilitating long-term regional monitoring programs, stewardship of environmental data, and regional planning efforts and regulatory compliance strategies. Through its governing board, the SCCWRP Commission, SCCWRP works to build scientific consensus and unify its 14 member agencies and other environmental organizations around best-practices approaches for improving management of aquatic systems.

Mission

SCCWRP's mission is to enhance the scientific foundation for management of Southern California's ocean and coastal watersheds. 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 water-quality and aquatic ecosystem 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. **Contaminants of Emerging Concern**
6. **Microbial Water Quality**
7. **Stormwater BMPs**
8. **Regional Monitoring**

Furthermore, SCCWRP conducts new and emerging research that has 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 five-year research vision for each of SCCWRP's major thematic research areas. Written for knowledgeable scientists working in each particular field, these full thematic Research Plans (available online) provide an overview of how SCCWRP conceptually approaches the research theme and how SCCWRP's multi-faceted research strategy fits together. These comprehensive technical documents also identify broadly supported priorities for research. CTAG and SCCWRP staff collaborate in all-day research planning workshops to update these documents on a rolling basis, typically every three years. 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.

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, consists of a series of concise summaries of SCCWRP's research directions within each research theme, plus 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, certain organisms serve as particularly useful indicators of ecosystem health because they integrate conditions at a site over time. In this way, these organisms can directly measure management effectiveness at protecting aquatic life and other designated beneficial uses for water bodies. Organisms used in bioassessment commonly have limited mobility and cannot escape the stressors affecting them (e.g., algae, bottom-dwelling invertebrates). Thus, these organisms integrate the effects of chemical contaminants, habitat alteration and other non-chemical stressors over time. Different biological assemblages also have different sensitivities to individual stressors, allowing focused forensic evaluations that can identify causal impacts. SCCWRP is focused on the development of a comprehensive bioassessment framework, including survey design tools and interpretation methods, that empowers environmental managers to use bioassessment data to inform regulatory and management decisions. SCCWRP's vision is that bioassessment can serve as the foundational tool for monitoring and managing diverse water body types across California and beyond.

SCCWRP has successfully developed bioassessment tools for streams, wetlands and marine environments that rely on an assortment of bioassessment organisms, including benthic invertebrates, fish, and algae. Additionally, SCCWRP is developing tools for comprehensive, headwaters-to-oceans bioassessments, including the development of novel indicators for priority habitat types (e.g., wadeable streams, estuaries, submerged aquatic vegetation, and soft-bottom coastal waters) that cover a range of trophic levels and that can serve as indicators of the functional health of water bodies. To support these efforts, SCCWRP is leading research projects in three broad areas: (1) assessing condition and support for beneficial uses by examining biological organisms, populations, communities and processes; (2) linking conditions to manageable stressors, both for water bodies in poor condition (i.e., causal assessment) and good condition (i.e., protective assessment); and (3) supporting the application of bioassessment data to management decisions (e.g., improving data access and interpretation).

This year, SCCWRP will continue to develop, refine, and expand its capacity to conduct both condition assessments and causal/protective assessments, as well as pursue development of guidance and decision support tools to inform management actions. SCCWRP's focus for 2021-22 will be on:

- **Condition assessment:** Building on past successes in developing bioassessment indices for freshwater and marine ecosystems, SCCWRP will focus on adapting these indices for climate change, and continuing development of bioassessment indices for priority habitats, including ephemeral streams, lakes and estuaries. There will be a particular emphasis this year on refining the interpretation of bioassessment information for modified aquatic systems, both within Southern California and in other parts of the state. In addition, SCCWRP will continue to explore molecular methods, including DNA metabarcode sequencing and quantitative PCR (qPCR), as a rapid, cost-effective alternative to traditional microscopic taxonomy for fish, benthic algae, and stream vertebrates. Finally, SCCWRP is exploring new ways to interpret and synthesize data from multiple indicators, such as multi-trophic network models, that can provide better insights about ecosystem function and beneficial use support than single-indicator assessments.

- **Linking conditions to manageable stressors**: SCCWRP will continue to evaluate the relationship between biological condition measures and stressors (ranging from conventional

pollutants such as chloride, to new and emerging pollutants) to help managers set stressor levels that will protect aquatic life. These relationships are foundational to SCCWRP's ability to develop tools that make causal assessment a reality and an integrated part of routine monitoring. For example, SCCWRP is developing prototype Rapid Screening Causal Assessment tools that include a web-based dashboard to enable application/interpretation of bioassessment data. These tools and their data interface will speed up the traditionally time-consuming process of analyzing stream bioassessment data to pinpoint which stressors are responsible for poor stream condition. SCCWRP will also develop a framework to link causal assessment results with specific, practical management actions to improve water body condition. Finally, SCCWRP will work toward developing tools that use bioassessment data to support protective management actions, including identifying water bodies that have high conservation value and water bodies that are healthy but vulnerable to future stressor exposure.

- **Supporting applications to management**: Perhaps the greatest obstacle to using biological data is their relative complexity compared to other types of monitoring data. To get around this obstacle, SCCWRP is developing tools capable of high-level syntheses of complex data sets, while also supporting deeper investigations for audiences requiring high levels of detail about their biological monitoring data. This work will be mainly accomplished through improved data science tools, such as easily understood data interfaces and automated report cards that advance open science principles, including analytical transparency and repeatability, as well as clear communication of results. Finally, SCCWRP will continue to support the consistent production and use of bioassessment data through the development of protocols for standardizing monitoring data, and through participation in workgroups focused on these goals. This includes development of web-based and video training materials that facilitate consistent application of bioassessment tools.

Full thematic Research Plan for Bioassessment (PDF)

Ecohydrology

Ecohydrology is the study of how changes to flow patterns impact the health of aquatic ecosystems. Streams, wetlands and other aquatic environments all experience routine natural variation in the timing, magnitude, duration and frequency of flows. While aquatic life has naturally adapted to these flow patterns, human activities can trigger significant disruptions to flows that alter the natural structure and composition of aquatic ecosystems. California's water resources management community needs to understand the relationship between alterations to environmental flows and ecological impacts to make optimal decisions about how to impound, divert, recharge and otherwise control the release of water to serve a variety of societal needs – from flood control to agricultural irrigation to water recycling. SCCWRP research is helping water resources managers take science-informed approaches to solving complex flow management issues. By developing tools and strategies that help managers evaluate various potential options for offsetting threats to environmental flows, SCCWRP is poised to help bring greater consistency, standardization and coordination to the design of environmental flow management programs across California.

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, changes in flow, and related physical and biological responses, 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 management actions, including stream restoration, 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 – and how these changes affect water resources management decisions. SCCWRP's focus for 2021-22 will be on:

- **Assessing flow duration to understand the extent of aquatic resources**: SCCWRP will continue working to help watershed managers in the Arid West and beyond understand the extent of their aquatic resources by developing critically needed tools that enable streams to be classified by their flow duration (i.e., as perennial, intermittent, or ephemeral). SCCWRP will continue to refine the recently released "beta" version of the Streamflow Duration Assessment Method (SDAM) for the Arid West, while also supporting the development of comparable tools for other regions of the United States, including the Western Mountains, the Great Plains, Alaska and Hawaii. SCCWRP's efforts will focus not just on SDAM development, but also on supporting agencies that seek to incorporate SDAMs into their programs (i.e., through the creation of training programs and data management and visualization tools).

- **Applying flow-ecology to water resources management**: SCCWRP is continuing to examine how to apply flow-ecology principles to optimally support water resources management, including urban stormwater and dry weather flow management, evaluation of climate change effects, and evaluation of water use and reuse proposals. SCCWRP is conducting investigations focused on the effects of flow management in three Southern California watersheds (Los Angeles River, San Juan Creek and Aliso Creek), with a goal of informing stormwater and wastewater management actions (including reuse) and stream restoration. These projects will help develop recommended environmental flow targets that sustain the health of freshwater fish, amphibians and riparian habitats, while also optimally balancing competing demands on finite water resources, especially reuse of treated wastewater effluent discharges and enhanced stormwater capture practices. These projects represent important early implementations of the recently developed California Environmental Flows Framework (CEFF) for Southern California urban watersheds. SCCWRP also is applying flow-ecology principles to assess hydrologic vulnerability of all coastally draining streams in the San Diego region in an effort to help inform basin planning and management in the region.

- **Evaluating the effectiveness of hydromodification management**: SCCWRP is developing a framework for evaluating the effectiveness of hydromodification management actions aimed at restoring and maintaining the physical and biological health of Southern California streams. Although sufficient management actions have occurred to begin evaluating the efficacy of recent hydromodification management approaches and the tools used to inform management decisions, comprehensive monitoring data at the appropriate temporal and spatial scales are rarely collected, limiting the capacity to evaluate performance effectiveness.

Thus, SCCWRP is conducting a regional field survey of Southern California streams, which were previously surveyed 15 years ago, to identify the appropriate monitoring timeframe, frequency, and spatial extent necessary for assessing performance effectiveness. SCCWRP will also develop recommendations to restructure monitoring programs and to standardize approaches for assessing performance effectiveness. Information compiled through these efforts will also be used to determine any necessary refinements to the hydromodification screening and assessment tools previously developed by SCCWRP and its partners.

- **Advancing species modeling for informing environmental flow recommendations**: SCCWRP is advancing the science of species occurrence and distribution modeling by applying this science to several southern California case studies. SCCWRP is drawing on previously developed statistical approaches that relate changes in flow to effects on biological communities (especially benthic invertebrates and algae). Concurrently, SCCWRP is exploring new hybrid statistical and mechanistic approaches for conducting assessments that enable proposed flow alterations to be evaluated in terms how they affect higher trophic communities, such as fish, amphibians, and birds, and piloting their application to inform environmental flow decisions. These initial models, which focus on flows within the Los Angeles River watershed, will be further developed to include stream temperature and evaluation of the effects of multiple stressors on biological communities in multiple watersheds. SCCWRP also intends to further expand these models to include consideration of interactions between physical modification of stream channels and flow alteration.

Full thematic Research Plan for Ecohydrology (PDF)

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 can also lead to low dissolved-oxygen levels that 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 man-made toxic contaminants, some level of nutrient input is necessary to sustain life. Consequently, environmental managers must balance the need to maintain nutrients that support aquatic life with the need to control the deleterious impacts of excessive nutrients and other water body conditions that can exacerbate eutrophication. SCCWRP is working to quantify how much nutrients in a given water body is too much, and how nutrients combine with other environmental factors to trigger eutrophication. SCCWRP's long-term goal is to develop comprehensive eutrophication management strategies, including the ability to pinpoint when and where eutrophication is likely to occur, how to prevent it, and how to mitigate it.

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 (i.e., nutrient) and biointegrity (i.e., aquatic life) policy to protect California's wadeable streams, lakes and estuaries. SCCWRP is also supporting the Water Boards' recently developed Freshwater Harmful Algal Blooms (HABs) Program in developing cost-effective methodologies to monitor HABs and their linkage to eutrophication. 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 HABs and declines in dissolved oxygen and pH. Across all of this work, SCCWRP is focused on: (1) Building consensus around conceptual models that identify symptoms of eutrophication (e.g., altered dissolved oxygen concentrations, increased algal abundance, acidification, toxic HABs) and their link to both nutrient loading and other contributing water body factors; (2) designing frameworks for assessing water body condition and identifying thresholds for specific symptoms that will protect human and ecosystem values while avoiding adverse impacts; (3) developing cost-effective monitoring and assessment strategies (4) building statistical and mechanistic numerical models that link eutrophication symptoms to nutrients and other factors, such as habitat and hydromodification, to examine environmental management scenarios that prevent an ecosystem impact; and (5) assisting in transferring new tools and strategies to environmental managers.

This year, SCCWRP research will continue building a knowledge base that allows HABs and eutrophication to be more effectively monitored and managed in California, both in fresh and marine waters. SCCWRP's focus for 2021-22 will be on:

- **Building the technical foundation for eutrophication targets in California water bodies**: SCCWRP is pursuing a multi-pronged approach to build the technical foundation upon which policy decisions regarding biointegrity, nutrient and eutrophication targets for California's wadeable streams, lakes and estuaries will be based. This year, SCCWRP will continue to advance the science supporting the State's proposed biostimulatory/biointegrity policy, which is intended to govern the health of wadeable streams, lakes and estuaries. This ongoing work includes refining statistical models that link algal and benthic macroinvertebrate community composition to pathways of eutrophication impacts; these models will support State decision-making on eutrophication (a.k.a. biostimulatory) targets. SCCWRP also will continue its work to support policy discussions for biostimulatory targets in lakes, including developing statistical models that relate harmful algal bloom and hypoxia endpoints in lakes to eutrophication gradients of nutrients and chlorophyll-a; this work is being coupled with landscape models that predict how land use and other remotely sensed data influence eutrophication risk. Finally, SCCWRP will continue demonstration projects illustrating how to apply a combined biostimulatory/biointegrity approach to watershed management decision support, with ongoing case studies in the Santa Margarita, San Joaquin and Sacramento River watersheds.

- **Assessing harmful algal blooms**: To understand the magnitude and spatial extent of HABs across marine, estuarine and freshwater systems, SCCWRP is studying the ecophysiological factors that drive HABs initiation and proliferation. This year, SCCWRP will continue its focus on: (1) supporting the State in launching a comprehensive inland Freshwater HABs Program monitoring and assessment strategy, including building monitoring methodology, infrastructure and coordination; (2) conducting field-based and remotely sensed status and trends assessments of HABs in lakes, streams and estuaries, including pinpointing which HAB organisms are present and which toxins are being produced; (3) comprehensively characterizing HAB drivers, including nutrients, temperature and hydromodification, and how these drivers trigger the production of toxins; (4) identifying factors that influence fate and transport of HAB toxins that are measured in edible shellfish and other organisms; and (5) supporting development of mechanistic numerical HAB models for estuaries and the California coastal ocean.

- **Biogeochemical effects of anthropogenic nutrients and carbon in the Southern California Bight**: SCCWRP will continue working with West Coast researchers to apply coupled physical oceanographic and biogeochemical models to examine how regional carbon dioxide emissions and discharges of land-based nutrient sources into the Southern California Bight and other locations along the California Coast are influencing coastal ocean acidification, hypoxia and HABs. SCCWRP and collaborators will be using the models to: (1) quantify causal linkages to particular sources (point source vs. non-point source) and pathways (river runoff vs. atmospheric deposition vs. ocean outfalls); (2) simulate alternate scenarios for wastewater nutrient management and water recycling to predict the efficacy of various management strategies to reduce eutrophication; and (3) explore how global climate change is altering the ocean state and how these changes influence anthropogenic nutrient transport, fate and effects. Finally, SCCWRP is facilitating conversations around the uncertainty associated with modeling analyses, with an ultimate goal to help managers optimally use these models to inform coastal nutrient management decisions.

Full thematic Research Plan for Eutrophication (PDF)

Climate Change

Global climate change will fundamentally alter how aquatic systems are managed. As anthropogenic carbon dioxide emissions drive increasingly severe changes to weather, rainfall patterns, and ocean temperature and chemistry, water-quality managers will be tasked with developing long-term strategies and management responses. Although climate change drivers operate primarily at a global scale, the impacts will largely be managed at a local scale. To that end, California managers must be prepared to confront the local impacts of climate change that are independent of water-quality impacts, including understanding how water bodies of all kinds are being altered by changing environmental conditions, and how the diverse plant and animal communities they support are impacted by these changes. SCCWRP is helping California water-quality managers connect rapidly-growing knowledge about the physical manifestations of climate change to aquatic ecosystem responses. SCCWRP's end goal is to provide managers with viable, cost-effective strategies and tools for mitigating and offsetting climate change's ecosystem impacts.

SCCWRP's research is focused around five main areas: (1) Altered hydrological flow patterns, which encompasses how changing rainfall and runoff patterns, drought cycles, and changing water use and reuse practices are impacting efforts by California's water resources management community to optimally protect the environmental flows that sustain freshwater aquatic ecosystems; (2) sea level rise, which encompasses how vulnerable animals and plants in coastal wetlands and other low-lying habitats will be impacted by rising sea levels in the coming decades, and how California's coastal resources management community can use these insights to protect sensitive species and preserve maximum ecological functioning; (3) warming waters, which encompasses how to protect both public and ecosystem health from spreading toxic cyanobacterial blooms, increases in pathogenic bacteria, and proliferation of other nuisance species that are becoming more common as waters warm; (4) ocean and estuarine acidification and deoxygenation, which encompasses how corrosive coastal ocean conditions and low dissolved oxygen levels threaten the health of marine food webs, and; (5) solutions for mitigating and offsetting the effects of climate change, including how California's water-quality management community can better control and manage human activities on land to mitigate ecological effects at sea.

This year, SCCWRP will continue to focus on understanding biotic responses to the stressors of climate change. SCCWRP's focus for 2021-22 will be on:

- **Evaluating climate change's effects on in-stream beneficial uses:** Given that climate change will affect rainfall patterns and temperature, which will, in turn, affect the ability of streams to support beneficial uses in the future, SCCWRP is coupling temperature response models with flow-ecology principles to evaluate the effects of climate change on aquatic life across Orange and San Diego County watersheds. First, SCCWRP is evaluating the effects of future changes in rainfall and water use patterns on stream flows and biological integrity, with a goal to inform flow management priorities. Next, SCCWRP is evaluating the linked effects of multiple stressors, including developing tools to relate climate change-induced flow and stream temperature changes to eutrophication and effects on biological communities. Finally, SCCWRP is evaluating hydrologic vulnerability on stream biological health in light of projected future changes in rainfall and land use.

- **Assessing the biological effects of ocean acidification and hypoxia:** SCCWRP is continuing to build unique capacity to assess the variability and trends associated with seawater chemistry conditions (temperature, oxygen, pH, productivity). SCCWRP will use these tools to continue investigating how multiple biological communities, including HABs, kelp, seagrass, pelagic and benthic organisms, are being affected by changing seawater chemistry and how these effects will intensify in the coming decades. SCCWRP's focus areas include: (1) identifying the pathways of biological effects and the best indicators for measuring these effects; (2) identifying the seawater chemistry thresholds at which these biological effects occur; and (3) developing statistical and mechanistic numerical models characterizing the relative importance of these effects, both individually and at a population level. SCCWRP will continue facilitating ongoing efforts to build international consensus on the thresholds at which sentinel organisms can be expected to experience adverse impacts of ocean acidification and hypoxia (OAH). SCCWRP also will continue laboratory experiments, field experiments, and historical data analyses to better characterize how multiple stressors, including OAH, are affecting economically and ecologically important marine populations; this work will include partnering on West Coast-wide acidification surveys and linking them to the Southern California Bight Regional Monitoring Program, as well as conduct a status and trends assessment of kelp based on historical data sets. Finally, SCCWRP is helping to develop integrative indices that predict potential effects of climate change stressors on various habitats, and that then can be extended to population-level effects; these tools will be used both to disentangle the effects of climate change and local anthropogenic inputs when modeling coastal eutrophication (see Eutrophication research theme), as well as to support California's climate change mitigation strategies.

- **Evaluating regional strategies and solutions to climate change**: SCCWRP is working not only to identify the adverse effects of climate change, but also to identify and quantify the efficacy of potential solutions to offset and mitigate these effects. The potential solutions that SCCWRP is investigating include: (1) how strategies such as augmenting accretion, management of mouth dynamics, and facilitating transgression could help reduce anticipated wetland losses associated with sea level rise; (2) how implementing "living shoreline" solutions could help biological communities in estuaries and similar ecologically fragile habitats adapt to sea level rise; (3) how aquatic plants (e.g., seagrass and macroalgae such as kelp) could fix carbon and remove nutrients that, via coastal eutrophication, exacerbate OAH

and HABs, and (4) how regenerative kelp farming – either alone or in combination with bivalve culture – could be optimally sited to minimize environmental impacts and bolster coastal economies.

Full thematic Research Plan for Climate Change (PDF)

Contaminants of Emerging Concern

Contaminants of emerging concern (CECs) refer to the thousands of chemical contaminants in aquatic environments that are rarely monitored, but for which emerging evidence shows they may pose a threat to ecosystem and human health. Introduced to water bodies through a wide array of human activities, CECs have the potential to impact the health of fish and other animals over time. But because these effects generally are not acutely lethal, California's water-quality management community has historically struggled to manage these contaminants and document their long-term, chronic biological impacts. SCCWRP is developing next-generation strategies and tools for comprehensively monitoring emerging contaminants in aquatic environments. And these strategies are not always focused on dissolved chemicals because new and potentially threatening CECs come in many forms – the latest being microplastics. SCCWRP's goal is to help water-quality managers efficiently and cost-effectively zero in on which CECs pose potential health risks to wildlife and humans.

SCCWRP's CEC research is centered around building, testing and refining tools and strategies that improve how emerging contaminants are monitored in aquatic environments. This CEC management paradigm is designed to help managers more cost-effectively and efficiently zero in on which of the tens of thousands of CECs in aquatic environments are potentially triggering adverse biological impacts. SCCWRP's research focuses on: (1) developing measurement tools for quantifying exposure to CECs; (2) understanding the ambient environmental occurrence of CECs; (3) characterizing the dose-response of CEC effects and the likelihood of these effects manifesting in sentinel species; (4) understanding sources, fate, and transport of CECs; (5) characterizing remediation strategies for CECs; and (6) transferring technology to end-user managers. SCCWRP is pursuing three main technologies to achieve these goals: (1) Bioanalytical cell screening assays to screen water bodies for bioactive chemicals, including development of reliable, quantitative linkages between cell screening assay responses and adverse effects at individual, population, and community levels of biological organization in southern California; (2) passive sampling methods to detect chemical contaminants at low concentrations in the environment for minimal cost; and (3) non-targeted chemical analysis to identify which of the thousands of chemicals that cannot be reliably measured using targeted methods might be generating biological effects.

This year, SCCWRP will continue expanding the bioanalytical screening toolbox and investigating the quantitative linkage between bioassay responses and biological effects in key species. SCCWRP will also continue developing and applying targeted and non-targeted chemical analysis methods, as well as novel approaches to passive sampling, to identify and monitor water-soluble CECs and biotoxins in the environment. SCCWRP's focus for 2021-22 will be on:

- **Bioanalytical screening methods**: SCCWRP is continuing to advance the use of high-throughput cellular assays as a cost-effective, rapid tool for screening a wide variety of bioactive CECs in aquatic environments. This year, SCCWRP will develop additional cell assay endpoints to screen for multiple additional classes of contaminants in aqueous matrices, including recycled water and ambient water. SCCWRP will also continue to apply these tools to monitoring programs (e.g., Surface Water Ambient Monitoring Program) and support their transition into routine adoption and use by water-quality agencies. In parallel, SCCWRP will continue to expand 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 novel sublethal endpoints (e.g., RNA-based gene biomarkers, developmental and immune endpoints) and compare these endpoints to bioscreening results.

- **Novel chemical sampling and measurement methods**: SCCWRP is continuing to pursue development and application of novel water sampling technology, in conjunction with targeted and non-targeted chemical analysis methods, to more effectively and efficiently identify and track an increasingly wide universe of CECs in aquatic systems. SCCWRP is evaluating how to obtain semi-quantitative estimates of mean concentration for suspect and unknown CECs collected in passive sampling. SCCWRP also is evaluating whether non-targeted CEC results from passive samplers are comparable to those from traditional grab sampling, which would broaden the management utility of passive sampling. SCCWRP also is ascertaining occurrence of novel tire wear compounds shown to have acute toxicity to fish in southern California waters. Finally, SCCWRP is continuing to develop and apply non-targeted methods to distinguish among sources of contamination in receiving environments subject to stormwater and/or wastewater discharge.

- **Microplastics measurement methods and health effects**: As the State Water Board and California Ocean Protection Council develop statewide strategies for managing microplastics in aquatic systems, SCCWRP is building a scientific foundation for crafting informed strategies that optimally protect wildlife and humans from the potential health impacts of microplastics exposure. SCCWRP is continuing an international intercalibration study, with nearly 40 participating laboratories worldwide, to evaluate multiple candidate measurement methods (and their variants) for microplastics in source water, sediments, and tissues; the goal is to determine accuracy, repeatability and reproducibility among labs, including the level of resources required for labs to make optimal measurements. SCCWRP also is conducting a series of studies to quantify the inputs, fate and transport, and bioaccumulation of various microplastic types and shapes for the region's streams, estuaries and coastal ocean. Complimented by studies that measure the effects from environmentally relevant exposure scenarios on the health of aquatic organisms, these studies will form the foundation of environmental risk assessments – and the basis of the statewide strategies - for microplastics.

Full thematic Research Plan for Contaminants of Emerging Concern (PDF)

Microbial Water Quality

Microbial water quality is a focused area of aquatic microbiology dedicated to minimizing the risk of human exposure to waterborne pathogens. Whether swimming and surfing at the beach, or consuming shellfish harvested from coastal waters, the public depends on rigorous, fully vetted science to rapidly detect aquatic microbial contamination and to inform remediation strategies. Advances in molecular microbiology are enabling the water-quality management community to develop incrementally stronger, more effective solutions for protecting public health. SCCWRP is working to improve methods for evaluating microbial water quality and assessing risks to public health from waterborne pathogen exposure. SCCWRP's goal is not only to improve the speed at which microbial contamination can be detected, but also to develop molecular methods for tracing contamination back to its source and pinpoint its origin point. SCCWRP also is focused on helping water-quality managers better understand how field measures of microbial contamination correspond to specific levels of health risk.

SCCWRP's microbial water quality research is focused around three major areas: (1) Rapid methods for microbial contamination detection, which involves validating the accuracy, sensitivity and applicability of DNA and RNA-based methods for measuring microbial contamination; (2) microbial source tracking, which involves using molecular methods to identify whether humans vs. various individual animal species are responsible for observed contamination – and to identify where in a watershed the contamination is coming from and potentially which specific type of stormwater or wastewater infrastructure is responsible; and (3) microbial risk assessment, which involves quantifying health risk for Southern California's beachgoing population through epidemiological studies, as well as through health risk modeling approaches such as Quantitative Microbial Risk Assessment (QMRA) that estimate illness risk based on site-specific considerations.

This year, SCCWRP will continue to focus on human fecal source tracking, a revisit of risk-based water quality objectives for recreational shellfish waters, and quantitative surveillance in wastewater of the SARS-CoV-2 virus that causes COVID-19. SCCWRP's focus for 2021-22 will be on:

- **Identifying human sources of fecal contamination during wet weather**: SCCWRP is working to identify specific sources of human fecal contamination in Southern California waterways during wet weather by tracking and quantifying the relative contributions of public sewers, private laterals, septic systems, illicit connections and illegal discharges, and individuals experiencing homelessness. This work, which includes quantifying both relative contributions and the factors that control these contributions, is a reflection of the fact that human fecal sources appear to be widespread in Southern California waterways during wet weather. During these short but dynamic storm events, source tracking is incredibly difficult when so many possible human sources are mixed together in stormwater runoff. These source-tracking investigations build on previous SCCWRP research that has found that the risk of gastrointestinal illness from body contact recreation during wet weather is greater than the risk illness during dry weather, and that genetic markers of human fecal contamination (i.e., HF183) and human pathogens are commonly found in wet-weather discharges. Related research this year will start to establish relationships between HF183 and human pathogens, utilizing QMRA to establish health risk thresholds for wet-weather discharges. With managers no longer asking "Are human fecal sources found in wet weather?" but rather "What are the human source(s) found in wet weather?" the goal of this research is to help managers most efficiently and effectively remediate human fecal sources to protect the public health of beachgoers following storm events.

- **Evaluating the SHEL water-quality standard**: SCCWRP and its partners are continuing to investigate whether a water-quality standard designed to protect the health of people who consume shellfish from Newport Bay in Orange County has been appropriately set. The study's goal is to examine whether California's existing standard for permissible fecal coliform bacterial levels in the water correlates to potentially unsafe levels of pathogens in the tissue of bivalve shellfish harvested from Newport Bay. If the water-column bacterial measurements of indicators positively correlate with pathogen levels found in the shellfish, researchers would conclude that California's existing standard for recreational shellfish harvesting is working as designed. However, if there is no relationship between water-quality indicators and pathogens found in the shellfish, the study could provide a scientific basis for developing a site-specific standard for Newport Bay, or trigger follow-up studies examining the appropriateness of using a fecal coliform-based standard to protect California shellfish.

- **Coronavirus surveillance of sewersheds**: SCCWRP is part of a national research team that is investigating the use of wastewater treatment plant influent as a more comprehensive COVID-19 surveillance system, given that infected people are known to shed the SARS-CoV-2 virus in their fecal material. The study will involve quantifying presence of COVID genetic markers in wastewater treatment plant influent, along with quantifying shedding rates and decay during transport to the facility. The study is intended to help address the existing lack of clear information about magnitude and trends in infection rates, as existing insights about infection rates are based on measuring infection in a small percentage of the population – and therefore slanted toward measuring individuals already showing illness symptoms. When completed, the project will provide decision-makers with a rapid, cost-effective tool for estimating pervasiveness of infections and for assessing the effectiveness of government-mandated behavior restrictions and business closures. The tool also will provide early-warning signs of future waves of infection, including from COVID-19 variants. The study is ongoing at about 50 sites nationally, with SCCWRP leading the effort for seven of them in Southern California.

Full thematic Research Plan for Microbial Water Quality (PDF)

Stormwater BMPs

Stormwater BMPs (best management practices) are a disparate collection of engineered solutions, landscaping modifications and other strategies for managing how water runs off the land during both dry and wet weather. Although Southern California's stormwater management community is expected to spend billions of dollars on stormwater BMPs in the coming decades to reduce contamination levels in runoff and better control flows, relatively little is known about how to optimize their design and maintain their long-term effectiveness. SCCWRP is developing BMP strategies and tools intended to bring clarity and confidence to the science and engineering of stormwater management. SCCWRP's focus is on building a comprehensive understanding of the sources, fates and effects of runoff across Southern California, then using these insights to help managers design maximally effective BMP interventions.

SCCWRP's stormwater BMP research is centered around four main areas: (1) Understanding BMP mechanisms and processes, which involves quantifying how different BMP treatment mechanisms

and processes remove various levels and types of pollutants from runoff; (2) developing design criteria for BMPs, which involves creation of decision support tools that help managers select optimal BMPs and combinations of BMPs for specific geographical and environmental settings; (3) optimizing long-term BMP performance, which involves developing strategies for monitoring and maintaining BMPs to maximize their long-term performance effectiveness; and (4) maximizing watershed-scale benefits, which involves developing frameworks and solutions for optimizing the synergistic effects of BMPs to improve and protect overall watershed health. SCCWRP prioritizes understanding not just performance effectiveness of BMPs themselves, but also the way BMPs influence the health of receiving water bodies – from hydrology and physical habitat to water chemistry to the biological communities they support.

This year, SCCWRP will focus on supporting management decisions for how to optimize the long-term performance effectiveness of BMPs. SCCWRP's focus for 2021-22 will be on:

- **Developing quantitative techniques and metrics for assessing BMP performance**: Given the difficulty that managers have in choosing the "right" BMP to address site-, watershed- and sewershed-specific objectives (due in part to the fact that many criteria that can be used to assess success), SCCWRP is working to assemble disparate metrics for BMP performance into a robust, quantitative index that scores BMP performance based on multiple criteria, including technical effectiveness, site opportunities and constraints, and long-term maintenance requirements. Managers will be able to choose from a wide variety of individual technologies in their BMP "toolbox" as they evaluate different potential BMP options for a given site. Drawing on data generated by BMP monitoring programs, SCCWRP intends to develop data structures and dashboards to support index calculation and compliance reporting, and to evaluate effectiveness of design and maintenance activities in near-real time.

- **Designing a comprehensive regionwide BMP monitoring network**: SCCWRP is working with the Southern California Stormwater Monitoring Coalition (SMC) to develop a regional program for site-scale BMP performance monitoring to answer critical management questions regarding BMP performance, design, and maintenance across Southern California. This monitoring network, which could be among the largest in the country, is predicated on well-defined research objectives, consistent and coordinated data collection, and a unifying framework for sharing data. Researchers will be able to leverage the regional monitoring network to cost-effectively generate robust, statistically relevant data sets covering a range of BMP types that serve multiple land uses across a spectrum of operating conditions. These data will be used to improve BMP selection guidance, streamline annual reporting, develop cost-effective asset management programs, and support Reasonable Assurance Analysis and Alternative Compliance. In parallel, SCCWRP is working with the SMC to create a monitoring program for non-structural BMPs to understand their effectiveness at reducing pollutant concentrations and loading; nonstructural BMPs (i.e., public education) are a category of management actions for which even less performance effectiveness information is available than for structural BMPs.

- **Informing adaptive watershed management strategies**: SCCWRP is working with regulated and regulatory stormwater managers to develop watershed adaptive management guidance that can support multi-decadal stormwater management planning. The guidance will help address the design of capital improvement projects estimated to cost billions of dollars in the coming decades. Although stormwater managers are building adaptive

strategies into planning scenarios on a regular basis, these focal-point decisions are often ill-defined, non-specific and unquantified. The guidance SCCWRP is developing will address what decisions need to be considered, what management options might be considered for different outcomes, and how to generate the appropriate data to inform these challenging adaptive decisions.

Full thematic Research Plan for Stormwater BMPs (PDF)

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?" 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 the 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 dozens of 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, serving as models for developing similar programs internationally They also are adaptive to pressing management needs and priorities. In particular, as climate change alters baseline monitoring data for species distributions and habitat quality across the region, researchers are adapting monitoring programs in multiple ways, including by developing climate change assessment tools to standardize and maintain climate variables, as well as by modifying existing ecological assessment tools to disentangle biological/habitat shifts linked to climate change from shifts linked to other human-induced stressors.

SCCWRP's best-known monitoring program is the Southern California Bight Regional Monitoring Program, conducted every five years since 1994. 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 (SMC) 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. Both programs renew their research plans regularly, keeping the programs focused on current management needs. The key to success in developing integrated monitoring plans 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 data and implement findings. Moreover, regional monitoring participants have come to rely on regional data

sets to interpret their own local monitoring data. Finally, regional monitoring provides an important launching platform for SCCWRP's member agencies and research collaborators to test, vet and calibrate new technologies and assessment tools.

This year, SCCWRP will continue to facilitate the 2018 cycle of the Southern California Bight Regional Monitoring Program, known as Bight '18, and the 2019-2023 cycle of the SMC Regional Watershed Monitoring Program. SCCWRP's focus for 2021-22 will be on:

- **Regional marine monitoring (Bight '18)**: SCCWRP is continuing to work with more than 80 partner agencies to complete the sixth cycle of the Southern California Bight Regional Monitoring Program (Bight '18), one of the largest and longest running ocean monitoring programs in the country. This integrated, ongoing regional monitoring collaboration provides holistic answers to questions regarding the extent and magnitude of anthropogenic impacts, the range of natural variability upon which scientists evaluate these impacts, and shifting baselines of natural condition as global pressures alter even our most untouched parts of the coast. Bight '18 is made up of five major study elements: Sediment Quality, Ocean Acidification, Harmful Algal Blooms, Trash, and Microbiology. Bight '18 includes monitoring of new habitats not previously monitored, new sampling techniques, new pollutants, and development and testing of new ecosystem response assessment tools. During each Bight cycle, SCCWRP facilitates the development of study designs, data management plans, data analysis, and co-authoring of final assessment reports. Since its inception in 1994, the Bight program has conducted comprehensive monitoring of approximately 1,500 square miles of near-coastal ocean, with more than 2,000 sites sampled.

- **Regional watershed monitoring**: SCCWRP is facilitating the third cycle of the Southern California Stormwater Monitoring Coalition (SMC) Regional Watershed Monitoring Program, which runs from 2019 to 2023. This year, SCCWRP will continue finalizing study designs and coordinating field sampling activities for the regional survey, which samples at more than 500 sites across all 17 major watersheds between the Ventura and Tijuana Rivers. Among the largest watershed programs in the nation, the program encompasses data on water quality, physical habitat and riparian condition, and biological communities, including benthic invertebrates and algae. The monitoring questions for the third five-year cycle are: (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? For the third cycle of SMC regional monitoring, participants are focusing more effort on trend assessment, and adding a new element focusing on mapping the extent of perennial, intermittent and ephemeral streams. Additionally, this cycle of regional monitoring is targeting assessment work at specific sites of interest, including soft-bottom engineered channels and sites where restoration efforts and/or implementation of stormwater BMPs (best management practices) are likely to affect biological condition.

- **Statewide estuary monitoring**: Estuaries are critical habitat for a multitude of species, including unique plants, fish nursery grounds, and migratory bird nesting. SCCWRP is working with a statewide team of partners to develop a monitoring and assessment framework for estuaries across the state. The framework will address which components of the ecosystem should be assessed, and how to evaluate the ecological function of the these highly heterogenous systems. SCCWRP is focusing initially on the 24 estuarine Marine Protected Areas (MPAs) across the state. SCCWRP will develop recommendations on suites of indicators (and associated sampling protocols) across multiple trophic levels that can be

used to assess key estuarine functions. SCCWRP also is developing approaches for contextualizing the resulting information using comparisons to reference, paired estuaries and regional ranges of condition. Ongoing field testing of the recommended indicators will be used to continue refining protocols.

Full thematic Research Plan for Regional Monitoring (PDF)

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 management-friendly documents such as the SCCWRP Annual Report and SCCWRP Director's Report. 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.

In addition, SCCWRP conducts research on burgeoning issues of management concern that have not yet grown into a thematic focus area. SCCWRP's adeptness in rapidly responding to pressing management needs is a trademark of SCCWRP research. The Emerging Research section of SCCWRP's 2020-21 research agenda will include:

- **Risk assessment**: SCCWRP is pursuing development of a potential new thematic research area that will focus on assessing the relative importance of various stressors impacting the health of aquatic environments, and on helping managers prioritize which stressor(s) are having the greatest effects on aquatic health and other beneficial uses. The aim is to support management decisions and implementation strategies by providing a relative risk ranking among multiple stressors in a water body, and evaluating the feasibility and socio-economic impacts of possible management solutions. Risk assessment relies on several steps including stressor exposure, biological effects, risk estimation, cost-benefit analysis, and risk communication. As this potential new research theme comes into focus, SCCWRP, which has decades of experience researching exposure and effects, intends to pilot research that will focus on ecological risk estimation and cost-benefit analysis for microplastics.

- **Guidance for site-specific threshold development**: SCCWRP is working to develop guidance for establishing site-specific objectives that can support environmental assessments for compliance-oriented programs. Although regulatory agencies have established processes for dischargers to develop site-specific objectives when water-quality objectives are not applicable to a site, the processes are often not straightforward, and existing guidance can be limited, creating inconsistencies and variation in how site-specific objectives have been established. SCCWRP is working to develop scientifically robust and publicly transparent frameworks that can guide managers in developing site-specific thresholds to protect aquatic life and other beneficial uses. Ongoing efforts include building out a database for the Los Angeles region that will enable SCCWRP to evaluate the feasibility of using a toxicity analysis method known as the Biotic Ligand Model (BLM) to develop copper site-specific objectives for freshwater streams.

- **Optimizing toxicity testing protocols**: SCCWRP is working to increase consistency, confidence and comparability of the *Ceriodaphnia dubia* chronic reproduction test, which is widely used in toxicity assessments. Despite its long history of use in compliance-based monitoring, the *C. dubia* test has been subject to culture crashes, sometimes inexplicable variability, and seemingly random toxic responses to negative controls. SCCWRP will investigate the test conditions and factors that can be controlled, and then develop quality assurance and quality control guidance to ensure labs can produce comparable, high-quality test results. The ultimate goal is to ensure management decisions based upon this toxicity test can be made with confidence.